

# ICES WGFTFB REPORT 2005

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## REPORT OF THE ICES–FAO WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR (WGFTFB)

18–22 APRIL 2005

ROME, ITALY



International Council for the Exploration of the Sea  
Conseil International pour l'Exploration de la Mer

**International Council for the Exploration of the Sea**  
**Conseil International pour l'Exploration de la Mer**

H.C. Andersens Boulevard 44–46

DK-1553 Copenhagen V

Denmark

Telephone (+45) 33 38 67 00

Telefax (+45) 33 93 42 15

[www.ices.dk](http://www.ices.dk)

[info@ices.dk](mailto:info@ices.dk)

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## Executive summary

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The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) met at the FAO Headquarters in Rome, Italy 18–22 April 2004. The Group addressed five Terms of Reference (ToRs). During the 2004 meeting, convenors for four of the ToR were appointed and given the responsibility of forming **Topic Groups** comprising of other interested WGFTFB members. Two of the ToRs are being considered over a two-year period, these Topic groups met to review the current literature, receive presentations on individual work items and adopt future actions for formation and presentation of their final reports, which will be given at the 2006 WGFTFB meeting. Three other topic groups worked by correspondence throughout the year to produce a series of review documents, outlining the state of the art, summarising the key issues and providing recommendations for future actions.

Following on from earlier discussions between FTC/WGFTFB and ACFM presentations were given on how the WGFTFB could expand and coordinate the inputs necessary for **Fisheries Based Advice and the Ecosystem Approach to Fisheries Management**. A summary of the Annual Meeting of the Assessment Working Group Chairs (AMAWGC), which identified the type of information that would assist in the advisory process, was given along with an overview of the changes within the ICES advisory process and the institutional structure of ICES. It was concluded that the WGFTFB would provide necessary information. However, due to the amount of inter-sessional work that this may require, some members felt that this would need further support from national institutions and may result in a diversion of resources (time). ICES National delegates should be made aware of this and transmit this information to their respective institutes. A term of reference for 2006 is proposed, using the North Sea as a case study, with a view to expanding this to cover other eco-regions in the future.

The **Topic Group meeting on Bycatch in Shrimp Fisheries** reviewed and evaluated recent technical developments in bycatch reduction devices (BRDs); including estimated global usage of BRD's; implementation plans for bycatch reduction in shrimp fisheries; and to assess adequacy of size selection in shrimp fisheries. This ToR was at the request of the FAO. Several presentations were given to the topic group meeting on bycatch reduction in shrimp trawls from a very wide geographical area (West-Africa, Latin America, Asia, Australia, USA and Europe). The main selective devices described were TED's (Turtle Excluder Devices) and JTED's (Juvenile and Trash Excluder Devices), most often in the form of sorting grids. These devices are being strongly promoted in Asia, Latin America and Africa. A tremendous amount of work is going on outside the ICES area and this topic group has established some very interesting links. The group concluded that:

*“Research between fishing technologists and industry stakeholders involved in coldwater and tropical shrimp fisheries should be initiated to further develop species-selective bycatch reduction devices, and to improve the size selectivity of shrimp and Nephrops in trawls. At the local, regional, and national levels, Bycatch/Discard Action Plans should be developed for shrimp fisheries. Where, in certain countries, reliance on catches of juvenile fish in shrimp-trawl fisheries exists, it should be reduced.”*

The **Topic Group meeting on the review of legislation relating to technical conservation measures** identified that during the past five years many changes have been made to fisheries legislation relating to gear design and applying to North East Atlantic fisheries. The European Commission has adopted several recovery plans and is scheduled to review technical conservation measures (TCM) legislation. The International Baltic Sea Fisheries Commission has adopted new measures to control fishing gear in their area over the past few years. Legislators, scientists and the fishing industry recognise however, that there are inconsistencies in the current range of legislation. The group produced an extensive list of national and international (EU) legislation pertaining to fishing gear design. Individual countries identified areas of leg-

isolation that give the greatest problems e.g., from an enforcement perspective; where there is a need for better TCM regulations or where the legislation is considered ineffective from a gear selectivity viewpoint. The group identified where there are inconsistencies in TCM legislation between adjacent waters, or between the scientific advice and/or stock management areas e.g., several mesh sizes applied for the same stock. Three sub-groups considered the following areas (i) Baltic; (ii) North Sea, Norwegian Sea, Skagerrak, Kattegat and West of Scotland and (iii) Western Waters. By way of illustration of the complexity and difficulties in EU legislation, the group used *Nephrops* fisheries as a case study. The overall findings were that there are a number of specific issues, which may be considered for revision; gear technologists should be involved in such a process and it is suggested that linkage with the ICES SG on Management Strategies would be appropriate. With regards to inconsistencies between areas, gear technologists should assist by describing the selective characteristics of different legislation (e.g., mesh size). The Chair of WGFTFB has been invited to discuss the Topic Groups findings with the EU Commission.

The **Topic Group meeting on Oil and Gas Industry Fishing Interactions** met to review and report on work done, identify information gaps and recommend re-search priorities on interaction between fishing gear, pipelines and other sub sea structures; and cuttings piles. The group collated a bibliography of over 50 papers, together with abstracts and summarised their content. Variations in guidelines for ‘overtrawlable’ and ‘trawl friendly’ criteria for subsea designs were identified as well as the need for updated information on fishing gear designs and operations to assist sub-sea design engineers. Similarly, there is a need to disseminate information on sub-sea designs that mitigate interaction problems. However, due to the highly confidential nature of offshore exploration, it is difficult to obtain such information. This limits the development of new mitigation designs due to the restriction of knowledge between competing companies. Attempts should be made by relevant bodies to provide generic, non-specific information that can help enhance development. Fishing gear technologists and gear manufacturers should cooperate on the development of simple design modifications to gear components e.g., doors and clumps, to reduce risk of snagging/hooks. There is little available information on improvements or modifications to gear design, and the group concluded that specific studies are needed with model as an appropriate first step. There is little information available on the interaction of gear and the cuttings piles created under drilling platforms. Application of appropriate techniques for assessing risks to structure, fishing gear and vessel from trials results is needed to increase confidence in the application of experimental results. While the issue of the potential spread of toxic or polluted cuttings material is an important aspect of abandonment policy there should also be consideration of the physical effects on fishing gear of impacting cuttings piles. Full-scale trials are needed to identify likely mechanisms of interaction between the piles and different gear components such as trawl doors, nets and in particular wires. There is a need to conduct impact/snagging field experiments with more up to date gear designs and on large diameter bundled pipelines, which are now commonly used by the offshore industry.

**Topic Group meeting on the use of multiple size selection devices in towed gears** convened during the 2005 meeting, and received several presentations on individual work items where selective properties of additional devices e.g., grids and square mesh panels, were compared with standard diamond mesh codends. The group produced a bibliography of current literature and agreed to expand this by sourcing grey literature. The key practical issues of implementation of additional devices for controlling size selection were discussed. These included handling and safety problems, the need for more complex legislation and enforcement officer training and additional costs to the fishing industry. A number of work items were identified and the structure of the report agreed. The group will aim to publish its findings as an *ICES Cooperative Research Report* and will continue to work by correspondence, presenting its findings during the 2006 WGFTFB meeting.

**Topic group on environmentally friendly alternative fishing gears for traditional species** worked by correspondence and met during the ICES ASC 2004. During the WGFTFB 2005 meeting the group met to collate and summarise available information (references) on how to attract/guide/direct fish towards static fishing gear such as a trap and pot gear system. A number of individual presentations were given during the Topic group meeting. The group will continue to work by correspondence through 2005–2006 and will report their findings to the WGFTFB meeting in 2006. The group agreed that efforts would be made to publish these findings as an *ICES Cooperative Research Report*.

**Term of Reference on the adoption of the OMEGA gauge and measuring protocol.** There is a need to standardise the measurement of mesh size. Scientists, netting manufacturers and enforcement personnel typically use different instruments. An EU funded programme “Development and testing of an objective mesh gauge”, known as the OMEGA project, was undertaken by a number of European scientific and enforcement bodies as well as netting companies. The main aim of the project was to design, build and test a new objective mesh gauge, suitable for fisheries inspection, fisheries research and the fishing industry. In support a Protocol for using the new gauge for fisheries inspection, research and netting manufacturing was drafted, taking account of legal aspects of mesh inspection, this protocol is included in the WGFTFB report 2005. It was concluded that:

**“The ICES-FAO Working Group on Fishing Technology and Fish Behaviour endorses and encourages the use of the OMEGA mesh gauge as the standard mesh measurement tool for scientific studies and recommends that all stakeholders apply the OMEGA protocol.”**

Prior to the 2004 WGFTFB meeting, the Working Group received three requests from the International Baltic Sea Fishery Commission (IBSFC). **The appropriateness of mesh sizes for the Baltic herring fishery; what mesh size of T90 equates to the current BACOMA window; and the appropriate hook size/shape needed for Baltic cod (MLS 38cm).** (i) For herring mesh size, it was concluded that due to high escape mortality estimates that mesh selection should not be relied on as a principal management tool for controlling fishing mortality. (ii) The available data suggests that 110 mm T90 gives broadly similar selection to a 110 mm BACOMA window inserted in a 105 mm codend – this advice is given together with several important caveats; and (iii) no advice could be given on hook size/shape due to lack of data but information on how to conduct experiments was given. Full details can be found in the 2005 ICES Advisory report.

The Chair of the WGFTFB participated in the **ICES Study Group on Salmon Bycatch in pelagic trawl fisheries (SGBYSAL)**. To estimate the total bycatch of Atlantic Salmon in the pelagic fisheries, the study group used ratios of salmon to target species catches from screening of commercial catches and from a range of scientific survey gears and applied these to disaggregated catch data from the commercial pelagic fisheries. The Chair of the WGFTFB recommended that due to operational and design differences between gear types (commercial and survey) and the absence of inter-calibration estimates, it was not advisable to use survey

gear data to provide estimates of commercial bycatches. Recommendations on how to calibrate between gears were given. As a result, estimates of bycatch have been downgraded from earlier.

## 1 Directive

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The directive of the WGFTFB is to initiate and review investigations of scientists and technologists concerned with all aspects of the design, planning and testing of fishing gears used in abundance estimation, selective fishing gears used in bycatch and discard reduction; and benign environmentally fishing gears and methods used to reduce impact on bottom habitats and other non-target ecosystem components, including behavioural, statistical and capture topics.

The Working Group's activities shall focus on all measurements and observations pertaining to both scientific and commercial fishing gears, design and statistical methods and operations including benthic impacts, vessels and behaviour of fish in relation to fishing operations. The Working Group shall provide advice on application of these techniques to aquatic ecologists, assessment biologists, fishery managers and industry.

## 2 Introduction

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Chair: Dr Norman Graham  
Institute of Marine Research  
P.O. Box 1870 Nordnes  
N-5817 Bergen  
Norway  
norman.graham@imr.no

Rapporteur: Dr Hans Polet  
Sea Fisheries Department  
Ankerstraat 1  
B-8400 Oostende  
Belgium  
hans.polet@dvz.be

Venue: Rome, Italy

Date: 18–22 April 2005

### 2.1 Terms of reference

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] (Chair: Dr Norman Graham, Norway) will meet in Rome, Italy, from 18–22 April 2005 to:

- a) Review and report on bycatch in shrimp trawl fisheries;
  - i) To review, and evaluate recent technical developments in bycatch reduction;
  - ii) To estimate global usage of bycatch reduction in shrimp fisheries;
  - iii) To review implementation plans in shrimp fisheries;
  - iv) To assess adequacy of size selection in shrimp fisheries.

(Topic leaders: Thomas Moth-Poulsen, Mass. Div Marine Fish, USA, Wilfried Thiele, FAO Rome, and Norman Graham, IMR, Bergen)

- b) Review issues relating to legislation on technical conservation measures relating to fishing gear design;

(Topic leaders: Dick Ferro, FRS, Aberdeen and Dominic Rihan, BIM, Dublin).

- c) Review and report on work done, identify information gaps and recommend research priorities on interaction between fishing gear; and
  - i) Pipelines and other sub sea structures;
  - ii) Cuttings piles.

(Topic leader: David Bova and Dick Ferro, FRS, Aberdeen)

- d) Review and report on the use of multiple size selection devices in towed gears to include the following topic;
  - i) Recent trawl size selection experiments where multiple selection systems have been assessed, e.g., square mesh panels, grids etc., considering the impact on the target and bycatch species;
  - ii) Developments in modelling multiple selection data;
  - iii) Practical issues relating to additional technical measures such as on board handling and material strength of the multiple selective devices and fisheries enforcement issues.

(Topic Leaders: Norman Graham, IMR, Bergen and Barry O'Neill FRS, Aberdeen will work by correspondence and meet at the 2005WGFTFB meeting and report to the WG in 2006);

- e) Explore the potential for alternative fishing gears for traditional species that are environmentally friendly and a responsible fishing method;

(Topic Leader: Bjarti Thomsen, Faores and *an interested subgroup will work by correspondence and meet at 2005 WGFTFB meeting and report their findings either at the 2006 WGFTFB or the ICES Symposium on Fishing technology in the 21st Century*)

- f) Consider a recommendation for the adoption of the OMEGA mesh gauge and measuring protocol to replace the existing ICES mesh gauge as the new standard gauge in accordance with the 2002 recommendation of the former ICES Study Group on Mesh Measurement Methodology (SGMESH);
- g) In a joint session with the Working Group on Fisheries Acoustic Science and Technology [WGFAST] on the 21 April, review and report on:
  - i) Advances in survey strategy, design, and gear (including observational techniques such as sonar, video, cameras, and longlines);
  - ii) Techniques for validating multi-frequency acoustical species methods, with attention to appropriate time, space and scale (e.g., longlines, gill nets, plankton nets, survey trawls, CUFES, cameras, video, and u-tow); and
  - iii) Methods for integrating multi-disciplinary data to elucidate forcing functions of fish abundance and behaviour (e.g., environmental conditions, fishing pressure, and vessel noise).

Contact Norman Graham or David Demer

## Supporting Information

Priority:

The current activities of this Group will lead ICES into issues related to the effectiveness of technical measures to change size selectivity and fishing mortality rates. Consequently these activities are considered to have a very high priority.

## Scientific Justification:

- a) Shrimp trawl fisheries (including *Nephrops*) are generally associated with the highest levels of discarding. Globally, a considerable amount of research has been conducted into technical gear modifications to minimise the degree of unwanted bycatch, some of mandatory in a number of fisheries. The ob-

jective of this ToR is to review the state of the art with respect to technical development, global usage and the current plans to implement such devices into commercial fisheries and to provide estimates of the potential benefits to fish stocks.

- b) This could provide technical assessment of the problems to inform decisions on the need for changes in this legislation e.g., changes to European legislation EC 850/98.
- i. There has been a trend to increase mesh size in many fisheries in order to improve selectivity. Larger mesh size codends will expand to greater diameters and hence each twine will support a proportionally greater volume and weight of fish. For safety reasons it can be argued that these codends should be strengthened and this is most easily done by altering twine thickness or the number of open meshes around the codend circumference or by using a lifting bag. It is known that these features of codend design also influence selectivity and may reduce the effect of the initial mesh size increase.
  - ii. Currently in many fisheries twine thickness is limited to a maximum value. Twine stiffness rather than thickness may be the characteristic governing selectivity. Evidence of these effects needs to be assessed.
  - iii. Meshes with unequal sides are banned in European legislation because selectivity may be reduced with codends made of such netting. It is doubtful whether a prosecution would succeed since there is no accepted means to measure the sides of a mesh (bar length). Formulation of a suitable definition of bar length should be considered.
  - iv. Fishermen have complained that an increase in mesh size disproportionately affects certain sectors of the fleet, which are thereby at an economic disadvantage. It is claimed that gears (such as seines) are already highly selective or have less impact on the environment. It is also asserted that lower powered vessels cannot take action to limit the increase in selectivity (e.g., by increasing towing speed). An assessment of these claims using all available evidence is required.
- c) The oil/gas industry in the NE Atlantic has matured and abandonment of structures at the end of their useful life is being considered. Policies and strategies for abandonment which need to be formulated by national governments should be informed by knowledge of interactions of fishing gear with associated sub sea structures and residues in order to assess potential problems such as loss of fishing opportunities, damage to fishing gear, safety to fishermen and fishing vessels and pollution. ICES is an appropriate body to collate existing knowledge and review the need for further work.

In particular there are recent proposals to install larger diameter (bundled) pipelines, which, over substantial distances, may not be buried or trenched. Work has been done and is planned on interaction of fishing gear and these pipelines. Mitigating measures have also been devised for many sub sea structures on the basis of model or full-scale trials but the information is not easily available.

Drill cuttings piles, which have accumulated under drilling platforms, may be of the order of 10m high and may contain hydrocarbon and heavy metal residues. These cuttings piles could be left on the seabed after the removal of abandoned drilling platforms. The interaction of fishing gear with them is unknown. There are issues of dispersal rates and the initial impact with fishing gear components.

- d) There are a considerable number of fisheries worldwide that have mandated the use of additional devices (other than codend mesh size) for adjusting

size selection. These include the use of escape panels (BACOMA etc) and grids such as the Sort-X. There is an increasing volume of evidence suggests that, in some instances, the same effect can be achieved simply by increasing the mesh size. The introduction of such devices may place an additional financial cost on the fishermen and complicate legislative procedures may be important considerations. In other fisheries, particularly multi-species, the benefits of such devices are that they are more effective with one species (or group) while not impacting on others, for example square mesh panels and *Nephrops* trawls. There may also be other benefits for managers; for example, these 'additional' devices may provide more predictable selectivity.

- e) Many fishing practices are essentially the same as when developed centuries ago. Many are energy inefficient and are deleterious to the environments. Here we aim to use the natural behavioural patterns of fish to develop energy efficient non-deleterious harvesting practices that may have applications in fisheries worldwide.

### 2.1.1 Participants

A full list of participants is given in Annex 1.

## 2.2 Explanatory note on meeting and report structure

Before the 2004 WGFTFB meeting an alternative approach to the way specific Terms of Reference (ToRs) were considered by the WG, was initiated by the Chair. This replaced the mini-symposium format used previously. For the ToRs (Topics) selected at the WG meeting individual convenors were appointed to oversee and facilitate work required to address the agreed objectives of the theme sessions. The topic groups identified than by correspondence throughout the year. The Chair asked each convenor of the ToR's to prepare and present a working document to the entire WG, reviewing the current state of the art, summarising the principal findings, identifying gaps in the knowledge where consultation with other experts was required and recommending future research needs.

Two days were allocated for the convenors and members of the individual Theme Groups to meet, finalise their reports and findings, and produce a presentation. The individual working documents can be found in annexes 3 to 5. This format was followed for five of the six ToRs.

The **summaries and recommendations** for the working documents for each ToR were reviewed by WGFTFB and were accepted, rejected or modified accordingly to **reflect the views of the WGFTFB**. However, the contents of these working documents do not necessarily reflect the opinion of the WGFTFB.

In addition to the presentation of the review report, each convenor was asked to select a small number (~3) of individual presentations based on specific research programmes. The abstracts are included in this report, together with the authors' names and affiliations. Although discussion relating to the **individual presentations** was encouraged and some of the comments are included in the text of this report, the contents of the individual abstracts were NOT discussed fully by the group, and as such they **do not necessarily reflect the views of the WGFTFB**.

### 3 WGFTFB and the provision of advice for fisheries-based management

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#### 3.1 General overview

In the run up to the 2004 WGFTFB meeting, a number of discussions were held between the Chairs of ACFM and FTC to determine ways in how the FTC and its working groups could contribute to the ICES advisory process. Full details can be found in the WGFTFB report for 2004. In February 2005, the Chair of WGFTFB was invited to participate in the Annual Meeting of Assessment Working Group Chairs (AMAWGC) to discuss what types of information the WGFTFB could provide and what format the information should be in and how and when to deliver it. The WGFTFB were also given information on the ICES advisory process and recent structural and operational changes. Further details are given in the following sections.

#### 3.2 The ICES Advisory Structure and feeding information into the system – how, where and when

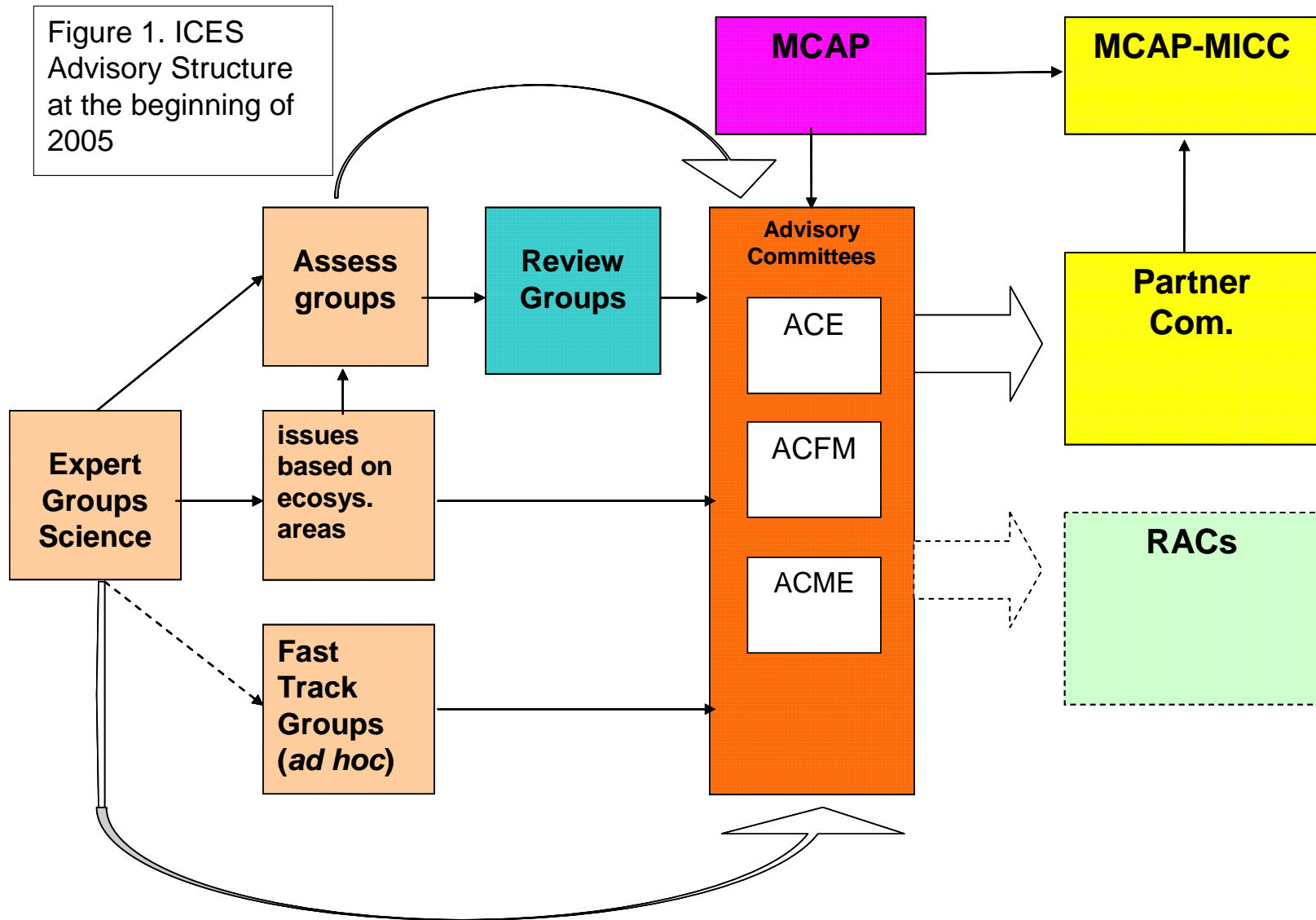
*Mette Bertelsen (ICES Advisory Programme Officer)*

##### Summary of presentation

An overview of the ICES advisory structure was presented (Figure 1), showing the inter-relationships between expert science groups, science and advisory committees. It was noted that ICES would continue to improve and strengthen operational links with partner commissions and develop relationships with the new Regional Advisory Committees and other stakeholders and continue to develop the ecosystem approach to fisheries management. Advice is increasingly given in an ecosystem and regional context (eco-regions), including consideration to mixed fisheries interactions and fisheries impacts on the ecosystem. With the growing attention to regional management areas there is also a growing importance on how ICES organises its work in terms of scientific analysis. The assessment procedures and formulation of advice as well as the function of WGRED and AMAWGC was presented as well as the timing of assessment WGs and ACFM, this information is important for the delivery of timely information from the WGFTFB. How and where the WGFTFB can interact was identified. There is a need to have information on fisheries and fisheries practices, evaluation of proposed or existing legislation, to evaluate options for reducing bycatch and especially on a number of issues relating to mixed fisheries – prediction of interactions between species, discard practices and fleet behaviour. The WGFTFB Chair should continue to participate in the AMAWGC meetings and WGFTFB should provide expertise directly to individual regional assessment working groups. As from 2005 the FTC Chair will be invited to take part in the October ACFM meetings to assure interactions. It would be beneficial if appropriate WGFTFB members could be identified as contact points, both in terms of regional advice and also in connection with the established fast track procedure to deal with ad hoc requests.

##### Discussion

The question is raised whether the current arrangement whereby “ex officio membership” to the ACFM is automatically the FTC Chair should actually be the case, not the Working Group Chairs. Perhaps it would be more appropriate for ACFM to have a much wider expertise base available to call upon. Working group Chairs used to take part in the ACFM meetings but since the review process have been taken out of ACFM meetings and now instead takes place in the review groups, the Working group Chairs no longer attend the Advisory meetings but take part in the respective review groups. It was also stressed that it is important that requests to Working Groups continue to be very specific and that two-way communication is firmly established between WGFTFB and ACFM.



### 3.3 Outcome of Annual Meeting of Assessment Working Group Chairs (AMAWGC)

*Norman Graham (IMR, Norway)*

The Chair gave an overview of the recent changes within the ICES advisory process, including issues relating to the Ecosystem Approach to Fisheries Management, the provision of fisheries and area based advice and the needs for a more integrated approach between science committees and working groups. A summary of the recent dialogue between FTC/WGFTFB and the Chair of ACFM and the outcome of the ad hoc group discussions given at the 2004 meeting was presented to the members of the WG. The role and function of the AMAWGC and the areas where the WGFTFB should contribute to the advisory process were presented as well as the need for collaborative work with other WGs. The possible contributions include the effect of gear changes; biological evaluation of TCM's; fleet dynamics and descriptions. The members were made aware of the new Advisory Report Structure and the sections that gear technologists could contribute to: The Fisheries and Their Impact; Effects of Fishing on the Ecosystem; Mixed Fisheries and Fisheries Interactions; Regulations and their Effects and Factors affecting Fishing Operations. Possible inputs into these headings were then presented in detail. The Chair then presented a proposal of how the WGFTFB should respond to these inputs and how to manage them at a working group level. The Chair proposed the following actions and requirements:

- Principal ToR for 2006
- Adopt a rolling ToR for the WGFTFB and allocate time for work at each subsequent meeting
- Set up ad hoc regional groups based on ICES Eco-regions and use these groups to deal with requests from other areas e.g., RAC's
- Produce working documents, in collaboration with the Study Group on Unaccounted Mortality in Fisheries and the Study Group on Survey Trawl Standardisation, to be presented to the regional assessment working group

### 3.4 Overview of the Scottish commercial fishing gear survey

*Robert Kynoch (Marine Laboratory, UK)*

#### Summary of Presentation

Technological creep in the fishing industry should be monitored on a regular basis, particularly when it affects fishing mortality. From a gear selectivity and effort perspective it is important to monitor changes in gear design and construction. By means of skipper surveys, information is collected on the gear usage of the (predominantly) demersal fleet in Scotland by the Marine Laboratory, Aberdeen; the questionnaire is given in Annex 2. The main reason is the lack of information on the issue in the national statistics. The aims are 1) to evaluate the effects of technical measures, 2) effort studies and 3) to monitor gear developments.

#### Discussion

The author was asked what the response rate was of the survey. He replied that the survey is a face-to-face process which proved to work well. The important thing is that it is a dialogue, a two way process where you give information and receive information. This is much appreciated by fishermen.

In Ireland the idea exists to give the form to inspectors to conduct a similar survey. This is however thought not to work so well because the relationship between inspectors and fishermen is thought to be not always good. But in Ireland the relationship between inspectors and fishermen is not problematic.

### 3.5 General discussion

The discussion evolved around two main issues, i.e., 1) who will give the advice and 2) how should it be organised.

1) Participation in the advisory process is a question of resources and this is seen as a key issue. Are experts allowed to allocate more national time to the WG than they are already providing? Not all WG members are in a position to take on ad hoc requests, especially if it is not clear how much commitment will be requested.

It is suggested that the resource allocation question be taken back to the clients and commissioning organisations for evaluation. Possibly ICES national delegates should consider this issue because it is a question of personnel and national resources. It was stressed, however, by the Chair that the extra workload is expected to be reasonable.

It is, however, important to recognize that, if the WG members do not engage in this process of delivering advice then the future role and relevance of the WG is questionable. The WG should not be in a situation where requests for advice are denied, although there was general agreement that the way requests for advice are handled now, i.e., in topic groups, is feasible, especially since membership of these groups is voluntary.

2) The main concern of the WGFTFB should be to deliver good quality advice, as far as available information allows. The underlying assumptions and gaps in knowledge should be clearly indicated.

It is suggested that request for advice should be handled by regional subgroups within WGFTFB on an ad hoc basis. This holds a risk; however, that there is not enough expertise in the subgroup and that the quality of the advice goes down. An exchange of experts between regions may be necessary. It is also suggested that the North Sea or the Baltic region would be a good test base to set up a working structure. Expansion to other areas can follow upon this pilot study.

WGFTFB is an ICES-FAO Working Group with a much wider focus than the NE-Atlantic region. It is expected that the advice will mainly deal with problems in the European area. This may result in the activities of the WGFTFB shifting to a rather narrow EU-centric geographical area and that membership from non-EU countries may contract accordingly.

The remark was made during the AMAWGC meeting that the WGFTFB is in “another orbit” compared to other ICES WGs. It was stressed however, that WGFTFB is a technological oriented working group and that the nature of its work is quite different to the bulk of the ICES activities. In the last years, however, a lot of effort has been made to create stronger links with other WGs. There is a general feeling that the WGFTFB has succeeded quite well in maintaining its own activities. It was felt therefore the nature of the work of the WG should continue within the current format, but that also concerted efforts be made to consolidate the links with other groups created. The remark was made that the WGFTFB should not only be a forum for providing information in response to specific requests but also be pro-active in bringing the WGs opinions across. The information provided is very small compared to the data and expertise we have available. This needs to be better promoted.

The way forward! There is a general feeling within the group that the topic groups are a good way of handling requests for advice. The suggestion was also made that the national reports could be extended to include fisheries information; bringing relevant information together e.g., monitoring of technological creep that this information could be very interesting for stock assessment. This was considered a simple way to collect and provide crucial information to the functioning of the Working Group but a structure of what information should be recorded is required.

## 4 Summary of recent WGFTFB advice to International Baltic Sea Fisheries Commission and Study Group on the Bycatch of Salmon in Pelagic Trawl Fisheries

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*Norman Graham (IMR, Norway)*

Three specific requests were made to FTFB. A report was submitted to ICES in July 2004 - full details can be found in the 2005 ICES Advisory report. The summary findings are as follows:

- i) **Evaluate the appropriateness of the mesh sizes allowed in the Herring trawl fisheries (rule 10 of IBSFC Fishery Rules) in relation to the correspondence between mesh size and the herring population size structure;**

*Due to the high escapee mortality rates observed, it is unlikely that controlling the length of first capture by mesh selection will provide any benefit to the stock and is likely to contribute to a considerable source of unaccounted mortality. There are a number of technical modifications that may be used to reduce the quantity of meshed fish (stickers) associated with pelagic trawls.*

- ii) **When new data are available perform an evaluation of the selective properties of trawls using 90 turned diamond meshes and advice on appropriate mesh sizes corresponding to the BACOMA gear 110 mm window; and**

*A meta-analysis of selectivity parameters obtained from 299 hauls made during 14 cruises was conducted. This resulted in selectivity estimates for 35 gear types, comprising of both T90 and BACOMA configurations. From this analysis, a model predicts that for both L50 and SR, a 110 mm codend constructed from T90 mesh gives the same selectivity as a 110mm BACOMA window fitted in a 105mm codend. However there are a number of caveats that must be considered. The individual cruises were not specifically designed or structured to answer the particular question posed. This presents a number of limitations for the statistical analysis. This may result in an under estimation of the random variation due to over-representation of some cruises. For example, 203 hauls with the T90 codend were used in the analysis, compared to only 96 for the BACOMA. Similarly, only 4 out of the 19 cruises were conducted using commercial vessels. Additionally, due to the confounding effects of factors such as twine thickness, the number of meshes in circumference and vessel type (Research of Commercial), it has not been possible to determine the effect of a number of these on the selectivity. In order to address this, further research that specifically aims to quantify such affects is needed before any advice on these parameters can be given.*

- iii) **Advise on hook parameters (size and shape) in longline fisheries that correspond with the minimum landing size of cod of 38 cm. Evaluate the relationship between the numbers of hooks fished in longline settings and discard rates**

*It is not possible for the WGFTFB to recommend a specific hook size and shape that corresponds to the minimum landing size of 38cm for Baltic cod as there is no selectivity data currently available that can be used to determine the appropriate hook parameters.*

- iv) **2. Bycatch of Salmon in Pelagic Trawl Fisheries**

The Chair of the WGFTFB was asked to participate in the **ICES Study Group on Salmon Bycatch in pelagic trawl fisheries (SGBYSAL)**. The study group had previously used ratios of salmon to target species catches from commercial catch screening and from bycatch ratios obtained from a range of scientific survey gears. The Chair of the WGFTFB recommended that in the absence of inter-calibration, operational and design differences between gear types, it was not advisable to use survey gear data to provide estimates of commercial bycatches.

Recommendations on how to calibrate between gears were given. As a result, estimates of bycatch have been downgraded from earlier.

#### **Discussion**

The remark was made that a recent report demonstrated that northern salmon stocks are healthy, while Southern stocks, are depleted and environmental issues may be a factor. This could be an interesting topic for this subgroup. It was also said that escape mortality is high and the industry should play a major role in developing measures to reduce bycatch.

## **5 ToR a: Topic group meeting on bycatch in shrimp fisheries**

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**Conveners: Thomas Moth Poulsen (FAO), Wilfried Thiele (FAO) and Norman Graham (IMR, Norway)**

### **5.1 General overview and presentation of principal findings**

This ToR was introduced by Thomas Moth-Poulsen (FAO). An overview was given of recent studies in this field; a summary report has been written and added to this report in (Annex 3) as well as one supporting Working Document (Annex 3, Appendix 1).

#### **5.1.1 Terms of reference**

To review and report on bycatch in shrimp trawl fisheries;

- a) To review, and evaluate recent technical developments in bycatch reduction;
- b) To estimate global usage of bycatch reduction in shrimp fisheries;
- c) To review implementation plans in shrimp fisheries;
- d) To assess adequacy of size selection in shrimp fisheries.

#### **5.1.2 Abstract**

Several presentations were given to the topic group meeting on bycatch reduction in shrimp trawls from a very wide geographical area (West-Africa, Latin America, Asia, Australia, USA and Europe). The main selective devices described were TED's (Turtle Excluder Devices) and JTED's (Juvenile and Trash Excluder Devices), most often in the form of sorting grids. These devices are being strongly promoted in Asia, Latin America and Africa. A tremendous amount of work is apparently going on outside the ICES area and this topic group has established some very interesting links.

One of the main problems in third world countries is that almost all bycatch is used and sold. If the ship's owner does not sell it, then it is taken by the crew or used by schools or hospitals. This has serious consequences for the management of the fisheries.

It was noted that the topic group has had some delay due to the tsunami disaster in southern Asia.

### 5.1.3 Participants

Bundit Chokesanguan	Rafael Ramiscal, Philippines
An Heui Chun, Rep. Of Korea	Andy Reville, UK
Steve Ears, Australia	Jacques Sacchi, France
Norman Graham (Co-Chair), Norway	Andrés Seefoo, Mexico
Pingguo He, USA	Bolu Solarin
Olafur Ingolfsson, Norway	Petri Suuronen, Spain
Terje Jørgensen, Norway	Wilfried Thiele (Co-Chair), FAO, Rome
Per-Olav Larsson, Sweden	Saul Sarmiento
Bob van Marlen, Netherlands	Phil Macmullen, UK
Thomas Moth-Poulsen (Chair), FAO, Rome	Mats Ulmestrand, Sweden
Charlotte Morgensen, WWF, Belgium	Kristian Zachariassen, Faeroes
Andrzej Orłowski, Poland	John Willy Valdemarsen, Norway
Hans Polet, Belgium	

### 5.1.4 Recommendations

Shrimp-trawl fisheries worldwide are characterised by high species diversity and complexity, particularly in relation to technical, ecological, social and economic issues. ICES/FAO WGFTFB recognises that there has been significant progress in reducing bycatch in shrimp-trawl fisheries. We acknowledge our appreciation of the valuable work that has been undertaken by fishermen, fishing technologists and others to improve conservation in these fisheries around the world. However, the need for continuing progress is also recognized, and in consequence the ICES/FAO WGFTFB recommends that:

- 1) **Research between fishing technologists and industry stakeholders involved in coldwater and tropical shrimp fisheries should be initiated to further develop species-selective bycatch reduction devices, and to improve the size selectivity of shrimp and *Nephrops* in trawls.**

Comment: # 1 International collaboration in this research is needed and should include the utilization of knowledge of inter-species behavioural differences and the identification, application and evaluation of innovative gear technologies, for example the use of ultra-low opening trawls, to reduce bycatch in shrimp-trawl fisheries

Comment #2 Recent research into improving size selectivity has not been successful at avoiding the capture of juvenile shrimp and *Nephrops*.

- 2) **At the local, regional, and national levels, Bycatch/Discard Action Plans should be developed for shrimp fisheries.**

Comment: These plans should identify objectives and goals with regard to the use or reduction of bycatch/juveniles/trash fish, suggest strategies for achieving these goals (including the implementation of bycatch reduction devices, closed areas etc.) and identify key performance indicators.

- 3) **Where, in certain countries, reliance on catches of juvenile fish in shrimp-trawl fisheries exists, it should be reduced.**

## 5.2 Individual presentations

### 5.2.1 The *Crangon* fisheries of Europe – lessons learned

*Norman Graham (IMR, Norway), Hans Polet (CLO-DvZ, Belgium) and Andrew Revill (CEFAS, UK)*

#### Abstract

Dr Andy Revill (CEFAS) presented a historical overview of the development of technical measures to mitigate the discarding of commercial species in the North Sea brown shrimp (*Crangon crangon*) fisheries. Some of the lessons learned from this programme included:

- a) A logical and systematic approach was deemed beneficial (see below)
  - Quantification of discard levels
  - Model discards to determine the impacts upon affected stocks
  - Develop focused mitigation measures
  - Model the benefits of introducing mitigation measures
  - Introduced appropriate legislation.
  - Undertake follow-up evaluation of effectiveness of technical measures and legislation.
- b) There were benefits from holistic coordinated international collaboration and action, particularly within the scientific community.
- c) Modelling of the impacts of discarding is critical. The numbers of discards may have little meaning until they are suitably modelled in order to determine their possible detrimental effects upon the affected stocks. For example a high discard rate of very young fish may not be problematic if most would die from natural mortality. Numbers of discards do not always directly correlate to the magnitude of their impacts.
- d) Although the target species was the same, considerable regional variations in discard patterns were observed, which required regionally focused mitigation measures to be developed.
- e) A consideration of the economic impact of discarding is perceived to have stimulated legislative action by the fisheries management.
- f) A pro-active approach to perceived problems is probably better than reactive responses.

#### Discussion

The question was raised how fishermen received the technical measures? The author replied that this is an issue that will be investigated in a further study, i.e., a post-introduction evaluation of the consequences of the legislation. One positive effect was less catch sorting on board and a better catch quality. There were, however, also drawbacks to the selective devices like e.g., clogging. In the Netherlands there was a lot of resistance to the new measures. Good communication with the industry was essential to overcome the problems.

### 5.2.2 Bycatch reduction devices in tropical shrimp trawl fisheries: Case studies from Australia and Kuwait

*Steve Eayrs (Australian Maritime College)*

#### Abstract

An overview is given of work done in Australia and Kuwait to reduce bycatch and discards in shrimp fisheries. A framework for the development and management of effective bycatch devices was presented. The framework consists of consecutive steps to follow.

The first case study presented was the northern prawn fisheries in Australia. As a first step, the bycatch issue was identified. The main problem is the turtle and shark bycatch. Public concern

and the US-embargo were seen as important factors on the road to solving the bycatch problem. Several selective devices were designed and built. Consecutively the designs were tested at sea. The TED's were very effective in excluding turtles. Also rays and shark reduction was good. Shrimp loss sometimes was a problem. In the next step the results were extended to the stakeholders by publications, presentations and awards. Boat visits were seen as a very positive action. Next, a bycatch management plan was developed and introduced. The plan must be flexible, user friendly and needed to foster innovation. Rules were not too detailed and apparently fishermen started further developing the devices. Fishermen were encouraged to develop and test TED's and BRD's and this was supported by the scientific community.

The Kuwait shrimp fishery has similar issues and the same approach was applied. The process is about halfway and running.

The experience has shown that it is important to:

- a) Establish a good relationship with fishermen,
- b) Have a focus on the benefits for the fishermen as well as the wider ecological benefits,
- c) Provide opportunities to fishermen to contribute to all processes,
- d) Implement well funded extension strategies,
- e) Apply the "KISS" principle: keep it simple and stupid,
- f) Try to satisfy all stakeholders and
- g) Have a continuous refinement and development.

Future work will concentrate on a greater knowledge on behaviour of shrimps & bycatch and on the refinement of the selective devices to perform well under all conditions of the fisheries.

#### **Discussion**

It was noted that obstruction of the grid can be a problem in certain areas and in that case introduction of TED's is problematic. The author replied that this is not so in the northern prawn fishery. Obstruction has been report with some shark species or occasional debris that can be difficult to exclude but this has not prevented the introduction of TED's. In other areas like e.g., Tasmania, obstruction of the grid would probably be a continuous problem, and their introduction would be very difficult.

### **5.2.3 The GEF/ FAO project "Reduction of Environmental Impact from tropical shrimp trawling, through the introduction of bycatch reduction technologies and change of management"**

*Wilfried Thiele (FAO)*

#### **Abstract**

FAO acts as executing agency for a five years project dealing with bycatch reduction technologies in tropical shrimp trawl fisheries.

Twelve countries around the tropical belt are participating in that project, from Africa are that Nigeria and Cameroon, from Asia Indonesia and The Philippines, from the Gulf Region Iran and Bahrain and from Latin America and the Caribbean Cuba, Costa Rica, Colombia, Mexico, Trinidad and Tobago, and Venezuela. As an Intergovernmental organisation participates the South East Asian Fisheries Development Centre (SEAFDEC) in the project.

Despite of different shrimp species targeted, different technologies used, and different market conditions, the common problem in all shrimp trawl fisheries are the height bycatch rate on juvenile fishes, which are normally discarded.

Main objectives of the project are:

- a) The introduction of bycatch reduction technologies adapted to the specific conditions in each country,
- b) The distribution of results of the project to other shrimp fishing countries, not participating in the project,
- c) To enforce the cooperation among countries in research on, and management of their shrimp and fish resources, and to create a better understanding of all stake holders of the interactions between shrimp trawl fishing gear and the environment.

The fishing industry in each county is active involved in the project and contributes to the project financial as well as through the provision of vessels for sea trial etc.

The project started in 2002 and will terminate in May 2007.

## **6 ToR b: Topic Group meeting on the review of legislation relating to technical conservation measures**

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**Convenors: Dick Ferro (Marine Laboratory, UK) and Dominic Rihan (BIM, Ireland)**

### **6.1 General overview and presentation of principal findings**

This ToR was introduced by Dick Ferro (Marine Laboratory, UK).

The Convenors issued a circular letter to appropriate WGFTFB members in European countries in December 2004 inviting participation in the Group and suggesting that they contact their respective enforcement agencies to ascertain their views on the current legislation. The Group worked by correspondence in early 2005 and met for a preliminary meeting in Lorient to identify some initial tasks in the review process. The agreed action points arising from this meeting were as follows:

- To make a list of any relevant national measures which are additional to EU Technical Conservation Measures in Regulation 850/98 and associated regulations.
- To make a list of the current Technical Conservation Measure issues, which are of highest priority or give the greatest difficulties to respective national industries e.g., including areas where there is perhaps a need for better Technical Conservation Regulations or the existing regulations are ineffective from a gear selectivity perspective.
- To identify inconsistencies in Technical Conservation Measures between adjacent areas in national waters e.g., mesh change from northern to southern North Sea, North Sea to Skagerrak/Kattegat or North Sea to West coast of Scotland; or where there are inconsistencies between scientific advice and/or stock management areas and the current Technical Conservation Regulations e.g., Northern Hake stock where several different mesh sizes apply within the same management area.

The Group then met in Rome on April 18 2005 during the WGFTFB meeting to discuss these issues (Annex 4). Items 1 and 2 highlight specific issues where legislation may be considered for revision. In many cases, detailed technical information is available which will inform these discussions. Gear technologists should be involved in collating and interpreting such information, as indicated in the right hand column of Table 2, for use by fishery managers leading the review process. Linkage with the ICES Study Group on Management Strategies (SGMAS) would also be useful and the 2005 report from SGMAS identifies the need for technical input as to the effectiveness of gear regulations in the development of management strategies.

The work on item 3 involved defining very carefully the legislation, which was in place in each sea area. This proved to be very difficult and it is clear that a comprehensive job could only be carried out with much effort from appropriate experts from enforcement and legal departments. Having said this, the Group can see that there is an important role for gear technologists at the following stage after the legislation has been defined and the differences between areas identified. For example, gear technologists could then estimate the selectivity of inconsistent gears and thus provide a quantified assessment of the significance of the inconsistency to management of the fishery. The WGFTFB Chair has been invited to discuss with the EU Commission progress in the Group's work at an early opportunity. If the Commission considers that further work would be beneficial then it is recommended that WGFTFB consider how to take the matter forward.

### 6.1.1 Terms of reference

To review issues relating to legislation on technical conservation measures relating to fishing gear design.

### 6.1.2 Abstract

During the past 5 years many changes have been made to fisheries legislation relating to gear design and applying to North East Atlantic fisheries. The European Commission has adopted several recovery plans and is scheduled to review technical conservation measures (TCM) legislation. The International Baltic Sea Fisheries Commission has adopted new measures to control fishing gear in their area over the past few years. The EU has made agreements with third countries (and other bodies such as NEAFC) on technical measures to be applied in jointly managed or international waters.

Legislators, scientists and the fishing industry recognise however, that there are inconsistencies in the current range of legislation. ICES approved a recommendation put forward by the Working Group on Fishing Technology and Fish Behaviour (WGFTFB) to address some issues relating to legislation on technical conservation measures that have a bearing on fishing gear design. The aim is to inform the debate which will be generated during the European Commission's review.

While the current exercise aims to inform the review of EU legislation and therefore concentrates on EU fisheries, there may be a similar worthwhile task to be done in other areas of the world.

### 6.1.3 Participants

Ludvig Ahm Krag (DIFRES, Denmark)  
 Ana O. Amodo (FAO)  
 Paolo Belcari (DSUA, Italy)  
 Eckhard Bethke (BFHFI/IFF, Germany)  
 Asta Hron Bjorgvinsdottir  
 (Univ. of Atureyr, Iceland)  
 Bong-Jim Cha (NFRDL)

Ronald Fonteyne (CLO-DvZ, Belgium)  
 Ulrik Jes Hansen (SINTEF, Denmark)  
 Rene Holst (DIFRES, Denmark)  
 Terje Jorgensen (IMR, Norway)  
 Arill Engås (IMR, Norway)

Pascal Larnaud (IFREMER, France)  
 Per Olov Larsson (IMR, Sweden)  
 Alessandro Lucchetti (ISMAR-CNR, Italy)  
 Waldemar Moderhak (SFI, Poland)  
 Charlotte B. Mogensen (WWF)

Michael Pol (Massachusetts Div. of Mar.  
 Fish., USA)  
 Jacques Sacchi (IFREMER, France)  
 Antonello Sala (ISMAR-CNR, Italy)  
 Mats Ulmestrand (IMR, Sweden)

#### 6.1.4 Recommendations

No recommendations can be given until discussions with the EU-Commission and other legislative bodies are held.

#### 6.1.5 Discussion

The main item in the discussion was the question whether this topic group should continue and in what form. There is already one planned action of the topic group, i.e., a meeting with the EC within the next few months to discuss the legislation review.

There was a general feeling that, beside the main present goal of the group, it would be interesting to identify the science that supported the existing legislation, or identify the absence of supporting science. What science is needed to develop sound legislation? The Chair indicated that ICES wants some input on this issue. The remark was made that it is standard procedure within the EC to involve scientific expertise in the legislative process although examples were given where this was not the case.

The question was raised whether it would be interesting to cooperate with the FAO initiative on a new gear classification. This was rejected because gear classification has a general worldwide application and legislation has a more regional focus. The suggestion was also made to investigate if regional differences in legislation steers the deployment of fishing effort.

In general the WGFTFB states that this group is very useful for the whole fisheries community and the EU. Complexity of legislation may not be an issue for administrators but it certainly is an issue for fishermen and enforcement agencies. Simplification is necessary because legislation may become of no value if complexity hampers enforcement.

It is often the case that legislation evolves through time by adding layers to it without reviewing the whole package of measures and therefore inconsistencies are bound to arise. The topic group has attempt to addresses these issues but has found that this work cannot be done solely by gear technologists And needs input from managers, enforcement agencies and stakeholders.. There is also a need to establish a framework to discuss these issues.

The conclusion of the WG was that the outcome of the meeting with EU should determine whether work on this topic should be continued and this could be determined at the FTC meeting in September.

## 7 ToR c: Topic Group meeting on oil and gas industry fishing interactions

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**Convenor: Dick Ferro (Marine Laboratory, UK)**

### 7.1 General overview and presentation of principal findings

*Dick Ferro (Marine Laboratory, UK)*

This ToR was introduced by Dick Ferro (Marine Laboratory, UK). An overview was given of the state of the art and the activities of the group.

#### 7.1.1 Terms of reference

To review and report on work done, identify information gaps and recommend re-search priorities on interaction between fishing gear; and:

- a) Pipelines and other sub sea structures;
- b) Cuttings piles.

### 7.1.2 Abstract

#### Introduction

A topic group was set up by the Working Group on Fishing Technology and Fish Behaviour (WGFTFB) in 2004 with the following terms of reference:

To review work done, identify information gaps and recommend research priorities on interaction between fishing gear and

- a) Pipelines and other subsea structures
- b) Cuttings piles

The group worked initially by correspondence. Preparatory work included a literature search for reports on trials and studies on the interaction between fishing gear and subsea structures. The Group then met in Rome on 20 April 2005 during the meeting of the WGFTFB. This report (Annex 5) was drafted and a presentation of its main elements made to the WGFTFB on 22 April. The participants and contributors are listed in the report.

Additional interesting and informative presentations were given to WGFTFB in plenary on 22 April by D. Askheim on the work of Det Norske Veritas, by B. van Marlen on the development of oil/gas exploration in the southern North Sea and its relation with the fishing industry and by U. J. Hansen on the model experimental work in a tow-tank at by SINTEF Fisheries and Aquaculture (at the flume tank in Hirtshals) and FORCE Technologies in Copenhagen to assess the interaction between fishing gear and protective subsea structures.

#### Information contained in the report

There is a brief descriptive section in the report on current status in development of oil/gas reserves in both Europe and Canada and the relationship to the fishing industry. The present control regime governing fisheries and offshore activities is described, including references to documents detailing industry standards relevant to the Norwegian and UK sectors of the North Sea.

The Group identified that one of the major drawbacks in this topic area was the unavailability of various classes of information, mainly because of commercial confidentiality. The report contains sources of relevant information in the public domain on various subjects e.g., on positions of seabed obstructions, fishing gear descriptions, their component sizes and weights and typical towing loads during fishing operations.

#### Review of available information on interactions

The main objective of the report is to provide a reference list of available reports on the interaction between fishing gear and subsea structures and cuttings piles. More than 50 references are quoted and further references are available within review reports quoted in the list. The full reference of each report is given in a table, together with a short abstract indicating the main findings. This information has been indexed using the following headings.

1. Interaction of fishing gear and seabed structures
  - 1.1. Pipelines
    - 1.1.1. Model scale
    - 1.1.2. Full-scale
    - 1.1.3. Mathematical models

- 1.1.4. Reviews
- 1.2. Frameworks protecting wellheads or other localised structures
  - 1.2.1. Model scale
  - 1.2.2. Full-scale
- 1.3. Rock dumps
  - 1.3.1. Full-scale
- 1.4. Underwater cables
  - 1.4.1. Full-scale
- 2. Interaction of fishing gear and cuttings piles
  - 2.1. Effect on cuttings piles

Using this information the Group identified gaps in knowledge, areas where there was a need for additional trials or improvement in dissemination of information.

This exercise was constrained by the limited access to more recent work on interactions between fishing gear and seabed structures. While there is an understandable need for commercial confidentiality, this should not be allowed to compromise design procedures. To preserve confidentiality and yet provide designers with important information affecting safety, a means should be found to compile generic, non-specific information on the requirements for design of seabed structures and of fishing gear to mitigate the effects of interaction. This compilation of generic information on design practice at an international level would help companies and individual engineers to learn from the experience of others and develop more sophisticated designs whereas at present basic lessons often have to be relearned through the repetition of e.g., model trials towing similar gears over similar designs of structure. Potential sources of information for providing such generic data are: responsible authorities who may record interaction incidents, offshore operators, fishing industry organisations, trials reports of model or full-scale tests as well as designers of subsea structures themselves.

## Conclusions

The main conclusions of the group are summarized under six headings. The topic group hopes that appropriate national bodies, such as fishing/offshore industry liaison groups, will take up these issues and initiate solutions for the benefit of both the fishing and offshore industries to improve safety, speed up and improve offshore design processes and inform government policy on abandonment.

### 1. Dissemination of information on fishing gear

Oil industry engineers designing subsea structures make use of information on dimensions and weights of, and loads generated by fishing gear equipment. In the experience of the group members, sources of such information are not well known by oil industry personnel who may have limited knowledge of the operation of fishing gear. The sources are poorly advertised although an example source of information on North Sea fishing gear is given in section 5. Improved dissemination of this information would be helpful. As fishing techniques develop there is also a need for this information to be updated. Furthermore there may be a need to establish the information on fishing gear components on an area basis (e.g., North Sea, Norway, North America), in order to take account of differences in fishing techniques and gear and vessel sizes.

The dissemination of information on fishing gear components, which are useful to oil industry engineers, needs to be improved. This information should be updated regularly, perhaps every 3 years. This task might be undertaken by the WGFTFB. There is a need for the data to be compiled on an area basis.

## **2. Dissemination of information on subsea structure design**

Based on experience of collaborating with oil and fishing industry in projects on interaction, there is concern that confidentiality restricts the availability to other potential users of the results of trials on interaction. To preserve confidentiality and yet provide designers with important information affecting safety, a means should be found to compile generic, non-specific information on the requirements for design of seabed structures and of fishing gear to mitigate the effects of interaction. Potential sources of information for providing such generic data are: responsible authorities who may record interaction incidents, offshore operators, fishing industry organisations, trials reports of model or full-scale tests as well as designers of subsea structures themselves. This compilation of generic information on design practice at international level will help design companies and individual engineers to learn from the experience of others and develop more sophisticated designs whereas at present basic lessons often have to be relearned through the repetition of e.g., model trials towing similar gears over similar designs of structure.

## **3. Effect of rigging and gear design on interaction**

Mitigating measures need to be developed by both sectors e.g., by engineers designing ‘over-trawlable’ or ‘fishing friendly’ structures but also by gear manufacturers and technologists redesigning or re-rigging fishing gear to reduce snagging risk. Quite simple changes to rigging may reduce the severity of impacts between gear and seabed structures. It is recognised that at present there are no incentives for gear manufacturers to help in designing fishing gear components with lower impact risk not because it could not be used as a competitive parameter, but because there is no available information on what could be done to prevent snagging/hooksing. Specific studies to assess the potential benefits of gear alterations may be useful and a first step would be to define a series of model tests for this purpose.

## **4. Interaction with cuttings piles**

There is little information available on the interaction of gear and the cuttings piles created under drilling platforms. As an element in determining abandonment policy there is a need to be able to assess potential hazards of interaction with fishing gear. While the issue of the potential spread of toxic or polluted cuttings material is an important aspect of abandonment policy there should also be consideration of the physical effects on fishing gear of impacting cuttings piles. Full-scale trials are needed to identify likely mechanisms of interaction between the piles and different gear components such as trawl doors, nets and in particular wires. The latter have the ability to cut through the base of the cuttings pile and are then likely to cause the net or a trawl door to wedge firmly in the material on impact.

## **5. Need for more trials on new gears and larger pipes**

Trawl gear designs are developing continuously, e.g., recently with the introduction of twin trawling and the use of heavy clump weights. There is also a trend towards larger, more efficient vessels in some fisheries towing heavier gear at higher speeds. More trials are needed on the interaction of offshore seabed structures and these new trawl systems and new trawling methods.

More trials are also needed on the interaction of fishing gear and large diameter pipes over 45” which are not buried or trenched

## **6. Risk analysis**

One of the main purposes of interaction trials is to assess the risk of hooking or damage for a particular combination of sub sea structure and fishing gear or to identify the preferred solution between two design options. The power of the experiment to estimate the significance of the result depends on the number of test runs. The Group recognizes that the number of runs is often limited for many reasons and that the fewer runs, the greater the uncertainty of the esti-

mated risk. Application of appropriate techniques for assessing risks to structure, fishing gear and vessel from trials results is needed to increase confidence in the conclusions.

### 7.1.3 Participants

Dick Ferro (Marine Laboratory, UK)

Bob van Marlen (RIVO, Netherlands)

Ulrik J Hansen (SINTEF, Denmark)

Terje Jorgensen (IMR, Norway)

Dag Øyvind Askheim (Det Norske Veritas, Norway)

### 7.1.4 Recommendations

The Topic Group report should be disseminated to relevant national and international bodies e.g., offshore and fishing industry producers organizations for consideration.

## 7.2 Individual presentations

### 7.2.1 Updating current DNV Guidelines on interference between trawl gear and pipelines

*Dag Øyvind Askheim (DNV, Norway)*

#### Abstract

The company DNV is an independent organization to safeguard life, property and the environment, serving both the offshore industry and the fishing industry. Globally, the company has about 5000 employees. One of the tasks is to reduce the interference between trawl gear and pipelines. The company performs impact tests of pipelines and cables in relation to fishing gear like beam and otter trawls. Based on detailed experiments, guidelines are given on the design of cables and pipelines.

The guidelines for industry practice, dating from 1997, are accepted for the North Sea but an update is needed. New information and technology has become available and the new standard will be based upon these new evolvments. Data are being collected on new trawl equipment and trawling practices. New guidelines are being written. The main challenge is to design equipment so that sub sea structures do not obstruct trawling. Any damage should be avoided because of extreme high costs. A dialogue with the fishing industry and offshore industry is set up.

#### Discussion

The author outlined that any relevant information from WGFTFB on new fishing equipment is very much welcomed by DNV.

The question was raised whether the DNV standard is internationally accepted. It was stated that it is accepted but that not every country applies it and certainly not the UK. Therefore it was felt there is a need to promote the standard in international fora.

The question was raised as to whether there are competing standards and it appears there is one in the UK, while some oil companies have developed their own standard. The remark was made that the environmental impact studies carried out in fisheries could be of interest for DNV but also vice versa while the methodologies applied could be of mutual interest.

### 7.2.2 Experiences with the interactions between offshore and fishing industries

**Bob van Marlen (RIVO, Netherlands)**

#### Abstract

This paper describes the experience in the interaction between North Sea offshore oil and gas production and the fishing industry from the early 1970s. Major sources of impact are seismic surveying, drilling, the presence of platforms, pipelines, underwater telephone cables and sub-sea facilities, and gas flaring. A number of model and full-scale experiments were carried out over the years on over-trawling of sub-sea structures with various types of gears. The impact and friction forces can be reduced by proper design of both gears and sub-sea structures, resulting in less damage to either fishing gear or the sub-sea structure.

#### Discussion

The author was asked whether the suggested adaptations to fishing gears are taken up by the industry. The majority of the gears are redesigned and shaped according to guidelines to protect pipelines. But fishermen have acted irresponsibly in recent times in the vicinity of pipelines even through modified gears exist.

### 7.2.3 Model testing as a tool for improving overtrawlability of sub-sea structures

**Ulrik Jes Hansen (SINTEF, Denmark)**

#### Abstract

The Authorities in Norway are requesting that most sub-sea structures set up by the off-shore industry relating to oil and gas extraction activities shall be overtrawlable. Over trawlability must be documented in model tests. The presentation gives the framework for that work, and shows a number of examples of different sub-sea structures set up on the Norwegian sector. The model tests are made in a tow-tank. Different fishing gears are discussed and their potential difficulties in being towed over a structure explained. Unfortunately most of this work is confidential because the industry has the exclusive rights over the results

#### Discussion

The author is asked whether there are satisfactory solutions to the complicated structures he presented. During the last 20 years solutions have always been found, but, engineers are often very naïve in designing these structures. The minimum cost, however, to repair a wellhead is 15 million euro, so the oil industry is keen to cooperate.

The question was raised if it can be expected that many more sub sea structures will be built in the Northern North Sea. It was replied that this will continue to be the case as new structures will be built while the exploration moves further north.

The issue of safety around pipelines was again raised because Sub sea structures attract fish and consequently fishermen engage in dangerous practices in trying to exploit these fish concentrations.

The author was also asked whether any research is currently being undertaken in Denmark to look at the design of fishing gear in relation to sub sea structures. He replied that sometimes e.g., trawl door manufacturers are invited to flume tank test of sub sea structures and this can be interesting for manufacturers who can sometimes easily redesign fishing gear to avoid damage to gear and the structures themselves.

The point was made that there is already a system called “fish safe” in the UK to increase the safety of fishing vessels in the form of a black box attached to the GPS that gives a signal when fishing in the vicinity of a sub sea structure.

## 8 ToR d: Topic Group meeting on the use of multiple size selection devices in towed gears

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**Convenors: Norman Graham (IMR, Norway) and Barry O’Neill (Marine Laboratory, Aberdeen)**

### 8.1 General overview and presentation of principal findings

This ToR was introduced by Barry O’Neill (Marine Laboratory, Aberdeen). An overview was given of the activities of the group.

#### 8.1.1 Terms of reference

To review and report on the use of multiple size selection devices in towed gears to include the following topic:

- a) Recent trawl size selection experiments where multiple selection systems have been assessed, e.g., square mesh panels, grids etc., considering the impact on the target and by-catch species;
- b) Developments in modelling multiple selection data;
- c) Practical issues relating to additional technical measures such as on board handling and material strength of the multiple selective devices and fisheries enforcement issues.

#### 8.1.2 Abstract

The group discussed the terms of reference to ascertain whether the ToRs should be expanded to include issues relating to the use of additional selectivity devices used for bycatch reduction. It was concluded that this would greatly increase the scope of the work so it was agreed to focus primarily on work relating to size selection of the target species. A summary of the current literature was given which focused mainly on rigid grids and square mesh panels. A number of individual presentations were given on the most recent research. This comprised of the following:

- Norwegian experiments that compared the selectivity of diamond mesh codends only and combined codend and grid in the Barents Sea demersal fishery for cod;
- Comparisons between a standard 100mm codend and a range of square mesh panel positions in the Scottish fishery for haddock and whiting;
- Icelandic experiments that compared normal diamond mesh selection with two types of T90 codends having different number of meshes in circumference, three types of rigid and flexible grids and a codend fitted with a Bacoma style window;
- French experiments to improve the selection pattern of *Nephrops* in the Bay of Biscay using a flexible grid as well as large meshes in the trawl wings to improve selection of hake;
- Italian work investigating the use of square mesh panels in the mixed fishery in the Adriatic;
- An overview of recent joint Scottish/Norwegian experiments

The topic group split to discuss recent developments and produce an initial list of references and; identify the key areas of legislative and practical concern. René Holst gave an overview of suitable analytical techniques for modelling multiple selection processes.

The group concluded that ‘additional’ devices could be broadly categorized in ‘hard’ and ‘soft’ for example rigid selection grids and square mesh panels. The practical issues that should be considered were identified and included onboard handling constraints relating to vessel size and gear handling equipment such as the use of net drums and power blocks, crew safety concerns and problems associated with material strength.

Legislative issues discussed focused primarily on the problems of increased complexity and training needs of enforcement officers. In a number of regions, ‘additional’ devices are patented and this can result in considerable additional costs on the fishing industry.

The individual participants presented an overview of the mandatory use of multiple selection devices by region to the group. Rigid and semi-rigid grids are mandatory in Norway, Iceland and Faeroe Islands, while mandatory use of square mesh and BACOMA style panels is widespread in Northern European fisheries.

Full details of the above issues will be reported in 2006.

The topic group agreed on the structure of the report was agreed and will include the following:

- An introduction including a synopsis of the issue;
- Identification of current legislative requirements by region;
- A literature review by device, including both published and grey literature;
- Practical consideration
- Summary conclusions.

The group agreed to aim to publish the work in the form of an ICES Co-operative research report or in a peer reviewed journal.

A task list for the participants was formulated and the group agreed to work inter-sessionally in 2005/2006. The Group’s findings and recommendations will be presented to the ICES-FAO WGFTFB meeting in 2006.

### 8.1.3 Participants

Alessandro Lucchetti, Italy  
 Claudio Viva, Italy  
 Antonello Sala, Italy  
 Erdman Dahm, Germany  
 Barry O’Neill, Scotland (Co-Chair)  
 Gabriele Buglioni, Italy  
 Gudmundur Gunnarsson, Iceland  
 Haraldur Einarsson, Iceland  
 Henry Milliken, USA  
 Kristian Zachariassen, Faroes  
 Ludvig Krag, Denmark  
 Marianne Farrington, USA

Ronald Fonteyne, Belgium  
 Waldemar Moderhak, Poland  
 Dominic Rihan, Ireland  
 An Heui Chun, Republic of Korea  
 Norman Graham, Norway (Co-Chair)  
 Olafur Ingolfsson, Norway  
 Paola Belcari, Italy  
 Pascal Larnaud, France  
 René Holst, Denmark  
 Rikke Petri Frandsen, Denmark

### 8.1.4 Recommendations

The topic group will continue to work inter-sessionally on the items listed above and will present the group’s findings and recommendations during the 2006 WGFTFB meeting.

### 8.1.5 Discussion

There was a general consensus that the group would like to continue the work. Any contributions, reports and references, particularly grey literature on the topic are welcomed. The question was raised as to the implication of all the work done so far with multiple selection devices as some of the studies strongly suggest that just increasing the mesh size is a much simpler solution than using selective devices. It was stated though that the circumstances have to be taken on a fishery-by-fishery basis and also taking account of the political and regional concerns. In the past there are incidences where the implementation of a selective device can be more acceptable than an increase in mesh size and it is also important to acknowledge that an increase in mesh size can be counteracted by the use of new (stiffer) netting materials. Some experiments have also indicated that the selectivity with e.g., grids is more stable than mesh selection. French experiments in the Bay of Biscay have shown that size selectivity for *Nephrops* works quite well.

The author stressed that it is not the intention of the group to suggest one solution or the other. The main aim was to evaluate the work done in this area.

## 8.2 Abstract of individual presentations

### 8.2.1 Size selection of cod by rigid grids – is anything gained compared to codend diamond meshes?

*Olafur Ingolfsson (IMR, Norway)*

#### Abstract:

Size selective grids were introduced into the Barents Sea demersal trawl fishery in 1997. It was believed at the time, that in comparison to standard diamond mesh codends, grids had better selective properties i.e., narrower selection range. Few studies have directly compared the selective properties of the combined grid and codend with that of the codend only. In this study we describe two experiments carried out in 2002 and 2003, where we directly compared the properties of codend selectivity for cod (*Gadus morhua*) with the combined selectivity of a Sort-V grid and a codend. In 2002 we used small-meshed covers, whereas the twin trawl method was used in 2003. In both experiments we compared the selectivity of a 135 mm codend only with that of a trawl fitted with a 135 mm codend and a 55 mm grid, which is the mandatory configuration. In 2003 we also estimated the selectivity of a 155 mm diamond mesh codend, having a  $L_{50}$  similar to that of the grid and 135 mm codend combination. The results presented no evidence that the grid and mesh combination had sharper size selection than codend meshes. The introduction of the grid therefore only increased  $L_{50}$ , and corresponded to a mesh size increase of around 20 mm. Mean selection length of the grid was inversely related to catch rates in the 2002 experiment when large catches were taken. Grid selection appeared less affected by seasonal variations in degree of stomach fullness or condition than mesh selectivity. Other situations where grid selection might perform better than mesh selection are discussed.

#### Discussion

The question was raised whether there was information available on post selection mortality. The author replied that experiments were done, also recently. There was no mortality of cod and saithe, irrespective of the selection device. For haddock there is mortality but no difference between the codend and the grid was observed.

The discussion further evolved around the effect of different variables on selectivity like catch rate, catch size, twine thickness, season, spawning etc. The author stated that all these variables were recorded and where relevant, the effects were described.

### **8.2.2 Square mesh panels in North Sea demersal trawls: Separate estimates of panel and codend selectivity**

*F.G. O'Neill, R.J. Kynoch and R.J. Fryer (Marine Laboratory, UK)*

#### **Abstract**

We report on trials to compare the selectivity of a trawl with no square mesh panel and trawls with a 90mm square mesh panel inserted 3 – 6m, 6 – 9m and 9 – 12m from the cod-line. We use smoothers to show that the nets with a panel in the 6 – 9m and 9 – 12m positions are more selective than that the net with a panel in the 3 – 6m position for whiting and maybe for haddock. For both species, all three trawls with square mesh panels are more selective than the net with no panel. For haddock, we also fit a six-parameter model to a subset of the data and hence find separate estimates of the selectivity of the panel and the codend. This model reflects the dual selection process of codend and panel and is a better fit to these data than the standard logistic curve.

### **8.2.3 A meta-analysis of data from experiments with T90 and BACOMA codends**

*René Holst (Difres, Denmark)*

#### **Abstract**

The present work has collated all available data with commercial specification from experiments with the BACOMA and the T90 codend. The collection of data includes experiments done within the BACOMA project as well as more recent data. The work aims at a comparative analysis of the two codends with the objective of identifying potential differences and key variables affecting the selectivity of the gears. The data originates from a range of independent sources and unrelated projects, inducing extra random variation. A pragmatic approach was chosen to accommodate this variability by assigning variance components to the cruises. An ad-hoc methodology was applied to analyse the three-level data and produce a predictive model.

### **8.2.4 Recent grid, codend and BACOMA panel selectivity experiments in Iceland**

*Haraldur Einarsson (MRI, Iceland)*

#### **Abstract**

In 1997, sorting grids were legalised in Iceland. Grids are an obligation mandatory for fishing in protected areas and in some cases also for fishing in areas which are closed for a limited time period. A new type of grid was legalised in Iceland in 2003 in the cod fishery, the flexi-grid with 55mm bars. Fishermen are not satisfied with the sorting grids and have pointed out some technical problems in using the grids. Codend sensors may not work correctly at high catch rates, the grid may be blocked and the fish filet may be damaged after hitting the grids, which causes price reduction.

The first grid experiment was conducted in April 2003 off the north coast of Iceland. This was a short survey on a research vessel towing twin trawl with three warps. Four hauls with 135mm codend and seven with flexi-grid had enough fish for selectivity calculations. Two short surveys were conducted in the same year on small fishing boats focusing on selectivity of haddock in trawl with flexi-grid with 55 mm and 50 mm grid. An experiment was also conducted in September 2004 on the research vessel at the same fishing ground as before, but with more hauls taken, i.e., four hauls with 135mm and six hauls each with 150mm, 135mm

BACOMA square mesh, 135mm T90° and eight hauls with Sort-V plastic grid and only one haul with Sort-V steel grid (Table x).

**Table 1: Main results from selectivity experiments done with twin-trawl methods.**

Type of experiment	COD			HADDOCK		
	Hauls	L50	SR	Hauls	L50	SR
<i>135 mm PE</i>	4+4	47.1	6.69	4	45.9	8.26
<i>150 mm PE</i>	6	53.1	7.91			
<i>BACOMA 135mm Ultracros</i>	6	51.1	7.84	3	50.0	5.67
<i>T90° 135mm PE</i>	3+3	49.8	7.96	1+1	49.9	6.73
<i>Sort-V Plastic + 135mm codend</i>	8	47.4	8.98	2	48.0	6.46
<i>Sort-V Steel+ 135mm codend</i>	1	50.8	6.15	1	50.5	5.15
<i>Flexi-grid 55mm+ 135mm codend</i>	7	53.1	7.91	4*	55.7	7.34
<i>Flexi-grid 50mm+ 135mm codend</i>				6*	51.6	8.29

\*Alternate trawling.

Analysis of the data is in progress but the first results are presented here (table 1). The statistic is logistic curves calculated in S-plus. The 50% retention length of cod in 135 mm codend in 2003 was 45 cm and selection range 5.25 cm. In 2004 the results for the same codend were 51 cm / 9.28 cm (L50% / SR). The difference between years is possibly because of different condition of the cod or sea temperature between years. Overall the results were 47.1 / 6.69. Haddock was only collected in 2004 for the 135mm codend. Then a two types of T90° were tried, three hauls with cod in each. The differences of the two T90° types were in the circumference of the T90° net compared with the circumference of the belly end in an ordinary diamond mesh, one was 67% of the circumference and the other 80%. The T90° 67% gave better results in L50 52.7 but higher SR 9.13 compared with T90° 80% which was 47.4 / 6.63. Overall results in T90° was 49.8 / 7.96 in cod (table. 1). BACOMA 3.5 meters long with knotless net (Ultracros) was tried and resulted in 51 cm in L<sub>50</sub>. Codend sensors were working well and the quality of the fish appeared very good from the fisherman's point of view. A new version of Sort-V grid was tried, the grid was made of plastic, similar as used in grids in shrimp fisheries. This type does not need floating and is therefore much easier to handle on board. However, the results were not satisfying with respect to improvement of the grid as the L<sub>50</sub> was nearly the same as for 135mm cod catch. There was only one haul with ordinary Sort-V and more data are needed here. The flexi-grid results or the year 2003 gave L50% 53.1, which is, interestingly, the same result as for the 150 mm codend. The surveys on the small fishing boats where the flexi-grid with 55 mm and 50 mm bars in haddock were tried resulted in high L<sub>50</sub> and a marketable fish were found escaping from the gear.

Finally, the numbers of ray and flatfish in the codend were compared to the numbers of cod, to see if there was a relationship between the (ray+flatfish)/cod ratio and L50 or SR causing the flat formed fish to block the meshes or effecting the selection somehow. There seems to be no tendency at all in this relationship, but the data need to be analysed further.

### 8.2.5 Selectivity improvement in bottom trawls operating in the Bay of Biscay

*Pascal Larnaud (IFREMER, France)*

#### Abstract

Since 2003, French professionals have been involved in a two-year program in order to improve the selectivity of bottom trawls operating in the Bay of Biscay e.g., involve substantial reductions of undersized catches without decreasing in an unbearable way the commercial catches. The program consisted to experiment selective devices in flume tank, on board scientific vessels and on board professional vessels. 177 campaigns with scientific observer on board were carried out, that is to say 805 days at sea observed or 2074 hauls. These tests were carried out on several fleets, several types of gear configuration and over several seasons. Four devices were tested and the results are:

- An average escape rate of 23.4% for undersized hakes for the large meshes (150mm) in the wings and the square allow to escape with however significant losses of commercial *Nephrops* and of commercial hake and the least total discards reduction;
- An average escape rate of 26.4% for undersized hakes for the square meshes panel placed just before the straight part of the trawl (on the top part of the baiting), with some loss on commercial hakes but the smallest losses of *Nephrops* and soles and the largest reduction of bycatch (up to 35%);
- An average escape rate of 25.2% for undersized hakes for the diamond meshes panel placed before the straight part of the trawl (on the top part of the baiting), with little escapement of hakes smaller than 8cm but good escapement on blue whiting.
- An average escape rate of 36% to 57% for small *Nephrops* for a flexible and resistant grid placed in the straight part of the trawl in a tilted configuration with commercial losses of approximately 0.1kg per haul.

The panel of square meshes seems the device allowing the best compromise between hake escapement and commercial losses. An extrapolation of the results in term of selectivity to the whole *Nephrops* fleet of the Bay of Biscay indicates that a generalization of the use of these devices would represent an escapement of more than 14 millions undersized hakes per year.

#### Discussion

From the discussion came a number of parameters that should be considered in selectivity work: a) the closure of the codend surely affects the selectivity, because of different dynamics of the codend; b) in experiments often new netting material is used but selectivity can change if netting gets older; c) twine gets less stiff over time; d) the shape of codends and of meshes change over time, which can affect selectivity; e) meshes can get bigger or smaller over time.

## 9 ToR e: Topic group on alternative fishing gears for traditional species that are environmentally friendly and a responsible fishing methods

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Convenor: Bjarti Thomsen (FFL, Faroe Islands)

## 9.1 General overview and presentation of principal findings

### *Bjarti Thomsen (FFL, Faroe Islands)*

This ToR was introduced by Bjarti Thomsen (FFL, Faroe Islands). An overview was given of the activities of the group.

#### 9.1.1 Terms of reference

To explore the potential for alternative fishing gears for traditional species that are environmentally friendly and a responsible fishing method.

#### 9.1.2 Abstract

At the FTFB 2004 meeting in Gdynia, Poland a terms of reference was suggested and adopted:

“To explore the potential for alternative fishing gears for traditional species that are environmentally friendly and a responsible fishing method”

The justification was:

Many fishing practices are essentially the same as when developed centuries ago. Many are energy inefficient and are deleterious to the environments. Here we aim to use the natural behavioural patterns of fish to develop energy efficient non-deleterious harvesting practices that may have applications in fisheries worldwide.

It was implied that “topic leader: Bjarti Thomsen, Faroes and an interested subgroup will work by correspondence and meet at 2005 WGFTFB meeting and report their findings either at the 2006 WGFTFB meeting or the ICES Symposium on Fishing technology in the 21st Century”

The group worked by correspondence and met during the ICES ASC 2004. The group decided to meet at the FTFB 2005 meeting to collect and summarize available information (references) on how to attract/guide/direct fish to/towards static fishing gear such as a trap and pot gear system. The group met on a one day session on Tuesday 19 April 2005 with Chair: Bjarti Thomsen and Rapporteur: Chris Glass. The session was attended by 21 scientists representing a wide range of research milieus.

The summary of possible stimulation methods was given as 8 introductory presentations:

- Svein Løkkeborg: Using Bait Odour to Attract Fish.
- Bjarti Thomsen: Acoustic herding and attraction of fish.
- Chris Glass: Light, Vision and Fish Guidance.
- Takafumi Arimoto: Light fishing in Japan.
- Hans Polet: Electric fishing.
- Emma Jones: Use of air-bubble curtains to influence fish behaviour.
- Oleg Lapshin: Fishing with pots and traps using attracting, guiding and directing action of physical stimuli in Russia and the countries of the former USSR.
- Craig Rose: Observing Fish Near Pot with Sonar and Camera.

The presentations gave an excellent overview of traditional stimulation techniques and brought in the latest development in this area.

Following the presentations the discussion concentrated on how currently available methods used in one part of the world could be introduced in other areas. The presentation on Russian developments in fishing techniques gave an overview of many techniques that might be applicable in other areas. It was identified that there might be a need to translate the vast amount of literature that is available in Russian. Another example is the development in the Newfound-

land trap for cod that might be applicable in North East Atlantic. A third example is the light fishing in Japan. This method is widely used in East Asia, but not in e.g., European waters. It was pointed out, that the light fishing in Japan has a very long history (800 years). The lack of experience might be a reason that this method is not used in other areas. It was stressed that when transferring fishing methods between areas one should avoid transferring the pitfalls.

Then the group discussed the drivers for introducing new methods, such as reducing habitat impact and efficiency (economics). One example is from Norway where fishermen increase revenue by delivering higher value fish, e.g., alive fish. It was concluded that we should learn from success stories and identify reasons, forces etc. that initiated application of new fishing gears. The discussion then turned towards innovation and the group tried to 'think out of the box'. This discussion was slow and only a few ideas emerged. The group tried to identify properties of 'a perfect fishing device'. It was encouraging to see, that several research milieus were represented in the group that had intentions to work on development of alternative fishing gear. From the presentations it was evident, that new understanding has been achieved during recent years, but has not yet been implemented in modern fishing. It was stressed, that we need more baseline information to answer questions like 'Why do fish behave the way they do'.

The group will encourage people to think about issues and see what basic research is needed.

The group will work for another year by correspondence and meet and report to FTFB 2006.

It was agreed to develop the text from the presentations and put it forward as a Cooperative Research Report.

### 9.1.3 Participants

Bjarti Thomsen, Faroe Islands, Chair	Pingguo He, USA
Chris Glass, USA, Rapporteur	Harald Wienbreck, Germany
Ken Weinberg, USA	Hans Polet, Belgium
Jacques Saccui, France	Jochen Depestele, Belgium
Svein Løkkeborg, Norway	Asta Hronn Bjorgvinsdóttir, Iceland
Emma Jones, Scotland	Mike Pol, USA
Dave Reid, Scotland	Vincent Benoit, France
Oleg Lapshin, Russia	Bavouzet Gerard, France
Craig Rose, USA	Ole R Eigaard, Denmark
Takafumi Arimoto, Japan	Stephen J. Walsh, Canada
Bundit Chokesanguan, Thailand	

### 9.1.4 Recommendations

Topic leader Bjarti Thomsen, Faroes and an interested subgroup will work by correspondence and report their findings and recommendations at the 2006 WGFTFB meeting.

### 9.1.5 Discussion

The remark was made that this topic is very interesting, given the upward trend in fuel prices. The problem of incidental catches of marine mammals should, however, not be forgotten and should also be included in the alternative gear discussion and development.

The author was asked whether there are also possible applications for monitoring or survey activities. If so, a cooperative research report would be interesting for the rest of ICES. The author replied that this is the case but that inter-calibration will be necessary.

## 10 ToR f: Adoption of the OMEGA gauge and measuring protocol

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**Convener: Ronald Fonteyne**

### 10.1 General overview and presentation of principal findings

This ToR was addressed by Ronald Fonteyne (CLO-DvZ, Belgium). The main aim of the presentation was to provide the WGFTFB with the necessary information to consider the new mesh gauge as a possible new standard.

#### 10.1.1 Terms of reference

Consider a recommendation for the adoption of the OMEGA mesh gauge and measuring protocol to replace the existing ICES mesh gauge as the new standard gauge in accordance with the 2002 recommendation of the former ICES Study Group on Mesh Measurement Methodology (SGMESH)

#### 10.1.2 Abstract

The present document is an extract from the draft final report of the R&D and Demonstration Project “Development and testing of an objective mesh gauge”, known as the OMEGA project, within the Fifth Framework Programme of the European Commission (Contract No Q5CO-01335).

The main aim of the project was to design, build and test a new objective mesh gauge, suitable for fisheries inspection, fisheries research and the fishing industry. In support a Protocol for using the new gauge for fisheries inspection, research and netting manufacturing was drafted, taking account of legal aspects of mesh inspection. The Protocol specifies the mesh dimension to be measured on mesh types commonly found in use. Detailed instructions are given on how to prepare and operate the gauge, the number of meshes to be measured and how to select those meshes. Guidance is given on whether to accept or reject readings. Gauges used for inspection purposes must be calibrated annually and instructions are included for intermediate checking of force and length measurements.

### 10.2 Recommendations

**The ICES-FAO Working Group on Fishing Technology and Fish Behaviour endorses and encourages the use of the OMEGA mesh gauge as the standard mesh measurement tool for scientific studies and recommends that all stakeholders apply the OMEGA protocol (Annex 1).**

### 10.3 Discussion

The author was asked whether the decision to increase the measuring force was political? Another member stated that the 100 N measuring force came out of a WGFTFB study group and that he needed more information on why the force went up by 25%. The author replied that no politics were involved. The demand came from net manufacturers and inspection agencies. The 125N increase has been decided based on the analysis of new data collected in the OMEGA project, so based on scientific evidence. The author also reminded the group that the study group that chose the 100 N had the choice between 100 and 130N at the time. The group went for 100 N as the most conservative option. This was more or less in accordance with the 5kg weight used with the wedge gauge, but this is almost never used so, not realistic. It was

also stressed that it is very important that all stakeholders involved can accept the instrument, not only the scientists.

The question was raised if we should use the omega gauge for selectivity work? This was confirmed. Using the same device for science and inspection could give a lot of data for fleet selectivity.

A remark was made that for meshes <35mm, a measuring force of 20 N is recommended by the OMEGA project group. In the study group, 40N was proposed, not 20N. Is 20 N the final decision? The author replied that it is a proposal, not a decision. Manufacturers had problem with distortion of the meshes when using 40N, so they proposed a lower force. A final conclusion is difficult because there are no real arguments to reject one force or another. There are not enough data to decide on this force so maybe more data should be collected. He also pointed to the possibility of an increase of the 40N measuring force to obtain a better match with measurements with the wedge gauge operated by hand force on 40 mm codends.

It was also said that it is not the decision of scientists to have this implemented in the industry.

The observation was also put forward that there may be an overlap at the borders between forces.

## **11 Summary of Study Group on Unaccounted Mortality in Fisheries (SGUFM) and individual activities**

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### **11.1 Activities to date**

The SGUFM was formed on 1 January 2004 and to date 13 members have been recruited from a variety of fields and disciplines, including: fisheries biology, marine ecology, fishing gear technology, fisheries management, stock assessment modelling and fisheries protection.

The group is currently reviewing and collating available information and data on all aspects of unaccounted mortality, in preparation for a workshop, to be held in September in Aberdeen, Scotland, UK. The main areas of investigation are:-

- Illegal and misreported landings;
- Discard mortality;
- Escape mortality;
- Ghost fishing;
- Habitat degradation; and
- Predation mortality.

Finally, a website is currently under construction to promote the activities of SGUFM and recruit further sources of information and data on unaccounted fishing mortality. The group is also actively seeking for funding to enable the site to be interactive, with the aim of engaging a wide spectrum of society in open dialogue, debate and an exchange of information on key aspects of unaccounted fishing mortality.

Future Activities

### **11.2 Proposed work programme 2004–2006**

To meet the Terms of reference and aims of the study group the following work items will be undertaken over the lifetime of the study group:

- 1) A comprehensive literature review will be conducted, building upon the work of the previous Study and Topic Groups. Working by correspondence.
- 2) Two workshops will be conducted in 2005 and 2006 to address the following issues:
  - a) Identify measurable components of unaccounted fishing mortality and define comparable indices for assessing their relative impacts, for different capture methods, in key fisheries; and
  - b) Collate available data on sources of unaccounted fishing mortality and produce a comparative summary of their relative impacts, for different capture methods, in key fisheries.
- 3) A sub-group will review and make recommendations on methods used to estimate escape mortality from towed fishing gears. They will work by correspondence and report in April 2006.
- 4) A final report will be compiled, based on items 1 and 2, summarising the relative impacts of each 'sub-component' of fishing mortality upon key commercially important species, by fishing method. The final report will be submitted to ICES in December 2006.

### 11.3 Workshop 2005

Workshop on Unaccounted Fishing Mortality (Convenor: M Breen (UK) to be held in Aberdeen UK, September 2005:

- a) identify measurable components of unaccounted fishing mortality; and
- b) define indices for assessing their relative impacts in key fisheries, for different capture methods.
  - The objective of this workshop will be to provide a forum to discuss and identify possible and measurable sources of unaccounted fishing mortality.

This workshop will discuss the potential for unaccounted fishing mortality in key fisheries, based on information and data currently being gathered by SGUFM. Measurable sources of unaccounted fishing mortality will be identified and prioritised, with respect to their likely impact upon commercially important species and the availability of relevant data. Comparative indices will be defined for assessing the relative impacts of different sources of unaccounted mortality in key fisheries, for different capture methods. This work will provide essential information and data for the work currently being conducted by SGUFM.

### 11.4 Developments in catch and discard visualisation software

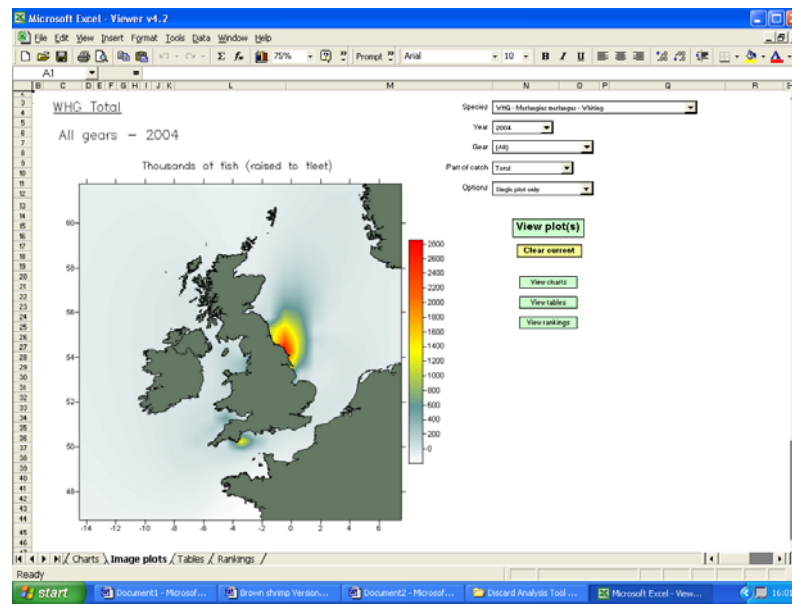
*Andrew Revill (CEFAS, UK)*

#### Abstract

Dr Andy Revill (CEFAS) presented a programme developed in CEFAS (Revill and Firmin) for displaying historical catch data (retained and discarded proportions) pertaining to the English and Welsh fishing fleets. The data (which includes both commercial and non-commercial species) has been collected under the EU data collection regulations and can be potentially be used for a number of purposes including:

- a) To identify the spatial and temporal trends in catches and also discards
- b) To quantify and identify likely causes of discarding
- c) To assess the effects of management interventions (technical measures etc.)
- d) To identify discarding temporal and spatial 'hotspots'

An example of spatial output from the programme is given below



Dr Revill (CEFAS) stated that it was his intention to collaborate with other fisheries agencies in the near future, with a view to incorporating their similar catch / discard databases into such a programme, in order to broaden its potential application and potential usefulness.

**Terms of reference**

The group has had no directed activities during the past year.

**Discussion**

A workshop on this topic will be held this year together with ASC. This is a kick-off to get the subject back on track with issues like discarding, escape mortality, ghost fishing, unreported and misreported landings. Any relevant input is welcomed. It is stressed that the potential output of this group is of value to the wider scientific and management community. This work is a very clear and important connection with other ICES work; demonstrating e.g., how unaccounted mortality can influence stock assessment is very important.

Will there be a theme session on this subject? No, only a workshop at the end of ASC. The possibility exists to have a theme session for next year.

The tool presented here gives a lot of added value to very costly data. The tool is however not yet used in stock assessment. All data that are recorded in discard sampling programmes can be incorporated like e.g., mesh size instead of fishing gear.

Question: Discarding can be induced by the market price. Can the relation of the importance of market price be investigated with the tool? There is no intention to do that for the moment but the tool can be used by others who can do that.

Question: Can discarding spatially over time be tracked with the tool? Yes; a demonstration is given.

## 12 FAO – FTFB gear classification initiative

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*John Willy Valdemarsen (IMR, Norway)*

### Abstract

The FAO has had a fishing gear classification since 1971 which has been a basic document for many fisheries organisations. It has a wide application and many text books have been based on it. But, as fishing gears develop, an update is necessary. The work has already started in FAO and should be taken further now. As the WGFTFB is an expert group in this field, it is the appropriate group to assist in this work. The new classification should be presented at the Coordinating Working Party on Fisheries Statistics (CWP) for formal adoption, planned for 2007. The CWP is a group of many institutions, including ICES. FAO holds secretariat. In the past, CWP has adopted several fisheries related classifications. But the group mainly holds statisticians and input from gear scientists is welcomed very much.

A similar exercise is going on for fishing vessels. This could also be considered by the WGFTFB, although this is not the main focus of the group.

### Discussion

The remark is made that this is an important exercise because of its wide use. Maybe it should be expanded to a terminology list in different languages because often problems in terminology and translation can have serious consequences. The reply was made that this is a large undertaking but this was indeed a recommendation of the group dealing with this. The FAO has a glossary, but it needs updating.

The question is raised whether the link should be made with managers for the update. There are issues like fleet descriptions and métiers that could expand the work significantly. But this can have a big importance. The discussion evolved further around who should be included in the work and the degree of detail required. It was decided to update the general classification as a first step.

## 13 WGFTFB web site

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The Chair of the WGFTFB would like to set up web pages on specific topics like e.g., the selectivity manual, freeware, events, symposia, pdf files of presentations etc. This is supported by the group.

## 14 Summary of posters and other presentations

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### 14.1 WWF – Smart Gear Competition

*Charlotte Mogensen, WWF Europe*

#### Abstract

Bycatch is currently a major fisheries management problem due to the adverse ecological impacts on certain marine species and the removal of biomass from marine ecosystems.

WWF launched an international competition to fish “smarter”, more selective, called the “Smart Gear competition” to seek solutions reducing the bycatch problem. Participants were invited to submit proposals on innovative ideas to develop gears or methods that will increase selectivity for target fish species and reduce bycatch of non-target species. The competition was judged by a coalition of scientists and fishermen. The three winning entries received

funding to take the design from the drawing-board stage to prototype development, testing, and initial manufacture. A new competition is scheduled for next year.

#### **Discussion**

The author was asked how the interest will be broadened. This will be done by presentations and expositions around the world and publications in the press like Fishing News. There was a general feeling that our WG should formalize a liaison with WWF in this field. We support the initiative and would like collaboration. However, some political issues within ICES are possible and the necessary contacts with the Secretariat will be made.

### **14.2 Poster – Selectivity comparison of diamond and square mesh codends of Mediterranean bottom trawl**

***Sala, A., Piccinetti C., Ferretti, M., Buglioni, G., Lucchetti, A., Palumbo, V., and Ungaro, N., ISMAR, Italy***

In the present study, the results and the procedures adopted in the research project “*Selectivity comparison of diamond and square mesh codends of Mediterranean bottom trawl*”, financed by the Italian Ministry of Agriculture and Forestry Policies are reported.

The main objective of this project is to study the effect of inserting square mesh codend into the traditional commercial Italian trawl. A comparative study was carried out to determine the selectivity and the efficiency of a traditional diamond and an experimental square mesh codends.

Prior the selectivity trials, the participants identified a fishery area in which square mesh codend was considered to be a potential benefit to the conservation of fish stocks.

The study of selectivity of the two codends was conducted in a fishing trip carried out in September 2004 on board the RV “*Andrea*”.

The covered codend methodology has been used. The cover was supported by circular hoops to minimize the possible masking effect. The data were analyzed using conventional techniques directed at making inferences on the effects of the itemized covariates on the selectivity parameters.

L50% was found to be positively affected by mesh configuration and codend catch. While only mesh configuration significantly affected SR. However, of these variables, mesh configuration was the one that most affected selectivity.

In the present paper the results obtained for red mullet (*Mullus barbatus*) have been reported. According to the proposed models, within the same codend catch, the change from diamond to square mesh configuration leads to expected increases of 2.8cm and -0.6cm in L50% and SR respectively.

Mean catches obtained for the main species with the two codends were compared using a two-way variance analysis. The factors were *codend* and *species*. The analysis showed that the *codend* effect was assumed consistent across levels of the *species* factor ( $p=0.417$ ), therefore in general the mean catches of the two codends could be considered not significantly different ( $p=0.082$ ). Even if there was no significant interaction between factors, one-ways analysis of variance was repeated for each species on sub-groups of data. Catch comparison results showed the general idea that for all the main species the square meshes codend was less efficient than the diamond codend. However, even if the catch coefficients between the two codends were around 80%, the catch differences resulted constantly not significant. In particular, for red mullet the size structure analysis showed that most of the individuals escaped have a TL lower than 12cm.

### 14.3 ATSELMED – Standardisation of selectivity methods for studies in the Mediterranean

*Jacques Sacchi (IFREMER, France)*

#### Abstract

A working group of the GFCM on the standardization of the selectivity methods applied to trawling in the Mediterranean sea, organized by IFREMER with the participation of FAO projects, COPEMED and ADRIAMED. Thirty scientists of eight Member States of the CGPM, and experts from Denmark, Finland, Argentina and Colombia, fishing gear technologists or persons in charge of research programmes on the selectivity of fishing gears met in IFREMER Sète (France).

Several consultations and workshops (SGMED/UE, GFCM, COPEMED, ADRIAMED) underline the need to bring a strong effort for improvement the selectivity of the Mediterranean trawl. (the most of trawl fisheries are concerned by catches of undersized fishes and discards, to provide reliable and update advices to the fishing industry which makes possible the implementation of technical measures ( « to apply as far as possible a process quality to any production of scientific results » - GFCM président Berraho - COPEMED, Madrid, July 2003).

#### I - Objectives

The main objectives of this working group were to strengthen the current knowledge and to determine clearly what it is necessary to adapt to the Mediterranean specificity, to define the most appropriated and reliable methodologies and experimental protocols for the different Mediterranean fisheries which must gain the agreement of scientists and fishermen.

#### II - Session 1 Case studies - Review of recent selectivity studies

A review of cases of studies achieved in the Mediterranean was made to get a comprehensive review of difficulties to put in practice the adopted methodologies and the statistical analysis focusing on the reasons of choice of methodologies which are used (experimental and statistic protocols), the encountered difficulties and strategies for implementing the selectivity measures to the professional fleet.

Ten papers were presented orally on most varied subjects like the study of multispecific in-shore fisheries and deep shellfish fisheries dealing with the following items:

- diamond meshes codend, square mesh codend, square mesh panel, grids, combination square mesh and grids
- net construction, twine measurements, handling on board
- selectivity methods double codend, cover codend, alternated hauls, retention codend for grid
- selectivity models (Fryer, Select)

#### III - Session 2: Behaviour and survival after escapement

The objective of this session was to discuss on research orientations which may be developed in the next future in Mediterranean. Two talks highlight the interest of the study of the role of the behaviour of the individuals fished the first for comprehension of the escapement by modelling of all surrounding physical variables and the second with for objective the evaluation of the effects of these variables on survival after escapement.

#### IV - Session 3 experimental Reliability and constraints

A general presentation of the various statistical methods considered for the study of trawl selectivity was made and their adaptability to the Mediterranean context was discussed. If most

of the various aspects of trawl selectivity are already largely detailed in the ICES handbook, it seems convenient to insist on their fundamental principles by paying particular attention in an attempt to make out what was essential and possible to adapt to the specific conditions of the various Mediterranean fisheries, in particular, the small mesh size of the codends, the large species diversity and the low level of catches.

#### **V - Remarks and recommendations**

Discussions appear that no experimental method can be privileged. Square meshes codend seem to bring some advantages in terms of selectivity for most of species but other experiments need to be carried on several fisheries and evaluated in terms of economy lost. If the grids can offer unquestionable advantages in term of selectivity for quite specific fisheries, their design, their installation still present some disadvantages in terms of risk of obstruction and the difficulty to handle them aboard small vessels. Whatever, the choice of the selective devices must be dictated by the will to stick to the professional fishing conditions and the supposed behaviour of the species which are meant to escape. The selective devices must be designed most carefully, special care being paid to the choice of materials.

The maximum of variables which may influence the effectiveness of capture (geometry of the trawl, speed of trawling, etc.) must be taken account. Particular recommendations were made on the need for the respect of the ISO standards of representation of the physical parameters (trawls, power, etc), for associating statisticians at the beginning of the study, to define an experimental plan and to answer the problem of the standardization of the results.

#### **VI - Proposals of actions for the next future**

##### *A - Network of technologists*

The necessity to be assisted by technologists to assess the stocks and for the sub-committee on environment (protection of certain species and ecosystems) incite to create a network of Mediterranean technologists. Each participant is thus asked to provide a list of technologists of their country likely to join this group of experts.

##### *B - Selectivity data base*

The goal is to draw up a complete list of all the bibliographical information on selectivity studies, including all the technical data and parameters of selectivity available.

##### *C - Practical guide of selectivity study*

The objective is to establish in a practical guide-line describing the main steps towards the achievement of a study dedicated to the selectivity of Mediterranean trawls so that the results be more easily comparable, and reliable by the respect of a protocol approved by the scientific community and the fisheries industry. It is not question of a new handbook on selectivity, the one published by the ICES fully covering the requirements on the matter.

##### *D - Dissemination of the results to the fisheries industry*

For a better implementation, the fisheries industry must be involved in the improvement of the feasibility and effectiveness of selectivity devices so that the fishermen adopt them more easily. The fisheries industry would be associated to the works of this group. This proposal could be presented at the next meeting of MEDISAMAC (association of Mediterranean fishermen).

#### 14.4 Traps, alternative fishing method for deep sensitive areas in the western Mediterranean Sea. Study on the possibilities of development of trap fishing for Mediterranean small scale fisheries on ecologically sensitive areas (poster)

*Jacques Sacchi and Serge Mortreux (IFREMER, France)*

##### **Abstract**

The expansion of fishing to the static nets and bottom trawl fishing involved a pressure of important fishing pressure on the species living in the canyons and on the hard bottoms of the continental slope of the Mediterranean coasts. These fishing techniques result in addition important captures of non commercial species and sometimes threatened species (e.g., selacians) and habitats deterioration.

It thus appears essential to limit the expansion of these techniques while proposing other more respectful alternatives of the environment and answering better the quality standards and the request of diversification of the market. Because their capture process is easily controllable and less aggressive, traps and pots are fishing methods respectful of the environment, answering to quality standards of Mediterranean fresh market. They appear consequently well adapted to the exploitation durable and responsible for ecologically significant zones like the canyons and the continental slope of the Mediterranean coasts.

##### **Methodology**

Adaptation to the context of the Mediterranean small scale fleet existing fishing techniques.

Participation of regional managers and fishermen organizations (Advisory group) to the project initiation, experimentations and solutions of implementation.

##### **Constraints**

Fishing grounds between 100 and 800 m made of hard and coral bottoms alternating with mud bottoms. Small fishing vessels of less 15m LOA and less of 200 HP. UE restriction on fishing capacity. Daily and seasonal activity share between different static fishing methods. Direct and local market of fresh fishes.

##### **Previous experimentations**

- 1) 1989 – 1991 Introduction of Spanish fishing trap for deep pink shrimp (*Plesionika edwardsii*) - (~200 to 300 m). Technical success but need to solve marketing problems
- 2) 2001 – 2003 - Development of a trap fishery for Norway lobster (*Nephrops norvegicus*) ~400 m. Technical success but need to solve conservation in life

##### **Project on Fish traps (Starting in 2005):**

Adaptation of Norwegian collapsible fish trap for Red sea bream (*Pagellus bogoraveo*), wreck groupers (*Polyprion americanus*), hake (*Merluccius merluccius*). Improvement of the design of existing fish traps, experiments on material resistance, ergonomics and manufacturing cost. Improvements of the selectivity of the trap to the targeted species (mesh size, funnel shape, colour, degradable material, escapement holes).

## 15 National reports

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### 15.1 Belgium

#### **Agricultural Research Centre Ghent – Sea Fisheries Department**

R. Fonteyne, H. Polet and J. Depestele

##### **Reduction of cod bycatches in flatfish and *Nephrops* beam trawls**

The EU-project “Research on effective cod stock recovery measures” (RECOVERY) (Contract Q5RS-2002–00935) has been continued and aims at a reduction of cod bycatches. A series of trials have been carried out on RV “Belgica” and on a commercial vessel with a lowered headline and a square mesh panel in the codend. The reduction of cod bycatch is low. One further sea trip is planned on a commercial vessel.

In a national project, a T90 codend and a separator panel in a flatfish beam trawl have been tested and further trials are planned.

The EU-project “NEphrops and CEtacean Species Selection Information and TechnologY” (NECESSITY) (Contract SSP8-CT-2003–501605) to reduce cod-bycatches in *Nephrops* beam trawls was continued. The same selective designs as in the RECOVERY project were selected and a first sea trip on RV “Belgica” is planned for the end of April 2005.

##### **Mesh measurement**

The EU R&D and Demonstration Project “Development and testing of an objective mesh gauge” (OMEGA) started in September 2002 with SFD as coordinator. Research institutes and fisheries inspection services from Belgium, France, Germany, Italy, the Netherlands, Spain and Scotland are involved as well as a Belgian and a Dutch instrument maker. A test type was built and was evaluated. Subsequently a modified prototype has been built and extensively tested in the lab and at sea by a large international group of future users, including netting manufacturers and fishermen. The OMEGA gauge has also been modified to allow also mesh measurements on set nets. A protocol for the use of an objective mesh gauge for fisheries inspection and research was written. The project was finished at the end February 2005. After acceptance of the final report by the Commission services a procedure will start with the aim to introduce the new instrument for inspection purposes in EC waters. The OMEGA gauge was well received by the European netting manufacturers. It is the intention to adopt the gauge as an ISO-CEN standard.

An objective mesh gauge, suitable for use by all stakeholders in the fishing industry, will provide a common standard of measurement and assist the integration of the scientific, industrial and enforcement aspects of fishery management.

Details on the OMEGA project can be found on the website [www.dvz.be/omega](http://www.dvz.be/omega).

##### **Alternative fishing methods**

A new research programme aiming at the introduction of more environmental friendly fishing methods was started in the autumn of 2004. The programme involves making an inventory of fishing methods worldwide including evaluation of their environmental impact and the introduction of impact mitigating technical modifications in existing gears. Proposals will be made to investigate complete new fishing methods in follow-up projects.

##### **Balancing Impacts of Human Activities in the North Sea**

The sustainable management of the North Sea is a very complex theme due to the interaction between the social, economic and ecological dimensions of the use-functions of the Belgian

part of the North Sea. A project (Balancing Impacts of Human Activities in the North Sea – BALANS) was started aiming to develop a first conceptual balancing model “Sustainable Management of the North Sea” for the policy makers and the users of the North Sea. The purpose is the correlation and the balancing between the different social, economic and social dimensions, through the elaboration of indicators, via the development of a conceptual policy model. As this type of research concerning the marine environment is still in an embryonic phase, the research boundaries are strictly limited to the use-functions sand- and gravel extraction, fisheries and related shipping.

### ***PROGRAMME 2005–2006 – BELGIUM***

#### **Reduction of cod bycatches in beam trawls**

Two EU-projects:

- Running: “Research on effective cod stock recovery measures” (RECOVERY) (Contract Q5RS-2002–00935)
- Running: *Nephrops* and cetacean species selection information and technology (NECESSITY) (Contract SSP8-CT-2003–501605)

Both projects aim at reducing the cod bycatch, one for flatfish beam trawls (RECOVERY) and one for *Nephrops* beam trawls (NECESSITY).

#### **Balancing Impacts of Human Activities in the North Sea**

The project “Balancing Impacts of Human Activities in the North Sea” (BALANS) will continue until September 2006.

#### **Mesh measurement**

The draft final report of the OMEGA project will be submitted to the Commission in April 2005. Follow-up of the procedure to introduce the new instrument for inspection purposes.

#### **Alternative fishing methods**

The inventory of fishing methods worldwide will be completed. Technical modifications of beam trawls to reduce the environmental impact will be extensively tested on board of commercial vessels.

## **15.2 Canada**

### **CSAR – Centre for Sustainable Aquatic Resources, Marine Institute of Memorial University of Newfoundland**

#### **Flume Tank Flow Study:**

A series of detailed tests were conducted to determine the flow characteristics of the Marine Institute Flume Tank. Flow profiles in both the vertical and transverse directions were developed to determine if corrective measures are required to improve water flow and whether the flow could be altered to achieve specific flow profiles for certain clients.

*Contact: George Legge (George.Legge@mi.mun.ca).*

#### **Snow Crab Pot Selectivity:**

Four experiments were undertaken in 2004 to investigate the feasibility of different snow crab pot designs. The goal was to develop a pot that caught significantly less undersized and soft-shelled crab in order to reduce handling mortality associated with discarding. Escape mechanisms, plastic collars, mesh size, and wire pots were investigated. Preliminary results have been encouraging.

*Contact: Paul Winger (Paul.Winger@mi.mun.ca).*

**Multi-level Trawl for Northern Shrimp:**

Sea trials were continued in 2004 to identify the vertical distribution of shrimp and capelin using a multi-level trawl. Preliminary results indicated a size related vertical distribution with larger shrimp dominating the catch in the lower band of the trawl.

*Contact: Harold DeLouche (Harold.DeLouche@mi.mun.ca).*

**Codpotting:**

Sea trials were continued in 2004 as part of a long-term study to improve the design and operation of baited pots for the capture of Atlantic cod. Preliminary results have been very encouraging and commercial trials are planned for 2005.

*Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).*

**Reducing Bycatch of Vaquita Porpoise:**

Alternative harvesting methods are being tested in the commercial shrimp fishery in the Northern Gulf of California in collaboration with the Mexican government and academic institutions to reduce entanglements of the critically endangered Vaquita porpoise. Various trap designs are being tested as an alternative to gillnets.

*Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).*

**American Plaice Live Release:**

This study investigated survivability and blood chemistry of American plaice following capture by bottom trawl at different times of the year and with varying tow duration. Preliminary results are positive.

*Contact Scott Grant (Scott.Grant@mi.mun.ca).*

**Atlantic Halibut Pots:**

The feasibility of catching Atlantic halibut in baited traps was investigated off the north coast of Prince Edward Island. Six experimental trap designs were tested and the behaviour of halibut and non-targeted species was observed using underwater cameras. Preliminary findings indicate entrance shape and location are critical.

*Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).*

**ACTIVITIES IN 2005**

In 2005, research initiatives at CSAR are being directed toward:

- the reduction of seabed contact by bottom trawl gears
- continued sea trials using a new multi-level shrimp trawl
- survivability of trawl caught American plaice
- commercial trials using alternative trap designs for snow crab
- commercial trials using baited pots for Atlantic cod
- research trawl design and standardization for NOAA

*Contact: Glenn Blackwood, Director - Centre for Sustainable Aquatic Resources, Marine Institute of Memorial University of Newfoundland, P.O. Box 4920, 155 Ridge Road, St. John's, NL, Canada, A1C 5R3. Telephone: 1 709 778-0430; Fax: 1 709 778-0661, e-mail: Glenn.Blackwood@mi.mun.ca*

## **Fisheries & Oceans Canada, Fisheries Management Branch, St. John's, Newfoundland and Labrador, Canada**

### ***ACTIVITIES IN 2004***

#### **Reducing Fuel consumption on <20' Shrimp Vessels**

Rising fuel prices, low market prices, and fluctuating currency exchange rates are reducing the viability of the Newfoundland shrimp fishery. To mitigate this somewhat, a project designed to reduce energy consumption on shrimp trawlers was carried out in three separate NAFO areas and on three vessels with different horsepower. A company was hired to produce three trawls incorporating such energy reducing devices as small diameter twines and ropes, larger meshes in the forepart of the trawl, and footropes with less bottom contact.

*Contact person: Gerald Brothers, Chief, Conservation Harvesting Technology, Fisheries Management Branch, Fisheries & Oceans Canada, P. O. Box 5667, St. John's, Newfoundland, Canada, A1C-5X1. Telephone (709) 772-4438, Fax. (709) 772-3628, e-mail: brothersg@dfo-mpo.gc.ca*

## **Fisheries & Oceans Canada, Science Branch, St. John's, Newfoundland and Labrador, Canada**

### ***ACTIVITIES IN 2004***

#### **Deriving length based conversion factors for survey bottom trawls: year 1**

In 2004, a series of comparative fishing experiments were to be carried out utilizing all three survey bottom trawls currently used for annual resource assessment in Atlantic Canada. These calibration experiments involve 2 research vessels towing side by side and tried to examine the selectivity and efficiency of all three bottom trawls. The goal was to derive vessel conversion factors for 2 vessels and one gear conversion factor for a new survey trawl for Quebec region. All 4 Atlantic Fisheries and Oceans Institutes participated but there was a limited amount of success due to vessel breakdowns and bad weather.

*Contact: Stephen J. Walsh, Aquatic Resources Division, Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, P.O. Box 5667, St. John's Newfoundland, Canada, A1C 5X1, Telephone 1 709 772 5478, Fax 1 709 772 4105; e-mail: walshs@dfo-mpo.gc.ca*

### ***ACTIVITIES IN 2005***

#### **Deriving length based conversion factors for survey bottom trawls: year 2**

In 2005, a series of comparative fishing experiments will be carried out utilizing all three survey bottom trawls currently used for annual resource assessment in Atlantic Canada. These calibration experiments will involve 2 research vessels towing side by side and will examine the selectivity and efficiency of all three bottom trawls. The goal is to derive vessel conversion factors for 2 vessels and one gear, and a one gear conversion factor for a new survey trawl for Quebec region. All 4 Atlantic Fisheries and Oceans Institutes will participate.

*Contact: Stephen J. Walsh, Aquatic Resources Division, Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, P.O. Box 5667, St. John's Newfoundland, Canada, A1C 5X1, Telephone 1 709 772 5478, Fax 1 709 772 4105; e-mail: walshs@dfo-mpo.gc.ca*

#### **Estimating the effect of shrimp trawling on snow crab mortality**

The overlap of snow crab and shrimp fishing grounds in the offshore area of northeastern Newfoundland is great. High fishing effort by shrimp trawlers may possibly lead to multiple encounters of crabs with shrimp trawls. DFO Science and Fisheries Management Branches are teaming up with industry to use a variety of experimental fishing and video techniques includ-

ing pot trapping, bag trawls rigged underneath the shrimp trawl footgear, an ROTV to video contact of crab with the trawl in the trawl mouth area, and an ROV to carry out pre and post trawling surveys, aimed at assessing damage and mortality of crabs due to interactions with shrimp trawls.

*Contact: Earl Dawe, Aquatic Resources Division, Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, P.O. Box 5667, St. John's Newfoundland, Canada, A1C 5X1, Telephone 1 709 772 2076, Fax 1 709 772 4105; e-mail: dawee@dfo-mpo.gc.ca*

### 15.3 Denmark (DIFRES)

Activities in 2004 have mainly been embedded in internationally coordinated EU projects, with particular focus on selectivity in commercial trawls.

A main objective of the EU-funded project RECOVERY is to reduce catches of cod while maintaining catches of other economically important species in the North-Sea mixed human-consumption fishery. Sea trials were conducted with a Danish Commercial fishing vessel to investigate differences in behaviour of commercial important species inside the trawl. Furthermore trials were conducted with a Norwegian research vessel using sonar and camera systems to collect information on fish behaviour inside the trawl.

The objectives of the EU project SURVIVAL are to describe how undersized cod, haddock and whiting escape from the trawl and to estimate their additional escape mortality rates. The studies require the use of advanced techniques to sample escaping fish during the various phases of trawling. Sea trials were conducted with a commercial Scottish trawler in February, Marts, May, June and August 2003 on the west coast of Scotland.

The EU project PREMECS II aims at developing a stochastic simulation model to assess the selective properties of codends in towed fishing gears. These types of simulation tools are expected to become increasingly important for designing cost intensive field and flume tank experiments and verifying experimental results. DIFRES will develop this area further in the future.

A national project (funded by DFFE) in collaboration with the Danish Fishermen's Association to develop selective trawls for the Kattegat and Skagerrak *Nephrops* (Norway lobster) fishery was finished. DIFRES's at-sea sampling programme indicated a particularly high discard rate in this fishery. Sea trials with a commercial vessel indicated that a developed escape window was successful in reducing the discard substantially. The escape window was introduced in the legislation by the EU to be used in the *Nephrops* fishery from 1 February 2005. National experiments aiming at improving the selectivity in the *Nephrops* fishery even further will continue in 2005 where new selective devices will be developed and tested. Furthermore, international research on improving the selectivity of *Nephrops* trawls will be intensified in the large-scale EU project (NECESSITY starting in 2004) aimed at reducing bycatches in European *Nephrops* fisheries. As part of this project, DIFRES will run experiments in Kattegat and Skagerrak.

Apart from being directly incorporated into scientific advice on technical management measures, the results from gear selectivity projects were used to describe and model fishery selectivity and at the same time addressing fisherman behaviour in relation to technological development, stock status and distribution, as well as economic and social considerations (see projects TECTAC and TEMAS in Fisheries Management section). Scientific advice-related activities included participation in an ICES expert group evaluating selectivity properties of trawls used in the Baltic Sea cod fishery.

Hydroacoustic activities included participation in PGHERS (ICES Planning Group for Herring Surveys) coordinating the international acoustic herring assessment survey in the North Sea,

Skagerrak and Kattegat as well as carrying out the Danish part of this survey in cooperation with other sections of HFI. Another activity was taking part in R/V Dana's contribution to the international acoustic Blue whiting/Herring assessment survey in the Norwegian Sea including the calibration part of this cruise. Research results from a tank experiment regarding the possible future use of acoustics for direct in-situ recognition of fish species, a work done in cooperation with the Fisheries Management section, was presented at the ICES Annual Science Conference and can be found on their website.

Research was conducted in a series of national and international projects to quantify and reduce the bycatch of marine mammals in Danish fisheries and to limit the impact of marine mammals on fisheries by means of: i) technical gear modifications, ii) the use of deterrent devices and iii) changes in fishing tactics. The EU-funded project PETRACET will be assessing the extent of the bycatch of dolphins in pelagic trawl fisheries in ICES divisions VII and VIII, whereas the EU-funded project NECESSITY aims at reducing the bycatch of dolphins in these pelagic trawl fisheries. Both projects were initiated in 2004 and will continue in 2005, where DIFRES will carry out experiments with wild dolphins to determine the relative efficiency of different acoustic deterrent signals and conduct trials in the commercial fishery with acoustic deterrent devices (pingers).

A national project addressing bycatch of harbour porpoise in Danish fisheries was initiated in 2004, with activities including trials in the commercial gill net fishery of the four different pingers commercially available. These trials will continue in 2005. Activities in this project also include testing different materials for use in increasing the detect ability of gill nets to porpoises.

A project co-financed by the Nordic Council of Ministers and "Elisabeth og Knud Petersens Fond" aimed at reducing seal impact on eel fykes was continued in 2004 with trials of fykes where the traditional netting was replaced by Dyneema® netting. Results are encouraging, but more trials are needed to assess the economic viability of this mitigation method. These trials will be conducted in 2005.

Scientific advice-related activities included participation in an ICES expert group advising on marine mammal ecology and in national expert groups on marine mammals.

## 15.4 Faroe Islands

### **Ground-gear experiments**

Experiments to reduce the impact on the bottom from trawl ground-gear continued in 2004. A new design of a gear was compared with a rock-hopper gear. Under-water video recordings showed that less sediment disturbance came from the new gear. The experiments will continue in 2005 where the fishing efficiency will be compared.

### **Scallop dredging impact**

For decades scallop dredging have been undertaken in a limited area east of the Faroes. Other potential areas exist, but because of possible negative bottom impacts, there have been reluctance to widen the dredging activities. A project has been initiated where bottom impact from scallop dredging in an undisturbed area will be investigated. Underwater video recordings and bottom sampling before and after dredging in a small area will be used to assess possible impact.

### **Corals reefs**

The impact from fishing on deep-sea corals reefs has become an issue in many areas. Corals reefs in the Faroese area have been mapped using information from interviews with fishermen and by underwater video observations. Underwater video recordings will continue in 2005 and

more detailed mapping will be undertaken. This information will be used in the discussion with stakeholders on preserving coral reefs.

#### **Development of static gear**

A two-year project to develop a fish trap for traditional species (cod, haddock and saithe) has been initiated. The first year the focus will be on using different stimulation to attract/guide/direct fish to the trap. The second year the focus will be on increasing the trap efficiency by developing more efficient entrance, prolonged bait dispensing etc.

#### **Size selectivity in shrimp trawls**

Size sorting in shrimp fishery has for a long time been of interest both to fishermen and to scientists and several attempts to achieve this has been undertaken. The Faroese Fishery Laboratory and trawl manufacturer "Vonin Ltd" will continue these experiments in 2005 with a special size-sorting grid. This project will be carried out in cooperation with companies in Canada and Greenland.

#### **Sorting grid for species selectivity in pelagic trawls**

In recent years increased bycatch of saithe and cod has been seen in the pelagic blue whiting fishery. Experiments to avoid bycatch using sorting grids have been initiated in 2004 and will continue in 2005.

Focus will also be on increasing the understanding of the water flow and fish behaviour inside pelagic trawls.

#### **Coloured gillnets for monkfish**

A few years ago a special fishery for monkfish in shallow water was initiated. During 2005–2006 the effect of different coloured nets on the fishing success will be tested. The different colours to be tested will be red, yellow, green, blue and transparent. Some 500 monkfish have been tagged in recent years, but none have been recaptured yet.

#### **Lanternfishes**

Research on Lanternfishes (*Myctophids*) was initiated in 2004. In cooperation with Russian, Norwegian and Icelandic scientist information on fish biology has been collected and the first experiments to develop a suitable fishing gear for this species has been conducted. The aim is to develop commercial fishery for such species.

#### **Cod tagging**

Since 1997, more than 22000 cod have been tagged on various locations on the Faroe Plateau. More than 6500 cod have been recaptured and stomach content from more than 1000 of these fishes has been analysed. This experiment provides valuable understanding of the migration pattern and feeding behaviour of cod on the Faroe plateau. Preliminary results were reported to the ICES 2003 Symposium in Bergen.

*Contact: Kristian Zachariassen (krizac@frs.fo) and Bjarti Thomsen (bjartit@frs.fo), Faroese Fisheries Laboratory, P. O. Box 3051, FO-110 Tórshavn, Faroe Island.*

## **15.5 Germany**

*Contact: Erdman Dahm*

***Technical- biological investigations:*****Selectivity of cod trawls in the Baltic**

Work on this subject concentrated in 2004 on the further collection of data on the now legal Bacoma codend with 110 mm mesh opening. A possible alternative to it, the codend made of netting turned 90 degrees (T90), was tested intensively as well on commercial boats as on research ships. After ICES has now confirmed its general equivalence to the legal Bacoma codend it is necessary to elaborate a detailed specification for the new codend. Differences detected in the selective properties of the T90 codend depending on the joining ratio of trawl and extension/ codend stressed the importance of this work for the optimum performance of the codend. The choice of netting material seems also to play an important role.

**Selectivity of eel in trawls in the Baltic**

A current decision of the EU- Commission forbids the catch of eels by active gear in the Baltic. Nevertheless, gear trials of the IFF were continued where by appropriate modification of the trawl a species selection of eel and other round- and flatfish is intended. The research after initial encouraging results is not very promising at the moment, partly due to the drastically reduced catches of silver eel which disguises possible effects.

**Optimization of gillnets to avoid unwanted bycatch of porpoises**

There are three lines at present followed to suppress the unwanted bycatch of small cetaceans in gillnets. The use of reflectors or inclusion of barium sulphate into the netting yarn has already been tried elsewhere with varying success. The work of the institute as in the year before was focused on the investigation of deterring panels made of very large meshes and of thick netting as recommended by Dutch scientists. It was detected that gillnets fitted out this way showed a reduced catchability compared to nets without deterring panels depending on the colour of the deterring panels. Those with green and white colour demonstrated a much more negative effect on the catchability than red ones. The acceptance of such construction by commercial fishermen will be rather low, particularly when taking into regard that the bycatch of porpoises is a very rare event in the German fishery.

**A new theoretical model for the determination of selectivity aiming at the reduction of research time and effort**

A new theoretical model of selectivity developed in the institute allows for the rapid calculation of the necessary mesh size for obtaining a distinct L50 value

***Technical investigations:*****A new research ship**

FFS "Solea" was replaced in 2004 by a new ship designed substantially in its research capabilities according to demand from the scientists of the BFA. As actual measurements in a marine noise test area showed, a significant noise reduction has to be named in first place which makes the ship competitive to any other newly built fishery research vessel. Further, the layout of the catch processing facilities with lift and conveyor belts reduces heavy manual labour to a minimum. Seven scientists are able to participate at a cruise. The ship has excellent seagoing properties as comparative tests with the old "Solea" and the work in the first months of service showed.

Plans for the replacement of the smallest research vessel "Clupea" in the pool of the Ministry for Consumer protection, Environment and Agriculture are discussed.

**Progress with a cableless video- transmission system**

The existing cableless video transmitting systems (STIPS) were used for underwater observations in a project on species selection in a flatfish trawl and also in an eel-trawl. A newly introduced bigger watertight loading hatch facilitates the maintenance of the equipment.

**A new mesh measuring device**

The IFF was actively involved into further laboratory and field tests of a prototype of the new OMEGA mesh gauge. Two demonstration events held in ports (Rostock and Cuxhaven) provided a good opportunity to provide the advantages and the handling of the new instrument to large groups of fishery inspectors from all over Northern Germany.

## 15.6 Iceland

*Contact: Haraldur Arnar Einarsson/Iceland*

**Size selectivity in ground fishery**

Two surveys have been carried out in selectivity trials for grids, BACOMA and codends with different mesh sizes. The third survey will be conducted in September this year where developed T90 codend and some other types of codend will be measured in selectivity. Method will be twin trawling. Species in focus will be cod and haddock.

*Contact Haraldur Arnar Einarsson, haraldur@hafro.is.*

**Species selectivity in pelagic fishery**

One trial have been contributed with sorting grid similar to the sorting grid in herring trawls, which have been in trial in the IMR-Bergen lead by Bjørnar Isaksen. The grid system need development to fit to the large blue whiting trawls. The bar distance will be 55 m. Trials will mainly focus at the blue whiting fishery with bycatch of saithe and cod. Sea trials will be conducted this spring and summer.

*Cooperation's work with the Hampidjan Ltd. Contact Haraldur Arnar Einarsson, haraldur@hafro.is.*

**Escapement in pelagic trawling**

In Icelandic waters much effort is exerted by the fleet using large pelagic trawls (Gloria) and mortality caused by mesh penetration in these trawls is potentially a large problem. The extent of mesh penetration in capelin and blue whiting fisheries using pelagic trawls has not been measured but one experiment in herring fishery did not show large scale mesh penetration. In next two attempts will be made to measure mesh penetration by capelin, herring and blue whiting in the pelagic trawl fishery by using underwater camera, sonar and cover bags.

*Cooperation with the Hampidjan Ltd. Contact Haraldur Arnar Einarsson, haraldur@hafro.is*

**Flying cod-pots**

Trial with cod pots for small-scale fishery. Pots are remade from Norwegian version. The main idea is to fish only cod in areas were haddock is to avoid. There are two year experience from fisherman and research as well in Iceland have shown this pot to fish fairly, and the cod in the catch is suitable fish for aquaculture purposes, but more development on the gear and research will be done in next one or two years.

*Contact Haraldur Arnar Einarsson, haraldur@hafro.is.*

### **Mortality in long-line fishery**

In last years the long-line and hand-line fishery has expanded following development in small plastic boats. This has raised a question about survival of the small cod that has been legally discarded in the handline fishery. A survival experiment done in July 2001, showed overall average mortality to be 43% in handline fishery, but it was striking to observe the surviving fish to be in relative “bad” condition compared to a control group that was caught by hooks but got a very gentle treatment. Last year a survival experiments was contributed of cod caught by long-line and released, tagged and stored for few weeks in aquaculture cages. The results are in process. Ólafur K. Pálsson, Hjalti Karsson, Haraldur A. Einarsson.

*Contact Haraldur Arnar Einarsson, haraldur@hafro.is.*

## **15.7 Ireland**

*Contact: Dominic Rihan, BIM rihan@bim.ie*

### **Selectivity Trials**

As part of an ongoing project to define selectivity parameters of standard and modified gears in Irish fisheries, two sets of trials were carried out in 2004. In March, trials on board the *Nephrops* twin-rig vessel “Girona” were carried out in the Irish Sea *Nephrops* fishery to gather selectivity data on standard *Nephrops* trawl designs used in the fishery and also with a trawl fitted with an inclined separator panel as used in the Irish Sea Cod Recovery Programme. The twin trawl method was used. This work will be supplemented by joint national research being carried out by BIM and the Irish Marine Institute attempting to assess the consequences of technical conservation measures on stock development for selected Irish fisheries through the inputting of appropriate selectivity data in simulation model being developed by the Marine Institute. The Irish Sea cod stock and the impact of the EU cod closure are being used as a pilot study for this work

In August a further set of trials were completed in the seine net fishery off the South coast of Ireland on board the “Cisemair” using the alternate haul method. Selectivity data was gathered on a standard seine net with 80mm codend; with a 100mm codend and with a 100mm codend and 90mm square mesh panel. This programme will continue in 2005.

### **Project NECESSITY - *Nephrops***

As part of the EU NECESSITY project, trials looking at acceptable gear modifications in the Celtic Sea *Nephrops* fishery with an inclined separator panels were carried out in June 2004 on the twin-rig vessel “Rose of Sharon”. Selectivity data for the standard *Nephrops* trawl used in the fishery and also with an inclined separator panel were collected. A follow-up set of trials were completed on the vessel Celtic Venture” in March 2005. An inclined separator panel installed in a four panel section to facilitate ease of installation and improve stability of the panel was tested. The twin trawl method was used for both sets of trials. Further sets of trials are planned for June and September testing different selectivity options. These trials will be carried out in the Celtic Sea and off the west coast of Ireland on the Aran Island prawn fishery respectively.

### **Project NECESSITY – cetacean bycatch**

Along with an analysis of cetacean reaction and behaviour to pelagic fishing gear, as part of this project BIM have been working with Aquatec Subsea Ltd to develop an interactive acoustic deterrent device. Design and construction of a prototype device was completed in February, following trials in June on Irish two pelagic vessels to establish background noise levels associated with the vessels and fishing gear which may cause false triggering of the interactive device or mask the deterrent noises emitted by the pinger. Experiments with captive dolphins were completed in the dolphinarium in Kolmarden, Sweden in March 2005 to test the interac-

tive system worked in a controlled environment and further tests will be carried out with wild animals in the Shannon Estuary later in the summer, followed by trials on board commercial vessels in the Albacore tuna pair pelagic fishery.

#### **Acoustic Deterrents**

On the request of industry, trials investigating the durability and practical deployment of acoustic deterrent devices which are to become mandatory in set net fisheries in the Celtic Sea in January 2006 under EU legislation. Four types of commercially available devices are to be tested in the hake, cod and monkfish tangle net fisheries. These trials will concentrate on technical issues rather than assessing bycatch rates directly and mirror similar work being carried out in the UK by SFIA.

#### **Project DEEPNET**

BIM and the Marine Institute were involved in a joint collaboration project (DEEPNET) with the Norwegian Marine Institute and the Seafish Industry Authority in the UK investigating the impact of “ghost nets” associated with the Anglo Spanish tangle net fishery for monkfish and deepwater shark species fishing off the west coast of Ireland and Scotland and in international waters west of Rockall and at the Hatton Bank. This study involves a description of the development and current level of effort of this fishery, simulation studies assessing discarding and spoilage rates in this fishery as a result of excessive soak times, as well as putting forward recommendations to EU and NEAFC for the future management of these fisheries, which are currently largely unregulated. A report was published in December 2004 and a follow up study is planned including a gillnet retrieval study scheduled for September 2005 in the Rockall Bank area on board an Irish vessel.

#### **Bluefin Tuna Tag and Release**

In 2003 and 2004 BIM in collaboration with Stanford University in South Carolina have successfully set up a Tag and Release Scheme for Bluefin tuna caught in the recreational fishery for this species that has developed in the last few years off the NW coast of Ireland. To date six Bluefin have been tagged and released with “pop-up tags”. Two tags have been recovered providing information on migration and distribution patterns. This project will continue in 2005.

### **15.7.1 Fisheries information**

#### **Mackerel**

Due to the 27% reduction of the mackerel quota in 2005, there was reporting of widespread slipping of small mackerel as fishermen targeted larger mackerel, which were attaining a higher market price. This is not a new phenomenon but was particularly problematical this year due to the large decrease in the quota. In previous years large scale slipping has caused problems later in the year when fishermen have reported catching large quantities of dead mackerel in certain areas when targeting demersal species. Many vessels have experimented with Turned 90 ° mesh in the codend of the trawls to try and reduce meshing of small mackerel. There are reports of limited success with this modification but no data is available.

#### **Monkfish**

Several of the Irish demersal vessels targeting monkfish in Area Via and VIIb with twin-rig scraper or double bosom trawls have now moved to codend mesh sizes of 150mm to reduce discards of unwanted species. The catch composition of these vessels is now almost exclusively made up of monkfish.

### **Albacore Tuna**

Despite Irish landings of Albacore tuna by pair pelagic trawlers being low in 2004, vessels did report corresponding low levels of cetacean bycatch. Though not tested it was felt that this was largely due to vessels tended to drop the headline of the trawls to 10–20 fm to target larger tuna.

### ***Nephrops***

There has been an increasing shift of effort to *Nephrops* by Irish vessels due to a combination of factors. With increasing enforcement of the monkfish quota, resulting in the detention of a number of Irish vessels, several vessels in the 20–24m category based in the south-west area have converted to *Nephrops*. Also due to the low price of whitefish species during 2004 and in early 2005, a number of Irish seine net vessels have also switched to *Nephrops*. It has also been reported that there has been a pre-dominance of small *Nephrops* on a number of grounds leading to an increase in discarding. In contrast in the last two years the grounds off the North-west coast on the Stanton Banks have begun to yield significantly higher *Nephrops* catches. This fishery may run into quota problems later this year as many of the smaller whitefish vessels working from the port of Greencastle have now begun targeting *Nephrops* in the months May-September.

### **Area Closures**

The Irish Sea cod closure from February to March was in place in 2004 and 2005. Due to a temporary tie-up by Northern Ireland whitefish pelagic trawlers during this period, activity in the restricted area of the cod box was greatly reduced. Irish *Nephrops* trawls continued to work in this area, and around 12 vessels fitted inclined separator panels to fish in the derogated “separator” zone of the closed area. Enforcement was reported to be low and fishermen reported that there was evidence that some fishermen circumvented the regulation by lacing up the opening at the top of the separator panel.

A voluntary closure off the North coast of Ireland has been put in place to protect juvenile cod in an area off Greencastle. Extensive tagging of cod in the area has been carried out to establish movements of juvenile cod, which are traditionally caught in this area in the autumn and winter. This project was initiated by the local industry.

### **Deepwater Gillnets**

Reports from the Irish Inspectorate and Naval Service have reported an increase in effort by gillnet vessels in Areas VIa and VIIb,c in 2004 and 2005. When inspected these vessels invariably have no rigged nets aboard only headline and footropes. It has also been reported that increasingly these vessels are targeted deepwater crab species, particularly at Rockall. The market for frozen crab has increased and with quotas now in place for siki shark, many of the vessels are now targeting crab. One vessel has switched exclusively to pots. There has also been an increasing amount of effort by gillnet vessels targeting hake off the Porcupine Bank areas. Many of these vessels are reported to be using the difference in mesh size regulations between Area VII and VIII and fishing with small mesh sizes of 100mm or less in this fishery, where a mesh size of 120mm is required. These vessels are reported to be working in pairs or groups of 3–4 vessels and are leaving their gear at sea to be tended by the other vessels, while coming into land.

### **Blue Whiting**

Due to the reduction of the mackerel quota, a larger number of Irish RSW vessels participated in the blue whiting fishery during 2005. Meshing of blue whiting at the top of the brailer section of trawls was found to be a major problem and one vessel has experimented with installing a large section of hexagonal mesh netting at the point in the gear where most meshing has

been observed. It is planned to try and do some comparative testing of this concept in the fishery in 2006.

## 15.8 Netherlands

*B. van Marlen*

### **Electric fishing**

Technical trials were carried out on the 12 m prototype of an electrified beam trawl in collaboration with the Ministry of Agriculture, Nature Management and Fisheries and a private company in April 2004. A detailed comparison of catch and bycatch was done in October–November 2004 and January 2005. Slightly larger sole and smaller plaice catches were found compared to the conventional trawl, and about 30% less benthos. Survival and physiology of plaice and sole were also studied in this period. The results seemed favourable for the electrified gear in the first week of observation, but with a longer observation time of two weeks the advantages disappear, probably due to infections causing additional mortality. Monitoring catches and economic performance during a long-term commercial trial has begun in April 2005.

### **Release of cod from demersal trawls (EU-project RECOVERY)**

Work continued on the demersal trawls, but no more work was done on beam trawls in The Netherlands. The second Periodic Report was produced and accepted. Skippers will be interviewed in 2005 on the subject of applying modified gears to reduce discards and release cod.

### **Reduction of cetacean bycatch in pelagic and fish bycatch in *Nephrops* fisheries EU-project NECESSITY (NEphrops and CEtacean Species Selection Information and Technology)**

*Nephrops*

A series of model tests were done in December 2004 in the flume tank of Hull on modified gears for the *Nephrops* fisheries in close cooperation with the fishing industry. Various gear modifications such as sorting grids, square mesh panels, inclined separator panels were developed, some were tested at sea, other are due to be tested in 2005. A start was made on the economic analysis of the effects of new gear, using Cost Benefit Analysis techniques. In France discard monitoring trips were done in the *Nephrops* fisheries to infer the exact times, areas and species involved.

*Cetaceans*

A beginning was made on the analysis of stomach contents of cetaceans to infer relationships between fish discarded and the presence of cetaceans around trawls. A workshop was held in Boulogne, France in February 2005 to study and discuss designs of gear modifications to release cetaceans with representatives from the fishing industry. Tests at sea are planned in the spring of 2005, both on commercial and research vessels. A prototype of an interactive deterrent device was made by AquaTec presented Feb 2005 to be tested further. A trip on FRV “Walther Herwig III” carried out by RIVO and BFAFi in March 2005 showed that a system of ropes in the middle of a pelagic net, designed to scare off cetaceans, affected the behaviour and passage of fish. Further work will be concentrated on release devices in the tunnel of the net.

### **Selective gears (national programme)**

An inventory was reported on the small-scale coastal fisheries in The Netherlands. This sector comprises of about 100 companies with a total of 200 boats (most with Loa < 20 m, engine power < 100 kW), landing some 600 tonnes annually (particularly: smelt (*Osmerus eperlanus*), sprat (*Sprattus sprattus*), cod (*Gadus morhua*), grey mullet (*Mugilidae*), flounder (*Platichthys flesus*). A large variety of both active and passive gears is deployed, ranging from

trawls, seine nets, fixed and floating gill nets, trammel nets, pots and traps, long lines, weirs and fyke nets.

## 15.9 Norway

### SINTEF

#### Full scale trials with T-90 codends

Two trials have been conducted on board Norwegian trawlers with a T90 codend (meshes turned 90°). The aim was to investigate the quality preserving properties in the new codend.

A codend was made for a pelagic trawl, where the whole length of the codend was made in T90. It was tested in herring and mackerel fisheries and compared to the vessels traditional codend. In another trial a whitefish codend was tested in a double trawl system on a factory trawler in the Barents Sea. Here the last 4 meters of the codend was made from knotless netting to further reduce a negative impact on the quality of the fish from the knots.

Fish quality was assessed according to mortality, external damages, initial muscle pH, development of rigor mortis and visual assessment of the fillet; colour, texture and various blemishes (gaping, blood spots, bruising etc). Catch size and selectivity issues were not covered.

The trials were part of the part of a larger project investigating possibilities to improve fish quality on board fishing vessels using different fishing methods, and testing the T90 codend was only part of the project.

The results showed little difference between the codends. In the pelagic fishery it was believed that the trawl hauls were too short (< 1 hour) for the fish to accumulate significant differences in damage, whereas in the whitefish trials any difference might be “blinded” by the presence of sorting grids, heavy chafers etc.

*Contact: Ulrik Jes Hansen: [ujh@sintef.dk](mailto:ujh@sintef.dk)*

#### Overtrawlability

SINTEF have been consulted in various overtrawlability projects for clients. Projects are confidential, but comprised both model tests in a tow-tank at FORCE Technologies, Copenhagen, and desk-top evaluation of sub-sea structures.

*Contact: Ulrik Jes Hansen: [ujh@sintef.dk](mailto:ujh@sintef.dk)*

#### Plate gear

Continued tests have been conducted in full scale and in the Barents Sea as well as in model scale in the SINTEF Flume Tank. The project is a joint project between SINTEF and Institute of Marine Research, Bergen.

An underwater video camera mounted on the headline of the trawls revealed that the new groundgear are functioning very well. Most remarkable is the way it travels over large stones and boulders, where it can be seen that only one or two plates are flipping back as the stone passes under. The traditional rock-hopper gear is seen to lift several meters to each side. Also the plate gear is seen to retain much more fish than the disks of the rock-hopper gear. Ongoing trials are aimed at improving the construction and mounting of the plate gear.

*Contact: Kurt Hansen: [kh@sintef.dk](mailto:kh@sintef.dk)*

#### Analysis of trends in fishing capacity development

According to the Food and Agriculture Organization of the United Nations (FAO), overcapacity in the fishing fleet poses a fundamental challenge in fisheries. Overcapacity leads to an

increased pressure on fish stocks and a decrease in economic profit. The fishing fleet is marginalized economically, and overcapacity creates allocation conflicts between different gear and vessel groups. In addition, the expenses to control and management increase. Although Norwegian authorities have introduced several restrictions, for example total allowable quotas (TACs), licenses, vessel quotas, and other regulatory measures, this analysis shows that the problems connected to overcapacity persist. Analyses of the technical capacity development show that there is an overall capacity expansion although the number of vessels is reduced.

The analysis of the capacity development is made possible by developing a method which integrate several technical components of the fishing vessel and gear dimensions. The analysis of the technical development is also an indicator of the dynamics of technological development over time. The result from the analysis discusses to what extent new technology outdates current management regimes and whether the concept of technology is sufficiently integrated into today's fisheries management. The important question is whether analyses of the technical capacity development can serve as a positive supplement to the traditional fisheries management, which largely is based on input from the scientific disciplines biology and economics.

Contact Dag Standal: [dag.standal@sintef.no](mailto:dag.standal@sintef.no)

## **Institute of Marine Research, Bergen**

### **Technological creeping**

An experiment is carried out in 2005, comparing the catch rates, species and length compositions between single and twin trawl in the demersal fishery for cod and haddock in the Barents Sea. The data has not yet been analysed. In 2006, comparison between different sweep angles will be carried out in the same fishery.

Contact: Arill Engås: [arill.engaas@imr.no](mailto:arill.engaas@imr.no)

### **Fish trawl development**

IMR, Bergen in cooperation with SINTEF Fisheries and Aquaculture, Hirtshals has developed a new design of a commercial fish trawl equipped with a new type of a sheering ground gear. Two versions of the trawl design - two and four panels were produced and tested with a commercial fish trawler off the coast of northern Norway in May-June 2004. The trawl performance, including the sheering ground gear was observed with a trawl-mounted camera and its catchability was compared with a traditional Norwegian fish trawl design (Alfredo 5) in a double trawl rigging. The trawl performance was convincing, and its efficiency for cod was better compared with that of the Alfredo 5 trawl equipped with a 21" rockhopper ground gear. The sheering plated ground gear passed easily across rough stony bottom without any gear damage during two weeks of trawling on normal cod fish grounds. Several vessels from Norway and elsewhere are presently experimenting with the plated ground gear and they report back improved catchability and drag reductions. Another outcome of this project is development of a lifting device based on rigid or flexible "plates" attached between an extra rope and the headline in such a way that the plates are tilted upwards 30–40 degrees relative to horizontal. Model tests with these lifting devices have been conducted in 1:10 scale in the Hirtshals flume tank with convincing results with regards to stability, drag and lifting performance. The two institutes continue to cooperate with the fishing industry and trawl manufacturers to commercial various components developed within the project.

Contact: John Willy Valdemarsen: [john.willy.valdemarsen@imr.no](mailto:john.willy.valdemarsen@imr.no)

### **Krill trawl development**

A multi codend design, where the belly was split into 9 codends, was produced in a size suitable for testing with a smaller 50' research vessel (M/S "Fangst"). Performance tests including

observation from at towed vehicle (Focus 400) and with proper Scanmar instruments, were conducted in June 2004. The nine codends had all similar front openings, and the trawl design performed as expected. Low densities of krill on the test grounds, however, resulted in inconclusive efficiency information for target species.

*Contact: John Willy Valdemarsen: john.willy.valdemarsen@imr.no*

#### **A selective shrimp trawl using behaviour differences between fish and shrimp**

An experiment with a 1X1 m frame divided into a lower 10 cm high horizontal slot below a 90 cm opening above, inserted in a squared mesh section in the aft part of a shrimp trawl belly was conducted in a Norwegian fjord in November 2004. Observations with a trawl mounted camera as well as catch distribution in the two codends covering the lower and upper part of the frame, confirmed the passive along netting guiding of shrimp and the directed swimming reactions of most fish species in the belly section of the trawl. Removal of the upper panel and the upper part of the side panels in front of the frame resulted in minor shrimp loss, whereas fish calmly swam out of the trawl through these outlets. IMR will, based on these observations, attempt to develop a selective device making use of behaviour differences.

*Contact: John Willy Valdemarsen: john.willy.valdemarsen@imr.no*

#### **A new environmentally friendly shrimp trawl concept**

IMR, Bergen in cooperation with SINTEF Fisheries and Aquaculture, Hirtshals is working on a shrimp trawl concept where the spreading forces is incorporated in the trawl itself by using a self-spreading ground gear, divided belly and flexible kites for horizontal "lift". The idea is that the sweeps/bridles in front of the trawl can be nearly parallel and that large trawl door can be replaced with smaller doors or some kind of roller weights. Work on this project is in progress.

*Contact: John Willy Valdemarsen: john.willy.valdemarsen@imr.no*

#### **A new demersal survey trawl**

IMR is presently working on a project with the objective of developing a generic trawl design that has the potential for taking quantitative catches of fish in survey strata.

A prototype design based on a sheering ground gear and divided belly has been designed and a 1:2 scale trawl will be tested in April-May 2005. Experiments in 2004 have shown that a plated ground gear reduce the under trawl escapement of cod significantly compared with a standard rockhopper ground gear as presently are used on the Campelen 1800 demersal survey trawl. Full-scale testing of a prototype survey trawl will be conducted in September-October 2005.

*Contact: John Willy Valdemarsen: john.willy.valdemarsen@imr.no*

#### **Mortality of fish crowded and slipped in purse seine fisheries**

Dense crowding of pelagic fish species like herring and mackerel is documented to cause mortality. In the purse seine fisheries for these species schools are often encircled by the seine net and crowded together at the vessel side in order to identify the species, size or quality of the catch. Unwanted catch is often slipped. Slipping at a late stage of crowding is believed to cause mortality among the released fish, thereby possibly creating a substantial unaccounted mortality in the purse seine fisheries. However, there is little documentation as to the magnitude of this mortality in relation to the density and duration of the crowding.

To document the consequences of crowding and slipping of pelagic fish in purse seine fisheries, survival experiments will be carried out in cooperation between the Institute of Marine Research, Bergen, the Norwegian Directorate of Fisheries and the fishing fleet. The first field

trials will be done in the coastal fisheries for mackerel at the west coast of Norway in August 2005. In the subsequent years focus will be switched to the offshore purse seine fisheries for mackerel and herring.

*Contact: Aud Vold Soldal: aud.vold.soldal@imr.no*

### **Survival**

Institute of Marine Research takes part in and acts as administrative coordinator of the EC Project Survival where Marine Lab, Aberdeen, DIFRES, Hirtshals and the North Sea Museum, Hirtshals also participate. The aim of the project is to document several aspects of unaccounted mortality of gadoids escaping in bottom trawl fisheries. The project is now into its third and last year. Norwegian scientists have taken part in activities in Scotland under the lead of Scotland and Denmark, and also been responsible for survival studies on fishing grounds with high fishing intensity at the coast of Finnmark, Northern Norway. These experiments are not yet completed.

*Contact: Aud Vold Soldal: aud.vold.soldal@imr.no*

### **Observation tools in passive gears**

Trials have been conducted to test and evaluate different techniques to observe fish behaviour in relation to gillnets. The techniques tested are multibeam echo sounder, sonar and the Echo-Scope. Among these tools, the Echoscope appeared to give the most promising recordings of fish movement near a gill net. This year an acoustic positioning system (Vemco) will be tested.

*Contact: Svein Løkkeborg: svein.loekkeborg@imr.no*

### **A new passive fishing gear**

A new fishing gear combining the catching principles of trap and pot has been designed. The handling performance of the gear during setting and hauling proved to be satisfactory, and underwater camera observations showed that the gear settled on the seabed without entanglement between the trap and pot parts. This year the catching performance of the new gear will be tested.

*Contact: Svein Løkkeborg: svein.loekkeborg@imr.no*

### **Sorting grid in pelagic trawl for herring**

Trawling for herring close to the coastline in fjords of Northern Norway is often associated by big bycatch of cod and especially big saithe. Trials with a grid system in the extension piece have given good results sorting saithe and cod. Fishing on dense shoals of herring (500 tons/h) has given rise to occasionally loss of herring. Work on the herring grid will continue with emphasis on how to get rid of herring loss.

*Contact: Bjørnar Isaksen, bjoernar.isaksen@imr.no*

### **Live fish technology**

Due to better landing price, several Danish seiners have converted to earlier invented technology for fishing, transporting and delivering live cod. The cod are either stored for a short period in pens before selling to the market, or allowed to grow for a couple of months more. In 2004, work has been concentrated on the methods and procedures for weighing live fish, mostly to ensure that fishermen delivering conventionally or live fish are given the same condition regarding how much fish they can catch. Technology for keeping line caught fish alive is partly developed, given the small coastal vessels an opportunity to participate in this "new" fishery. This work will continue.

*Contact: Bjørnar Isaksen; bjoernar.isaksen@imr.no*

#### **Observation and gear development in seine net**

A simple system with handy cam recorders in aluminium tubs has given a lot of good video footage of seine net used for flatfish, cod, saithe and haddock. The equipment has given interesting results, especially due to the weight balance of the seine nets used in Norway. Small changes in towing/hauling speed can easily get the seine net to take off. Many fishermen have therefore adjusted their nets according to the new findings – a manoeuvre that definitively has given a more steady catch performance of the gear. A new bottom contact for seine netter has therefore been developed.

Seine nets are nowadays more and more equipped with groundgear like “skirt” in stead of lead- or chain droppers. Underwater observations have given ideas of how to rig and balance the skirt to improve both the catch performance as well how to get rid of reasonable big stone caught by the ground rope.

A new surface towing vehicle (paravan) equipped with video link has recently been tested. Video signals are sent by cable from the seine net up to the surface and transmitted onwards to the seine vessel 1200 meter away. This equipment gives an excellent opportunity to do in situ observation of seine net, using just on vessel.

*Contact: Bjørnar Isaksen; bjoernar.isaksen@imr.no*

#### **Bycatch of King Crab in passive fishing gear**

Off the coast of Northern Norway in the Varangerfjord Area two experiments have been performed.

- 1) In the gillnet fishery for lumpsucker often great bycatch of king crab has been taken. Therefore a trial was performed where the gillnets were set on norsels with height from 0.5 to 2 meters. But for all heights the catch of lumpsucker were reduced below an acceptable level even though crab catches were significantly reduced.
- 2) To partly replace gillnets in the cod fishery and to avoid bycatch of king crab fish pots were floated about 0.7 meters above seabed and compared to standard pots placed on the bottom. The catches of the king crab were reduced to zero in the floated pots while the catch of cod increased with approximately 20% for the floated pots.

*Contact: Dag Furevik; dag.furevik@imr.no*

#### **EU Recovery project**

This multi-national project that aims to reduce capture of cod is ongoing. Flume tank tests with models were conducted in collaboration with fishing industry representatives. During these consultations, it was concluded that insufficient quantifiable behavioural data was available in relation to towing speed, diurnal effects and trawl size. Trials on the Scottish RV ‘Scotia’ were undertaken in April 2004, in which further behavioural observations were conducted together with an assessment of the effect of position of a horizontal separator panel, relative to the fishing line. Data is currently being analysed. In November 2004, trials were conducted on the Norwegian RV ‘Johan Hjort’ where further tests with the Echoscope were undertaken. Results from the Echoscope were severely hampered due to bad weather. Further data on separator panel position was obtained. Analysis of the 3D Echoscope data is ongoing, this has proved to be time consuming, but recent software modifications have speeded up the process.

*Contact: Norman Graham; norman.graham@imr.no*

**EU Necessity project**

The pan European project Necessity focuses on improving bycatch selectivity in *Nephrops* trawls. The programme has recently begun, with a large number of trials planned across Europe; IMR is coordinating the selectivity work package. IMR, in collaboration with IMR-Sweden and the Danish institute, DIFRES, plan to conduct trials with a bycatch exclusion panel in the *Nephrops* fishery in the Northern North Sea late in 2005.

Contact: Norman Graham: [norman.graham@imr.no](mailto:norman.graham@imr.no)

**A comparison of selective properties of grid and diamond mesh codends**

Two experiments were carried out in 2002 and 2003, where we directly compared the properties of codend selectivity for cod (*Gadus morhua*) with the combined selectivity of a Sort-V grid and a codend. In 2002 we used small-meshed covers, whereas the twin trawl method was used in 2003. In both experiments we compared the selectivity of a 135 mm codend only with that of a trawl fitted with a 135 mm codend and a 55 mm grid, which is the mandatory configuration. In 2003 we also estimated the selectivity of a 155 mm diamond mesh codend, having an  $L_{50}$  similar to that of the grid and 135 mm codend combination. The results presented no evidence that the grid and mesh combination had sharper size selection than codend meshes. The introduction of the grid therefore only increased  $L_{50}$ , and corresponded to a mesh size increase of around 20 mm. Mean selection length of the grid was inversely related to catch rates in the 2002 experiment when large catches were taken. Grid selection appeared less affected by seasonal variations in degree of stomach fullness or condition than mesh selectivity.

Contact: Terje Jørgensen: [terjej@imr.no](mailto:terjej@imr.no)

**15.10 USA****NORTHEAST****Massachusetts Division of Marine Fisheries – Conservation Engineering Program**

Michael Pol ([mike.pol@state.ma.us](mailto:mike.pol@state.ma.us)) and Mark Szymanski

**Testing the Selectivity of Gillnets to Target Haddock in the Gulf of Maine**

Selectivity trials using demersal gillnets with mesh sizes ranging from 4.5–6.5 inches (114–165 mm) were conducted to provide management information for design of a special access program to target haddock *Melanogrammus aeglefinus*. A cooperative research program with the Gulf of Maine Research Institute. Testing is currently underway.

**Development of a Species-selective Haddock Trawl without a Horizontal Separator Panel**

A haddock *Melanogrammus aeglefinus* (“five-point”) trawl was designed and flume-tank tested based on the raised-footrope trawl design. Intended to pass over cod, the prototype achieved fishing line heights ranging from 30 cm to 150 cm off-bottom with bottom gear consisting of just five chains. Fishing line height was easily adjustable using extra chain in the lower bridle. The design was also stable at varying towing speeds and could be adjusted for high and low aspect trawl doors. Field testing is scheduled for June 2005.

**Cod Potting in Massachusetts: A demonstration project**

Atlantic cod *Gadus morhua* pot designs developed by Phil Walsh at the Centre for Sustainable Aquatic Resources, Memorial University, Newfoundland are planned for testing in May 2005 in Massachusetts Bay. We are particularly interested in controlling discard mortality associ-

ated with daily trip limits and gillnets. Coated wire, collapsible frame, and rigid frame designs will be tested in 10 soaks.

#### **Further Testing of Cod-Avoiding Trawl Net Designs**

Larger-scale testing of two successful Atlantic cod-avoiding trawl designs was conducted in autumn 2003 and March 2004. The two designs, one removing much of the top square, and the other replacing much of the top square with 203 mm square mesh, reduced cod catch rates when targeting flatfish by >72 % when tested on smaller (<20 m) fishing vessels. The testing is being conducted using a twin-trawl method, an unusual gear type for fishermen in the region. Testing has been hampered by atypical absence of fish of the right species and permit issues. Final field testing is planned for the second half of 2005.

#### **Further Tests on Low Profile Flounder Gillnets to Reduce Cod Catch in the Gulf of Maine**

The project will test two designs of low vertical profile gillnets of 8 meshes deep (MD) of different floatation and hanging ratios compared with regular 25 MD cod gillnets, foam core flounder nets and tie-down flounder nets. This project is a continuation of research conducted independently by the University of New Hampshire (UNH) and Massachusetts Division of Marine Fisheries (DMF) on low-profile flounder gillnets. The nets with lower vertical profiles have been shown to reduce cod catch while maintaining comparable flounder catch. Scheduled for the second half of 2005.

#### **The Design and Preliminary Testing of an Innovative Scallop Dredge**

This project aims to optimize the hydrodynamic action needed to lift scallops using vorticity generators. If successful, it may be possible to develop a dredge that does not rely on formidable contact with the bottom, but instead is towed over the bottom, inducing scallops to rise up for capture by a mesh bag that does not drag along the seabed. Collaboration with Cliff Goudey of MIT, slated to begin in the second half of 2005.

#### **DMF Conservation Engineering Webpage**

Final reports, other publications, and samples of edited videos produced by DMF's Conservation Engineering program are now available online at:

<http://www.mass.gov/dfwele/dmf/programsandprojects/consengg.htm#conservation>

*Manomet Center for Conservation Sciences - Marine Conservation Program*

*Dr Chris Glass (glasscw@manomet.org)*

#### **Rigid Mesh Escape Panel**

The project was designed to explore the potential of a rigid, large mesh panel for selecting larger fish in the multispecies groundfish fishery in the Gulf of Maine. Work commenced on this project in May of 2004. The panel, inserted along the net between the extension and the codend, measured 2 m in length and was constructed of elongate meshes 60 mm wide x 200 mm long. The panel extends along the entire circumference of the net. Each vessel towed the experimental codend, equipped with the rigid mesh panel, and a conventional codend in alternate tows. Both codends were made of 6.5" (165 mm) diamond mesh. Planning is underway to complete field research aboard three vessels in June-July 2005.

#### **Inclined Separator**

This program was designed to look at methods for separating flatfish from round fish (particularly Atlantic cod *Gadus morhua*) in conventional towed fishing gears. A version of the inclined separator panel also used in the Irish Sea *Nephrops* fisheries was tested. Results indicated that significant separation between upper and lower sections of the net, in terms of weight, occurred for cod, monkfish *Lophius americanus* and gray sole *Glyptocephalus cynoglossus*, which is more abundant in the upper section, and crustaceans (specifically crab and

lobster *Homarus americanus*), which were more abundant in the lower section. Preliminary work began in 2003 and continued in 2004 with the rigging of several New England groundfish vessels to tow this inclined separator. Two outreach meetings were held in the region to provide information to interested parties. Completed investigations have demonstrated the potential to separate cod from other groundfish species and implications for reducing cod bycatch and discard are significant. Further studies will commence in June 2005 with completion planned for July 2005.

#### **Inshore Large Mesh Monkfish Trawl**

This program was designed to test a bottom trawl net that reduces bycatch of groundfish and reduces bycatch of undersize monkfish *Lophius americanus* in a directed monkfish fishery. The experimental trawl is constructed of 12" (305 mm) diamond mesh throughout the entirety of the net. This was towed in conjunction with a control net made up of a 6" (152 mm) body attached to a 6.5" (165 mm) diamond codend developed to meet current groundfish regulations. Data resulted in a promising ability to selectively catch monkfish while releasing other regulated groundfish and undersized monkfish. Further study was completed with the inclusion of a traditional 6" body groundfish trawl with an experimental 12" codend. Field work was completed in June 2004 and a final analysis of data is being compiled.

#### **Offshore Large Mesh Monkfish Survey**

This project was designed to test the effectiveness at using a large mesh trawl net in eliminating undersized monkfish *Lophius americanus* and other un-wanted species while successfully harvesting a clean catch of marketable monkfish. The survey took place on Wilkinson's Basin which is an area in the Gulf of Maine historically known for high level of monkfish stocks during the months of November thru March. Two boats performed side-by-side tows in a grid pattern and compared catch data. The control vessel towed a trawl that met current groundfish regulations. The experimental vessel towed a net made up of 10" (254 mm) mesh throughout the entirety of the trawl. Field work was completed in February 2005 and analysis is in the process of being completed.

#### **Bycatch Reduction by Behavioural Modification**

This project has been designed to reduce bycatch using fish behavioural response to visual alterations in a regulated groundfish trawl. Escape panels were made of 7" (178 mm) hexagonal mesh and 7" square mesh, both known for holding their shape under strain, and were sewn onto the body of the net. Attached to this escape panel was a section of dark tarp which covered the entire circumference of the extension. A 3" (76 mm) diamond codend was used to collect the majority of species that passed through the extension for review. Previous research with scup and squid populations maintained that certain species would react in an adverse manner to the dark shadow in the net. This would cause them to challenge the mesh before reaching the dark tunnel allowing smaller fish the opportunity to escape through the panel. Two vessels were used in collaboration of this project. Data collection has been completed and information is currently being analyzed and a final report is expected soon.

#### **Morphology and Selectivity**

Conventional approaches to reduce bycatch and discard include modification of mesh size and or mesh configuration but generally are not species-specific. With the lack of viable information pertaining to fish morphometrics particular to individual species, it is difficult to assess correct mesh geometry in collecting marketable species while cutting down on bycatch. This program is designed to acquire morphometric measurements (including length, width, height, girth and cross-sectional area and shape) throughout a calendar year to account for seasonal variability. The work is providing essential data to fine-tune research conducted on species-specific trawls. Data collection has been completed and a model is being produced that will

allow gear managers and researchers to accurately predict a mesh size which will capture marketable fish while releasing undersized individuals.

*University of New Hampshire*

*Pingguo He (pingguo.he@unh.edu)*

Two projects to separate roundfish and flatfish during trawling were continued with sea trials. A “RollerGrid” was designed and tested, and tests will continue during the summer and fall of 2005. A trawl with soft separator panels and visual effects is being tested. Further sea trials are planned for April of 2005.

Two projects to separate haddock *Melanogrammus aeglefinus* from other groundfish species were funded. Flume tank tests have been completed on the initial designs of a separator trawl and a raised footrope trawl. Sea trials will be conducted this spring and fall.

A project to test shallower gillnets to reduce cod has been completed. The new low profile nets of 8 meshes deep (MD) caught significantly less cod than other three types of nets including 12 MD, and 25 MD standard cod nets and 25 MD tie-sown nets. Catch of flounders were comparable between the 8 MD nets with standard 25 MD cod net. A new project to compare Danish-style flounder nets with other standard and low profile nets has initial sea trials during this summer.

A project to reduce small fish and small shrimps in shrimp trawls has started this winter. The project uses kites to spread meshes in the codend to let small fish and small shrimps escape during fishing. Sea trials were completed in 2004. Results are being analyzed.

A preliminary project to use a modified Nordmøre grid to reduce finfish in the Gulf of Maine shrimp fishery was completed with promising results.

Sea trials to determine selectivity of codend mesh sizes/shapes have been completed. We tested 6”, 6-1/2”, and 7” (152, 165, 178 mm) diamond codends and 6-1/2” and 7” square mesh codends, and 6-1/2” knotless square, T-90 mesh and diamond mesh with and without chafing gear. A kite-assisted codend cover was developed and used during the tests. Selectivity properties for cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, yellowtail flounder *Limanda ferruginea*, American plaice *Hippoglossoides platessoides*, and witch flounder *Glyptocephalus cynoglossus* were determined. Data are being analyzed.

*University of Rhode Island – Rhode Island Sea Grant*

*Kathleen Castro, David Beutel, Laura Skrobe (lskrobe@uri.edu), and Barbara Somers*

## OUTREACH

### **Regional Bycatch Assessment Team**

The National Marine Fisheries Service (NMFS) established Regional and National Bycatch Assessment Teams (NBAT and RBATS) that were charged with developing the Bycatch Implementation plans for the agency. Rhode Island Sea Grant (RISG) is a member of the Northeast (NE) Regional Bycatch Team and has played a critical role in developing a process that involves stakeholder input into the plan. The first Bycatch Workshop was held in June 2004 and fisheries extension specialists from the NE and the Mid-Atlantic Sea Grant Programs acted as facilitators for the small group breakout sessions to discuss priorities. These proceedings and subsequent NE Region Bycatch Implementation Plan are now available from the NMFS at their website. This process served as a template for the other regions of the country.

### **Northeast Regional Gear Conservation Engineering Working Group: Educational Workshops and Bycatch Forum**

A recent project funded by the NMFS Saltonstall-Kennedy award to the University of Rhode Island (URI) has provided the initial funding to establish a working group of gear conservation engineers and behaviourists in the Northeast. This project has resulted in a variety of products including: educational workshops on gear selectivity by an international specialist and catch comparison conducted by staff from the NMFS Northeast Fisheries Science Center, and the development of a web site for Gear Conservation Engineers [http://seagrant.gso.uri.edu/reg\\_fish/gear/index.html](http://seagrant.gso.uri.edu/reg_fish/gear/index.html) that explains bycatch, issues surrounding different gear types, solutions, experts, references, links to other groups, and events.

The initial project ended in December of 2004 and has been continued through a project funded by the Northeast Consortium. This second proposal is designed to provide a mechanism to continue this valuable collaboration among gear researchers and fishermen by providing additional educational workshops and a mechanism for interaction. Workshops will be conducted on topics that include additional information on comparative gear studies and discard mortality methods and analysis. The project will also provide funding for fishermen to attend the annual NMFS Bycatch Forum which is critical for their active participation in the NMFS implementation plan development. This forum will continue to be an annual event sponsored by NMFS and co-sponsored by Sea Grant. RISG will continue to act as a member of the steering committee for this important process.

## **RESEARCH**

### **Bycatch Reduction in the Directed Haddock Bottom Trawl Fishery**

A study was funded through the NMFS Cooperative Research Partners Initiative to investigate the effects of employing a large mesh faced (top, bottom, and side wings) bottom trawl on reduction of cod *Gadus morhua* and other bycatch from the directed haddock *Melanogrammus aeglefinus* bottom trawl fishery. Commercial fishing vessels will be used to conduct the sea sampling in cooperation with URI. URI will also lead the data analysis, interpretation, and outreach. The project is designed to investigate the quantity and catch composition of bycatch, particularly cod and flounders, of the currently regulated trawl net and the experimental net. The change of bycatch between the regulated trawl net and the experimental net will be evaluated. Fieldwork is expected to begin in June 2005.

### **2005 Fishery-Independent Scup Survey of Hard Bottom Areas in Southern New England Waters**

A fishery-independent scup *Stenotomus chrysops* survey of ten separate hard bottom sites in Southern New England and two sites, located on the scup spawning grounds in Vineyard Sound, will be sampled for a one-month period. Unvented fish pots will be fished on each site from June through October. Two commercial vessels will conduct the fieldwork and URI will lead the data analysis and report preparation. Staff from the RI Department of Environmental Management, Division of Fish and Wildlife and the Massachusetts Division of Marine Fisheries will collaborate with the project. The project is designed to collect scup from ten separate hard bottom sites, which are not sampled by current state and federal finfish trawl surveys. The length frequency distribution of the catch will be statistically compared to each of the other collection sites, to finfish trawl data collected by NMFS, and to data collected during a similar project conducted during 2004 by the same researchers.

### **Bycatch Characterization in Directed Fisheries through Alternative Management Schemes**

The Rhode Island Commercial Fisherman's Association (RICFA) is currently developing a pilot program to better address the needs of the commercial summer flounder *Paralichthys dentatus* industry, while reducing its impact on the resource. The proposed fishery will be a

rights-based, community managed, non-competitive, sector allocation program that is designed to generate lower mortality rates through improved selectivity strategies, gear technology, and a wider range of landing limits. The URI – Rhode Island Sea Grant Fisheries Extension Program is aiding in the collection of preliminary data in 2005 and is in the process of trying to obtain grants to conduct more thorough data collection beginning in the 2006 summer flounder fishing season. The focus of the research will be to document existing fishing mortality rates that exist under the current quota management system and compare them to those that occur in the community managed, sector fleet. The comparison and contrast of these two different management tools through a comprehensive mortality study will help to determine which better lends itself to a sustainable fishery. This study will be conducted over a period of two years, the first year will address summer flounder and the second year will investigate scup *Stenotomus chrysops*.

**Winter Flounder Size Selectivity Study for 6.0” Diamond, 6.5” Square, 6.5” Diamond, and 7.0” Square Shaped Mesh Codends**

This study evaluated the selection properties of several mesh configurations to provide guidance for assessing the impact of minimum size limits and codend mesh size restrictions on yield of winter flounder *Pleuronectes americanus*. The catch efficiency and size selectivity of four experimental codends (6.0” (152 mm) diamond, 6.5” (165 mm) square, 6.5” diamond, and 7.0” (178 mm) square) were measured with the alternate haul method using a small mesh.

*University of Massachusetts – Graduate School of Marine Sciences and Technology*

*Kevin D. E. Stokesbury (kstokesbury@umassd.edu)*

**Population biology and dynamics of the sea scallop resource from Virginia to the Hague line, USA.**

Since 1999 the University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST), members of the commercial sea scallop *Placopecten magellanicus* industry, the Massachusetts Division of Marine Fisheries, with additional support from the sea scallop TAC-set-aside program, have completed 48 video cruises surveying Georges Bank and the Mid-Atlantic (>240 days at sea). This analogue video library contains footage from over 80,000 video samples, covering the entire scallop resource (54,793 km<sup>2</sup>) in 2003 and 2004. Further, it includes numerous video surveys on a finer scale focusing on scallop aggregations primarily in the closed areas of Georges Bank. These data provide assessments of scallop and other macroinvertebrate densities, and sediment and habitat distributions in closed and open areas of Georges Banks from 1999 onward.

The sampling procedure for these surveys is a centric systematic design for placing stations on a 1.57 or a 5.56 km grid (0.85 or 3.0 nautical miles). At each station the survey vessel deploys three video cameras mounted on the sampling pyramid. Two downward looking cameras provide 3.235 m<sup>2</sup> and 0.8 m<sup>2</sup> views of the sea floor. The third camera is side-looking and provides a profile view of the sea floor. After the first quadrat the pyramid is raised so that the sea floor can no longer be viewed, the vessel drifts for 20 to 50 m and then the pyramid is lowered again to obtain a second image. This procedure is repeated four times to provide four quadrat samples at each station. Images of the sea floor are recorded on Super-VHS tape. Along with each image, the time, depth, number of scallops observed, and latitude and longitude obtained from a differential global positioning system with a Wide Area Augmentation receiver (DGPS- WAAS) are recorded.

The sea scallop abundance data from these surveys have been used to manage the sea scallop fishery. Preliminary maps of the sea floor detailing the substrate and sea scallop distributions are being considered for sea scallop and groundfish management. Based on 2003 data a closure was implemented that will protect the area of high sea scallop recruitment in the southern portion of the Hudson Canyon closed area extending south into open waters. Further, the

southern portion of Closed Area II may be opened earlier than scheduled due to the high natural mortality observed in this area.

Stokesbury, K.D.E. 2002. Estimation of sea scallop, *Placopecten magellanicus*, abundance in closed areas of Georges Bank. *Trans. Am. Fish. Soc.* 131:1081–1092.

Stokesbury, K.D.E., B.P. Harris, M.C. Marino II and J.I. Nogueira. 2004. Estimation of sea scallop abundance using a video survey in off-shore USA waters. *J. Shellfish. Res.* 23:33–44.

Three more manuscripts are in preparation.

In 2005–2006 we will continue examining the population biology and dynamics of the sea scallop, *Placopecten magellanicus*, from Virginia to the Hague line, USA, including:

- 1 ) Examine the abundance, spatial distribution and size structure of sea scallops throughout its range in US waters from the Hague Line to the Southern Mid-Atlantic including inside and outside closed areas.
- 2 ) Continue to examine site-specific growth, mortality and movement by conducting and/or analyzing tagging experiments.
- 3 ) Continue the environmental assessment of the scallop fishing grounds.
- 4 ) Continue using the above information to develop a temporal-spatially specific fisheries management system for the Georges Bank scallop resource.

*Massachusetts Institute of Technology – Center for Fisheries Engineering Research, MIT Sea Grant College Program*

*Cliff Goudey (cgoudey@mit.edu)*

#### **Stretch-Mesh catch controls**

In collaboration with Gloucester fisherman Nino Randazzo, a trawl was fitted with a section of elastic netting in the extension as a way to reduce the catch and regulatory discard of large catches of undersized groundfish. The cylindrical portion of diamond mesh was manually constructed to regulation 6” (152 mm) mesh using shock cord (bungee) instead of normal twine. The elastic properties of the cord were selected to provide 12” (305 mm) mesh once the drag of the catch reached 1,000 pounds (454 kg). The concept proved feasible but during preliminary tests no large aggregations of groundfish were encountered to allow a determination of efficacy.

#### **Whale-Free Buoy efficacy tests**

A buoy designed to resist entanglement by marine mammals was tested using a vessel-mounted apparatus that simulates the dynamics of a fin or fluke as it encounters the buoy line of fixed fishing gear. The significance of currents and the direction of encounter on the likelihood of entanglement were revealed. In general, the innovative buoy easily resisted snagging and released at loads approximately one tenth the current requirements for conventional buoy line weak links. Conventional buoys were found to catch at the line/buoy intersection. The Whale-free Buoy has received a U.S. patent.

#### **Demonstration of an AUV in gear impact studies**

The utility of an autonomous underwater vehicle (AUV) in assessing the impact of fishing gear on the seabed has been demonstrated. Using both side-scan and imaging sensors, the extent and depth of tracks along the seabed can be quantified along with their endurance (detection) over time.

### **Selective gillnets for winter flounder**

A project has begun to determine the selectivity of a new design of gill net aimed at targeting winter flounder *Pleuronectes americanus*. Using a combination of height, tie-downs and innovative construction materials, the nets will be evaluated for use in a directed flounder fishery.

### **Low-impact scallop dredge**

A project has begun to develop a habitat-sparing scallop dredge that will employ large-scale vorticity generation as a way of making scallops vulnerable to capture without the use of bottom contact.

### **Sand lance sampling gear development**

Gear for the biological assessment of sand lance *Ammodytes americanus* is being developed for use in an ecological study of their role in the Stellwagen Bank ecosystem. Three methods will be compared, a fine-mesh beam trawl, a 10 sq. m. vertical water column sampler, and eel traps. The sampling is intended to quantify abundance and determine seasonal migratory patterns. The goal of the project is to understand the functional role of sand lance in the local food web.

### **Passive acoustic detection of cod and haddock**

Autonomous Underwater Listening Stations (AULS) have been developed for monitoring fish vocalizations from spawning aggregations of cod and haddock. The inexpensive probes are set like passive fishing gear and record for 60 hours at a sampling rate of 11 kHz. We have collected over 500 GB of acoustic data in two years of deployments in the Gulf of Maine. Seasonal and diurnal trends have been examined and auto-detection methods are underdevelopment.

The goal of the work is to evaluate the method as a means of determining the when and where of cod *Gadus morhua* and haddock *Melanogrammus aeglefinus* spawning to enable more effective protective closures. In addition we are looking at the significance of ambient and episodic noise on vocalization activity and its potential in interfering with communication possibly essential for successful spawning.

Deepwater AULS probes (1,500 m) are now under development to allow surveys to extend into basins and onto seamounts.

*NOAA Fisheries Northeast Fisheries Science Center - Protected Species Branch*

*Henry Milliken (Henry.Milliken@noaa.gov)*

The Protected Species Branch has been looking to mitigate the capture of sea turtles in fishing gear. In 2004 we were involved in three projects that included two gear types, Chesapeake Bay pound nets (similar to a fish weir) and scallop dredges.

### **Pound net study**

In 2004, a 42-day study was conducted utilizing a modified leader design in pound nets (similar to a fish weir) to reduce the incidental take of sea turtles. During this study, both standard leaders and modified leaders were fished in close proximity and switched between pound net sites. At the conclusion of this study, the control leader had taken seven hard shell turtles (Loggerhead *Caretta caretta* and Kemp's Ridley *Lepidochelys kempi*) and the experimental leader took no hard shell turtles. Additionally, the modified leader did not adversely affect the catch of the targeted fish. Unfortunately, one leatherback turtle *Dermochelys coriacea* was taken in the modified pound net leader.

In November 2004 a group of pound net fishermen, NMFS and NGO staff met to discuss how to reduce the probability of further leatherback encounters. Although the fishermen expressed

concern that encountering leatherback turtles was an unusual event, the group decided that making the vertical lines stiffer would be a solution that would likely reduce the probability of further leatherback entanglements and would be economically feasible.

In 2005 we will be testing this modified leader with the stiffer twine.

#### **Scallop chain mat study and video study**

In 2004 the NMFS Protected Species Branch supported research with the fishing industry to study the effects of the addition of chains rigged in 12" (bar) squares in a scallop dredge. The modification, a chain mat that physically excludes turtles, did not catch a turtle in over 2400 hauls, while the standard dredge caught seven loggerhead sea turtles. An issue was raised after the study about how the turtles interact with the scallop dredge. During a separate study on two commercial vessels fishing in areas of high turtle concentrations, NMFS sponsored scientists developed methodologies to video scallop dredges and the effects of high concentrations of scallop viscera on the attraction of sea turtles. Although no turtles were encountered, further research utilizing video is planned.

Proposed research for 2005

- Fifty-five days of research testing stiffer ropes in the pound net leader to reduce the probability of hard shell and leatherback encounters.
- Continued work with the scallop dredge fishermen to mitigate concerns about possible unaccounted mortality occurring with the use of the chain mat.
- Research using video in trawls that operate in areas with higher levels of marine mammal bycatch. This research is being conducted to attain behavioural information on marine mammals in trawl gear that can possibly be used to devise bycatch reduction technologies.
- Studies on the effectiveness of a square mesh panel in the *Loligo* and *Illex* squid, mackerel *Scomber scombrus* and butterfish *Peprilus triacanthus* trawl fishery to reduce the bycatch of cetaceans and sea turtles.

## **NORTHWEST**

### **Oregon Department of Fish and Wildlife – Marine Resources Program**

*Robert W. Hannah (bob.w.hannah@state.or.us)*

#### **Sablefish/Halibut Fixed Gear Behaviour Research**

We investigated the use of a DIDSON ultrasonic imaging sonar to study sablefish (*Anoplopoma fimbria*) behaviour near baited pot gear in collaboration with NMFS, Alaska Fisheries Science Center. We also observed halibut (*Hippoglossus stenolepis*) approaching and attacking baited longline hooks. The imaging sonar provided views ranging from 3 to 20 meters from the camera, much farther than infrared or visible light cameras, with presumably less impact on normal fish behaviour. We observed sablefish approaching and exploring the gear and entering the pots. Fish were visible up to 9 meters away, on all sides of the pot, a much larger field of view than had been obtained with infrared or normal light video cameras. Mud and debris stirred up by the activity of fish did not substantially block the ability of the camera to see fish within and behind the mud cloud, while normal video was completely obscured.

In the spring of 2005, we will be testing the imaging sonar in our selective flatfish trawl. We will attempt to observe fish response to the approaching footrope and headrope, as well as fish behaviour in the areas of the wings, sweeps.

### **Rockfish Recompression Behaviour**

In fall 2004, we used a low-light underwater video system to observe recompression and release of various rockfish species captured by angling gear. Rockfish captured at depths greater than about 10m often show signs of severe barotrauma caused by expanding swim bladder and bloodstream gases, such as popped eyes, protruding oesophagus and bulging gill membranes. Often these fish are rendered virtually immobile by expanded gases, making them appear dead. The buoyancy from gas expansion also interferes with the fish's ability to return to depth upon release. We used a camera-cage system to observe rockfish with barotrauma as they were lowered to a depth of about 20m and released via a remotely triggered cage door. Most rockfish species showed signs of substantial and rapid recovery from barotrauma symptoms, exhibiting apparently normal behaviour upon release at depth. One exception was blue rockfish (*Sebastes mystinus*), which showed moderate numbers of fish which simply floated upwards when the cage door was triggered.

In 2005, we hope to extend this work to fish captured from depths beyond 65m to see if the degree of recovery declines as depth of capture increases.

*NOAA Fisheries Alaska Fisheries Science Center*

*Fisheries Behavioural Ecology Program, Newport, Oregon, USA*

*Bycatch-Related Gear Research*

*Michael W. Davis (michael.w.davis@noaa.gov)*

Studies with sablefish *Anoplopoma fimbria*, Pacific halibut *Hippoglossus stenolepis*, walleye pollock *Theragra chalcogramma* and lingcod *Ophiodon elongatus* have shown the importance of fish size, physical injury, and behaviour impairment in determining delayed mortality rates in discards and escapees from net gear. Physical injury and behaviour impairment occurred at a greater proportion in smaller fish than in larger fish. High-grading and discarding of smaller fish can result in increased unaccounted fishing mortality. Behaviour impairment may be an important source of unaccounted mortality through predation on discards and escapees from trawling operations. Present and future studies in the next two years focus on developing quantitative field measures for physical injury using fluorescent dye and behaviour impairment which is correlated with delayed mortality rates. Also experiments will be initiated to determine the relative importance of light, temperature, water mixing and crowding on initiation of fish responses to bycatch reduction devices and subsequent escape behaviour.

### **Performance of Baited Fishing Gear**

*Allan Stoner (al.stoner@noaa.gov)*

Capture of fish with baited fishing gear depends upon feeding motivation, movement patterns, and sensory capabilities in the target species as well as the design of gear. A review article published in 2004 summarizes how environmental variables can influence feeding in fishes and the consequences with respect to stock assessments conducted with baited gear (A.W. Stoner 2004. *J. Fish Biol.* 65:1445–1471). Also in 2004, the Fisheries Behavioural Ecology Program used high-frequency imaging sonar (acoustic camera) for the first time to observe behaviour of sablefish and Pacific halibut around fixed gear including fish pots and baited hooks set in deep water. With an acoustic image extending out to 10 m, observations can be made on approaches to baits, movement patterns and behaviour on all sides of fixed gear. Traditional cameras are being used to explore behaviour of Pacific cod around fixed gear, and to investigate variation in active space. The research group continues to conduct laboratory experiments in Newport, Oregon, to quantify the effects of environmental variables on the performance of baited fishing gear. These experiments include observations on olfaction, loco-

motion, and feeding motivation as influenced by temperature. Understanding variation in gear performance is critical to accurate stock assessment estimates.

### **Trawl Efficiency Research**

*Cliff Ryer (cliff.ryer@noaa.gov)*

For survey and commercial trawls, selection of flatfish species and sizes is strongly influenced by fish behavioural reactions to the ground-gear. These behavioural reactions are influenced by environmental parameters, most notably illumination. Responses by flatfishes to simulated passage of trawl sweeps were examined in a large laboratory flume equipped with controlled light, infrared illuminators and video cameras. Ambient illumination influenced the behaviour of northern rock sole *Lepidopsetta bilineata*, Pacific halibut *Hippoglossus stenolepis* and English sole *Parophrys vetulus*. In the light, fish stayed low to the bottom and herded. In darkness, fish tended to rise off the bottom and let the sweep pass beneath them with herding. This result, which suggests that the sweeps on bottom trawls may be relatively ineffective at stimulating herding behaviour in flatfish at night or at great depth, is currently being tested in the field using dual frequency imaging sonar (DIDSON).

*NOAA Fisheries Alaska Fisheries Science Center*

*Conservation Engineering Project, Seattle, Washington, USA*

*Craig Rose (craig.rose@noaa.gov)*

### **Salmon Excluders**

In 2004, the Conservation Engineering project of the AFSC and industry partners continued development of trawl modifications to reduce salmon (*Oncorhynchus* sp) bycatch in pollock (*Theragra chalcogramma*) fisheries. Many vessels tried a design developed in 2003 and reported that while salmon bycatch may have been reduced, many experienced damage to and around the excluders and apparent reductions in pollock capture where pollock were highly concentrated and when many jellies were encountered. Cameras put on some of these vessels indicated that animals were entrained just ahead of the excluder device in these conditions, creating a bulge that affected water flow and fish behaviour and overstressed the net. Designs to improve salmon escapes and durability were developed and tested in model scale in a flume tank. Full-scale observations were made during a NMFS charter, using underwater video and sonar systems. A new scanning sonar system, first deployed during this cruise, was particularly useful in imaging the development of the fish bulges. Its greater range, relative to video and other sonar systems, provided consistent images of the entire excluder section.

Performance testing of the resulting excluder was then conducted under an exempted fishing permit. Salmon escapement from excluders was measured at 9% for chum salmon *Oncorhynchus keta* and 43% for Chinook salmon *Oncorhynchus tshawytscha*, while losing less than 3% of the pollock. Modifications did protect the excluder and surrounding mesh from damage and reduced (but did not eliminate) the formation of fish/jelly bulges.

### **Behaviour of fish around baited pots**

We observed the behaviour of sablefish (*Anoplopoma fimbria*) and Pacific halibut (*Hippoglossus stenolepis*) around baited pots and longline hooks, using a high-resolution, rapid-update sonar (DIDSON) and underwater cameras with infrared illumination. With its wide field of view and imaging relative to the plane of the seafloor, the sonar provided clear, trackable information on fish movements and pot/hook attacks and capture success. Camera observations provided more detail over a much smaller area – one end of the pot or a few hooks.

Planned work for 2005

- 1) Further improvements on salmon excluders will be tested.

- 2) To assure that tests with a recapture net reflect real-world performance, a test of the current salmon excluder design will be done with many paired tows, instead of a recapture system.
- 3) A halibut excluder for groundfish fisheries made only of flexible materials will be developed and tested.
- 4) We will examine the effects of raising more of the sweeps and bridles higher above the seafloor on both herding effectiveness and effects on the seafloor.

*NOAA Fisheries Alaska Fisheries Science Center*

*Survey Trawl Gear Research, Seattle, Washington, USA*

**Assessing the effect of light intensity and light penetration on the availability of walleye pollock (*Theragra chalcogramma*) to the bottom trawl and echo-integration surveys**

*Stan Kotwicki (stan.kotwicki@noaa.gov) and Alex De Robertis*

A series of field measurements designed to test if light intensity affects the distribution and feeding of pollock were conducted by incorporating light measurements to existing surveys of pollock abundance in the eastern Bering Sea (EBS) in 2004. The main goal of this research is to determine if surface light intensity and light penetration affect the vertical distribution of walleye pollock and, thus, availability to bottom trawl and echo-integration surveys. Currently, these surveys are used as independent estimates of abundance, but our results may provide the means to integrate the results from these surveys and establish a relationship between light penetration and availability of walleye pollock to bottom trawls. If this relationship is established, it has the potential to reduce uncertainty in biomass estimates from the stock assessment model for walleye pollock in the EBS and to increase our understanding of pollock stock dynamics in the EBS.

**Factors affecting net performance of the bottom trawl**

*Ken Weinberg (ken.weinberg@noaa.gov) and Stan Kotwicki*

As part of the 2004 eastern Bering Sea survey, a variety of measurements designed to assess net performance across the entire survey area were collected and analyzed with generalized additive modelling. Factors such as sediment size, weight and contents of the catch, vessel, individual net effect, and age of the trawl were looked at in addition to depth, wave height, towing speed, and crabbing which have been shown previously through field experiments to affect the performance of the 83–112 Eastern survey bottom trawl. Preliminary results indicate sediment size, individual nets, and a net's age likely contribute to the variability in our trawl performance measures.

## **16 New business**

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### **16.1 Recommendations**

#### **16.1.1 Date and venue for 2005 WGFTFB Meeting**

WGFTFB proposes a 5-day meeting in 2006 at the Izmir University premises in Izmir, Turkey. A 5-day meeting was deemed necessary due to the high workload expected. The suggested dates are Monday 3th – Friday 7th April 2006.

#### **16.1.2 Proposed Terms of Reference for the 2006 WGFTFB Meeting**

The ICES/FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) (Chair: Dr Norman Graham, Norway) will meet in Izmir, Turkey, from Monday 3th – Friday 7th April 2006.

**Topics:**

- i) A review of the species and size selectivity issues relating to commercial and survey pelagic and semi-pelagic trawls.

A report will be presented to WGFTFB in April 2006.

*Proposed by Haraldur Einarsson and Chris Glass*

- ii) WGFTFB should explore the means by which it can best provide appropriate information for assessment working groups and ACFM in fishery and ecosystem based advice. This will include the information required for fisheries-based forecasts, technological changes and changes in fishing practices, implementation of regulations and other fleet adaptations, ecosystem effects of fishing and potential mitigation measures. This advice will be focussed on the North Sea and address the assessment WG tasks as identified in the report of AMAWGC.

*Proposed by Dave Reid (FRS Aberdeen), Dominic Rihan (BIM), and Norman Graham (IMR)*

- iii) The Topic Group from 2004 on alternative fishing gears for traditional species that are environmentally friendly and responsible fishing methods will be continued for a further year, reporting to WGFTFB in 2006.

*Bjarti Thomsen, Faroes*

- iv) The Topic Group from 2004 on the use of multiple size selection devices in towed gears will be continued for a further year, reporting to WGFTFB in 2006.

*Norman Graham, IMR, Norway and Barry O'Neill, FRS, Aberdeen*

- v) A topic group should be formed to:
- Review and update the existing “Definitions and classification of fishing gear categories” to the same detail level as in the FAO Technical Paper 222
  - In collaboration with the FAO Working Party on Fisheries Statistics, will contact appropriate national and international fisheries management bodies to determine the current status and usage of gear classifications. The group will identify inconsistencies between adjacent areas and make recommendations for any actions needed to harmonise the use of gear classifications. The group will also identify specific gear parameters that could be monitored to provide better estimates of commercial CPUE.

*Proposed by Wilfried Thiele, FAO and John Willy Valdemarsen, IMR, Norway*

Will work by correspondence and report at ICES-FAO FTFB WG meeting in 2006.

The Co-Chairs will invite members to the group representing important FAO regions to assist in the revision process.

**Supporting Information**

Priority:	The current activities of this Group will lead ICES into issues related to the effectiveness of technical measures to change size selectivity and fishing mortality rates. Consequently these activities are considered to have a very high priority
Scientific justification:	Action Item 1.12.5, 1.13.1 3.16, 3.18 -i Action Item 4.11.3, 5.5 -ii Action Item 3.17, 3.18 -iii Action Item 3.16, 5.11 -iv

## Action Item 5.8 -v

i) In the last decade there has been increasing pressure on pelagic species in the north Atlantic as well as in other areas. There are reports of widespread discarding, slipping and meshing in many pelagic fisheries but little research has been carried out into improving gear design and selectivity to mitigate these problems. Bycatch of non-target species, for example demersal species, also remains a problem in some fisheries. There is also uncertainty as to whether fishing pressure influences the migrations or shoaling behaviour of pelagic species including capelin.

It is proposed to relate current pelagic trawl designs to fish behaviour in the trawl in order to identify gear modifications that might improve gear selectivity. A review of all known information on pelagic trawl selectivity will be carried out including industry initiatives using T90 and hexagonal mesh, on which there has been only limited technical assessment. A review of current knowledge on fish behaviour and escape mortality will also be carried and this will cover both the target pelagic species and bycatch species. Gaps in the information base will be identified. The expected output will be the identification of areas of further gear research and fish behaviour to improve the selectivity of pelagic trawls.

ii) WGFTFB is receiving requests for advice that require it to apply its expertise in novel ways. This topic will be undertaken over two years and be structured in an incremental way. Reports will be made to FTFB and AMAWGC in 2006 at which point the approach taken will be reviewed. The two-year duration reflects the complexity of the task, particularly for countries like Norway with diverse fleets and fisheries, and it will be undertaken in collaboration with assessment groups at a national level. The main areas to be covered will be:

- 1) The fisheries and their impacts, including information on vessel and gear types, recent technological changes within the fisheries and the potential impacts (quantitative and qualitative) of future developments.
- 2) Effect of fishing on the ecosystem, including identifying those fisheries with significant discard and ghost fishing problems, with data on discard and escape mortality, where gear-related technical measures can reduce ecosystem impacts and where there are possibly ineffective technical measures.
- 3) Mixed fisheries and fisheries interactions, providing additional information on medium or high discard practices, assessing the potential for using catch information rather than landings and the identification of more localised species interactions.
- 4) Regulations and their effects including a summary of legislation relating to fishing gear construction and operation in the region, best estimates of the selective properties as per legislative description (if available), information on the scale and type of regulation circumvention and, where regulations are 'optional'; identifying the degree of uptake where possible. Also identifying any other unregulated aspects of design and operation that may have significant selection or ecological effects.
- 5) Factors affecting fishing operations; for example any major changes in fishing patterns will be noted and these changes and their potential causes will be reported and interpreted. Similarly, if it is foreseen that fleet operational changes may take place, this will also be noted.

iii) There are a considerable number of fisheries worldwide that have mandated the use of additional devices (other than codend mesh size) for adjusting size selection. These include the use of escape panels (BACOMA etc) and grids such as the Sort-X. There is an increasing volume of evidence that suggests that, in some instances, the same effect can be achieved simply by increasing the mesh size. The introduction of such devices this may place an additional financial cost on the fishermen and complicate legislative procedures may be important considerations. In other fisheries, particularly multi-species, the benefits

	<p>of such devices are that they are more effective with one species (or group) while not impacting on others, square mesh panels and <i>Nephrops</i> trawls being one example. There may also be other benefits for managers; for example, these ‘additional’ devices may provide more predictable selectivity.</p> <p>iv) Many fishing practices are essentially the same as when developed centuries ago. Many are energy inefficient and are deleterious to the environments. Here we aim to use the natural behavioural patterns of fish to develop energy efficient non-deleterious harvesting practices that may have applications in fisheries worldwide.</p> <p>v) A common nomenclature and definition of fishing gears used in world fisheries is fundamental for discussions of many gear related issues. A modern fishing gear classification should reflect the diversity of fishing gears in use as well as being useful for management purposes. Besides the fishing gear classification developed by FAO in 1971 with later revisions, countries and regional fisheries management bodies have adopted their own classifications. The joint FAO/ICES working group FTFB is the most competent global group to identify and describe the fishing gears used globally. As the present gear classification was developed several years ago a need for an update is expressed by the Coordinating Working Party on Fisheries Statistic (CWP) and other global bodies dealing with fishing gear.</p> <p>There are a number of examples where different codes for a given gear are applied at a national and international level; making direct comparisons between national statistics problematic. To harmonise gear codes across areas is a considerable undertaking and may take several stages. In the first instance the group will identify inconsistencies between and within fisheries regions and compare these to the updated FAO gear classification codes. The group will identify an appropriate actions required to harmonise gear code usage including identification of relevant stakeholders e.g., stock assessment scientists, gear technologists and data managers, necessary for such an undertaking.</p> <p>Fisheries management bodies are often dependant on catch per unit fishing gear effort for stock assessment purposes. A better understanding of the catching performance of the various gear units might be useful to facilitate this task. The work to be conducted by the topic group is in consultation with the users of such data identify how fishing gear technologist can assist in the development of proper fishing gear classes, including indicators of catching performance of such gear units.</p>
Resource requirements:	The research programmes which provide the main input to this group are already underway, and resources already committed. The additional resource required to undertake additional activities in the framework of this group is negligible. Having overlaps with other meetings of expert groups of FTC increases efficiency and reduces travel costs.
Participants:	The Group is well attended (~60 members)
Secretariat facilities:	N/A
Financial:	None required. Having overlaps with other meetings of expert groups of FTC increases efficiency and reduces travel costs.
Linkages to Advisory Committees:	The questions of bycatch reduction, fisheries information and survey standardization are of direct interest to ACFM and seabed damage is of direct interest to ACE.
Linkages to other Com-	This work is of direct relevance to the Working Group on Ecosystem Effects of Fisheries,

mittees or Groups:	WG on Fishery Systems, WG on International Bottom Trawl Surveys, Baltic Committee, Marine Habitat Committee, Resource Management Committee and Living Resources Committee
Linkages to other organisations	The work of this group is closely aligned with similar work in FAO
Cost share:	

### 16.1.3 Workshops

- i) Discussions were held during the Joint Session with the WGFST to investigate the possibility of a workshop on underwater technology, analysis and statistical techniques for the observation of fish and plankton behaviour, species validation and benthic habitat mapping. A steering committee comprising of David Summerton (USA), Emma Jones (UK), Norman Graham (Norway), Rudy Kloser (Australia) and David Demer (USA). The group will work by correspondence and will submit a proposal to the Consultative Committee in autumn 2005.
- ii) A **Workshop on Unaccounted Fishing Mortality** [WKUFM] (Convenor: M Breen (UK) will be held in Aberdeen UK for 3 days, in 25–27 September 2005 to:
  - a) identify measurable components of unaccounted fishing mortality; and
  - b) define indices for assessing their relative impacts in key fisheries, for different capture methods.

## 16.2 Advice requested

No requests for advice received.

## 16.3 Proposals for theme session for ASC 2007

A theme session/topic is proposed that will bring together expertise in all aspects of lost and abandoned fishing gears. The session will address all significant issues arising from the phenomenon of ‘ghost fishing’ and is expected to have outputs including:

- quantifying the global scale of ghost fishing and its impacts on commercial and non-target species,
- case studies of identifiable ‘problem’ fisheries,
- the identification of effective mitigation measures, including the use of regular exercises to retrieve lost gears, and
- guidelines for the development of specific codes of conduct to reduce loss rates for those categories of fisheries where gear loss is problematic.

### Justification

The loss or abandonment of static gears – particularly gill nets – has been identified as a serious issue in some fisheries because it can give rise to the phenomenon of ‘ghost fishing’. A number of reviews and research programmes have been undertaken into gear losses in the North Atlantic and adjacent and other areas over the last 20 years or so. These have shown quite clearly that the impacts of lost gears can be significant, particularly in deep water fisheries. The work has also identified the factors that predispose fisheries to high levels of gear loss and the measures that can be taken both to limit loss and to mitigate impacts. These factors raise issues that include inter-sectoral conflicts, spatial management of effort, gear specifications, operating protocols, levels of fishing mortality and a range of other ecosystem impacts.

The session will seek to produce holistic solutions to these problem areas encouraging inputs from a range of disciplines.

*Phil MacMullen SFIA, UK and Dominic Rihan, BIM, Ireland*

## 16.4 ICES and other Symposia

### **Fishing Technology in the 21st Century: Integrating Fishing and Ecosystem Conservation**

The symposium will consist of a five-day symposium with invited keynote and plenary speakers, who will provide perspective, insight, and challenges to the participants. The conveners encourage scientific contributions from all around the world dealing with technological, ecological, and socio-economic facets of mobile and static gear fisheries for finfish and shellfish on the following topics:

- Ecosystem sensitive approaches to fishing: reconciling fisheries with conservation through improvements in fishing technology.
- Current status of mobile and static sampling gears used in resource surveys.
- Fishers' responses to management measures and their socio-economic effects.
- Stakeholder forum: Integrating fishers' knowledge with science and stakeholder needs: the future of fisheries management?

### **International Conference on Fish Behaviour**

A conference covering many aspects of fish behaviour will be held in the Institute for Biology of Inland Waters in Borok, Nekouz, Russia in November 2005. Deadline for registration is 10 June 2005. Further details and online registration can be found on <http://www.ibiw.ru/>. To access the registration and submissions page 'click' ENG in the top left hand of the page and select conferences from the menu.

## Annex 1: List of participants

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Name	Address	Phone/Fax	Email
Anao Amado	FAO-FIRI (external legal consultant) Marino Albesa 51-3 46022 Valencia Spain	+ 34 653411836	<a href="mailto:anolam75@yahoo.es">anolam75@yahoo.es</a>
Takafumi Arimoto	Tokyo Univ. of Marine Sci. & Tech. 4-5-7, Konan, Minato-ku 108-8477 Tokyo JAPAN	+81-3-5463-0470 +81-5463-0360	<a href="mailto:tarimoto@s.kaiyodai.ac.jp">tarimoto@s.kaiyodai.ac.jp</a>
Dag Øyvind Askheim	Pipeline engineer, DNV Veritasveien 1 N-1322 Høvik Norway	Tel: (+47) 67 57 74 87 mob: (+47) 41 61 77 55 Fax (+47) 67 57 99 11	<a href="mailto:dag.oyvind.askheim@dnv.com">dag.oyvind.askheim@dnv.com</a>
Gérard Bavouzet	IFREMER 8, rue François Toullec F-56100 Lorient, France	TEL: +33 297873830 FAX: +33 297873838	<a href="mailto:gerard.bavouzet@ifremer.fr">gerard.bavouzet@ifremer.fr</a>
Paola Belcari	DSUA - University of Pisa (Italy) Via Volta, 6 56126 Pisa Italy	+39-050-2219022 +39-050-49694	<a href="mailto:belcari@discat.unipi.it">belcari@discat.unipi.it</a>
Mette Bertelsen	ICES H.C. Andersens Boulevard 44-46 1553 Copenhagen V Denmark	+45 33 38 67 26 +45 33 93 42 15	<a href="mailto:mette@ices.dk">mette@ices.dk</a>
Eckhard Bethke	Eckhard Bethke Federal Research Centre for Fisheries, Institute for Fishery Technology and Fishery Economics Palmaille 9 22767 Hamburg Germany	+49 40 38905 203 +49 40 38905 264	<a href="mailto:eckhard.bethke@ifh.bfa-fisch.de">eckhard.bethke@ifh.bfa-fisch.de</a>
Asta Hronn Bjorgvinsdottir	The University of Akureyri Iceland v/Nordurslod 600 Akureyri Iceland	+354 4630900 +354 4630999	<a href="mailto:astahronn@internet.is">astahronn@internet.is</a>

<b>Name</b>	<b>Address</b>	<b>Phone/Fax</b>	<b>Email</b>
Gabriele Buglioni	National Research Council Institute of Marine Science (ISMAR) Fisheries Section Largo Fiera della Pesca 2 60125 Ancona Italy	TEL: +39 071 2078828 FAX: +39 071 55313	<a href="mailto:g.buglioni@ismar.cnr.it">g.buglioni@ismar.cnr.it</a>
An Heui Chun	National Fisheries Research and Development Institute 408-1 Shirang-Ri, Gijang-up, Gijang-Gun Bu- san, 619-902, Rep. of Korea	Tel: 8251720256 0 FAX: 8251720258 6	hcan@nfrdi.re.kr
Dr Erdmam Dahm	Bundesforschungsanstalt f. Fischerei Institut für Fischereitechnik Palmaille 9, D-22767 Hamburg, Germany	TEL: +49 40 38905188 FAX: + 49 4038905264	erdmann.dahm@ifh.bfa-fisch.de
Jochen Depestele	Sea Fisheries Department Ankerstraat 1 B-8400 Oostende Belgium	+ 32 (0)59 34.22.63 + 32 (0)59 33.06.29	<a href="mailto:jochen.depestele@dvz.be">jochen.depestele@dvz.be</a>
Steve Eayrs	Australian Maritime College Bagot St 7276 Beauty Point Australia	Tel: 61 3 63354424 FAX: 61 3 63354459	<a href="mailto:s.eayrs@fme.amc.edu.au">s.eayrs@fme.amc.edu.au</a>
Ole Eigaard	DIFRES Charlottenlund Castle 2920 Charlottenlund Denmark	(45) 33 96 33 00 (45) 33 96 33 33	<a href="mailto:ore@dfu.min.dk">ore@dfu.min.dk</a>
Haraldur Einarsson	Marine Research Institute P.O. Box 1390, Skúlagata 4 IS-121 Reykjavík, Iceland	TEL: +354 5520240 FAX: +354 5623790	haraldur@hafro.is
Dr A. Engås	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen, Norway	TEL: +47 55236808 FAX: +47 55236830	arill.engas@imr.no
Marianne Farrington	New England Aquarium Central Wharf 02110 Boston, MA United States	1 617 973 5251 1 617 723 6207	<a href="mailto:mfarr@neaq.org">mfarr@neaq.org</a>
Mario Ferretti	CIRSPE VIA DEI GIGLI D'ORO, 21 ROME IALY	+39 06 6869400	<a href="mailto:MFERRETTI@CIRSPE.IT">MFERRETTI@CIRSPE.IT</a>
R.S.T. Ferro	Fisheries Research Services Marine Laboratory P.O. Box 101, 375 Victoria Road, Aberdeen AB11 9DB, UK	TEL: +44 1224 876544 FAX: +44 1224 295511	ferro@marlab.ac.uk

Name	Address	Phone/Fax	Email
L. Fiorentini	I.R.Pe.M. - C.N.R. Largo Fiera della Pesca 1, 60125 Ancona, Italy	no telephone and fax number available	fiorentini@irpem.an.cnr.it
Ronald Fonteyne	CLO Sea Fisheries Depart- ment Ankerstraat 1, B-8400 Oostende, Belgium	TEL: +32 59 342254 FAX: + 32 59 330629	ronald.fonteyne@dvz.be
Rikke Frandsen	DIFRES, North Sea Centre, P.O.Box 101, 9850 Hirtshals, Denmark	TEL: +45 3396 3300 Fax: +45 3396 3260	rif@difres.dk
Chris Glass	Div. of Marine Fisheries, Center for Conservation Sciences, 81 Stagepoint Road P.O. Box 1770, Manomet, MA 02345, USA	TEL: +1 5082246521 FAX: +1 5082249220	glasscw@manomet.org
<b>Norman Graham (Chair)</b>	Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway	TEL: +47 55236961 FAX: +47 55239830	norman.graham@imr.no
Gudmundur Gun- narsson	Hampidjan Flatahraun 3 220 Hafnarfjordur Iceland	Tel: +354 530 3300 FAX: +354 530 3309	gg@hampidjan.is
U. Jes Hansen	SINTEF Fisheries and Aqua- culture The North Sea Centre, P.O. Box 104, 9850 Hirtshals, Denmark	TEL: +45 9894 4300 FAX: +45 9894 2226	ujh@sintef.dk
Dr Pingguo He	University of New Hampshire 137 Morse Hall, Durham, NH 03824, USA	TEL: +1 6038623154 FAX: +1 6038627006	pingguo.he@unh.edu
Bent Hermann	Institute for Fisheries Man- agement and Coastal Community Devel- opment North Sea Centre, P.O. Box 104, 9850 Hirtshals, Denmark	TEL: +45 33 96 32 04 no fax number avail- able	bhe@dfu.min.dk
René Holst	Danish Institute for Fisheries Research Department of Marine Fisher- ies North Sea Centre, P.O. Box 101, 9850 Hirtshals, Denmark	no telephone and fax number available	rho@dfu.min.dk

<b>Name</b>	<b>Address</b>	<b>Phone/Fax</b>	<b>Email</b>
Olafur Ingolfsson	IMR C.Sundsgate 64 1870 Bergen Norway	+47 55236813 +47 55236830	<a href="mailto:olafuri@imr.no">olafuri@imr.no</a>
Cha Bong Jin	National Fisheries Research and Development Institute 408-1, Shirang-Ri, Gijang-up, Gijang-Gun, Busan, 619-902, Rep.of Korea	Tele: 82517202582 FAX 82517202586	holdu@hanmail.net
Emma Jones	Fisheries Research Services Marine Laboratory P.O. Box 101 375 Victoria Road Aberdeen AB11 9DB United Kingdom	TEL: +44 1224 876544 FAX: +44 1224 295511	jonese@marlab.ac.uk
Terje Jørgensen	Institute of Marine Research P.O. Box 1870 Nordnes, N-5817 Bergen, Norway	TEL: +47 55 238500 FAX: +47 55 238531	terje@imr.no
Ludvig Ahm Krag	DIFRES, Nordsøcentret, PO box 101, 9850 Hirtshals, Denmark	TEL: +45 33963206 FAX: +45 33963260	lak@dfu.min.dk
R. Kynoch	Fisheries Research Services, Marine Laboratory, P.O. Box 101, 375 Victoria Road, Aberdeen AB11 9DB, United Kingdom	no telephone and fax number available	kynochr@marlab.ac.uk
O.M. Lapshin	Russian Federal Res. Inst. of Fisheries & Oceanography (VNIRO) 17, Verkhne Krasnoselskaya, Moscow 107140, Russia	TEL: +7 0952649721 no fax number avail- able	lapshin@vniro.ru
Dr Per-Olov Larsson	National Board of Fisheries, Institute of Marine Research, Box 4, SE-453 21 Lysekil, Sweden	TEL: +46 523 18707 FAX: +46 523 13977	per- olov.larsson@fiskeriverket.se
Pascal LARNAUD	IFREMER 8, rue François Toullec F-56100 Lorient France	Tel: 33 2 97 87 38 41 FAX: 33 2 97 87 38 38	<a href="mailto:pascal.larnaud@ifremer.fr">pascal.larnaud@ifremer.fr</a>
Svein Løkkeborg	Institute of Marine Research Nordnesgaten 50 5817 Bergen Norway	+47 55236826 +47 55236830	<a href="mailto:svein.lokkeborg@iMrno">svein.lokkeborg@iMrno</a>
Alessandro Lucchetti	National Research Council Institute of Marine Science (ISMAR) Fisheries Section Largo Fiera della Pesca 2 60125 Ancona Italy	TEL: +39 071 2078828 FAX: +39 071 55313	<a href="mailto:a.lucchetti@ismar.cnr.it">a.lucchetti@ismar.cnr.it</a>

Name	Address	Phone/Fax	Email
Phillip MacMullen	Sea Fish Industry Authority Seafish House, St Andrew's Dock, Hull HU3 4QE, United Kingdom	TEL: +44 1482 327837 FAX: +44 1482 587013	p_macmullen@seafish.co.uk
Bob van Marlen	Netherlands Institute for Fisheries Research Haringkade 1, P.O. Box 68, NL-1970 AB IJmuiden, Netherlands	TEL: +31 255 564780 FAX: +31 255 564644	bob.vanmarlen@wur.nl
Dr W. Moderhak	Sea Fisheries Institute ul. Kollataja 1, PL-81-332 Gdynia, Poland	TEL: +48 58 620 17 28 ext. 258 FAX: +48 58 620 28 31	moderhak@mir.gdynia.pl
Thomas Moth-Poulsen	FAO Viale delle Terme di Caracalla 00100 Rome Italy	Tel +39 06 570 55034 FAX +39 06 570 55188	<a href="mailto:thomas.mothpoulsen@fao.org">thomas.mothpoulsen@fao.org</a>
F.G. O'Neill	Fisheries Research Services, Marine Laboratory, P.O. Box 101, 375 Victoria Road, Aberdeen AB11 9DB, United Kingdom	TEL: +44 1224295343 FAX: +44 1224295511	oneillb@marlab.ac.uk
Prof. K. Olsen	The Norwegian College of Fishery Science University of Tromsø N-9037 Tromsø Norway	TEL: +47 776 460 01 FAX: +47 776 460 20	kjello@nfh.uit.no
Dr Andrzej Orłowski	Sea Fisheries Institute ul. Kollataja 1 PL-81-332 Gdynia Poland	TEL: +48 58 620 17 28 ext. 215 FAX: +48 58 620 28 31	orlov@mir.gdynia.pl
Kevin Peach	Fisheries Research Services Marine Laboratory P.O. Box 101 375 Victoria Road Aberdeen AB11 9DB United Kingdom	TEL: +44 1224 876544 FAX: +44 1224 295511	K.Peach@marlab.ac.uk
Michael Pol	Massachusetts Div. of Marine Fisheries 50A Portside Drive Pocasset, MA 02559 USA	TEL: +1 5085631779 FAX: +1 5085635482	mike.pol@state.ma.us
<b>Hans Polet (Rapporteur)</b>	CLO Sea Fisheries Department Ankerstraat 1 B-8400 Oostende Belgium	TEL: +32 59 342253 FAX: +32 59 330629	hans.polet@dvz.be

<b>Name</b>	<b>Address</b>	<b>Phone/Fax</b>	<b>Email</b>
Rafael Ramiscal	BFAR/National Fisheries Research and Development Institute 940 Quezon Avenue 1100 Quezon City, Metro Manila Philippines	Tel: 632-3746570 FAX: 632-3746570	rv_ram55@yahoo.com
Dave Reid	Fisheries Research Services Marine Laboratory P.O. Box 101 375 Victoria Road Aberdeen AB11 9DB United Kingdom	TEL: +44 1224 876544 FAX: +44 1224 295511	<a href="mailto:D.Reid@marlab.ac.uk">D.Reid@marlab.ac.uk</a>
Dr Andy Revill	CEFAS Lowestoft Laboratory Lowestoft Suffolk NR33 0HT United Kingdom	TEL: +44 1502524531 FAX: +44 1502524546	a.s.revill@cefass.co.uk
Dominic Rihan	An Bord Iascaigh Mhara Crofton Road Dun Laoghaire Co. Dublin Ireland	TEL: +353 12144104 FAX: +353 12300564	Rihan@bim.ie
Dr Craig Rose	Alaska Fisheries Science Center F/AKC2 NMFS, NOAA 7600 Sand Point Way N.E. Seattle, WA 98115 USA	TEL: +1 206 526 4128 FAX: +1 206 526 6723	craig.rose@noaa.gov
Jacques Sacchi	IFREMER Avenue Jean Monnet BP 171, 34203 Sète, France	no telephone and fax number available	Jacques.Sacchi@ifremer.fr
Dr Antonello Sala	National Research Council Institute of Marine Science (ISMAR) Fisheries Section Largo Fiera della Pesca 2 60125 Ancona Italy	TEL: +39 071 2078828 FAX: +39 071 55313	a.sala@ismar.cnr.it
Dr D. Somerton	Alaska Fisheries Science Center NMFS/NOAA 77600 Sand Point Way, NE Seattle, WA 98115, USA	TEL: +1 206 526 4116 FAX: +1 206 526 6723	david.somerton@noaa.gov
Dr Petri Suuronen	Institut of Marine Sciences Passeig Maritim de la Barceloneta 37 08003 Barcelona Spain	Tel: +34 93 230 9568 FAX: +34 93 230 9555	<a href="mailto:petri.suuronen@rktl.fi">petri.suuronen@rktl.fi</a>
Bjarti Thomsen	Faroese Fisheries Laboratory Noatun 1 P.O. Box 3051 110 Torshavn Faroe Islands	TEL: +298 353900 FAX: +298 353901	bjartit@frs.fo

<b>Name</b>	<b>Address</b>	<b>Phone/Fax</b>	<b>Email</b>
Mats Ulmestrand	National Board of Fisheries Institute of Marine Research Box 4 SE-453 21 Lysekil Sweden	TEL: +46 52318727 FAX: +46 52313977	mats.ulmestrand@fiskeriverket.se
J.W. Valdemarsen	Institute of Marine Research P.O. Box 1870, Nordnes N-5817 Bergen Norway	no telephone and fax number available	john.willy.valdemarsen@imr.no
Dr Benoit Vincent	IFREMER 8, rue François Toullec F-56100 Lorient France	no telephone and fax number available	benoit.vincent@ifremer.fr
Claudio VIVA	DSUA - University of Pisa (Italy) Via Volta, 6 56126 Pisa Italy	+39-050-2219095 +39-050-49694	viva@discat.unipi.it
Dr Steve J. Walsh	Dept. of Fisheries & Oceans Northwest Atlantic Fisheries Centre P.O. Box 5667 St John's, Nfld A1C 5X1 Canada	TEL: +1 709 772 5478 FAX: +1 709 772 4105	walshs@dfo-mpo.gc.ca
Harald Wienbeck	Federal Research Centre for Fisheries, Institute for Fishery Technol- ogy and Fishery Economics Palmaille 9 22767 Hamburg Germany	+49 40 38905 182 +49 40 38905 264	harald.wienbeck@ifh.bfa- fisch.de
Ken Weinberg	NOAA, Alaska Fisheries Sci- ence Center 7600 Sand Point Way NE, Bldg 4 Seattle, WA 98115-0070 USA	TEL: +1 2065266109 FAX: +1 2065266723	Ken.Weinberg@noaa.gov
K. Zachariassen	Faroese Fisheries Laboratory Nóatún P.O. Box 3051 FO-110 Tórshavn Faroe Islands Denmark	TEL: +298 353900 FAX: +298 353901	krizac@frs.fo

## Annex 2: Scottish gear survey questionnaire

SQUARE MESH PANEL			
Name :	Number :	Panel fitted : Yes / No	Number of panels (if more than 1, record on extra sheet)
Horsepower :		Length :	meshes or metres
Skipper :	Phone :	Width :	meshes or metres
Agent :		Distance of rear end from codline	
		Distance in from selvage (No. of diamond meshes) :	
		Mesh size (mm) :	Single / Double *
Start Date :	End Date :	ICES Area fished:	Twine thickness (mm) :
No of gear types on board :		Gear codes used :	Knotted / Knotless *
No of hauls per gear :		No of hrs fished :	Twine material or trade name @ :
Reason for gear change :			
NET DETAILS (If two nets used during voyage record on extra sheet)			
Manufacturer :			
Type of net (e.g. L/Trawl, Twin prawn or Seine etc) :			
Number of meshes round fishing circle :			
Mesh size at fishing circle (mm) :			
Ground gear type :		Total length :	
Ground gear details :			
EXTENSION (Working section)			
<b>1<sup>st</sup> Section- If extension incorporates different sections in its construction then enter details of section nearest to codend into 2<sup>nd</sup> section.</b>			
Length :	meshes or	metres	
Mesh size (mm) :			
Twine thickness (mm) :		Single / Double *	
Twine material or trade name @ :			
No of meshes round extension:			
2 <sup>nd</sup> Section (if applicable)			
Length :	meshes or	metres	
Mesh size (mm) :			
Twine thickness (mm) :		No of meshes round extension:	
Twine material or trade name @ :			
LIFTING BAG			
Yes / No (If no then) is Bottom chafer fitted : Yes / No			
Mesh size (mm) :		Single / Double *	
Twine thickness (mm) :			
Twine material or trade name @:			
NOTES			
* Circle one item.			
@ Examples of inputs for twine material or trade name: Compact, high tenacity PE, low tenacity PE, green braide or Brezline etc.			
Any queries contact Rob Kynoch (ext:5478) or Iain Penny (ext:5688)			

## Annex 3: Topic group report on bycatch in shrimp fisheries

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### Introduction

This report came about as a result of request by FAO at the annual ICES-FAO FTFB meeting in Gdynia in Poland June 2004. The request was to form a topic group (Appendix 1) to review the bycatch in the world shrimp fisheries. The topic group was Chaired by Thomas Moth-Poulsen, FAO with Wilfried Thiele, FAO and Norman Graham, IMR, Bergen as Co-Chairs, with the following Terms of Reference:

- i) to review and evaluate recent technical developments in bycatch reduction;
- ii) to estimate global usage of bycatch reduction in shrimp fisheries;
- iii) to review implementation plans in shrimp fisheries;
- iv) to assess adequacy of size selection in shrimp fisheries.

It aims to give an overview of individual fisheries, including information on fleet structure, gear types and economic importance, previous studies to improve selectivity, current and upcoming legislation as well as recommendations for future research or legislative intervention.

It contains a section with a general overview of the Northern Shrimp (*Pandalus borealis*) and brown shrimp (*Crangon crangon*) fisheries. An additional Working Document on new methods to further minimise bycatch in the *Pandalus* fishery is also provided (Appendix 1). Both these fisheries do not differ much between countries and are therefore presents by fishery rather than by country. Following this, there are presentations on work in tropical fisheries by countries associated with the GEF/FAO programme (see Section 6.2.3). The length of the individual reviews does not reflect the relative importance of the different fishery, but merely what literature was available or where members of the topic group contributed with reviews. Finally a section presents the recommendations of the topic group.

Before dealing with the technical detail of bycatch reduction however it is important to consider some more general matters. Amongst these are the conditions that are necessary to ensure that more selective technology can be introduced successfully into a fishery. This topic is important because a failure to address the underlying issues will almost certainly lead to the introduction of inappropriate measures that, in turn, may be ineffective or rejected by fishermen.

Technology does not exist in a vacuum. Introducing and managing change has to be approached in a holistic manner. Expertise in some of the topics discussed here is not normally in the domain of fisheries technologists so may need to be brought in to a project.

Here we discuss some of the factors that need to be taken into account when preparing for technical change. It should be emphasised that, whilst no single fishery would need to attend to all these factors they all have some relevance. This section, whilst brief, hopefully serves to introduce some issues to consider when approaching the introduction of any particular innovation.

### The initial approach

The first and perhaps most fundamental principle is to be clear about what is needed. This may start with a qualitative view that discard levels are high, that growth over fishing seems to be problematic or that bycatch levels are falling as a result of shrimp trawling. From this initial view a consensus needs to be built as to the identity of the problems, their nature and scale and the likely results of inaction. This phase ends with agreement as to the objectives of technical change – what exactly is to be achieved?

Achieving a consensus implies taking a range of views into account and this can only be achieved if legitimate stakeholders are identified and engaged. This is a two-way process and may not be the norm in artisanal fisheries. Traditionally stakeholders may simply have been those who exercise influence in a fishery but it is important also to include those who are most impacted by the introduction of new conservation measures – typically fishermen, fish buyers and, increasingly, environmental advocates.

### **Developing a framework**

Assuming that a biological/conservation case is made for technical innovation then the human aspects have to be addressed. Preparation for change demands the drafting of an operating framework which will usually acquire some statutory basis. It must also contain a strategic approach that can be monitored for success and modified as necessary. Preparation also has to involve an assessment and understanding of the human dynamics of the fishery: what drives fishermen's behaviour? how are they likely to view change? how can incentives be used to encourage the adoption of more selective gears? At the same time it may be appropriate to benchmark the *status quo*, to identify what constitutes 'best practice' in the fishery and to investigate whether the market is likely to be looking for any form of accreditation in the future. This could include ecolabelling of some kind.

### **Carrying through**

Developing the framework will usually require sound knowledge of the fishery. If this is not available it may be necessary to undertake a review that includes the status of the science base and the social and economic dimensions of the fishery. A stakeholder group can be convened in order to add new perspectives to this process and to contribute to the later stages. It will be necessary to review the arrangements for monitoring fishing activity and to consider how best to assess compliance levels and the need for enforcement.

A set of possible technical measures needs to be identified. These may be existing generic BRD designs, or research may have already resulted in the design of measures proven to be effective and practicable under local conditions. In the former case further research may be needed or some partnership arrangement with fishermen may enable the development of workable local variants.

Change can seldom be imposed successfully and at short notice. It is usually necessary to have some transitional period during which structural and operating adjustments can be made. These may include some relaxation of prescriptive management requirements so that fishermen can experiment with gear modifications. Financial support can also be considered that would cover some of the costs of change. Confidence building through demonstration projects should also be considered along with adequate technical support and extension work.

Finally the framework needs to incorporate some process by which progress can be reviewed – and recorded where appropriate. If this process reveals that the objectives of the exercise are not being realised then there must be scope to rethink either the technology, or the objectives themselves.

### **Incentives**

It is usually worth looking systematically at the incentives that can be deployed in order to encourage the uptake of gear modifications. Where they clearly exist they should be promoted to fishermen. Examples might include:

- improved quality of target catch through the loss of megafauna,
- market feedback to recognise and reward improved performance,

- market access that would not otherwise be available,
- access to fishing grounds that might otherwise be closed, and
- hedging against possible future technical restrictions.

As a corollary disincentives are also often encountered. Sometimes these exist because of mistaken perceptions that fishermen may have about any particular technical change; sometimes they are real and need to be addressed in a more concrete way. Typical examples here include:

- the increased cost of modifications either to buy or perhaps because of increased drag,
- the inconvenience of operating more complex gear, maybe resulting in lost fishing time,
- safety aspects, particularly working with rigid devices on artisanal vessels,
- the potential loss of marketable target species, and
- the loss of bycatch that has some market value.

All these aspects need to be taken into account when considering technical innovations in order to reduce bycatch levels. Each fishery is unique and demands a singular approach but the reality in most is that conservation has to be given a higher priority than hitherto. Fishermen need to consider their emerging role of stewardship of the marine environment. Those working with them, to help secure their future, need to be aware of the complexity of managing change. A demonstrable commitment to conservation is needed from all concerned. The following sections contain very many examples of this process being undertaken successfully.

## The recommendation of the topic group

### Preamble

Shrimp-trawl fisheries worldwide are characterised by high species diversity and complexity, particularly in relation to technical, ecological, social and economic issues. ICES/FAO WGFTFB recognises that there has been significant progress in reducing bycatch in shrimp-trawl fisheries. We acknowledge our appreciation of the valuable work that has been undertaken by fishermen, fishing technologists and others to improve conservation in these fisheries around the world. However, the need for continuing progress is also recognized, and in consequence the ICES/FAO WGFTFB recommends that:

**1. Research between fishing technologists and industry stakeholders involved in cold-water and tropical shrimp fisheries should be initiated to further develop species-selective bycatch reduction devices, and to improve the size selectivity of shrimp and *Nephrops* in trawls.**

*Comment: # 1* International collaboration in this research is needed and should include the utilization of knowledge of inter-species behavioural differences and the identification, application and evaluation of innovative gear technologies, for example the use of ultra-low opening trawls, to reduce bycatch in shrimp-trawl fisheries

*Comment #2* Recent research into improving size selectivity has not been successful at avoiding the capture of juvenile shrimp and *Nephrops*.

**2. At the local, regional, and national levels, Bycatch/Discard Action Plans should be developed for shrimp fisheries.**

*Comment:* These plans should identify objectives and goals with regard to the use or reduction of bycatch/juveniles/trash fish, suggest strategies for achieving these goals (including the implementation of bycatch reduction devices, closed areas etc.) and identify key performance indicators.

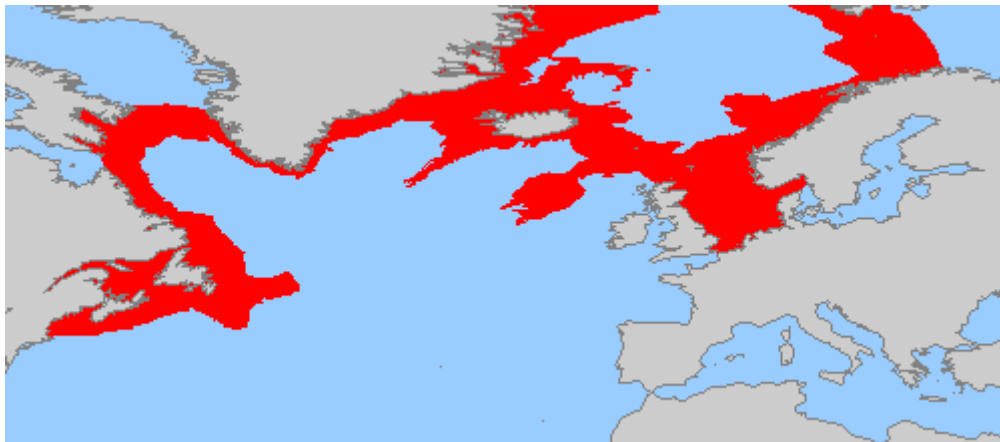
**3. Where, in certain countries, reliance on catches of juvenile fish in shrimp-trawl fisheries exists, it should be reduced.**

## An Overview of bycatch reduction legislation in the *Pandalus borealis* (Northern Shrimp) Fisheries of the North Atlantic and its effectiveness

Norman Graham, IMR, Bergen, Norway

### Introduction – overview of the fisheries

The Northern Shrimp, *Pandalus borealis*, is widely distributed in the boreal waters of the North Atlantic, North Pacific and Arctic Oceans. The fisheries associated with the North Atlantic stock are considered in this paper. The southern boundary of the stock on the western Atlantic is the Gulf of Maine, while the North Sea forms the southern limit of the stock in the eastern Atlantic (Figure 1).



**Figure 1: Distribution of northern shrimp in the North Atlantic.**

Commercially this is one of the most important shrimp species of the North Atlantic. Fisheries began in the 1950s and 1960s, concentrating in the Barents Sea and Western Greenland; in more recent years also more to the south fisheries for the species have started, e.g., in the Gulf of St. Lawrence, the Bay of Fundy and the Gulf of Maine (as far south as Gloucester, Mass.). There is an intensive fishery around Iceland and off the Norwegian coast. In the Kattegat and Skagerrak it is fished for by Danish vessels. In the northern and central North Sea Danish, Norwegian, British, German and Dutch trawlers fish for the species. The principal actors in engaged in this fishery are Canada, Greenland and Norway. The stock is exploited both within national territorial and waters and in a high seas international fishery, largely regulated by NAFO.

In common with many shrimp fisheries, a comparatively small mesh size must be used in order to retain the target species. Current minimum mesh sizes (MMS) range from 34 – 44mm. Typically, shrimp grounds also coincide with nursery grounds for many commercially important fish species e.g., redfish, cod, Greenland halibut. As a consequence, many shrimp fisheries are characterised as having considerable bycatch and discard problems. In line with the expansion of the fisheries, problems of bycatch also increased.

Canada accounts for the single largest contribution of shrimp catches in the North Atlantic, accounting for over 30% of the total landings. The shrimp fishery began in the late 1970's off the coast of Labrador and Newfoundland. With the declining groundfish stocks, the stock of *Pandalus* grew considerably resulting in increased fishing activity both north and southward (Bowering and Orr, 2004). The fishery, initially conducted by large vessels (>500t), but by the mid 1990's, the inshore sector had rapidly expanded; now accounting for approximately 50% of the total landings.

The main component of the Greenland fishery occurs in the Davies straight, between Canada and Greenland, with a smaller fishery off the east coast. The commercial fishery developed gradually in the 1950's and 60's and was generally confined to coastal waters. Now, the shrimp fleet operating in Greenland is categorised by comparatively old, small inshore vessels and more modern large shrimp factory offshore vessels. The inshore fleet accounts for 43% of the total TAC. Almost all catches are taken using demersal otter trawls, with an ever-increasing tendency towards the use of multiple rigs, particularly used by the larger offshore vessels, which process their catch onboard.

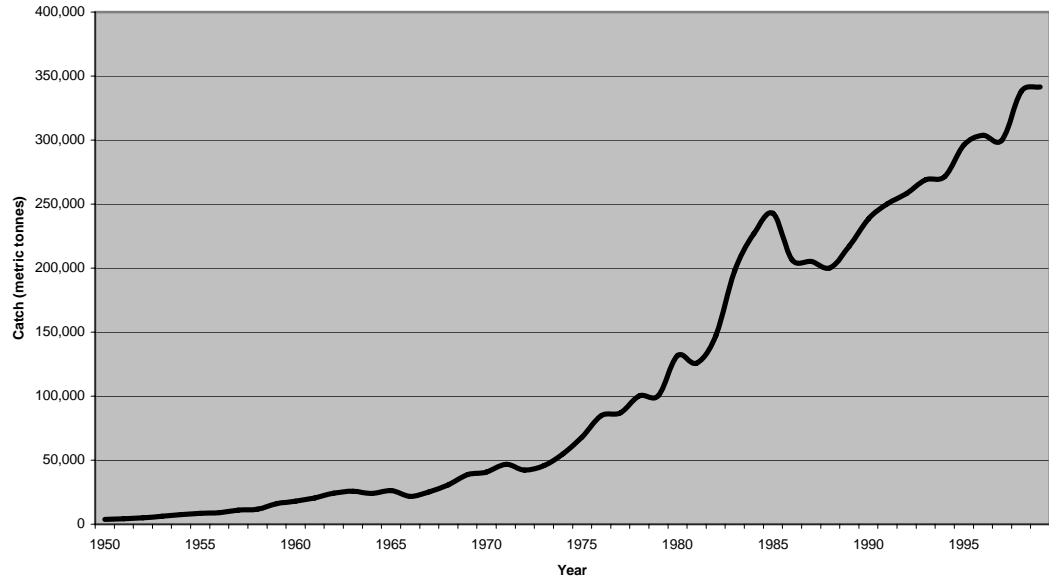
Norwegian vessels began to exploit the shrimp fisheries in the Barents Sea and Svalbard area in 1970. Russian vessels entered the shrimp fishery in 1974. The catches increased continuously until 1984 when the total catch reached a maximum of 128,000 t. Vessels using double trawls entered the fishery in 1996 and since then the effort has increased continuously and in 2002 approximately 35 Norwegian vessels had the technology to use double trawl or even triple trawl. The majority of the offshore fleet is dual purpose, also fishing for groundfish species. The technological advancement in the fleet has been considerable. Traditional 'fish' vessel owners have recently purchased shrimp licenses from the smaller and outdated inshore fleet (Standal, 2003). This may be potentially problematic for the resource as the shrimp fishery in the Barents Sea is not subject to quotas or effort regulations. The more important fishery around the Svalbard area is only subject to days-at-sea effort regulations. Smaller vessels, typically less than 50 GRT, exploit the shrimp fishery south of 62° North in the Norwegian Deeps.

**Table 1: 1998 catches of Northern Prawn by country (source FAO).**

INTERNATIONAL LANDINGS (1998)			
Canada	103407	USA	3678
Greenland	69567	Lithuania	3107
Iceland	62728	Sweden	2283
Norway	56176	Spain	1365
Faeroes	13359	Scotland	1364
Denmark	8094	England	595
Estonia	5533	Others	1942
Russia	4895	<b>Total</b>	<b>338093</b>

The Faeroese fleet operate within other EEZ's and International waters, operating principally in the East Greenland, Barents Sea and Flemish cap fisheries, only limited experimental fishing has been conducted within the Faroese EEZ.

The fisheries in the North Sea, principally exploited by the Danish fleet occur on the Fladen Ground and in the eastern part of IVa (Norwegian Deeps). Scottish vessels report a small percentage of the total landings from this area. The fishery has seen the general increase in the use of multiple trawls.



**Figure 2: Global catches of Northern Shrimp 1950–1999.**

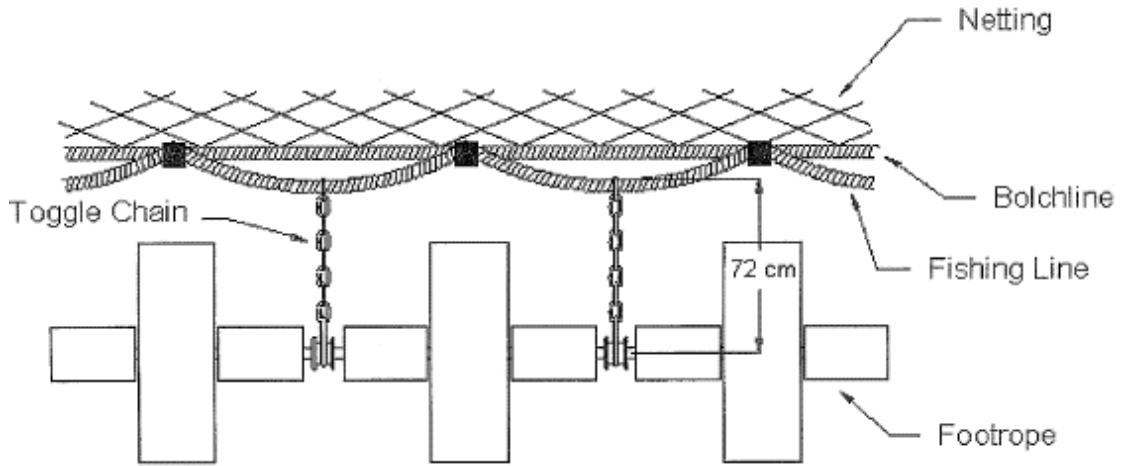
### Technical measures to reduce bycatch

The Nørdmore grid is the most widespread gear related technical measure used in the North Atlantic shrimp fishery to reduce bycatch. The concept came from a shrimp fisherman, Paul Brattøy, who lives in the Nørdmore area of Norway, hence the name. He developed the grid, which had comparatively large bar spacing initially used to exclude the bycatch jellyfish often found on shrimp grounds. Following the success of this device, a series of formal experiments with a grid system having narrower bar spacing (19 mm) were undertaken in Norway (Isaksen *et al.*, 1992). Their research demonstrated that considerable reductions in the bycatches of cod, haddock, redfish, Greenland halibut and polar cod with minimum loss of shrimp (~5%). Isaksen *et al.* (1992) provides L50 estimates based on pooled data for the key discard fish species the estimate for both cod, redfish and haddock is 12 cm and about 15 cm for Greenland halibut, although for this species, the selection profile was asymmetric with a flattening of the curve after the 75% length. In 1991, Canadian researchers tested grid technology on the Gulf of St Lawrence fishery. A number of vessels were fitted with 19mm Nørdmore grids with retaining bags fitted to the escape outlet, the catch retained in this was used to estimate the quantity of bycatch escaping from the trawl as well as monitor potential shrimp loss. On average, the reduction of bycatch was 97% with only a 2% loss of shrimp! Other experiments in the Eastern Scotian Shelf showed bycatch reductions of 97, 100, 95, and 100% for plaice, cod, redfish and haddock respectively (Brothers, 1998).

Balfour (1993) reports an extensive number of individual catch comparison experiments where a number of bar spacing (22, 25 and 28mm) were tested. Due to the inherent variability associated with catch comparison experiments, it is not possible to see an effect due to bar spacing. However, the bycatch reductions reported for all grid types are considerable.

Grimaldo *et al.* (2004) provides selectivity estimates from experiments conducted in the Svalbard area with a 19 mm plastic grid, with a novel ‘tear’ drop shape, which was designed in order to improve water flow through the grid in an attempt to reduce shrimp loss. Average L50’s and SR for cod were 18.5 and 3.4 cm; haddock 16.0 and 5.3 cm and 20.2 and 5.4 cm for Greenland halibut. The authors note that the selection parameters were similar to earlier experiments with normal ‘round’ bars. The estimates of L50 appear to be considerably larger than those reported by Isaksen *et al.* (1992).

Although the Nørdmore grid is particularly effective at reducing the bycatch of gadoids, in certain fisheries e.g., NAFO division 3KL, the capture of juvenile Greenland Halibut is problematic. Recent research (Bowering and Orr, 2004) suggests that the bycatch associated with the fishery in NAFO sub-area 2 and division 3KL result in a potential yield loss of between 900–1400 tonnes annually. Modifications to ground gear attachment to the trawl footrope offer a potential method to mitigate the bycatch of this species. By increasing the length of the footrope connecting chains, which attach the ground-gear to the trawl, escape gaps are formed that allow for the passage of the juvenile Greenland halibut. Unfortunately the author has been unable to obtain literature that provides information on the effectiveness of the ‘toggle chains’.



**Figure 3: Schematic diagram of toggle chain attachment as per NAFO regulations.**

The square mesh panel has been shown to reduce the levels of bycatch associated with the *Nephrops* fisheries of the North East Atlantic (Graham and Ferro, 2004). Lehman and Munch-Petersen (1993) report on experiments in the Danish *Pandalus* fishery where they tested the effectiveness of a 95 mm square mesh panel inserted into a 35 mm net, just in front of the codend. The authors report a reduction in catches of haddock and whiting below minimum landing size of 42 and 56% respectively.

The bycatch of economically important species (*Nephrops*, monkfish and marketable round fish) is important to the Danish fleet operating in the North Sea. Madsen and Hansen conducted experiments that utilised the sorting efficiency of the Nørdmore grid together with a square mesh panel inserted behind the grid in order to improve the selectivity of the shrimp trawl while maintaining catches of commercially important species. The grid was hinged to facilitate onboard handling, but unlike the traditional Nørdmore grid, two escape gaps, into the codend, were inserted at the top and the bottom of the grid. The idea was to allow *Nephrops* to pass through the lower 15 cm gap and continue into the co-end while an upper gap of 30 cm to allow larger fish to pass through. Directly behind the upper escape hole, a panel of 110 mm square mesh panel was inserted to facilitate the escape of fish. The design reduced the bycatch of cod, haddock and whiting both above and below MLS with no impact on monkfish with increases of 44 and 33% in catches of shrimp and *Nephrops* respectively. Total reductions of 48, 80 and 88% for cod, haddock and whiting respectively. Higher reductions in bycatches of fish below MLS were noted for all three species. It is concluded that the mesh size of the square mesh panel can be manipulated to control the size profile of fish catches while the increased catches of shrimp and *Nephrops* are attributed to differences in trawl performance due to the reduction in bycatch.

Poor selectivity of target species remains a problem in a number of fisheries. Several experiments with both mesh size and orientation (i.e., square) as well with size selective grids have been conducted. Balfour (1993) tested three meshes sizes, 45, 50 and 55 mm in the NAFO region 2J and 3K. No significant difference was observed in the selection profiles between the three codends (L50's and SR respectively 13.0, 6.2cm; 12.8, 4.9 cm; 14.4, 4.9 cm).

### Technical conservation measures in use

The first section of this summary has provided an overview of the fisheries and the range of gear related technical measures available to mitigate some of the bycatch problems, the next sections identify the range of measures that are actually applied on a regional basis and outlines the remaining bycatch problems affecting the fishery today.

#### *High Seas Fisheries*

Legislation can be broadly split into two distinct areas. A fishery for *Pandalus* exists in a number of areas outside national jurisdiction (i.e., 200 nm), principally on the Grand Banks and Flemish Cap area off the Eastern seaboard of Newfoundland; these are regulated under the auspices of the North Atlantic Fisheries Organisation (NAFO), while the remainder are managed under national regulatory controls. NAFO have responsibility for the management of the stocks in NAFO division 3M (Flemish Cap) and 3L. NAFO use a range of regulatory measures to control the exploitation of the shrimp stock and for the management of bycatch.

A mix of TAC's and effort control systems are employed, TACs are used in area 3L while effort control, controlled through the allocation of total number of days and vessels. The minimum mesh size in all shrimp fisheries under NAFO jurisdiction is 40 mm. In 1993, the NAFO council raised concerns about the impact the developing fishery on the Flemish cap on the stock of juvenile redfish. The use of Nørdmore grids with a bar spacing of 28 mm became mandatory in 1994 in an attempt to reduce the bycatch of redfish. However, NAFO (1994) reviewed the legislation relating to sorting grids and concluded that the 28 mm bar spacing was too large as this did little to reduce the bycatch of redfish smaller than 21 cm. In view of this the legislation was revised and since 1994, all vessels operating in NAFO divisions must use a Nørdmore shrimp grid with a bar spacing of 22mm (Table 2). In NAFO division 3KL vessels must also use toggle chains with a minimum length of 72cm in order to reduce the bycatch of Greenland halibut (turbot). In addition closed areas, depth restrictions (no fishing shallower than 200m) and seasonal entry restrictions are applied in NAFO area 3L. Bycatch restrictions in areas 3L and 3M are applied to minimise the degree of bycatch. If the catch exceeds 2.5% (3L) or 5% (3M) of the total catch vessels must move 5 nautical miles from the position of their last tow.

#### *USA*

Nørdmore grids with a bar spacing of 1" (~25mm) are mandatory in the Gulf of Maine *Pandalus* fishery.

#### *Canada*

In the territorial waters of Canada, Nørdmore grids (grates) have been mandatory since 1993, the maximum bar spacing varies, depending on the fishery, which are sub-divided into Shrimp Fishing Areas (SFA's). Vessels less than 65' operating in the northern shrimp fisheries must use a grid with a maximum bar spacing of 22 mm, where as all vessels fishing in the Gulf of St Lawrence the minimum bar spacing is 25 mm. For all vessels over 65', the bar spacing limit is 28mm. In the northern shrimp areas, 71 cm toggle chains are mandatory to reduce the bycatch of Greenland halibut. Recently observed increases in the stock are attributed, in part at least, to the use of toggle chains. Minimum mesh size in all shrimp fisheries is 40mm.

### ***Faeroe Islands***

The majority of Faeroese vessels operate in international waters or in the economic zones of other countries, notably the territorial waters of Greenland, Norway, Russia and the disputed zone around Svalbard. In view of this, Faeroese vessels are subject to the fisheries legislation laid down for these regions. Only a limited experimental fishery was undertaken in Faeroese waters in 2002 and 2003 with minimal catches.

### ***Greenland***

The Nørdmore grid, with a bar spacing of 26 mm is mandatory for the larger offshore fleet and was introduced into legislation in 2001, while the inshore vessels have a dispensation from using sorting grids. The current minimum mesh size is 44mm. In addition to the gear regulations, Greenland legislation also prohibits fishing in areas with high bycatch, particularly red-fish and employs permanently closed areas to protect this stock.

### ***Iceland***

Shrimp fishing is carried out using a shrimp trawl with a 36 mm codend. For deepwater shrimp fishing, fishing gear must be fitted with a finfish excluder (Nordmore grate) with 22 mm bar-space. Vessels pursuing deepwater shrimp thus end up with no fish catches. In defined offshore areas where juvenile shrimp are likely to be caught, juvenile shrimp excluder or a 40 mm square mesh codend are also mandatory. Inshore shrimp is caught by small vessels, they are exempted from the requirement of using a Nordmore grate but must use a 36 mm square mesh codend.

Icelandic vessels are also allowed to use grids to improve shrimp selectivity, the 'Húsavík grate' (Figure 4) and the 'ICEDAN grate'. The distance between the bars is at least 7 mm on the lower part and at least 9 mm on the top part (average of 10 measurements). The grate is positioned in the trawl belly, behind the Nordmøre grid and a small meshed netting funnel in front of the grid, if possible. The ICEDAN grid consists of two grids; one for sorting out fish, and one for sorting out small shrimp. The small shrimp excluder is shorter than the fish grid and is mounted behind it in such a way that the distance between the grids is more at the top than the bottom.

Surveillance of inshore shrimp fishing places its main emphasis on monitoring the mix of juvenile fish in the catch, as it is known that when 0-group fish are plentiful they are not all excluded even if a square mesh net in the codend is used. If large numbers of young fish are present in catches, or 900 or more of so-called juvenile units per 1000 kg of shrimp, the fishing area concerned is closed and will not be reopened until surveys show that juvenile fish is below the reference level in the area in question.

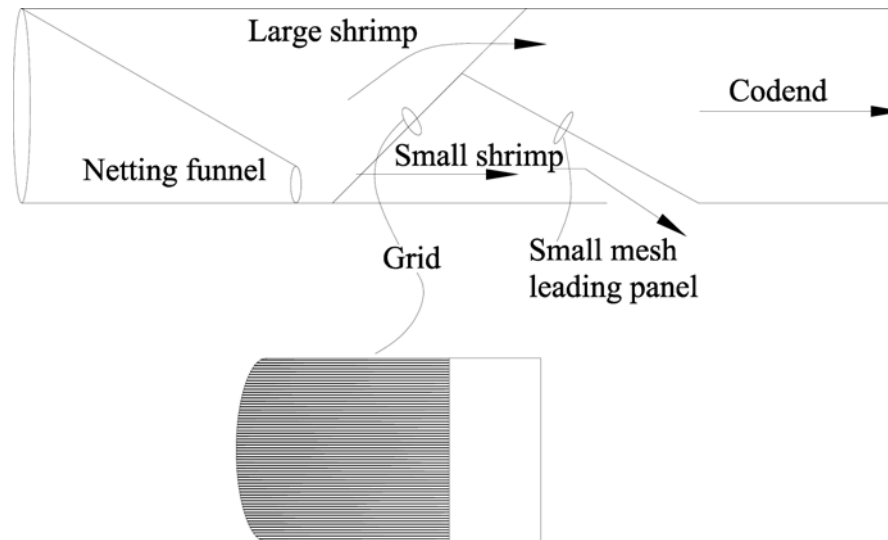


Figure 4: The 'Húsavík grate'; a juvenile shrimp excluder.

### *Sweden*

In the coastal shrimp fishery of Sweden trawling for *Pandalus borealis* is admitted in waters deeper than 60 m. Only one single trawl per vessel allowed (multiple rigs are banned). In order to limit the size of the trawls used, a number of additional legal requirements are made. Each trawl door shall not weigh more than 350 kg and not exceed 2.7 m<sup>2</sup> in area. Species selective Nordmøre grid is mandatory (19 mm bar spacing). Minimum mesh size is 35 mm. Maximum ground rope length of is 50 m (between arm ends). Maximum head rope length is 38 m. Maximum circumference at ground rope centre is 130 m.

### *Norway*

In the Svalbard area the shrimp fisheries are regulated by number of effective fishing days and number of vessels by country. In the Barents Sea and Svalbard area, Norwegian rules are that the fisheries be regulated by fishing licences and by smallest allowable shrimp size (maximum 10% of catch weight may be < 15 mm carapace length, CL). Fishing grounds are closed if bycatch limits given as number of individuals in 10 kg of shrimp are exceeded. In 2004 and 2005 the values of allowed bycatch are set at eight for the sum of cod and haddock, ten for redfish and three for Greenland halibut per catch of 10 kg shrimp. Sorting grids in the shrimp trawls first became mandatory operating within the Norwegian 12 miles zone in February 1990. In October 1991 this directive was extended to apply to shrimp trawls used in all of the Norwegian EEZ. In 1993 the Joint Norwegian Russian Fisheries Commission agreed that the sorting grid was to be mandatory for all vessels conducting shrimp fishery in the Barents Sea and the Svalbard area. The maximum bar spacing permitted is 19 mm in all areas. Two different mesh size regulations are used in the Barents Sea, 35 and 40 mm.

### *EU – North Sea and Skagerrak*

A number of Danish and Norwegian vessels use a Nørdmore grid on a voluntary basis. Bar spacing range from 19–22 mm and typically use grids constructed from plastic. A 70 mm square mesh panel is mandatory in areas under the jurisdiction of the EU (Anon, 2005).

## Ongoing issues

### Technological creep

There have been a number of technological changes in fleets, with more modern offshore vessels replacing the older, less efficient coastal fleet. The one exception is in Canada, where allocation key alterations in the mid 1990's encouraged the development of the near shore sector. The modernisation of the fleet has resulted in more efficient vessels due to their ability to operate in more hostile conditions for example the ability to operate in areas subject to ice and their ability to deploy multiple rig trawls. A number of the more modern vessels are operating with up to four trawls. A number of regions have also experienced reductions in the traditional ground fish stocks and/or individual vessels allocations due to overcapacity. As a result, increasing effort has been focussed on the shrimp fishery. This is particularly problematic in fisheries where no catch allocation system is applied e.g., the use of effort control only (e.g., Flemish Cap and Svalbard) or no controls at all (Barents Sea). This has undoubtedly led to a rapid increase in commercial catch per unit effort and if technological creep continues with inappropriate control (TACs or effort) potential problems for the shrimp stock may occur in the future. It is therefore important that technological changes in the fleet are monitored and quantified and utilised to control entry into the fishery, apply appropriate effort controls of TACs.

### Bycatch

Bycatch problems associated with the fleet operating in the North Sea still remains an issue. The principal problem is that a number of other species e.g., monkfish, are of commercial interest to the fishermen, rendering the traditional Nørdmore grid economically inappropriate. However, the system developed by Madsen and Hansen (2001) demonstrates that significant reductions in bycatch can be obtained while maintaining catches of commercially important species.

### Target species selection

Cod- end selection appears to be poor in a number of fisheries and some nations apply catch composition legislation, prohibiting the retention of catches which comprise of shrimp below minimum catch size above a percentage of the catch composition e.g., Norway. Experiments with increased mesh sizes show little promise for improving size selection; however size-sorting grids used in Iceland may be worth considering in other fisheries.

## Conclusions

- The fishery for *Pandalus* has expanded rapidly in the past two decades, being one of the most important commercial species in the North Atlantic
- The widespread use of Nørdmore grids in the North Atlantic has resulted in large-scale reductions in the level of bycatch that typified the fishery in earlier years.
- Bycatch levels are also controlled by the use of closed areas and fishing depth restrictions in many regions – the introduction of sorting grids has opened up a fisheries that would otherwise been closed.
- Size selection of the target species is problematic in a number of fisheries and can be restrict fishing opportunities through the use of catch composition regulations. Size sorting grids for shrimp show promise – research should be conducted into their potential for wider use.
- Bycatch of 0-gp fish remains problematic in many fisheries but recent advances in the understanding of fish and shrimp behaviour have resulted in new trawl design technologies that can reduce the capture of 0-gp fish – these should be pursued further (Valdemarsen, 2005 Appendix 1).

- Technological creep has increased dramatically in recent years – this should be monitored closely and quantified particularly in fisheries that rely on effort control schemes or are unrestricted.
- Bycatches are high in the North Sea fisheries – adoption of the modified grid system described should be encouraged.
- There is a lack of data in the available literature to ascertain the stock effects of the current range of TCMs.

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**Table 2: Overview of technical conservation measures to reduce bycatch in the *Pandalus* fishery.**

COUNTRY/REGION	MMS	NØRDMORE GRID	BAR SPACING	BYCATCH LIMIT	OTHER BRD'S
NAFO	40	Y	22 <sup>3</sup>	Y	Toggles
EU	40	N	NA	Y	SMP/Grid
Greenland	44	Y <sup>1</sup>	26	Y	N
Faeroe	N/A – International fleet				
Canada	40	Y	28	Y	Toggles
Norway	35 - 40	Y	19	Y	
Iceland	36	Y <sup>1</sup>	22	Y	Square mesh codend <sup>2</sup> , Shrimp Grid
USA		Y	25mm		

<sup>1</sup> Inshore sector has dispensation for grid

<sup>2</sup> Used by inshore fleet as alternative to grid

<sup>3</sup> Reduced from 28mm in 1994

## ***Nephrops* fisheries**

An extensive overview of the *Nephrops* fisheries of the North East Atlantic and Mediterranean was conducted by the WGFTFB in 2003 and is published as an ICES Cooperative Research Report (Graham and Ferro, 2004).

## **North Sea brown shrimp (*Crangon crangon*) fishery**

### **The brown shrimp (*Crangon crangon*) fisheries of the North Sea: a review of discards and bycatch, technical measures and their efficacy**

Norman Graham<sup>\*a</sup>, Hans Polet<sup>\*b</sup> and Andrew Revill<sup>\*c</sup>

\* Equal Authorship

<sup>a</sup> Institute of Marine Research, Bergen Norway;

<sup>b</sup> CLO- Sea fisheries Department, Oostende, Belgium;

<sup>c</sup> CEFAS Lowestoft Laboratory, England

## **Overview of the fishery**

The fishery for *Crangon* (Figure 5) occurs in the shallow coastal waters of the southern North Sea. The fleet consists of around 650 vessels (< 221kW main engine power), predominately using small mesh twin (~20mm) beam trawls. Domestic landings are between 25 and 30 thousand tonnes per year and are ranked in the top 5 species of the North Sea in terms of economic value, worth approximately 80 million Euros in 2000. The brown shrimp are cooked onboard the vessels with the principal markets in Northern European countries.



Figure 5: *Crangon crangon*.



Figure 6: Principal North Sea *Crangon* fishery areas.

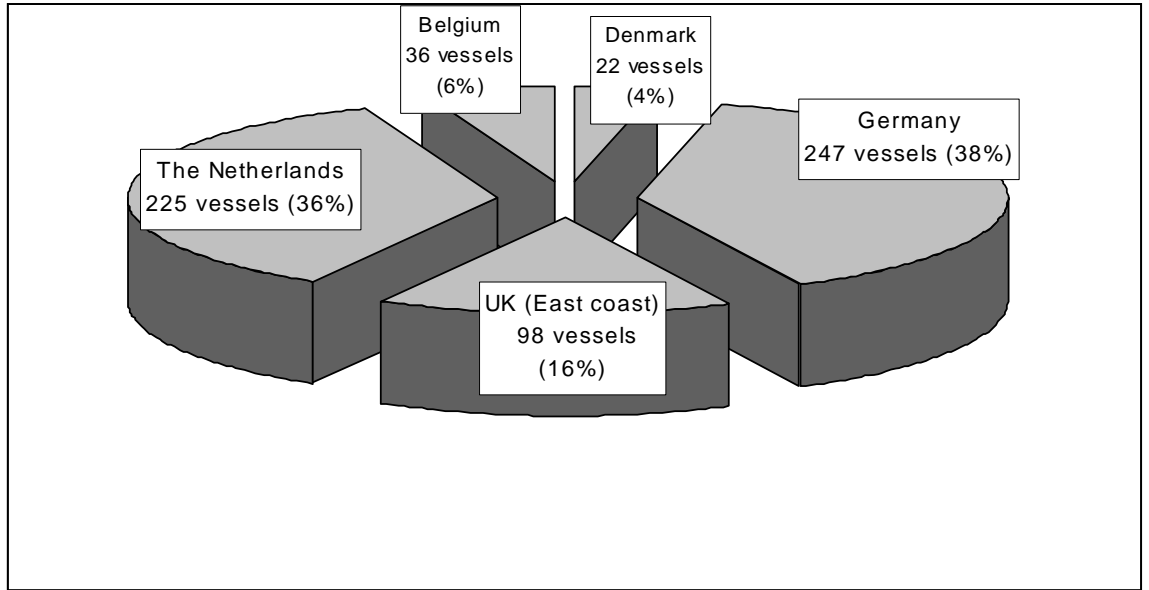
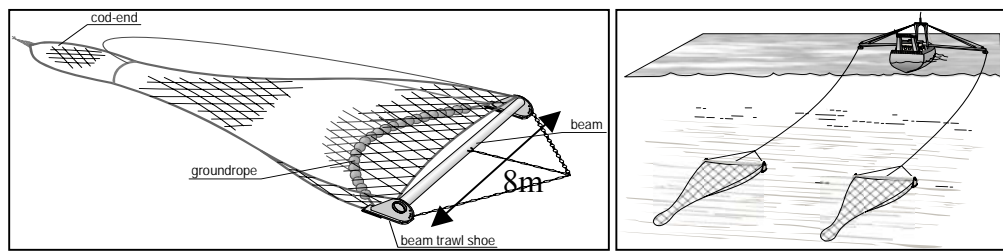


Figure 7: Vessel numbers by country (1996).



Figure 8: Typical twin-rig shrimp beam trawler.



**Figure 9: Schematic diagram of beam trawl.**

### **Unwanted bycatch and discarding in the North Sea brown shrimp fisheries**

There is a significant discarded bycatch of unwanted juvenile fin-fish which results from the small mesh size used, and the fact that the *Crangon* fishing grounds are located in an area which is also nurseries for significant numbers of these juveniles. Principal bycatch species are plaice, whiting, cod and sole (Zijlstra *et al.*, 1982). Belgium is the only country to report by-landings of white fish of any significance (van Marlen *et al.*, 1998).



**Figure 10: Typical catch composition.**

**Table 3: Estimated number of fish discarded by country in 1996/97 (numbers in millions).**

	PLAICE	SOLE	WHITING	COD
<b>Denmark</b>	33.7	0.1	1.1	3.0
<b>Germany</b>	724.7	8.7	9.8	17.3
<b>The Netherlands</b>	157.5	4.0	22.3	16.9
<b>Belgium</b>	2.2	1.5	9.2	0.5
<b>UK (East coast)</b>	9.9	1.3	12.9	4.6
<b>Total</b>	<b>928.1</b>	<b>15.7</b>	<b>55.3</b>	<b>42.3</b>

### The impact of discarding upon the affected stocks

To estimate the potential loss to the commercial whitefish fishery caused by discarding in the shrimp fishery, Graham (1997) developed a predictive model using cohort analysis with catchability estimates, predicted a potential loss of approximately 2000 tonnes of plaice. Following this work, a more extensive discarding sampling programme was initiated under the auspices of an EU project. Van Marlen *et al.*, (1998) estimated that 928, 55, 42 and 16 million individual plaice, whiting, cod and sole respectively were discarded in one fishing year (1996/1997) in the North Sea fishery (Table 3).

If not caught by the shrimp fishers, some of these fish would survive to be caught by fishers in the North Sea. Using a modified version of the model developed by Graham (1997) using effort data, Revill *et al.* (1999) estimated that a complete reduction in bycatch in EU *Crangon* fisheries may result in an additional 2,000 tonnes of cod, 1,500 tonnes of whiting, 12,000 tonnes of plaice, and 600 tonnes of sole being landed annually by North Sea whitefish fishers (Table 4).

**Table 4: The biological and economic significance of discarding in the European *Crangon* fisheries.**

SPECIES	LOSSES TO NORTH SEA SPAWNING STOCK BIOMASSES RESULTING FROM EUROPEAN <i>CRANGON</i> DISCARDING	LOST ANNUAL N. SEA LANDINGS RESULTING FROM EUROPEAN <i>CRANGON</i> DISCARDING	AVERAGE EUROPEAN FISH MARKET VALUE OF RESULTANT LOST ANNUAL LANDINGS
Plaice	6 – 16 %	7,300 – 18,800 tonnes	17.9 million Euro
Sole	0.4 – 2 %	150 – 1,350 tonnes	3.9 million Euro
Cod	0.5 – 2 %	1,000 – 3,200 tonnes	1.9 million Euro
Whiting	0.6 – 2 %	900 – 2,400 tonnes	1.2 million Euro

### Bycatch reduction techniques

Three principal methods to reduce discards in *Crangon* fishery, the sieve net, Normore grids and electrical stimulation have been investigated. The first two rely on physical size differences between the target species and the bycatch, while electrical stimulation utilises behavioural differences.

The sieve net is the most commonly used device and has been used on a voluntary basis by many fishermen. It consists of a cone of larger mesh netting inserted inside the main body of the trawl. The apex of which forms an escape outlet. The smaller shrimp pass through the meshes while the larger bycatch is guided out the funnel. Grids work on a similar principal by physically restricting the passage of bycatch. However, both methods still allow the capture of 0-gp fish, which is a significant in a number of fisheries.

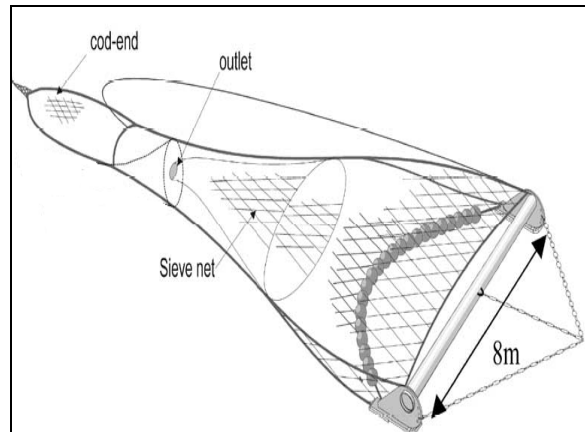


Figure 11: Schematic of sieve net.

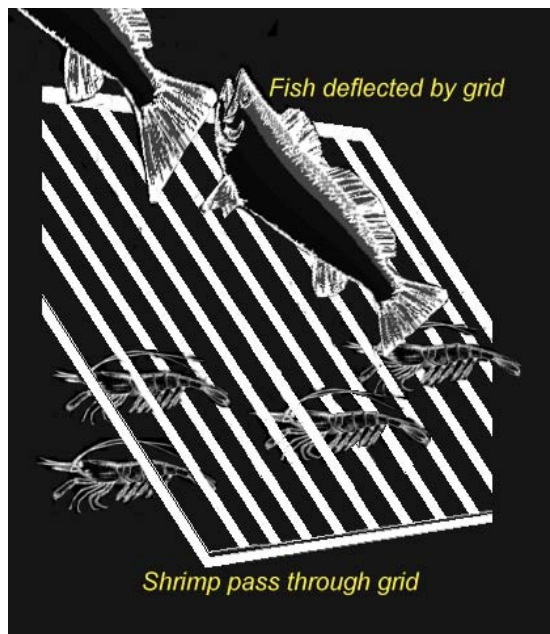


Figure 12: Schematic of Nordmore grid.

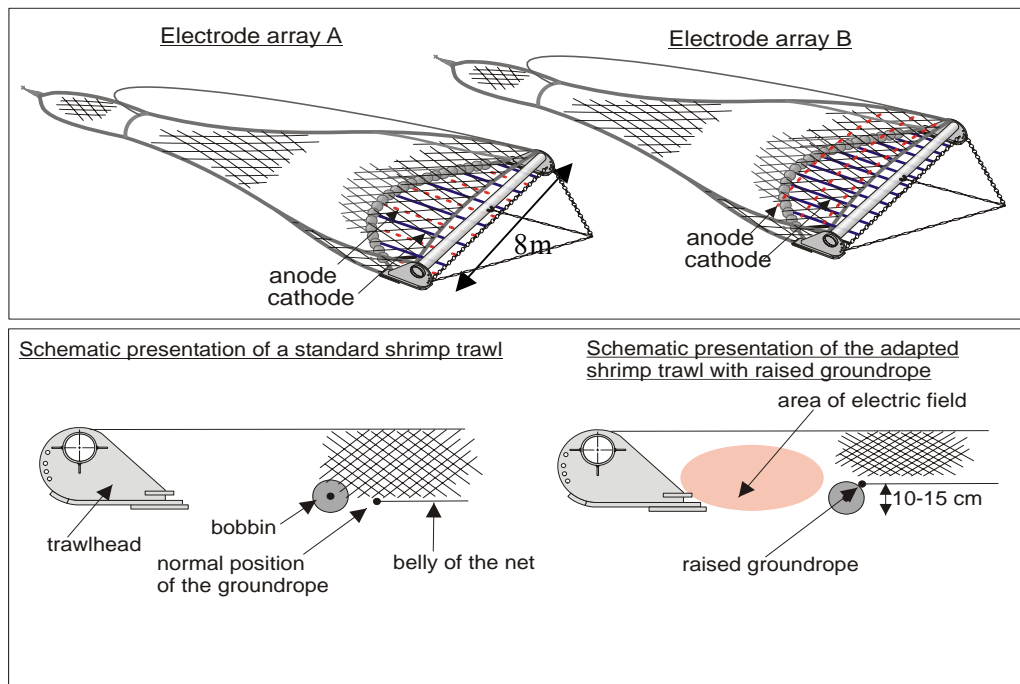


Figure13: Electric pulse beam trawl.

### Biological modelling of the benefits from introducing 'bycatch reduction devices' into the fishery

An analysis by Reville *et al.*, (1999), demonstrated that a recovery of lost landings due to discarding in the shrimp fishery could be achieved of between 10 and 95% depending on the size composition of discards. An example from this analysis is given in Figure 13.

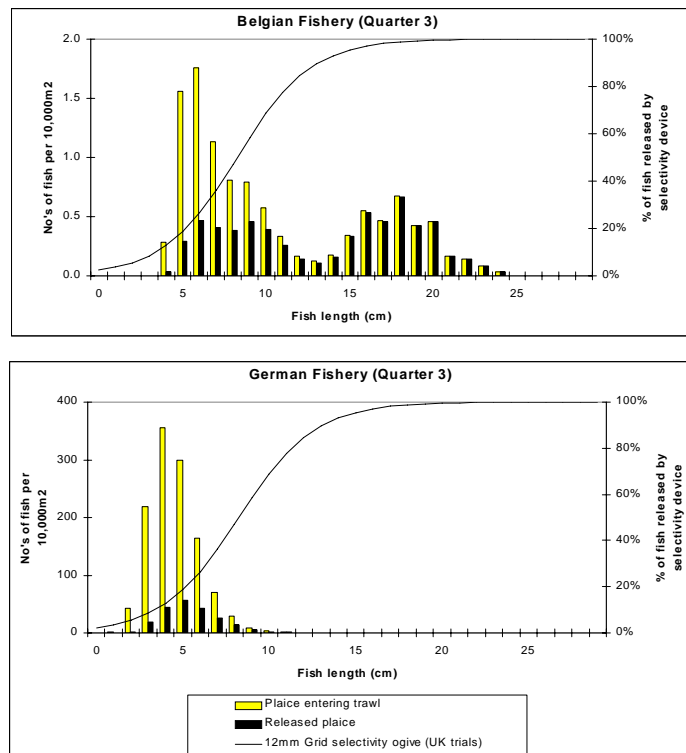


Figure 13: An example of the predicted effects of using a bycatch reduction device (example shown: Nordmore grid).

## Current status of bycatch reduction device usage in the North Sea brown shrimp fishery

In 2002 the EU made it mandatory for the use of bycatch reduction devices to be used in all European fisheries. All vessels targeting brown shrimp in European waters have since been required to use either a grid or a sieve net. Fishermen have almost universally opted to use the sieve net, rather than the grid as it is perceived easier to handle. The efficacy of the grid and the sieve net are broadly comparable in terms of discard reduction.

The electrical pulse trawl is still under development and is not available for commercial use at present (2005).

## Lessons learned from the development of effective discard mitigation measures for use in the North Sea *Crangon crangon* fisheries

- a) A logical and systematic approach to the bycatch problem (detail below) was used. This approach could be used as a template for other fisheries with similar problems:
  - The compilation of a detailed fleet and effort inventory (1995/96);
  - The quantification of discard levels (1996/97);
  - The modelling of discards to determine the impacts upon affected stocks (1999);

- The development of mitigation measures (1999/2001);
  - The modelling of the potential benefits to the affected stocks of introducing mitigation measures (bycatch reduction devices);
  - Appropriate legislation introduced;
  - The undertaking of follow-up evaluation of effectiveness of technical measures and legislation.
- b) International collaboration and coordinated unilateral action was essential.
- c) The numbers of discards may have little meaning until they are suitably modelled in order to determine their detrimental effects upon the affected stocks. For example a high discard rate of very young fish may not be problematic if most would die from natural mortality.
- d) Although the target species was the same, considerable regional variations in discard patterns were observed, which required regionally focussed mitigation measures to be developed.
- e) A consideration of the economic impact of discarding stimulated legislative action by the fisheries management.

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## Bangladesh

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### Abstract

The shrimp catch by trawlers was 3 700 t for 1998/99. In addition, about 16 000–17 000 t of shrimp are caught by artisanal gear from mechanized boats.

Giant tiger (*Penaeus monodon*) is the most valuable and hence the targeted species. But the highest contribution to the total production is from brown shrimp (*Metapenaeus* spp.) (almost two thirds of the total).

It is estimated that the shrimp trawlers catch 45 000–52 000 t of fish. The species composition depends on the water depth. In the shallower waters (40 to 70 m) the croaker and grunter species are mainly found whereas breams and scads are predominant in the deeper waters (70–100 m). Only about 20% (with a tendency to increasing) of the fish caught is landed for sale at the local markets, 80% are thrown over board.

In 1998/99, the industrial trawling fleet which is supposed to work beyond the 40 m depth line, included 44 shrimp trawlers and 15 white fish trawlers. Besides, large artisanal fleets operate in estuaries and coastal waters and contribute 95% of the total marine production, including four to five times more shrimp than from the industrial trawlers.

The main problems reported include: wastage of resources by bycatch discarding, catching a large number of shrimp broods (fry) and juvenile fish, conflicts between industrial and artisanal fishermen, habitat destruction by trawling, increasing poverty of coastal fisherfolk through the expansion of the fishing industry.

### Overview of individual fisheries

Bangladesh is situated at the northern end of the Bay of Bengal between latitude 20°34' and 26°38' north and 88°01' and 92°41' east. The country is endowed with vast inland water resources in the form of rivers, flood-plains, ponds, etc., and marine water, the Bay of Bengal, having great fisheries potential. The inland water of Bangladesh is over 4 million hectares. The country has a 710 km long coastline and approximately 1 million hectares of territorial waters extending up to 19 km. The nation's economic zone extends 320 km (200 nm) out to the sea from the baseline. The total marine water area of Bangladesh is about 164 000 km<sup>2</sup> of which more than 24 000 km<sup>2</sup> is shallower than 10 m. The marine waters of the Bay of Bengal are nutrient rich providing a suitable habitat for fish production. Marine fisheries consist of the industrial fishery using large trawlers and the artisanal fishery using mechanized and non-mechanized boats. The contribution of fisheries to the national economy of Bangladesh is substantial, particularly with reference to food consumption, nutrition, employment and export. The sector contributes 4.7% to the national GDP, 7% to the agricultural GDP and 10% to the export earnings. The average annual growth rate of the fisheries sector over the years is 4.6%. The fisheries sector provides full-time employment to 1.2 million professional fishermen and 11 million part-time fisherfolk, the total of which is about 10% of the total population of the country.

The fisheries sector contributes about 78% of the animal protein intake in Bangladesh. However a continuous increase in fish production has not been able to cope with the fast-growing population. The country's fish production has increased from 640 000 metric tonnes (inland 545 000 metric tonnes, marine 95 000 metric tonnes) in 1975–76 to 1 373 000 metric tonnes (inland 1 079 000 metric tonnes, marine 294 000 metric tonnes) in 1996–97. But, at the same time, because of a fast increase in population the per capita fish consumption has declined from 33 to 20 g.

At present the marine fisheries sector contributes only about 22% of the country's total production, despite a sizeable marine and brackish water area within the EEZ. This sector has not been properly developed so far. Because of an unplanned and irrational increase in fishing effort many of the marine fish and shrimp stocks have already declined. As a result, coastal fishing has become non-remunerative and the fisherfolk are getting poorer, thus putting more and more damaging pressure on the resources.

The marine fisheries living resources in Bangladesh are seriously affected in many ways due to shrimp trawling. There is also some fishing effort in the marine and estuarine area which damages the marine bio-mass severely. The most detrimental fishing gear among these is the shrimp fry collection gear and the estuarine set bagnet. So far it is observed that the catch rates of most of the species from marine sources are declining. The other damaging activities, which have harmful effects on the living resources, include water pollution like industrial discharge and oil pollution. Lack of proper surveillance and management due to institutional weakness are also considered responsible for the adverse effects on the marine fisheries resources. Due to stock depletion and reduction in catches for the artisanal fisheries multiple problems have emerged, including unemployment for a major group of the coastal fisheries communities living along the coast.

The commercial trawl fishery developed in Bangladesh from 1972. At the present there are 45 shrimp trawlers and 14 finfish trawlers in operation. The finfish trawlers also include six trawlers owned by the Bangladesh Fisheries Development Corporation (BFDC) a public sector body. The overall length of shrimp trawlers varies from 20.5 to 44.5 m and that of the finfish trawlers ranges from 28.0 to 30.5 m. The engine power varies from 350 to 1200 HP, but mostly falls within the range of 550–850 HP. The manpower employed in the fish and shrimp trawl fisheries consists in about 23 crew members on board commercial trawlers, 6–10 and 3–15 on board mechanized and non-mechanized boats respectively.

The finfish trawlers mostly carry out single trawling from the stern with high opening bottom trawl nets with 60 mm mesh size at the codend. The shrimp trawlers use outriggers and operate two to four nets at a time. These trawlers use modern shrimp trawl nets with the codend having a mesh size of 45 mm. The headrope length of the shrimp trawl net ranges in the trawler fleet from 15 to 26 m. and almost all of the vessels are equipped with modern navigation, communication and fish finding equipment.

The shrimp catch by trawlers was 3 700 t for 1998/99. In addition, about 16 000–17 000 t of shrimp are caught by artisanal gear from mechanized boats.

It is estimated that the shrimp trawlers catch 45 000–52 000 t of fish. The species composition depends on the water depth. In the shallower waters (40 to 70 m) the croaker and grunter species are mainly found whereas breams and scads are predominant in the deeper waters (70–100 m). Only about 20% (with a tendency to increasing) of the fish caught is landed for sale at the local markets, 80% are thrown over board.

In 1998/99, the industrial trawling fleet which is supposed to work beyond the 40 m depth line, included 44 shrimp trawlers and 15 white fish trawlers. Besides, large artisanal fleets operate in estuaries and coastal waters and contribute 95% of the total marine production, including four to five times more shrimp than from the industrial trawlers.

### **Target and non-target species**

#### Major shrimp species exploited

The Bangladesh offshore commercial trawl fishery has been developed on the basis of the valuable exportable Penaeid shrimp resources. The commercial shrimp species are listed here:

<i>SCIENTIFIC NAME</i>	<i>ENGLISH NAME</i>
1. <i>Penaeus monodon</i>	Giant black tiger
2. <i>Penaeus semisulcatus</i>	Tiger
3. <i>Penaeus japonicus</i>	Tiger
4. <i>Penaeus indicus</i>	Indian white
5. <i>Penaeus merguensis</i>	Banana/white
6. <i>Metapenaeus monoceros</i>	Brown
7. <i>Metapenaeus brevicornis</i>	Brown
8. <i>Metapenaeus spinulatus</i>	Brown
9. <i>Parapenaeopsis sculptilis</i>	Pink
10. <i>Parapenaeopsis stylifera</i>	Pink

The percentage composition of different commercial shrimp for a 6 years period are given below:

YEAR	TIGER	WHITE	BROWN	OTHERS
1992–93	12.30	7.70	60.60	29.40
1993–94	8.91	13.33	50.86	26.90
1994–95	12.49	8.01	55.70	23.80
1995–96	7.91	9.15	57.85	25.09
1996–97	9.58	6.25	59.83	24.31
1997–98	8.61	5.44	55.49	30.46

Among the shrimp exploited *Penaeus monodon* is the most valuable and hence is the targeted species. But the highest contribution in the total production, however, is made up by *Metapenaeus monoceros*, brown shrimp. The major penaeid shrimp and demersal fish are abundantly distributed within the 100 m depth

Fish landings by the commercial trawler fleets are within the range of 8 000–12 000 metric tonnes which is only 20% of the actual catch while 80%, equivalent to 35–45 000 metric tonnes (White and Khan, 1985) are discarded as low value bycatch at sea.

The main problems reported include: wastage of resources by bycatch discarding, catching a large number of shrimp broods (fry) and juvenile fish, conflicts between industrial and artisanal fishermen, habitat destruction by trawling, increasing poverty of coastal fisherfolk through the expansion of the fishing industry.

It is estimated that 80% of the fish caught by shrimp trawlers is discarded at sea. The amount of bycatch discarded was estimated to be 35 000–40 000 metric tonnes. This wastage is alarming in a country like Bangladesh where there is a serious scarcity of fish to meet the national demand. Reasons for bycatch discards are identified as follows:

*Technical:*

- Limited chilling or cold storage capacity, especially in smaller trawlers.
- Possibility of heat shock damage to high value shrimp by retention of large volumes of fish, and
- Difficulties related to transfer to other vessels at sea.

*Financial:*

- Low price of landed bycatch vis a vis shrimp;
- Lack of market development for value added product options, and
- Lack of marketing infrastructure

*Institutional:*

- Trawler owners are entirely motivated by high returns from shrimp and are not interested in landing bycatch.

There is a lack of policy regarding the discard issue and a systematic observation and research programme on the subject should be initiated.

The major reason for discarding is size rather than species. Discards of under-sized fish of commercial fish species have a particularly negative impact on the resources. There is no system in Bangladesh to assess the discard amounts.

Non-commercial, non-edible, species have obviously little access to markets and are therefore wasted most of the time.

Years of experience from similar fisheries around the world has clearly demonstrated that the production of certain fish products, such as frozen minces are not perceived as fish by the prospective consumer.

When the net is hauled and the catch spills on the deck, it is immediately sorted by the crews with priorities in mind. Recovery of the shrimp is the first consideration; second is the selection of large high value fish. During every part of the voyage, it is most likely that all other components of the catch will be thrown back to sea. This includes genuine trash, which cannot be utilized (for example seaweed, molluscs, non-penaeid crustaceans and small inedible fishes) and also smaller (but often larger than 15 cm) low value species of fish, like croakers (*Sciaenidae*), cat fish and jack fish (*Carangidae*). Only toward the end of a voyage, when the available storage space is easier to predict, attempts are made to retain the miscellaneous bycatch. The BOBP and NRI studies on shrimp bycatch during 1990–91 indicated that no solution has been found to utilize the bycatch.

### **Review of previous studies to improve catch composition**

There has not been much research so far on shrimp fisheries in general and on shrimp trawling in particular. Valid scientific information in this regard is still lacking. No estimate of the type and amount of bycatch has ever been made so far.

### **Current legislation**

Though trawl fishing has been restricted to operate within the 40 m depth contour they are found operating even up to a depth of 10 m. The most common shrimp and fish species exploited by the trawl nets are *Penaeus mondon*, *P. merguensis*, *P. indicus*, *Metapenaeus monoceros*, *M. brevicornis*, hartail, promfret, goat fish, cat fish, croakers, bombay duck, lizard fish, etc.

The Government of Bangladesh promulgated the Marine Fisheries Ordinance for the management and conservation of marine fisheries resources. Under the provision of the Ordinance the Government framed the Marine Fisheries Rules. The Ordinance and the Rules is the main regulatory legal framework for the management of the marine fisheries resources of Bangladesh. For the management of the trawl fisheries the Government has limited the number of trawlers to 73 which are allowed to operate in the EEZ of Bangladesh. The number of shrimp trawlers has been limited based on the previous survey results. At present the Government has

a proposal, based on advice from various experts, to reduce the number of the existing 45 shrimp trawlers which are to be replaced by fish trawlers. The reasons behind this is that it is already proved that the shrimp trawlers are responsible for the wastage of resources by discarding the bycatch and also for damaging the marine ecosystems. The present management measures, under the Marine Fisheries Ordinance, have a provision to protect the fisheries resources. Some of the important provisions in the Ordinance are as follows:

*i) Limiting the fishing days*

The shrimp trawlers are permitted to fish for 30 days and the catch for each trip must have a least 30% fish in the total catch. This measure was enforced in order to limit the discard of bycatch.

*ii) Facilitating escape of bycatch and small size fish and shrimp*

Mandatory 45 mm mesh size at the codend for the shrimp trawl nets is being enforced to facilitate the escape of small size fish, shrimp and the juveniles of larger fish. However, during the towing operation, the codend of nets are stretched and as such the mesh opening tends to become smaller restricting the escape of small fish. So the effectiveness of this system needs to be evaluated.

*iii) Depth zone restriction of 40 m*

There are provisions for restricting the shrimp and fish trawling within a 40 m depth zone. This measure at present is not in force due to a High Court injunction against it. This measure although initially designed to establish the rights of the artisanal fisherfolk is also to protect the nursery grounds of marine fish and shrimp including the smaller groups of fish and shrimp in the area. The survey results indicate that about half of the marine fish stock lives within the 40 m depth zone.

*iv) Turtle excluder device (TED)*

The use of the Turtle Excluder Device has been made mandatory to save turtles from being caught by the trawl nets. However, this order, again, is not in force due to a High Court injunction against it.

Provision for the present management measures which were designed in order to reduce the amount of catch wasted by the shrimp trawl fisheries. The measures are to be implemented by the Marine Fisheries Office under the Department of Fisheries. The use of a prescribed mesh size is being ensured by random inspection of the trawlers before and after every fishing trip. Shrimp trawlers are not allowed to fish for more than 30 days and are encouraged to keep the bycatch on board as far as possible. The mandatory provision of landing at least 30% fish of the total catch is also monitored. The Bangladesh Navy also takes part in regulating the trawlers activities.

The effectiveness of mesh size regulations in decreasing the amount of bycatch by the shrimp trawl nets in the tropical waters of the Bay of Bengal has not yet been studied. But from the assumption based on the studies in other parts of the world it was found that the mesh size regulation of the coded is not very effective in facilitating the escape of small or juvenile fish. Studies in this regard are essential to validate this assumption. Other measures such as the limitation of fishing to 30 days and the mandatory provision for landing certain quantities of fish, no doubt may help to bring some positive effects. These measures can be made more effective if, based on studies; the fishing days were further reduced. Preventing the shrimp trawlers from operating within the 40 m depth contour would help to bring down the quantity of bycatch discards as more than 50% of the fish stock, mainly the smaller groups of fish and shrimp, live within this depth zone.

The use of a Turtle Excluder Device (TED) to reduce catches of turtles is not popular with the trawler owners as they argue that it would also allow large size commercial fish to escape from the net. This is not totally unfounded as the design proposed for the TED has vertical bars, which would prevent the large size commercial fish from entering the codend. More studies on the effectiveness of BRDs and TEDs in reducing bycatch is necessary. The Government of Bangladesh made the use of the Turtle Excluder Device (TED) mandatory for shrimp trawlers to save the sea turtles. However, this is not in force as the trawler owners filed a petition in the High Court against it on the plea that this would result in catch reduction. The Court has put an injunction against this until further orders.

The bycatch reduction devices (BRD) used in other countries of the world have not been tested in Bangladesh yet. There are several designs of BRDs and experiments must be conducted to select the most effective ones for the tropical multi-species fisheries of the Bay of Bengal.

Modifying the codend of the net can facilitate the bycatch reduction. As the trawl net during the towing operation stretches longitudinally, the mesh opening in the codend tends to be smaller thereby reducing the escape of small fish. By using square meshes instead of diamond meshes in the codend, the meshes stay open thereby facilitating the escapement of small fish.

As far as the economic aspect of bycatch utilization is concerned, it has so far not been very profitable for the shrimp trawl owners to bring the bycatch back to land. In a country like Bangladesh where there are widespread food prejudices, with the majority of the people taking a negative approach to seafood, it is very difficult to market sea fish. However, the consumption of sea fish is increasing day by day due to short supply of fresh water fish in the markets and the trawler owners are landing more and more species of fish/bycatch. Shrimp is still the targeted species and when there is a better shrimp catch, the bycatch is usually discarded.

### **Recommendations for future research or legislative intervention**

- to study different types of BRDs in shrimp and fish trawl nets,
- to study advantages and disadvantages of using diamond mesh in the codend of shrimp/fish trawl nets,
- to study the stock and MSY of the pelagic fishery resources in the Bay of Bengal and recommend an appropriate method of exploitation,
- to study the stock and MSY of other resources such as lobster, squid and cuttlefish and to find an appropriate method of their exploitation and utilization,
- to study the stock and MSY of shrimp resources,
- to study the proper utilization of bycatch,
- to study the benthic fauna as well as damage caused by shrimp trawling with protection measures,
- to study the conservation and propagation of seaweed,
- to establish data base management system through computer networking for the industrial and artisanal sectors should be established,
- to conduct socio-economic studies on trawler fishery, and
- to evaluate extension and motivation programmes which should be undertaken for the industrial as well as artisanal stakeholders.

## Indonesia

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### Abstract

In 1996, the trawl fishery in Arafura Sea caught around 20 000 t of shrimp (80% Penaeids, mainly banana shrimp (*P.indicus*, *P.merguiensis*) 35% of the total, tiger shrimp (*P. semisulcatus*) and endeavour (*Metapenaeus ensis*). In addition, there are important shrimp fisheries outside the Arafura Sea (with trammel nets, gillnets, and bottom seines).

The shrimp/bycatch ratio ranges from 1:8 to 1:15. The vessels retain and land more and more edible fish for the domestic markets but the discard rates of small fish (juveniles) are still high.

The shrimp trawlers are supposed to use a Turtle Excluder Device (TED) or a Bycatch Reduction Device (BRD).

In 1999, 453 vessels were involved (small wooden vessels fishing with one trawl, larger steel vessels using two trawls with outriggers).

Fishing with a trawl for shrimp is only allowed in the Arafura Sea and beyond the 10 m isobath (and with a licence to fish).

The main problems reported include: weakness of monitoring and control of implementation of the regulations, lack of awareness of the existing fisheries regulations, increasing fishing effort and very high discard rates.

### Overview of individual fisheries

In 1999, 453 vessels were involved (small wooden vessels fishing with one trawl, larger steel vessels using two trawls with outriggers).

In 1996, the trawl fishery in Arafura Sea caught around 20 000 t of shrimp (80% Penaeids, mostly banana shrimp (*P.indicus*, *P.merguiensis*) 35% of the total, tiger shrimp (*P. semisulcatus*) and endeavour (*Metapenaeus ensis*). In addition, there are important shrimp fisheries outside the Arafura Sea (with trammel nets, gillnets, and bottom seines).

The shrimp/bycatch ratio ranges from 1:8 to 1:15. The vessels retain and land more and more edible fish for the domestic markets but the discard rates of small fish (juveniles) are still high.

Since 1969, when the shrimp fishery started commercially, the trawl has been the main gear used. There are three types of trawl used in the Arafura Sea, namely:

- 1) **Double rig shrimp trawl**: the headrope length is between 15 and 26 m. The mesh size of the codend is generally 11/14 inches (30 mm) and made of polyethylene (3 80D/72). A trynet, with a headrope length between 2 and 4 m is used.
- 2) **Single rig stern trawl**: headrope length between 26 and 35 m.
- 3) **“Quad trawl”**: this type has 4 codends. The headrope length is between 20 and 25 m.

In general, the duration of fishing trips vary from 40 to 60 days and the average total days at sea are approximately 280 days per year. There are approximately 7–9 hauls a day.

In 1999, there were 453 shrimp trawlers in operation. In general, the 50 GT trawlers, or smaller, are stern trawlers, whilst the larger ones are outrigger trawlers. Haul duration is between 2 and 3 hours, with towing speeds varying from 2 to 3 knots.

According to Presidential Decree (Keppres) No. 085/1982 each unit should be equipped with a BED (Bycatch Exclusion Device) which is a modified form of TED (Turtle Excluder Device).

### Fleet Structures

Presently, there are 453 units trawling for shrimp in the Arafura Sea. The size varies from 19 to 849 GT.

**Table 5: Number of trawlers by size in GT.**

Size class (GT)	Units
10–20	1
20–30	7
30–50	37
50–100	191
100–200	171
>200	46
TOTAL	453

It should be pointed out that the predominant size of the trawler is 10–100 GT, followed by 100–200 GT. The smaller vessels (<100 GT) are mostly wooden vessels. The overall length varies from 20 to 45 m. The trawler's age varies from 7 to 40 years.

### Target and non-target species

Catch composition consists of Penaeids species as the target species and demersal fish as well as other (non fish and non shrimp) as a bycatch. The main species caught are given in Table 6.

**Table 6. The main species caught by shrimp trawlers in the Arafura Sea**

Family	Species	Indonesian name	English name
Demersal fish Leiognathidae	<i>L. bindus</i> <i>L. equulus</i> <i>Gazza minuta</i>	Petek, peperck	Pony fishes
Sciaenidae	<i>Johnius sp</i> <i>Ototithes ruber</i>	Tigawaja, gulamah	Croakers, jewfishes
Ariidac	<i>Arius thalasinus</i> <i>Arius maculatus</i> <i>Arius cealatus</i>	Manyung	Cat fishes
Dasyatididae	<i>Dasyatis kuhlii</i> <i>Himantura uarnak</i> <i>Hypolophus sephen</i> <i>Rhinoptera javanica</i>	Pari	Stingrays
Gerreidae Lutjanidae	<i>Gerres abbreviatus</i> <i>Gerres acianes</i> <i>Gerres filamentosus</i> <i>Lutjanus bohar</i> <i>Lutjanus erythropterus</i> <i>Lutjanus Johni</i>	Kapas-kapas  Bambangan, kakap	Silver biddies  Snappers

Family	Species	Indonesian name	English name
Mullidae	<i>Lutjanus malabaricus</i> <i>Upenerus sulphunerus</i> <i>U. bensasi</i>	Kuniran, biji nangka	Goat fishes
Nemipteridae	<i>U- tragula</i> <i>Nemipterus hexodon</i> <i>Nemipterus japonicus</i> <i>Nemipterus peroni</i>	Kurisi	Threadfin breams
Polynemidae	<i>Polynemus plebeius</i> <i>P. sextarius</i>	Kuro	Threadfin
Pomadasydae	<i>Pomadasyds kaakan</i> <i>P. maculatus</i> <i>P. multimaculatus</i>	Gerot-gerot	Grunt sweetlips
Synodontidae	<i>Saurida tumbil</i> <i>S. undosquamus</i> <i>S. micropterus</i>	Beloso	Lizard fishes
Teraponidae	<i>Terapon threraps</i>	Kerong-kerong	Grunters
Trichiuridae	<i>Terapon jarboa.</i> <i>Trichiurus savala</i> <i>T. lepturus</i>	Layur	Hairtails
Penacidae	<i>Penaeus monodon</i> <i>P. semisulcatus</i> <i>P. merguensis</i> <i>P. latisulkatus</i> <i>Metapenaeus</i> spp. <i>Parapenaeopsis</i> spp.	Udang windu Tiger Udang putih Udang raja Udang dogol Udang krosok	Black tiger Flower tiger Banana King shrimp Endeavour Rainbow shrimp

The shrimp composition consists of 19–35% tiger shrimp *Penaeus semisulcatus*, 29–43% banana shrimp *Penaeus indicus*; *Penacus merguensis*, and 21–31% of endeavour shrimp. The catch compositions vary every year, depending on the fishing area.

The crustacean production increased by approximately 10% per year, from, 11,018 tonnes in 1990 to 17,864 tonnes in 1997. The crustacean composition was dominated by penaeids shrimp of black tiger, banana, endeavour, and rainbow shrimp *Parapenaeopsis* spp.

Other crustacean compositions were swimming crab, mudcrab, and lobster in relatively small quantities.

Other groups of species such as bivalve, sea snake and other live organisms were rarely caught. Based on 450 hauls made by RV “Bawal Putih II”, only seven turtles were accidentally caught.

The catch data of a 380 GT double rig shrimp trawler in the Arafura Sea, during 1990–1998, pointed out that the catch composition consisted of approximately fish 83–89%, shrimp 7–13%, and other organisms 3–6%.

In the Bintuni waters, the recorded fish catch was 74–79%, shrimp 20–24%, and other organisms 1–2%. In 1996 the fish and shrimp ratio was 95:4.

Catch composition of fish in the Dolak waters was between 84–95%, shrimp 4–13%, and other organisms 2–8%. This varies each year.

In Kaimana the recorded ratio was 77–86% of fish, 11–16% of shrimp, and 2–7% of other organisms.

While in the Aru and adjacent waters, the composition of the catch was 81–90% fish, 8–14% shrimp, and 1–9% other organisms

### **Review of previous studies to improve catch composition**

Research on fishing gear began in 1982 with the introduction of the Turtle Excluder Device (TED) on shrimp trawl in the Arafura Sea (Monintja, Daniel. R; Sujastani, T., Surachman, M., 1982). Furthermore, in 1997 research was carried out on the possibility of improving earlier model of TED (introduction of super shooter TED; Nasution, Ch., 1997).

The research was aimed at developing a type of TED that would be easy to use, would not affect the catch (fish and shrimp) and would be easily accepted by fishermen. The appropriate technology has still to be found and further experiments are required.

### **Current legislation**

In Indonesia trawling for shrimp is restricted: Presidential Decree No. 39 of 1980 bans trawls, however, Presidential Decree No. 85 of 1982 allows shrimp trawl operations from the shore, 130oE of East Indonesia if using Turtle Exclusion Device (TED) or Bycatch Excluder Device (BED).

Fishing with a trawl for shrimp is only allowed in the Arafura Sea and beyond the 10 m isobath (and with a licence to fish).

#### ***Trawl Banned and Shrimp Trawl Operation***

Before Law No. 9 of 1985 on Fisheries, Government Regulation (PP) No. 15 of 1990 on Fisheries Business and Ministry of Agriculture Decree No. 815 of 1990 on The Authority of Fisheries Business License in the certain scale is a responsibility of the Local Government (Provincial Fisheries Service), that refers to Government Regulation No. 64 of 1957. Licences for fishing vessels used by foreign companies are issued by the Directorate General of Fisheries.

If capital investment is available, the licence is authorised by the Capital Investment Coordinating Agency/BKPM.

Regarding trawling by national companies licences are issued by the local government, within the limits established by the regulations in Indonesia. For the Arafura Sea, licences for trawling are issued by both the Directorate General of Fisheries and CICA/BKPM (for fisheries businesses that have a facility of capital investment of Foreign Capital Investment/PMA and Domestic Capital Investment/PMDN).

With regard to the development of fisheries, the use of trawlers is controlled in order to maintain the fisheries resources sustainability and to prevent social conflicts among fisheries, mainly in the coastal areas where there is heavy fishing pressure by fishing vessels of different sizes. In light of this, fishing zones for fishing vessels has been established to avoid resources being damaged and conflicts arising among the fishermen. Ministry of Agriculture Decree No. 607, of 1976, regulates the zone. To protect small-scale fisheries from large-scale operations in their fishing grounds, the fishing grounds are divided into several zones to be utilised respectively by certain sizes of fishing vessels. Based on the decree, four areas/fishing zones are identified, as follows:

a) Fishing Zone I excluding:

- inboard fishing vessels > 5 GT or inboard fishing vessels > 10 HP.
- all trawl (beam trawl, otter trawl and pair/bull trawl).

- encircling gillnet and drift gillnet.

b) Fishing Zone II excluding:

- inboard fishing vessels > 25 GT or inboard fishing vessels > 50HP
- otter board length > 12 meters
- mid water trawl or pelagic trawl and pair trawl

c) Fishing Zone III excluding:

- inboard fishing vessel > 100 GT or inboard fishing vessel > 200 HP
- otter board length > 20 meters
- pair trawl.

d) Fishing Zone IV.

Trawl is the most effective fishing gear used to catch demersal fish, but also the cause of conflict of interests with the small-scale fisheries sector which has simple fishing gear, most of them set, passive, gear which are caught in the trawls.

The zone problem, especially in the Arafura Sea is not regulated by Ministry of Agriculture Decree No. 607 of 1976, however, there is another regulation which requires shrimp fishing to be undertaken beyond the isobath line 10 meters (Presidential Decree No. 85 of 1982). This regulation in the Arafura Sea, does not limit the development of uncontrolled trawling. Therefore, under Presidential Decree No. 39 of 1980, the government decided a ban on trawling, the implementation of which is being done step by step.

The Ministry of Agriculture Decree No. 503/Kpts/Um of 1980 on Steps for Implementation of Banned Trawls Phase I include a description of the trawl models which are banned. A Joint Cooperation Decrees (SKB) issued by three ministries, Home Affairs, Trade and Cooperation and Agriculture (No. 596/Kpts/Um/8 of 1980, No. 183 of 1980, No. 345/Kpb/VIII of 1980) includes guidelines for the Transfer of Fishing Vessel Free Trawl. Other Decrees of the Ministry of Agriculture regulate fishing activities such as Ministerial Decree No. 694/Kpts/Um/9 of 1980 which concerns "Boundaries of Fishing Ground Area for Fisheries Business using Trawl" and Ministry of Agriculture Decree No. 542/Kpts/Um/6 of 1981 limiting the number of trawlers in the Province outside Java, Bali and Sumatera respectively.

The last phase was to ban trawling in all Indonesian waters through Presidential Introduction No. 11 of 1982 on Implementation of Presidential Decree No. 39 of 1980 which states that the remaining trawls used from 1 January 1983 are now banned totally in all Indonesian waters.

However, since the total trawl ban was issued, the government still allows specific types of trawls such as shrimp trawl. Considering that - shrimp production is needed to generate foreign currency, - the technology exists to reduce bycatch from trawl, - there are still fishing grounds which has not been exploited and - capital investment policy (both Foreign Capital Investment/PMA and Domestic Capital Investment/PMDN), shrimp trawling is still authorized in areas such as: Arafura waters, Kei, Tanimbar and Aru, beyond 130oBT East.

Regarding its implementation, the regulations concerning fishing zones and trawl specifications are subject to violation. Gillnets or surrounding nets are modified or fishing operations are adjusted to take advantage of existing trawl regulation. The utilisation of certain gear in coastal areas creates severe conflicts between fishermen.

Indeed, monitoring at sea is conducted by both Fisheries Officers and Law Officers (Indonesian navy/TNI AL and Marine Police). However, because of the lack of means, financial and human resources, violations are frequent.

## **Controlling of shrimp trawl net**

As previously mentioned, the fisheries resources management has regulations. The implementation is, generally, as follows:

### **(1) Fisheries Resources Allocation**

“Fisheries Resources Allocation” basically concerns the fishing effort being authorized in given areas, including for shrimp trawling. It is issued by means of Ministry of Agriculture Decree No. 995/Kpts/IK.120/9 of 1999. This Decree estimates the TAC for shrimp to 17,200 tonnes (while for demersal fishes, a total of 197,400 tonnes). Therefore, if the average CPUE for shrimp trawl net is around 10 ton/year (with fishing vessels 150–200 GT) then the number of shrimp trawl net to be operated in the Arafura Sea would be 156. Considering that the number of shrimp trawl net operated in the Arafura Sea is now 453 for a production amounting to approximately 49,830 tonnes, the conclusion is that shrimp is being over-fished in the Arafura Sea.

### **(2) Mesh Size Regulation**

The regulation concerning mesh size is found in the Ministry of Agriculture Decree No. 392/Kpts/IK.120/4 of 1999: the minimal mesh size requirement is usually 25 mm (1 inch). This also applies to shrimp trawl net.

### **(3) Bycatch Excluder Device (BED)**

A pre-requisite of shrimp trawl net operation is the use of fish selective gear. The goal is to select fish in certain sizes. A BED can be installed between the body and the codend (Certain dimensions of the BED are adjusted to match the size of the trawl net). Shrimp fishing companies have the obligation to use BED in the Arafura Sea.

However, fishing companies report that BED is cumbersome and that it reduces the effectiveness of the trawl operation. Therefore, more research is required.

### **(4) Regulation for Fishing Zones**

The regulations concerning the Fishing Zones aims to: 1) conservation of fisheries resources, especially in coastal areas, protection of nursery grounds, 2) protection of small-scale fisheries from competition with larger scale fisheries, 3) avoid conflicts among fishermen, in general.

The regulations concerning fishing zones is now found in the Ministry of Agriculture Decree No. 607/Kpts/Um/9 of 1976 but it does not concern shrimp trawling operations since it does not apply to the Arafura Sea. In East Indonesia, only shrimp trawling is regulated with a use limited to beyond the 10 meters isobath line (Presidential Decree No. 85 of 1982).

The 10 meters isobath line limit is often not applied and shrimp trawlers often operate inshore where the depth is less than 10 meters in depth, even in estuaries. In these conditions, nursery grounds for shrimp/fish are affected and the sustainability of the resources is threatened.

### **(5) Pre-requisites for Fishing Vessels**

The Ministry of Agriculture Decree No. 392 of 1999 regarding Fishing Zones authorizes Indonesian and Foreign Fishing Vessels to operate in the IEEZ area (except in the Malaca Strait) using (whatever fishing gear is used) vessels not more than 350 GT. In accordance with the above, shrimp trawl net is authorized in the Arafura Sea only with trawlers less than 350 GT.

### **(6) Utilisation of Fish Bycatch**

The fishery companies that have licenses to use shrimp trawl net have to hand over “fish bycatch” to the Fisheries/Cooperatives State owned Company/BUMN. Regulation on utilisation of fish bycatch is included in the Presidential Decree No. 85 of 1982 and Ministry of Agriculture Decree No. 930/Kpts/UM/12 of 1982 and the Directorate General Fisheries Decree No. IK 010/S3.8063/82K. While the optimal fish bycatch utilisation is in line with responsible fisheries principles, the above mentioned requirement of keeping the bycatch on board is, practically, not easy to implement because of room limitation in the fish hold and time and effort which would have to be dedicate to handling this portion of the catch

## **Recommendations for future research or legislative intervention**

### Future Research

Several points should be seriously considered:

- 1 ) Accurate fisheries data concerning biology and economic parameters is a fundamental requirement, for shrimp fisheries, in general, as well as regarding bycatch. Such information is the basis for proper management of the fisheries;
- 2 ) conditions of the environment are essential for resources sustainability and development; consequently continuous monitoring of environmental conditions is necessary;
- 3 ) unavoidable bycatch should be utilised to a maximum, not only for immediate profit but first and foremost to provide animal protein to the coastal community; as a result, studies concerning fish product development, including using unavoidable bycatch, should be carried out;
- 4 ) several bycatch reduction technologies exist; the problem is to identify a technology effective in the specific local conditions and which would be accepted by the local fishery industry; additional research is required in this field;
- 5 ) to ensure proper management and development of any fishery, a solid and rational institutional system should be established, including for correct monitoring and control of on-going fisheries (Monitoring, Control and Surveillance system, MCS).

Based on the above-mentioned points, it is concluded that relevant research programmes should include:

- 1 ) accurate and continuous data collection through log books and observers programmes;
- 2 ) regular monitoring of resources and environmental factors;
- 3 ) research for improving bycatch reduction technology and bycatch product development;
- 4 ) institutional strengthening and development for proper shrimp trawl fisheries management.

## Philliphines

### Abstract

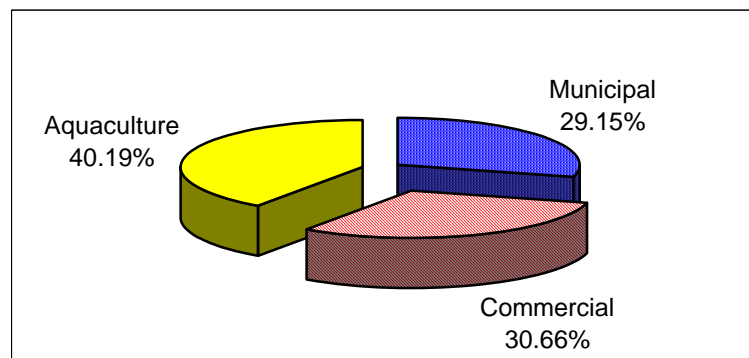
In 1997, shrimp catch was 7 156 t (90% *Acetes*) from the industrial fleet (445 vessels in 1997) and 25 334 t from the artisanal sector (over 50% of the catch are white shrimp (*P. merguensis*) and endeavour prawns (*Metapenaeus ensis*); industrial and artisanal trawls are major gears to catch penaeid shrimps; other common gears are push net (for *Acetes*) fyke net, gillnet, fish corral, beach seine and filter net.

Shrimps constitute only about 10% of the total catch in trawl fisheries. Discard rates are unknown but likely to be relatively small as there is a market for most of the captured fish. Shrimps mainly go to the local markets. Juveniles and other small sized low-value fish are utilized as human food or as feed for aquaculture depending on their quality.

All industrial vessels need a licence to fish. Registration of municipal vessels (small-scale) is devolved in the local government units. Mesh sizes less than 30 mm are not allowed in trawl shrimp fishing. Partial/total closure of some trawl areas are implemented due to declining catch rates.

In order to ensure sustainability of the shrimp fisheries the challenge is to develop solutions that retain bigger fish allowing juveniles as well as protected species to escape while not causing immediate economic loss for the fishers.

### Overview of individual fisheries



**Figure 14: Philippines fish production by sector, 2003.**

The fishery sector in the Philippines contributed 2.2% in Gross Domestic Product valued at P95.5 billion pesos for the year 2003. The industry had always been a major source of livelihood for the country's 1 million coastal population or around 12% of the rural labour force.

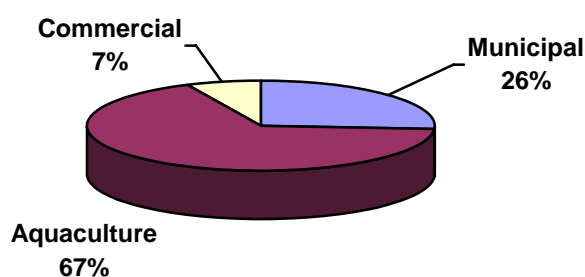
Fisheries are divided into three sub-sectors, namely: municipal, commercial and aquaculture with production shares of 29.1%, 30.7% and 40.2% respectively of the total fish production of 3.6 M mt in 2003. Municipal and commercial are capture fisheries distinguished on the basis of vessel gross tonnage. Commercial fisheries include fishing operations that use vessels of more than 3 gross ton (GT). Municipal fisheries, on the other hand, involve the use of vessels of 3 GT or less, including operations that do not involve the use of watercraft. Hence, the municipal fisheries roughly translate into traditional, artisanal or small-scale fisheries, while the commercial fisheries commensurate to the industrial or large-scale type fisheries.

The trawl industry can be likewise categorized based on vessel size. Municipal trawl sector applies a wooden dugout fishing crafts or “*banca*” measuring 5 to 12-meters over-all length and propelled by 10–90 horse power gasoline or diesel engines. The commercial trawl sector utilizes bigger-sized boat with greater engine power, and further classified as: small-commercial (3.1 to 20 GT); medium-commercial (20.1 to 150 GT); and, large-commercial type (150.1 and beyond). The over-all length of the boat exceeds 15-meters and driven by 150–500 hp engines often equipped with mechanized pulleys for hauling the net. In 1997, there are about 445 commercial licensed trawl fleets. 62% were classified as small-commercial, 37% medium commercial and 1% large-commercial. The fleet size of municipal trawlers, however, is unaccountable but estimated in a larger portion.

Trawl has been contributing around 13.3% to the annual capture fish production in 1992–1997. The municipal trawl sector ranked 6<sup>th</sup> among the most productive municipal fishing gear next to gillnet, hook and line, beach seine fish corral and ringnet. The trawl commercial sector, on the other hand, placed 3<sup>rd</sup> next to purse seine and ringnet in terms of commercial fish production.

Considering its contribution to production, trawl fishing is very important: around 9% of the total production in some commercial areas such as Ragay and San Miguel, 12% in Sorsogon and Manila Bays; and even higher in the municipal waters. In addition, trawling obviously employ a significant number fishermen.

Trawl fishing is the most common fishing method to catch shrimp although other gears are also used including set and towed shrimp gillnet, pushnet, seine net, lift net and stationary traps (i.e. fish corral, fyke net, filter net, etc. The rate of capture and the catch composition depend on the type of gear and the mode of operation, but, in general, shrimps constitute a minor part of the catch. Penaeid shrimp species are normally sparsely distributed and often better catches at night. The large shrimps are, in general, exploited, in deeper waters while small species such as *Acetes* are seasonally caught (southwest monsoon) in the inner portions of the bays.



**Figure 15: Percentage shrimp production by sector.**

The economic shrimp resource base of the country belongs from the *Penaeid* family. These are the *Penaeus merguensis* (white shrimp), *P. semisulcatus* (tiger shrimp) and *Metapenaeus ensis* (endeavor shrimp). Other important shrimp species include the *Acetes* as raw material for shrimp paste and brown rough shrimp (*Trachypenaeus fulvus*) usually processed in dried

form. Many species are found throughout the country from brackish, fresh and marine water forms but in less quantity (Del Mundo, 1990; Caces, 1973; Motoh, 1980).

Shrimps for export come entirely from culture ponds. Production from capture fisheries (municipal and the commercial) are locally consumed. The percentage distribution of shrimp and production performance by sector from 1992 to 1997

**Table 7: Shrimp Production by sector (1992–1997) in metric tons.**

SECTOR	1992	1993	1994	1995	1996	1997
<b>Aquaculture</b>	78,386	95,816	92,647	89,196	78,067	41,454
Municipal	43,880	27,810	26,497	32,068	31,100	25,334
Commercial	4,997	9,860	9,153	9,027	8,741	7,156
Total	127,273	133,486	128,297	130,291	117,908	73,994

**Table 8: Shrimp production and relative abundance by species in marine capture fisheries.**

SPECIES	1992	1993	1994	1995	1996	%
Municipal	43,880	27,810	26,497	32,068	31,100	(100)
<b>I. Inland</b>	8,480	3,351	3,139	4,735	5,291	(16)
Freshwater shrimp	8,474	1,249	1,439	3,606	3,971	75
Fresh water lobster	6	2,025	281	422	711	13.8
White shrimp			1,216	431	360	4.4
Endeavor prawn			192	237	225	4.4
<i>Acetes</i>		77	11	39	24	0.7
<b>II. Marine</b>	35,400	24,459	23,358	27,333	25,809	(84)
White shrimp	13,085	12,756	10,144	9,856	9,108	40.3
<i>Acetes</i>	16,209	6,241	6,432	8,966	8,657	34.0
Endeavor prawn	4,268	3,110	4,794	5,672	5,179	16.9
Brown rough shrimp	910	946	1,059	1,680	1,739	4.6
Tiger prawn	928	1,406	929	1,159	1,126	4.1

**Table 9: Commercial shrimp production by species (1992 to 1996) in metric tons.**

SPECIES	1992	1993	1994	1995	1996	%
<i>Acetes</i>	4,003	8,992	8,292	8,232	8,144	90.0
Endeavor prawn	427	387	341	382	252	4.3
White shrimp	294	435	486	288	220	4.1
Brown rough shrimp	229	35	26	119	117	1.3
Tiger prawn	44	11	8	6	8	0.2
Total	4,997	9,860	9,153	9,027	8,741	100.0

The trawl fishery is acknowledged to have contributed significantly to the country's increased fish production since its introduction in the 1950s. Even with the present assertion that trawl is contributory factor to resource depletion and environmental degradation and subsequent regulation, it still continues to exist as a major fisheries in almost all trawlable, including the above-reported areas.

## Target and non-target species

Shrimps constitute a minor portion of the catch of shrimp trawlers in many areas with fish and other species comprising the bulk. Utilization of fish catch is maximized, even small and low valued species are dried or processed and sold in markets and consumed as human food. Trashfish which may include small-sized low valued and juveniles of commercial fish including larger sizes spoiled due to poor handling, and which utilization or discarding depend on volume and availability of buyers or users for aquaculture feed and fish meals. Smaller vessels on short trips usually bring all catch onshore.

**Table 10: Municipal Shrimp Production by species (1992–1996) in MT.**

SPECIES	1992	1993	1994	1995	1996	%
<i>I. Inland</i>						
Freshwater shrimp	8,474	1,249	1,439	3,606	3,971	75
Freshwater lobster	6	2,025	281	422	711	13.8
White shrimp			1,216	431	360	4.4
Endeavor prawn			192	237	225	4.4
<i>Acetes</i>		77	11	39	24	0.7
Total Inland	8,480	3,351	3,139	4,735	5,291	(16)
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White shrimp	13,085	12,756	10,144	9,856	9,108	40.3
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Tiger prawn	928	1,406	929	1,159	1,126	4.1
Total Marine	35,400	24,459	23,358	27,333	25,809	(84)
<b>Total Municipal</b>	<b>43,880</b>	<b>27,810</b>	<b>26,497</b>	<b>32,068</b>	<b>31,100</b>	<b>(100)</b>

**Table 11: Commercial Shrimp Production by species (1992 to 1996) in MT.**

SPECIES	1992	1993	1994	1995	1996	%
<i>Acetes</i>	4,003	8,992	8,292	8,232	8,144	90.0
Endeavor prawn	427	387	341	382	252	4.3
White shrimp	294	435	486	288	220	4.1
Brown rough shrimp	229	35	26	119	117	1.3
Tiger prawn	44	11	8	6	8	0.2
<b>Total Commercial</b>	<b>4,997</b>	<b>9,860</b>	<b>9,153</b>	<b>9,027</b>	<b>8,741</b>	<b>100.0</b>

## Review of previous studies to improve catch composition

Limited studies have been initiated to improve the selectivity of trawls. As a consequence of the US shrimp embargo, the Philippines was one of the SEAFDEC member countries to test turtle excluder device (TED). There was not any observed interaction with sea turtles during the study however escapement of fish ranged from 6.9–11.6% using the Hooped, Super Shooter and Thai Turtle Free Device (modified super Shooter) with the latter indicating advantage over the other types in terms of lesser fish and shrimp escapement. Tests on a shrimp “separator device” also were found not applicable in dissociating shrimp and fish component of the catch.

A study on Selective Shrimp Trawling using “separator device” was recently conducted by Dickson in Manila Bay (1997). It was observed during the study that with an average catch rate of about 10 kg per hour, a 10.3% only were shrimps. Bycatch species which included fishes and invertebrates other than shrimps contributed to about (46.4% relative abundance) and 408.82 kg (43.3% relative abundance), respectively. Shrimp species included: brown rough shrimp (*Trachypenaeus fulvus*), 4.54%; tiger prawn (*Penaeus semisulcatus*), 3.52%; and greasy back shrimp (*Metapenaeus ensis*), 1.15%. It is worth mentioning that the quantities of shrimps caught were found slightly less when trawls are equipped with “separator device”: a mean catch of 10.31 kg/hr against 9.79 kg/hr while the shrimp species composition was found almost similar.

## Current legislation

In the 1980's, decreased production and profits, increased costs and rising competition among resource users prompted the establishment of certain restrictions in many fisheries including trawl fisheries.

In commercial trawling, measures included seasonal and aerial closures/restrictions (closed season- Fisheries Administrative Order (FAO) 130; 131; 132; 134; 136; 137 and 142); closed areas / designation of fishing zones, i.e., prohibition of fishing within 7 km distance from shore (LOI 1286), Presidential Decree (PD 281) and within 7 fathoms deep (RA 3048); LOI also 1328 closed commercial trawl fishing within 7 km from the shoreline and within 7 fathoms deep on a nationwide basis. Other related regulations were also promulgated to trawls and other fishing in various specific areas in the country.

The most recent was RA 8550 (1998), also known as The Philippine Fisheries Code, which under its implementing rules (Fisheries Administrative Order 201) prohibits active fishing gears like trawl in municipal waters (within 15 km from shore). The minimum mesh size regulation for trawl and other gears is 3cm except for gears to capture peneaid shrimps for pond-culture, shrimp/prawn fry, and small but relatively matured species such as *Acetes* (FAO 155)

In addition, the Local Government Code (RA 7160) also designated waters within 15 km from the shoreline as municipal waters and the responsibility to manage the fisheries therein has been devolved to local government units. Specific fishery measures are now being formulated and enforced by the local governments which regulated or banned trawling in their respective jurisdictions.

## Recommendations for future research or legislative intervention

Obviously the current practice in shrimp trawl fishery is not sustainable where catches include high proportion juveniles. Research, development and institutionalizing (policy formulation/implementation) the use of BRDs focusing on juveniles should therefore be a priority.

In addition, existing unavoidable bycatch (the quantities of which may vary much according to fishing grounds) and their utilization should be assessed and carefully studied, taking into account the socio-economic aspects and implications in introducing technical measures to address issues on hand.

## Bahrain

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### Abstract

The shrimp (95% *P. semisulcatus*) catch was 2.571 t in 1997 during the season authorized for shrimp fishing or nine months. (The fishing season is now being reduced from nine to six months.)

With a mesh size in the codend of 30 mm, which is common, the amount of bycatch is not known.

For the 1997/98 shrimp season, there were 306 licensed boats. The majority of them are 16–19 m in length doing single net stern trawling, mainly at night.

Bycatch Reduction Device has been tested with encouraging results.

The main problems reported include: some evidence of overfishing consisting in reduced catch rates and more small sized shrimp in the catch, bycatches of fish, including large quantities of juveniles that are so far discarded.

### Overview of individual fisheries

Bahrain Fishing Company (BFC) was the first established company to commercially exploit shrimp resources. This company started its fishing operations in March 1967 (FAO 1978). American and Japanese markets were the main purchasers of shrimp catches, most of which were exported as headless shrimp (Boerema and Job, 1968).

In the first two years of its operation, BFC operated eight trawlers. Eight more trawlers were soon added in 1968. Further, two more boats were added to the fleet in 1973 (FAO, 1978). In 1976 some of these trawlers were replaced and the total number reduced to 15 boats (FAO, 1978). All trawlers were double rigged (outrigger trawlers), using Gulf of Mexico trawl nets. Their headrope length ranged from 14 m in the case of small boats, to 17 m in the case of big boats. Mesh sizes of these nets ranged from 45 to 50 mm. All boats were steel hulled; their length ranged from 15 to 23 m.

BFC was the only company allowed to fish in Bahrain waters. The fishing season of this company usually started in Maniffa grounds off Saudi Arabia during July and August. From September to February, both Saudi and Bahrain grounds were fished (FAO, 1978). Total landings of this sector included the catches from both Bahrain and Saudi waters (Boerema and Job, 1968; Boerema, 1969; FAO, 1973; FAO 1978).

After a sharp decline in catches in the 1978/79 season and in the early 1979/80 season, shrimp trawling became uneconomical and the BFC ceased fishing in August 1979 (Abdulqader, 1983). A revival of the industrial sector of the Bahrain shrimp fishery started in 1980/81, but it experienced low catch rates. This fleet operated 4 double rigged trawlers which had been trawling for fish since 1975.

The artisanal trawl fishery started in 1971 (Abdulqader, 1983) by fishermen previously involved in the barrier trap fishing. In 1976, there were 26 full time shrimp trawlers in this category mainly operating from Sitrah jetty. All of these boats were made of wood known locally as “banoush”. After the implementation of the registration and a licensing scheme in 1983, shrimp trawlers increased to 68 boats (Abdulqader, 1988). In 1985, the number increased to 495, with small boats forming 54% of the total.

From 1971 to 1985 artisanal shrimp fishermen were manually hauling the nets. Winches were introduced in 1986 by the Directorate of Fisheries. In 1997 about 86% of the fleet were equipped with winches.

Since the start of the artisanal shrimp fishery, the Sitrah pier was the main landing site for this sector. This was due to the closeness of this site to the main artisanal fishing grounds. After the implementation of a shrimp fishing ban period in 1980/81 (Abdulqader, 1982), the northern grounds became more important to the artisanal fleet. With that change the Manama landing site became an important shrimp landing site. The shrimp fishing ban regulation, and the introduction of winches, shifted the artisanal fleet to exploit deeper waters in the north.

Shrimp landings from industrial and artisanal fishing fleet are presented in Figure 1. High landings were observed for the industrial fleet before the crash of the fishery in 1979. The second period of industrial landings started in 1980 (Figure 12).

The increase in the size and fishing power of the artisanal fleet resulted in a gradual reduction of the industrial fleet's role in shrimp fishing. The latter fleet was able to fish only for a few weeks of the season. In 1997, a decree was issued to totally ban fish trawling in Bahrain waters. This decree resulted in the removal of all industrial boats from the shrimp and fish fisheries. These boats had become dependent on fish trawling.

Bahrain shrimp fishing boats vary in size and composition. Wood is the traditional material used in boatbuilding. Recently, the number of fibreglass boats has increased. Low maintenance cost and lighter weight are to the advantage of the fibreglass boats which fishermen now prefer.

Regardless of the building material used; all big and medium size boats are built following the traditional boat design which is well known in the Arabian Gulf area and adjacent seas. Banoush is the local name used for these boats.

Most of big and medium boats are equipped with winches, while in most of the small boats, nets are retrieved manually. Most of the fishing boats use second hand car engines or diesel engines to power their winches. Also many shrimp boats use hydraulic winches.

In the 1997/98, the total number of shrimp boats was 335 boats. About 14% of these boats had no winch; 49% were fibreglass boats. Bahrain shrimp fleet includes boats from 5 to 23 m in total length. The majority of these boats are about 16 m length. The Bahrain fleet contains a considerable number of small boats. All boats used in the present shrimp fishery are powered either with outboard (class A boats), or inboard engines. Engines of 300, 200 and 50 horsepower are most common in the Bahrain shrimp boats. The 450 horsepower engines are used by steel hulled boats. These steel boats were banned from the Bahrain shrimp fishing fleet in 1997. Most of Bahrain shrimp boats were built in Bahrain and the United Arab Emirates. Most of boats built in UAE are fibreglass big boats, while most boats built in Bahrain are wooden boats. Most of shrimp fishermen depend on GPS navigation in their fishing operations.

A single net of the Gulf of Mexico flat type is used per fishing boat. According to the boat size, nets varied in size from 5 to 24 fathoms footrope lengths. Cod ends are usually made of 1.182 inches (30 mm), 65 double-twine netting. The remainder of the net is usually made of 1.5 inches (38 mm), 35 double-twine netting. One or two rows of chains (8 mm thickness) are usually used. Nets equipped with two rows of chain are towed with higher speed.

Doors used with net are made of wood. Steel is used in these doors to support wood pieces, and to form the door base. The common door used is 140 cm length by 70 cm width, and about 80 kg in weight. All shrimp fishing boats trawl with a single net.

The catch is sorted into shrimp, crab, and commercial fishes. The remaining catch is discarded at the sea. This last portion usually includes non-commercial fish, juveniles of commercial

fishes and occasionally marine turtles. At end of the season, catches usually contain significant quantities of small shrimps other than *P. semisulcatus*. These shrimp are partially kept during the periods of high market demand.

From 1998, the Bahrain shrimp fishery was based only on the artisanal fleet. This fleet has grown over time and thus became very efficient. The word “artisanal” is no longer valid to define Bahrain’s shrimping sector. A commercial sector is a more appropriate term to describe the present shrimp trawl fisheries

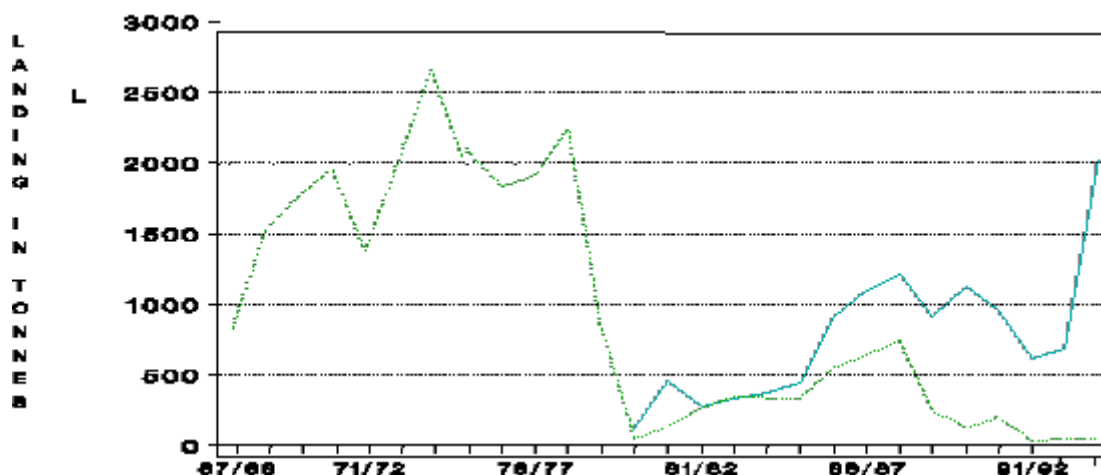


Figure 12: Shrimp landings from artisanal (solid line) and industrial sectors from 1967/68 to 1993/94 fishing seasons. (Source: FAO 1978, and Fisheries Statistical Services, 1998a).

The shrimp fishing grounds extend from a depth of 2 to 20 m. There are three major shrimping areas: western, northern and southern area. The approximate locations of the shrimp fishing grounds were determined with fishermen’s assistance (Abdulqader and Mehic, 1996). Fishermen identified fifty shrimp fishing grounds within Bahrain waters. Local names are used to identify these grounds. Total shrimping area is estimated at about 871 km<sup>2</sup>. Ghumais fishing ground located at the south, is the biggest fishing ground (area 163 km<sup>2</sup>), it makes up 18.7% of the total shrimping area. The second important ground is Umm-Adood (area 105 km<sup>2</sup>) found in the north, which makes 12.1% of the total shrimp grounds.

## Target and non-target species

Seven penaeid species were found in Bahrain waters (Abdulqader, 1999). Commercial shrimp landings are mainly from a single species, *Penaeus semisulcatus*. The six other remaining species makes about 5% of the annual shrimp landings. Two species *P. latisulcatus* and *Metapenaeus kutchensis* grow to good size. The remaining four species *M. stebbingi*, *Trachypenaeus curvirostris*, *Metapenaeopsis stridulans*, and *M. mogiensis* are smaller and are usually partially or entirely discarded. Catches of small sized shrimp frequently exceed the amount of big shrimp catches at the end of the season (February and March).

Increasing shrimp trawl selectivity is an important solution to minimize fish bycatch. Fish catch rates in Bahrain waters are generally low. Discard from shrimp trawls commercial bycatch may be contributing in decreased fish catch rates.

In Bahrain waters, turtles are incidentally caught in shrimp trawls. The magnitude of these incidences is difficult to assess especially as turtles are not landed for human consumption. Turtles caught are alive and just usually returned to the sea. The shrimp fishing logbook scheme provided a good opportunity for data collection on turtle incidence in shrimp trawls. Collection of turtle incidence data started with the 1997/98 shrimping season. Results of the 1997/98 season were completed and presented in Abdulqader (draft). Information provided below is based on this work.

From the 1997/98 shrimp season, an additional column was introduced into the shrimp fishing logsheet. In this column, fishermen were instructed to note down, on a daily basis, the number of turtles found in their catches. The 'X' symbol was used to indicate turtle absence. Since fishermen only use one local name for sea turtles, it was not possible to differentiate different turtle species.

In the 1997/98 season, there were 1,229 turtle incidences from 54,831 fishing days. Out of the 20 fished areas during the 1997/98 season, turtles were found only in 12 of these grounds. The "Umudood" area received most of the fishing effort and was the second highest in turtle incidence. The highest turtle incidence was found in "Qumais" fishing area, which had the second highest amount of fishing effort.

Turtles were not found in the western grounds, including Aleslah and Khur Fasht areas. Turtles were also not found in other areas, including Buoy 25, Jaradah, Mina Sulman, Jaw, Ras Albar, Umalnaisan, and Tibab.

The highest number of turtle incidences and fishing effort were in October 1997. Turtle incidence declined in the following months and was at the minimum by February 1998. Fishing effort also shows a similar declining trend during these months but by a smaller magnitude. Turtles were found in the shrimping ground throughout the season.

## Review of previous studies to improve catch composition

Research projects has been conducted to develop a Bycatch Reduction Device (BRD) for Bahrain shrimp fishery.

Initial experiments concentrated on evaluating square mesh as a means of reducing fish bycatch (Abdulqader and Mansoor, 1996). A rigid grid was developed to exclude big mammals and to facilitate the escape of small fish. The Radius Square Mesh (RSM) was used instead of Square Mesh (SM). Escape areas for small fish and big mammals were covered by collecting bags. All mammals which escaped from the nets were collected in these bags. The preliminary results of these experiments were encouraging. (Table 1) which also gives an idea of common bycatch species.

**Table 13: Species/group, percentage escape in number from a BRD experiment on 18 August 1997. Numbers in brackets indicates number of species.**

SPECIES (NUMBERS) / GROUP NAME	% ESCAPED
<i>Lethrinus sp.</i> (3)	15.4
<i>Siganus canaliculatus</i>	71.4
<i>Gerres sp.</i> (3)	30.8
<i>Rhabdosargus haffara</i>	48.9
<i>Upeneus sulphureus</i>	23.2
<i>Nematalosa nasus</i>	11.1
<i>Scomberomorus commerson</i>	12.5

SPECIES (NUMBERS) / GROUP NAME	% ESCAPED
<i>Scolopsis taeniatus</i>	36.8
<i>Alepes melanopetra</i>	63.6
<i>Selar crumenophthalmus</i>	76.5
<i>Arius thalassinus</i>	43.8
<i>Carangidae</i> (7)	38.9
Other sp. (14)	49.0
<i>Sepia</i> sp.	31.6
<i>Protunus pelagicus</i>	1.7

Further experiments were conducted by covering areas of escape of small fish and big mammals. The aim of these experiments was to set the specification of the Bahrain BRD.

In February 1999 a new research project on BRDs was started. This programme aims to test the BRD with seasonal variations in fish abundance and change in the physical properties of sea water.

## Current legislation

At present, shrimp fishing in Bahrain is not restricted to water of certain depths. Except for the shrimp ban period, fishing can be practised at any time and in any area regardless of the depth.

The GCC Fisheries Committee (fourth session, 3–4 October 1996) proposed an expansion of the shrimp fishing ban period to 6 months. The ministerial meeting in November 1996 approved this. For the unique social and economical conditions, Bahrain was excluded from the immediate enforcement of this regulation. In Bahrain the ban period was extended gradually from three to four months only. Further expansion of the ban period received strong opposition from Bahraini fishermen. The GCC countries had great concern about the non-implementation of the six months ban period. This matter will be discussed at a future ministerial meeting.

Bahrain fisheries suffer from inadequate enforcement of fishing regulations (Directorate of Fisheries 1993). This problem was defined as a major obstacle to development of the Bahrain fisheries. In order to establish better control, surveillance, and management, the cabinet issued Decree Number 6 for the year 1997 to create a special committee to address and enforce fishing decrees. This committee includes officials from the Ministry of Works and Agriculture (Directorate of fisheries), Ministry of Information and Cabinet Affairs (television, radio, press), Ministry of Housing, Municipalities, and Environment (Environment Affairs, Municipalities), Ministry of Interior (Coast Guard Directorate), and the Ministry of Labour and Social Affairs.

The Fisheries Enforcement Committee initiated significant surveillance and control efforts during the 1997/98 shrimp ban period. This effort was still not enough to achieve full implementation of shrimp fishing regulations. Illegal shrimp fishing was again reported during the 1999 ban period.

## Recommendations for future research or legislative intervention

Bahrain fisheries suffer from inadequate enforcement of fishing regulations (Directorate of Fisheries 1993). This problem was defined as a major obstacle to development of the Bahrain fisheries. In order to establish better control, surveillance, and management, the cabinet issued Decree Number 6 for the year 1997 to create a special committee to address and enforce fishing decrees. This committee includes officials from the Ministry of Works and Agriculture (Directorate of fisheries), Ministry of Information and Cabinet Affairs (television, radio, press), Ministry of Housing, Municipalities, and Environment (Environment Affairs, Muni-

palities), Ministry of Interior (Coast Guard Directorate), and the Ministry of Labour and Social Affairs

Lower catch rates, longer trawling periods, and smaller shrimp sizes, are all indicators of over-fishing in the Bahrain shrimp fishery. In addition, the shrimp fleet contains a wide size range of boats. This includes small boats, which mainly operate on shallow waters, and big boats, which operate in deeper waters. This contracting fishing strategy prevents the proper management of the Bahrain shrimp fishery. The future management requirements should assure that all fishing boats should maintain the same fishing strategy. This can be achieved by setting the minimum and maximum size limits of the fishing fleet. This regulation excludes small boats, and consequently prevents catching small shrimp during the season.

To ensure protection of shrimp recruits, a ban area regulation might be considered. This regulation might prevent fishing and other destructive activities in specific areas. These areas should be determined as important shrimp nurseries. However, since enforcement is still inadequate, it would be difficult to secure and protect these sensitive nursery areas.

Abdulqader and Naylor (1995) suggested that important shrimp nursery areas are found in the shallow water areas south of Fasht Al-Adhom. These waters also may be the spawning ground for *M. stebbingi* and *M. kutchensis* (Abdulqader 1999). Therefore, it is important to protect these shallow waters against fishing operations and other human activities. A distance of 1 mile from the coast or from coral reefs may be an appropriate distance.

To achieve adequate protection of shrimp recruits, it is necessary to extend the shrimp ban period to six months. Both March and August should be included in the ban period. The GCC Fishery Committee also proposed a similar time period for the shrimp ban period.

Over capacity is a major problem in the Bahrain shrimp fishery. The number of fishing boats increased from 26 to about 400 between 1976 and 1999. The increase in the number of fishing boats has resulted in less catch per boat. This is creating difficult economic conditions for these boats. During bad seasons, several boats were unable to continue and were forced to leave the fishery. The present number of boats exceeds the potential of the stock. According to Abdulqader (1995) 73 full time boats are enough for this fishery. The first step toward reducing the number of boats is to stop issuing new shrimp fishing licenses.

Bahrain shrimp fishery suffers from extremely high fishing effort and recruitment over-fishing. Any development plan should set 1) an upper size limit for trawl nets, and 2) lower and upper size limits for the shrimp fishing boat.

### **Increasing Net Mesh Size**

Increasing mesh sizes may contribute towards increasing net selectivity. Increasing mesh sizes will also reduce the resistance of the nets during operation. This will be economically beneficial to the fishing boat. The present minimum mesh size (30 mm) is relatively small. For the future, the increase of minimum size to at least 40 mm should be considered.

### **Implementation of BRD**

The present experiments proved that the use of the BRD in the Bahrain shrimp fishery would be beneficial to the fishery and the marine environment. These benefits need to be highlighted and demonstrated to the fishermen. These benefits included: 1) reducing the sorting time; 2) improving shrimp quality; 3) maintaining net efficiency for a longer period; and 4) maintaining the bio-diversity of the environment. Demonstrating these benefits will convince fishermen to adopt the BRD.

For successful BRD adoption by shrimp fishermen, it is important that they believe in its importance. They should understand the operation concepts of the BRD and should be able to handle problems arising from use of the device. An extension programme should be initiated to demonstrate the necessity of the device to achieve responsible fishing. Also fishermen need training on how to make the device and how to solve problems that may arise from using it. Training also will be required for the Coast Guards who should focus on legal specifications of BRDs, and procedures to verify these specifications.

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## IRAN

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### Abstract

The estimate of the shrimp catch was 6 780 t for 1998. The main species differ according to fishing ground, e.g., tiger shrimp (*Penaeus semisulcatus*) is 80% of the catch in Bushehr Province while more than two thirds consisted of banana shrimp (*P. merguensis*) in Hormozgan Province. It is worth mentioning the huge development of shrimp aquaculture since 1995. The amount of shrimp exported has increased over the last few years.

As an estimate, shrimp would be about 10–17% of the total catch when using shrimp trawls, juvenile fish being about half of the total catch.

The shrimp fishing fleet consists of 39 outrigger trawlers (decreasing over the last few years) and around 2 400 smaller traditional “Dhow” boats or FRP craft doing single trawling. The number of licences for trawling has been, over the last few years, seriously curtailed.

In each province the season for shrimp trawling lasts approximately six weeks: The opening is based on continuous survey of maturity and body length of shrimp, the closure is decided when trawl surveys indicate that only 20% of the shrimp stock remains. Fishing at night is prohibited in certain areas. In Hormozgan Province a control of the discards exists.

The main problems include: resources which are overfished; threat to fishing grounds and sea habitats due to expanded exploitation with very large bycatch; Lack of a defined and organised participation of fishermen, (interested parties) in rebuilding and protection of resources; lack in the fisheries management plans of consideration to biological and socio-economic factors; lack of regional collaboration in applying regulations.

A several-year programme is proposed for shrimp fisheries and their sustainable development with a precautionary approach. The programme includes: - improvement of the fishing technology with the introduction of bycatch reduction devices (BRDs) as a follow up to the tests carried out in 1997; - biological and environmental studies - better control of the fishing effort; - improvement of management plan; - adequate extension work and education to encourage

the improvement of practices within industry; - improvement of fishing industry participation and relevant regional cooperation.

## Overview of individual fisheries

The industrial shrimp trawlers (steel vessels) tow two trawls simultaneously with outriggers. This type of trawl has a four-seam design originating from the Mexico shrimp fishery. The wooden boats (Dhows) tow a single shrimp net and the FRP craft also use single trawl nets. The size and design of the nets is different according to vessel power and region.

The table below presents the amount and value of shrimp exported during past few years:

**TABLE 14: Shrimp exports**

YEAR	1991	1992	1993	1994	1995	1996	1997	1998
Export/tonne	849	1630	1000	1188	931	2100	2489	3095
Value/000\$	5574	7800	7000	9000	3588	8664	8986	9567

Three types of fleet are currently shrimp trawling and these can be divided into two sectors:

### **A: Industrial sector (steel vessels)**

There are 39 steel trawlers between 20 to 30 m in length (mean length is 27m); the engine power for these vessels ranges from 250 to 600 kw (350 to 800 HP) and mean power is 750 HP.

### **B: Artisanal sectors (wooden vessels and small GRP boats)**

Approximately 870 wooden vessels with 16 m average length (14 to 20 m), width 4.5 to 6.5 m and with 73 to 160 kw (100 to 220 HP) engine power, an average of 180 HP; the vessel capacity is between 45 and 65 tonnes.

Approximately 1 500 fibreglass (GRP) boats with 7 m mean length and 25 to 45 hp engines make up the third type of shrimp trawlers vessels.

Therefore today more than 2 400 vessels (i.e., about 1/4 of the total number of fishing vessels) are engaged in the catch of shrimp during the fishing season. Shrimp fishing makes more than 15 000 direct employment opportunities as fishers and also many indirect jobs in marketing, processing, distribution, etc.

## Target and non-target species

The Iranian shrimp fishery extends along much of the Iranian coast (with the exception of Sistan province in the southeast) and is divided into three regions or provinces, namely, Bushehr, Hormozgan and Khozestan.

The South's share in total catch is about 60% and 4–5% of this amount consists of shrimp.

The total shrimp catch reported in 1998 was 6 780 tonnes.

The catch volume in over recent years by province is indicated in the following table:

**Table 15: Shrimp catch by province.**

PROVINCE/YEAR	1996	1997	1998
Khozestan	876	990	1,330
Bushehr	3,460	1,870	2,650
Ilonnozgan	1,850	2,000	2,800
TOTAL/tonnes	5,885	4,860	6,780

The shrimp species found in the Iranian waters are as the following:

- *Penaeus merguensis* (Banana shrimp)
- *Penaeus semisulcatus* (Tiger shrimp or Green tiger prawn)
- *Parapenaeopsis stylifera* (Kiddi shrimp)
- *Metapenaeus affinis* (Jinga shrimp)

The dominant target species in Honnozgan Province is banana shrimp (70%) and 30% for *Metapenaeus affinis*, Tiger shrimp and *Parapenaeopsis stylifera*. Tiger shrimp dominate in Bushehr Province (80%) and 20% of shrimp catch in this province is for *Metapenaeus affinis*. The dominant target species in Khozestan Province are *Metapenaeus affinis* and *Parapenaeopsis stylifera*.

In shrimp trawling the target species is shrimp, the rest of the catch in this study is referred to as bycatch. About 10–17% of the total catch consists of shrimp. The bycatch in this study is divided into three major categories:

- a) Small fish, under 15 cm in length, are 10–25% of the total catch.

They are all discarded. This group comprises:

- *Theraponidae*, pony fish, threadfin bream 40–60%
- shad, crab, mullet 20–30%
- sardine, cat fish 15–25%
- croaker, *Triacanthidae* 5–10%

Juvenile fish: (40–60% of the total catch)

The juvenile fish discarded are usually under 30 cm in length and comprise:

- flounder, Indian flat head, cat fish, tongue sole 40–60%
- - shark, lizard fish, sting ray, sea bream 30–40%
- - silver pomfret, black pomfret, croaker, hair tail, snapper 10–20%

(3) Large Fish: (10–20% of total catch)

Large fish more than 30 cm in length comprise:

- lizard fish, sting ray, flat head, shark, croaker 75%
- hair tail, grouper, southern meager, grunt 15%
- others 10%

The Cancun Declaration (Mexico, 1992) provides that “States” should promote the development and use of selective fishing gear and practices that minimise waste of catch of target species and minimise bycatch of non-target species.

The Iranian shrimp fishery is typical of many tropical shrimp fisheries world wide being characterised by a wide variety of bycatch species. In the Persian Gulf as in other tropical areas many different species found in the same fishing ground, at the same time. The result is that due to the diversity of species in shrimp trawling grounds unwanted species is unavoidable.

## Review of previous studies to improve catch composition

Following are some BRDs that have been tested in Iran so far:

### Squaremesh window

This is one of the simplest BRDs. The window allows fish to escape upwards through large square mesh, while the shrimp that do not swim as well as fish are carried away with the currents into the codend.

### Parallel ropes

Such a bycatch reduction device with parallel ropes consists in a window with parallel ropes extended lengthwise along the trawl (in place of square mesh). It is normally located in the same position as the square mesh window.

### Fisheye

A fisheye is a small elliptical opening, steel framed which is arranged in the codend to allow some fish to escape. It faces forward in the upper part of the codend. It is worth mentioning that fish passing into the codend must turn to swim forward to escape through this device.

### Cone

The cone is not a BRD by itself but it is an element designed to increase the efficiency of BRDs to exclude fish from the trawl. It consists simply of two panels of netting attached to a small wire hoop and inserted behind a BRD such as: fisheye, square mesh window; the cone impedes the passage of fish into the codend and stimulates them to swim forward and through the escape openings.

### Rigid Grid

The NAFTED was originally used by the Australian Maritime College to exclude large animals such as shark, stingrays and turtles (however some experience shows that in general small fish are also excluded). The NAFTED BRD features a grid, with a bar spacing appropriate to local conditions, secured to the trawl at 45 degrees. A panel of netting guides all animals to the bottom of the codend and prevents shrimp loss through the escape opening in the top of the codend. Large animals are physically guided through the escape opening while shrimp and other small animals pass through the bars and into the codend.

## Current legislation

In each province the season for shrimp trawling lasts approximately six weeks. For the opening of the fishing season, two elements, maturity and body length of shrimp, are studied through field survey. Different fishing grounds may be opened on different dates, if required.

Normally, in Bushehr province the fishing season begins early in mid-August and ends in late September. In Hormozgan, it begins mid-October and extends to late November and finally in Khuzestan province it begins in mid/end October and extends to late December. The fishing

season is closed on the basis of field studies to determine the percentage of the reserved stock and is closed when trawl surveys indicate that 20% of the shrimp stock remains.

The other management measures include a reduction of the number of new licences for shrimp trawling (this number has been, the last few years, seriously curtailed), introducing and applying some BRDs, control of fishing in the concerned fishing ground, control of discards (only in Hormozgan Province), etc. The number of vessels in the shrimp fishery has been less and less over the past few years, especially in industrial fleets, led by Iranian fisheries Companies, while the number of small GRP boats is increasing.

## Recommendations for future research or legislative intervention

The participants in the Working Group on shrimp and demersal fishes held in May 1996 (Kuwait) observed that the amount of bycatch resulting from intensive shrimp trawling in the Persian Gulf is becoming a very serious problem for the demersal fish stocks and for the sustainability of fisheries in the region. As overfishing is a problem in every Persian Gulf country with shrimp trawling industry having a serious impact on non-target species, i.e., bycatch, it is recommended that bycatch reduction devices (BRDs) be tested in the region and introduced with the commercial fishery.

## Cameroon

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### Abstract

In 1996, the trawler landings consisted of 9 258 t of fish and 571 t of shrimp, (only, because companies do not declare the real quantities caught). These are *Penaeus notialis*, *Penaeus kerathurus* and *Parapenaeopsis atlantica*.

The bycatch constitutes normally around three quarters of the landed catch and around 75% of the finfish landed are juvenile. Only bycatch products are sold at the local markets. The quantity discarded at sea is unknown.

There were in 1998, 65 shrimp and 9 fish trawlers under the Cameroon flag, most of them operated within joint venture arrangements (so called 'time charter' companies).

The shrimp trawlers were initially fishing in waters of more than 30 m; later on they started to explore the coastal zone near estuaries, where nurseries are located and where the amount of fish caught greatly increased.

However, trawling within the zone of three nautical miles from the coast is, theoretically, prohibited (As well as the catch of juvenile fish). There is no legal fishing season.

The main problems reported include: over capacity and too high pressure on shallow water areas (where the nursery grounds are located), therefore, huge quantities of juvenile fish in landings; poaching by foreign boats is also mentioned

### Overview of individual fisheries

The marine fisheries of Cameroon are divided into two major sub-sectors: the industrial fisheries and the small scale/artisanal ones.

## Average characteristics of Cameroonian industrial trawlers

CHARACTERISTICS	1969	1999
Overall length (m)	22	25
Gross registered tonnage	98	145
Engine horsepower	400	600

The shrimp trawlers use two or four nets simultaneously, one or two on each side of the vessel towed at the extremities of two outriggers (Florida type). The Florida type with twin trawls was introduced in Cameroon in 1998 by the CAMECRUS Company, which acquired 20 steel built boats from Spain. These boats have the following technical data:

**Vessel**

Type of ownership: private company named CAMECRUS.

It is the leading company in the shrimp fishery with 25 boats.

**Description of the boats:**

The boats were built in Spain in 1998. The autonomy during fishing activities is 30–35 days.

Registered Gross tonnage: 135

Overall length: 30 m

Average engine horsepower: 750 HP

Towing speed for fish 3nm; shrimp: 2nm

Fish finding equipment: Echo sounder FC 581 series 8831 01 64

Input: 10.5 30 ov

Frequency: 50 KHZ at shallow sea; 200 KHZ at deep sea.

Quad-rig (two twin trawls), each trawl:

- Length of head rope: 18.20 m; diameter: combined wire: 16–18 mm;
- Length of ground rope: 22.20 m; diameter: 18 mm;
- Total length of the trawl: 22 m;

Shrimp processing facilities on board:

8 freezing plates are available for 16 trays of 20 kg per tunnel;

Freezing temperature: -32° C;

Freezing duration: 3 hours;

Cooling room capacity: 60 metric tonnes.

**Operations:**

The shrimp trawlers operate mainly along the Cameroonian coastal area.

However some are fishing in Mozambique, Gabon and Equatorial Guinea

Duration of the fishing trip:

Nearest area: 3 hours

Far area: 6–8 hours

General distribution of the bottom:

Muddy and sandy near the main rivers (Wouri, Sanaga, Nyong and Rio del Rey),

Rocky at Kribi, Campo and Limbé.

Average trawling depth: 25 m

List of target species:

Shrimp

Croaker, Barracuda, Sole (high value species) and others.

Other companies use also outrigger trawlers but not with two twin trawls but two main trawls only and a try net. The wings and the belly of the trawl are made of polypropylene and the codend of polyamide. The average mesh size of the codend of shrimp trawl varies between 25 and 33 mm, according to the company, the size of the boat and the size of the net. None of the boats uses bycatch reduction devices (BRDs).

The fishing industry is dominated by the so called ‘Time Charter’ companies which are a kind of joint venture involving nationals holding a ‘Fishing Authorisation’, and foreigners with boats. The Cameroonian counterpart receives royalties from his partner who owns the catch. This catch is fraudulently exported and sold abroad. Only bycatch products comprising mainly juvenile fish are sold in local markets. Nine ‘Time Charter’ companies were registered in 1998. In addition, three local companies (COPEMAR, SOCIAA, and CAMECRUS) sell their products locally, except for shrimp which is exported.

The shrimp trawlers which exploit the pink shrimp (*Penaeus notialis*) operate mainly in the coastal zone between the Cameroon and Rio del Rey rivers. Sometimes, they operate off the Sanaga River. The pink shrimp are dominant at a depth of 30 to 60 m. The Guinea shrimp (*Parapenaeopsis atlantica*) and the Caramote prawn (*Penaeus kerathurus*) are found in the shallower coastal sector of 10 to 30 m depth. The main fishing grounds for those species are located between Sanaga River and the Ambas Bay.

Artisanal shrimp fishing is practised in estuaries and creek zones. This is mostly located in artisanal fishing camps of Mabeta and Mboko in Fako Division, as well as Mokala and Bamusso in Ndian Division. Only one type of net is used for this purpose. This net is locally known as “ngoto”. The ngoto is used to exploit small estuary shrimp, *Nematopalaemon hastatus*. It has a conical shape and is 7 to 9 m long with a circular or rectangular opening depending on the type used. The ngoto has a very small mesh size (mosquito net) and the species caught has a mean length of about 6 cm. The ngoto is normally attached to a monoxyle or plank canoe of 7 to 11 m long and about 1.7 m wide with as propulsion mean, paddle or sail but in most cases, 8 or 15 horsepower engine. Nearly 200 fishing canoes are active in the fishing camps of Mabeta, and 75% of them are motorised.

## Features of Cameroonian artisanal fishery

RESULTS	1983 SURVEY	1995 SURVEY
Number of main fishing villages	57	206
Number of canoes	6,011	7,335
Range of canoe length	4 – 17 m	4 – 20 m
Non – motorized canoes	67%	73%
Motorised canoes	33%	27%
Total number of fishermen	18,625	24,136
Percentage of indigenous fishermen	10 %	17 %
Percentage of immigrant fishermen	90 %	83 %

Sources: Njock (1985); Njifonjou *et al.* (1995).

## Target and non-target species

A brief research and observation mission was carried out on board a shrimp fishing trawler in 1999 to study the discards: identifying the different species which are discarded and analysing the length frequency distribution of the various species. Out of samples amounting to a total of 67 kg of discards, two categories of fish were identified:

- the low commercial value bycatch totally discarded (hairtail, shad, crabs), and
- the juveniles of marketable fish.

The composition of the samples was as follows:

- Marin debris 21%
- Hairtails (*Trichurus lepturus*) 16%
- Crabs 13%
- Shad (*Ilisha africana*) 8%
- Other juvenile fish 42%

The analysis of specific composition of the samples shows that nearly 40 different species are caught and discarded (Table 16).

**Table 16: Various species identified in the discards of shrimps fishing trawlers.**

N°	COMMON NAME	FAMILY NAME	SCIENTIFIC NAME
1.	Soles	<i>Soleidae</i>	<i>Synaptura sp</i>
2.		<i>Cynoglossidae</i>	<i>cynoglossus senegalensis</i>
3.	Bonga (sardine)	<i>Clupeidae</i>	<i>Sardinella maderensis</i>
4.			<i>Ethmalosa fimbriata</i>
5.	Bars	<i>Scianidae</i>	<i>Pseudotolithus senegalensis</i>
6.			<i>P. typus</i>
7.			<i>P. elongatus</i>
8.	Petits capitaines (Fritures)	<i>Pomadasyidae</i>	<i>Pomadasyis rogeri</i>
9.			<i>Galoides decadactylus</i>
10.			<i>Polydactylus sp</i>
11.			<i>Brachydeuterus auritus</i>
12.	Grands capitaines	<i>Polynemidae</i>	<i>Pentanemus quin-quarius</i>

N°	COMMON NAME	FAMILY NAME	SCIENTIFIC NAME
13.	Disque		<i>Drepana africana</i>
14.	Fritures		<i>Eucinostamus melanopterus</i>
15.		<i>Tetradontidae</i>	<i>Lagocephalus laevigatus</i>
16.		<i>Bagridae</i>	<i>Chrysichtis ne-grodidigitatus</i>
17.	Carangues	<i>Carangidae</i>	<i>Selen dorsalis</i>
18.			<i>Alectis alexandri-</i>
19.			<i>nus</i>
20.			<i>Caranx hippos</i>
21.			<i>Caranx senegalus</i>
22.			<i>Chlorocombrus chrysurus</i> <i>Trachurus sp</i>
23.	Ceintures	<i>Trichiuridae</i>	<i>Trichiurus lepturus</i>
24.	Raies	<i>Rajidae</i>	<i>Raja miraletus</i>
25.		<i>Dasyatidae</i>	<i>Dasyatis margarita</i>
26.	Barracuda	<i>Sphyraenidae</i>	<i>Sphyraena piscato-</i> <i>rium</i>
27.		<i>Sparidae</i>	<i>Pagellus spp</i>
28.			<i>Dentex spp</i>
29.	Rasoirs	<i>Clupeidae</i>	<i>Ilisha africana</i>
30.	Crabs	<i>Calapidae</i>	<i>Calappa</i>
31.		<i>Squillidae</i>	<i>rubroguttata</i>
32.		<i>Portunidae</i>	<i>Squilla aculeata</i> <i>calmani</i>
33.	Mulets	<i>Mugilidae</i>	<i>Mugil spp</i>
34.			<i>Mugil capunil</i>
35.	Seiche	<i>Sepiolidae</i>	<i>Sepia spp</i>
36.	Shrimps	<i>Peneidae</i>	<i>Penaeus notialis</i>
37.			<i>P. keraturus</i>
38.	Carpes	Lu Fisheries research is carried out by the Limbé Fisheries and Oceanographic Research Station (SRHOL). As far as the shrimp resources and fisheries are concerned, no proper research has been carried out so far (regarding for instance stock assessment and the actual level of exploitation). <i>tjanidae</i>	<i>Lutjanus spp</i>
39.	Congres		<i>Conger</i>
40.	Machoirion	<i>Ariidae</i>	<i>Arius heudeloti</i>
42.	Ceintures	<i>Trichiuridae</i>	<i>Trichurus lepturus</i>
43.	Sharks		

## Review of previous studies to improve catch composition

Fisheries research is carried out by the Limbé Fisheries and Oceanographic Research Station (SRHOL). As far as the shrimp resources and fisheries are concerned, no proper research has been carried out so far (regarding for instance stock assessment and the actual level of exploitation), but in 2004 BRD experiments has been conducted with Square-mesh window codends and 90° turned meshes codend with good results.

## Current legislation

The law in force regarding the fishery sector is Law No. 94/01, dated 20 January 1994, on Forestry, Wildlife, and Fisheries. Its Decree of application No. 95/413/PM, dated 20 June 1995, defines conditions of access to marine living resources. Its Chapter IV deals with the protection of fisheries resources in five specific zones close to the coast within the three nautical miles sector from the shore. Trawling activities are prohibited inside these sectors. Other texts of application are expected for the limitation of the mesh sizes and the regulation of the fleet capacity.

## Recommendations for future research or legislative intervention

The traditional fishing grounds for finfish trawlers are supposed to be at least 3 nautical miles off the estuaries in the coastal sector between Rio del Rey-Bibundi Bay and River Nyong estuary and possibly outside the 20 m depth exploited by the small scale fisheries. Unfortunately, studies (Njock, 1979) indicate that finfish trawlers concentrate their fishing effort in the coastal sector between 6 m and 25 m. This sad situation, existing since the early 1980s, has now become more serious. The consequence of the intensive exploitation of coastal areas, is a serious threat to demersal resources that are mostly caught at the juvenile stage. Thus, there is a need to enforce fishing regulations in this coastal zone (0–25 m depth) in order to avoid conflicts between the industrial and the small scale fisheries. A realistic solution to this problem is the establishment of an effective system of monitoring, control and surveillance.

The existing fishery regulations is, to a large extent, not fully implemented (the prohibition of trawling within the three nautical miles zone is the best example), for various reasons including:

- the recent Fisheries Law (Law No. 94/01 of 20 January 1994) and its text of application have not been fully explained to the fishing communities. This is due to the lack of means to enable fishery officers access to fishing settlements;
- because of control problems, sanctioning has been very difficult and in some cases impossible. Sanctioning of offenders would indeed be a good way to increase the awareness of stakeholders; there are no specific programmes made up by the Ministry in charge of fisheries to explain, educate and motivate the fishing population regarding the fishery regulations; the Environmental Law which regulates activities in respect to pollution of coastal waters and erosion is not implemented because the texts of application are not ready;
- the national artisanal fishing population is only 17% while the rest are aliens. It is obviously more difficult to make that the aliens apply the regulations of the nation where they operate;
- lack of an efficient system of monitoring, control and surveillance.

## Mozambique

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### Overview of individual fisheries

Prawns constituted the main commodity exported in 2001, with a value of US\$ 85 million, while the annual value of all exported fish products was US\$ 130 million.

The fishery sector is divided into three categories; 1) The artisanal fisheries of coastal communities along the coastline and in inland waters, which produce both for subsistence and commercial sale; 2) The semi-industrial fisheries by intermediate size boats (10–20 m in length), mainly involved in shallow water marine shrimp fisheries and the kapenta fisheries in

Cahora Bassa - these provide for local consumption and export; and 3) The industrial fisheries with larger vessels (> 20 m), fishing for shallow water shrimp and resources in deeper waters, mainly for export.

It is estimated that artisanal fisheries land some 70 000 tonnes per year. The semi-industrial fleet lands 11 500 tonnes of which shallow water shrimp contributes 1 500 tonnes and kapenta in Cahora Bassa contributes 9 000 tonnes. In 2001 the industrial fleet of 80 vessels licensed in Mozambique landed 10 000 tonnes of which 9 000 tonnes were shallow water shrimp. The shallow water shrimp fisheries are in commercial terms by far the most important with an export of 9 000 tonnes worth US\$ 85 million in 2001.

The most important commercially exploited stocks, including shallow water shrimp and deep water lobster, have been assessed to be highly or fully exploited.

## Target and non-target species

In Mozambique, fresh un-chilled bycatch is kept in heaps on the deck of the trawler. It is collected at sea by coastal communities using non-motorized small boats or canoes. The fish enters the traditional food chain: it is salted, dried or smoked in the villages and sold in rural and urban markets.

Bycatch comprises about 80 percent of the total catches (Table 17). The most abundant families/groups are Sciaenidae, Trichiuridae, Brachyura (crabs), Engraulidae, Haemulidae and Synodontidae, and the most abundant species include *Otolithes ruber* (tigertooth croaker), *Johnius amblycephalus* (bellfish), *Johnius dussumieri* (bearded croaker), *Trichiurus lepturus* (largehead hairtail), *Arius dussumieri* (blacktip sea catfish), *Pellona ditchela* (Indian pellona), *Thryssa vitrirostris* (orangemouth thryssa) and *Pomadasys maculatum* (saddle grunt).

**Table 17: Annual percentage of bycatch from 2000 to 2002.**

YEAR/MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
2000			53	51									52
2001								80	85				82
2002						79		87	79				81

Catch composition varies depending on the area trawled, and catches may be clean or may include different degrees of mud, sponges, algae, etc. Figure 16 shows fish catch composition by family for 2000 and 2001.

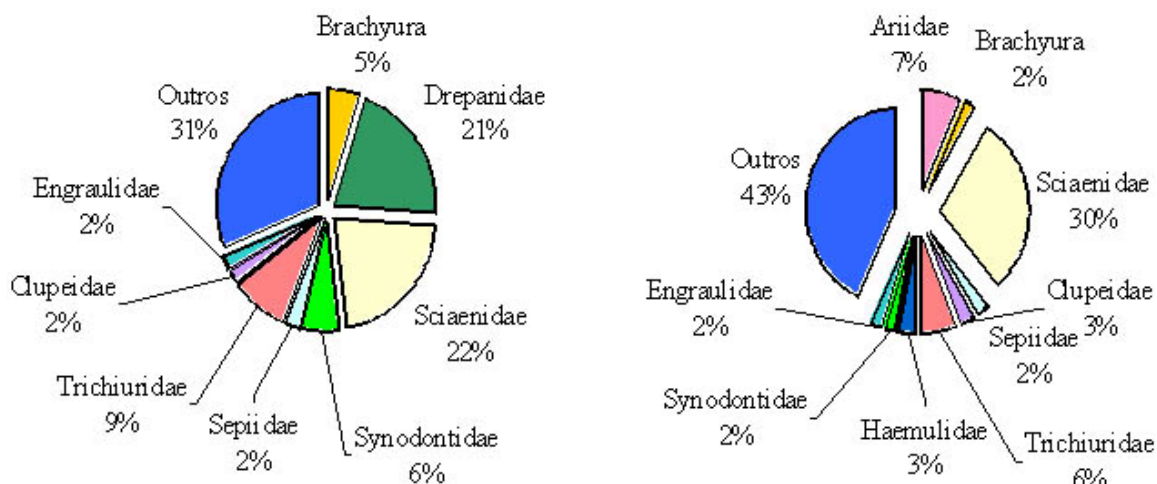


Figure 16: Main catch composition of fish for 2000 (left) and 2001 (right) (Palha de Sousa and Baltazar, 2002).

## Review of previous studies to improve catch composition

In 1993, over a 15 day period, experiments with a 0.9 m x 1.5 m aluminium grid in the aft and top section of a shallow prawn trawl were undertaken on the fishing grounds for shallow water shrimps along the coast of Mozambique. For the most abundant species (white and brown prawn), the grid gave a better size selection (more small shrimps were excluded from the catches) compared to an experimental codend with 60 mm mesh size. The best results were obtained with a grid with 14 mm bar distance and when the grid had an angle of attack close to 33 degrees.

The fish bycatch was normally between two and four times the weight of shrimps caught, and the catches contained mainly species with a maximum length of 25–30 cm. As an overall result the exclusion of fish by weight through the 60 mm codend was much higher (83 percent) than for any grid version tested (36.4 percent to 76 percent). The size selection on fish was sharper with grids compared to the 60 mm codend. The results were preliminary due to the short test period and the small number of hauls using 54 mm and the experimental 60 mm codends (Isaksen and Larsen, 1993).

In 1995, following the recommendation from the 1993 grid experiments, further experiments were undertaken with the “top-grid” system with a 14 mm bar spacing to further understand the effect of the grids. The results showed that 60 mm codends gave very clean catches retaining the biggest tigertooth croaker (*Otolithes ruber*) and bearded croaker (*Johnius dussumieri*). With the 54 mm codend, smaller sizes and greater numbers of the same species were retained. As for the 1993 experiments, the grid had a very good separation of Indian pellona (*Pellona ditchela*) and orangemouth thryssa (*Thryssa vitrirostris*).

## Current legislation

The main measures are:

- closed season of three months;
- control of mesh size of the nets (55 mm);
- annually quotas for each vessel;
- limitation of number of vessels;
- closed fishery (no more entries);

- no industrial trawlers are allowed to trawl in water less than 10 m deep and less than one nautical mile from the coast.

At the moment the Government has put into practice management measures that require the companies to offload an annual quantity of bycatch of at least double the shrimp quota for each vessel.

## Recommendations for future research or legislative intervention

The Ministry of Fisheries has to enforce the use of bycatch. The measures that have been taken until now are not effective. Some of the reasons for this include fear of theft from vessels and fears of disrupting this extremely important source of foreign revenue. Taking into account the needs for food of Mozambican people, efforts to reduce their impoverishment, and the over-exploitation of most common fish resources in recent years, we have to change our attitude and think about ways to solve bycatch problems. There is wastage occurring in high value fisheries resources. This misuse is undertaken for economic reasons by a minor group of companies and, while people are starving, should be considered morally wrong and needs to be solved. Administrative measures have to be put forward in a strong way, including use of devices for excluding bycatch. Mozambique is currently developing a fisheries policy and a bycatch policy will be included in this.

## Nigeria

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### Abstract

Shrimp is an important export commodity which earns Nigeria over US \$75 million annually. However demersal shrimp trawling generates a lot of fish bycatch. Investigation of the performance of bycatch reduction devices (BRD) as an attractive and environmentally friendly option to mitigate the problem of bycatch in shrimp trawling has commenced. Trawl nets with BRD codends including 90° turned, square mesh panel and square mesh codend were more selective and retained much lower volume of bycatch/trash fish compared to trawl net with diamond mesh codend. A comprehensive investigation of bycatch trades as well as appraisal of the socio-economic implications of the reduction in bycatch has commenced and recommendations will be proffered to ameliorate the impacts on the various beneficiaries. Appropriate regulatory measures and effective monitoring, control and surveillance strategies will also be put in place.

### Overview of individual fisheries

Nigeria lies between latitudes 4°16'-13°52' N and longitudes 2° 96'-14° 37' E. It has a coastline of 853km which borders the Atlantic Ocean in the Gulf of Guinea. It has a maritime surface area of 46000km<sup>2</sup> between 0 and 200m water depth. The continental shelf is relatively narrow and the width ranges between 14.8km in the west off Lagos and 27.8km in the east off Calabar. In 1978 Nigeria declared a 200 nautical miles Exclusive Economic Zone (EEZ) which covers an area of 210,900km<sup>2</sup> over which it has sovereign rights for the purpose of exploiting conserving and managing its fisheries resources.

The fisheries within the territorial waters and the EEZ can be broadly classified into (a) Brackish water or estuarine canoe fishery in lagoons, creeks and estuaries.

- a) Coastal (artisanal) canoe fishery within 5 nautical miles non-trawling zone. Other artisanal group targets pelagic species as well as sharks and sail fishes in deep sea.
- b) Industrial coastal (inshore and offshore) fishery. Deep water fisheries resources which have economic potentials include the tuna and drift fish *Arioma* species.

### *Shrimp fisheries*

Artisanal fishermen use stow or filter net to catch shrimps in the brackish water lagoons, creeks and estuaries. The conical filter net with a codend mesh of 10mm is towed in the coastal waters 1–2 nautical miles from the shore to catch cray-fish *Nematopalaemon hastatus*. The fishing unit is made up of planked canoe (LOA 7.5 – 9.5m) powered by 15–40Hp out-board engine. An observer programme conducted at the Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria in 2004, showed that cray-fish and bycatch were captured at a ratio of about 5–8 parts of cray-fish to 1 part of fish bycatch which comprised of 25 species belonging to 20 species.

The Nigerian Trawlers' Owners Association (NITOA) an umbrella organization of about 35 Fishing companies, operates about 250 Nigerian flagged registered vessels in 2004. The Fishing companies include Atlantic Shrimpers with over 70 vessels, Banarly, Honeywell, Sea Gold, Tarabaroz and Kulak. The majority of vessels (about 23.0 – 25.0m Length Over – all (LOA) and built in USA) are shrimp trawlers for catching marine shrimps worth US \$75 million annually in the export markets. The double rigged/outrigger refrigerated vessels usually operate four nets day and night at a towing speed of 2.5 – 3.0 knots and trawling time of 3 hours. The shrimp trawl nets usually have 4 seams, a turtle excluder device (TED) fitted in a codend extension and codend of 44mm stretched mesh size. The TED regulation came into force in 1996 to protect the sea turtles. Recently it was observed that the sea turtles have grown bigger and the current effort is to modify the existing TED and provide a larger exit opening for the turtles to escape and also optimize capture of shrimps.

The target shrimps include white shrimp *Penaeus notialis*, brown prawn *Parapenaeopsis atlantica*, tiger shrimp *Penaeus kerathurus* and giant shrimp *P. monodon*.

All the fish caught (landed or discarded) by the shrimp trawlers are considered to be bycatch which is made up mainly of under-size, immature and juveniles of commercially important demersal fish species. The multi-species bycatch is made up mainly of Sciaenidae (croakers), Cynoglossidae (soles) and Polynemidae (threadfins). The ratio of shrimps to fish bycatch ranged between 1:9 and 1:15. The volume of bycatch in industrial shrimp trawling is astronomically high and considerably larger than the volume of bycatch in small scale artisanal fisheries. The design, construction and experimental trials of Bycatch Reduction Devices (BRD) including square mesh codends have commenced in order to mitigate bycatch problems associated with shrimp trawling.

Socio-Economic component of the project is investigating in details bycatch trades in shrimp fisheries including the implications of reducing the volume of fish bycatch.

The shrimp catch was 10 807 t in 1997, pink shrimp (*Penaeus notialis*) being the most common shrimp species while, with the increase in demand, shallow water brown shrimp are now caught in larger quantities.

Vessels are using trawls with 44 mm mesh size in the codend and are, theoretically, using the Turtle Excluder Device (TED). Bycatch of fish occur, but discard ratios are not known.

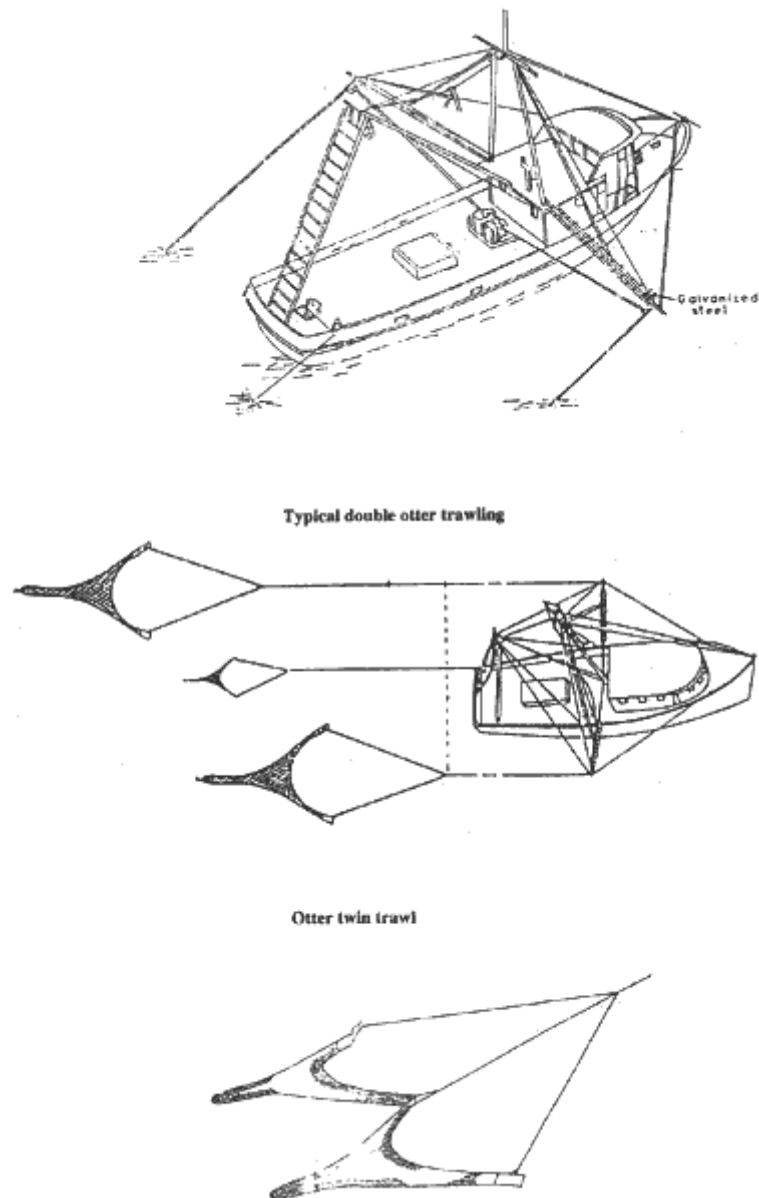
The small-sized fish caught by the shrimping vessels are sold at local markets, fresh, smoked or dried by women.

In 1999, 187 vessels were licensed for inshore shrimp fishing. The major companies with large fleets are joint-ventures. All are grouped within a "Nigerian Trawler Owners' Association" (NITOA).

There is no regulation regarding fishing season. The increasing illegal fishing for brown shrimp within the five nautical miles non-trawling zone gives rise to conflicts with artisanal fishers. Landing of all catch is mandatory in Nigeria.

The Nigerian coastal waters are most probably over-exploited with regard to shrimp resources; the breeding grounds/nurseries of commercially important fish/shell fish species are affected; large quantities of juvenile fish are caught.

Figure 17 is a technical sketch of a shrimp trawler with outriggers showing the general arrangement of the vessel, the two shrimp trawls and a try net. It is worth mentioning that the motorized vessels operating in coastal areas locally known as “Motor Fishing Vessels” have been arranged and equipped to meet the international standard of shrimp production and processing facilities.



**Figure 17: Shrimp trawler with outriggers.**

Although the Industry complains about the questionable feasibility of the fishery, with falling catches and rising fuel prices, brand new trawlers are still ordered in Alabama, and in general the fleet is new and well maintained. The trawlers are almost all quad-rigged with two otter-board trawls from each beam. The system uses two wooden doors and a centre sledge on each

side (two trawls), doors attached with almost no bridles directly to the trawl wings, and the three wires from the two doors and the sledge joining into one trawl warp. A small sample trawl is used during the tow to see if there is any catch on the particular fishing ground. If this is not the case after 5 min. tow, the quad rig is hauled and the vessel steams to another ground.

As far as the shrimp trawl are concerned, the netting material is either polyethylene (PE) or polypropylene (PP) and meshsize in all trawl sections, apart from the codends, is between 51 mm and 55 mm. The twine diameter is around 1.4 - 1.6 mm in all sections except the codend with 1.9 mm and more, of diamond mesh type. The legal codend meshsizes for the fish trawl net and shrimp trawl net are 76 mm and 44 mm stretched respectively. The technical drawing of a typical shrimp trawl net is given in Figure 4.

The otter boards are not uniform in weight and dimension. Dimensions are: 2.00 – 4.00 m in length and 1.00 – 2.00 m in height; the weight is 200 kg – 270 kg; the backstrops are about 4.5 m long made of steel wire ropes of 14 – 16 mm diameter with G-hooks; the pennants are usually 7.00 m long wire rope steel of 14 mm in diameter with G-hooks and recessed links. Shackles 21 – 22 mm are used.

### **Fishing Efforts/Practices/Crewing**

Government policy currently permits 100% foreign ownership.

The double-rigged/outrigger refrigerated vessels operate day and night using their booms to pull either two or four otter shrimp trawl nets with tickler chains. Turtle Excluder Device (TED) regulation came into force in 1996 to protect the sea turtles. The towing speed is between 2.5–3.0 knots and trawling time is about 3 hours.

The vessels are crewed with about 3 000 foreign and Nigerian crew the later being mostly home - trained Mate certificate holders and 2nd class Engineers. The skippers and chief engineers are mostly Asian and Ghanaian nationals.

In 1999, 31 vessels were licensed to trawl for fish and 187 for shrimps, a considerable drop from the total of 306 vessels licensed in 1997 (266 of which were to trawl for shrimps). This drop is attributable to ageing, non-operational vessels, the withdrawal of most of the 13 m LOA medium-sized vessels from operation and the 1999 licence fee of N 120 000/year for each shrimp trawler above 20 GRT. The Licensing pattern showed a significant shift from fishing to shrimping in the post-SAP (Structural Adjustment Programme) era of 1986 when inshore shrimping vessels rose in number from 54 to 132 in 1988. The change was induced by the desire of investors to earn highly value foreign exchange through shrimp exportation; but this puts the shrimp resources under more severe pressure

### **Target and non-target species**

The commercial penaeid shrimps being exploited in the Nigerian coastal waters predominantly inhabit the soft mud substrate of the Niger Delta and eastwards to Cross River. They occur too in Lagos West Grounds. Their order of importance in the inshore shrimp fishery of Nigeria is:

- *Panaeus notialis* (White prawn) down 27 m to 45 m)
- *Parapenaeopsis atlantica* (Brown (or Guinea) shrimp) down 9 m - 27 m)
- *Parapenaeus longirostris* (Rose or Red deep water shrimp) down 150 m - 200 m)
- *Penaeus krathurus* (Striped or tiger shrimp).
- *Palaemonidae*, *Nematopalaemon hastatus* (Estuarine prawn) also occur in the Nigeria waters but are mostly exploited by the small-scale fishermen

The socioeconomic value and demand for trashfish is not very transparent. These undersized fish are obviously traded at sea before the ship returns to harbour and is maybe an unofficial

part of the pay to the crew. However the fleet managers claims that they are not interested to land this fraction, because several incidences had happened where the ship were attacked by pirates immediately after that kind of trade had been going on, because the pirates then knew money were present at the ship. In Nigeria the catches has declined considerably lately, and today journeys of 45–60 days is common to fill the ship whereas 14 days were common few years ago. The captains seem concerned about landing small undersized fish from valuable species like croakers (*Scianidae*). The concerns is also to some extent on the bycatch of small shrimp (about 50% of this fraction is discarded) although many of these consists of shrimp species that does not grow big.

## Review of previous studies to improve catch composition

The Nigerian Institute of Oceanography and Marine Research (NIOMR) undertook a lot of surveys in the past under the Marine Fisheries Resources programme. The research results provided the scientific basis for the promulgation of the repealed Sea Fisheries Decree No. 30 of 1971 under which for example fishing in the Lagos West grounds (i.e., The area of the continental shelf adjacent to the Lagos and the then Western States) was prohibited. Licensing as well as mesh size regulations were also introduced.

Another survey was carried out between December 1998 and March 1999 using a commercial shrimping vessel during the brown shrimp season. The bycatch was confirmed to comprise juvenile of commercially important species and other species whose maximum length at infinity does not exceed 35 cm; this group constituted more than 70% of the bycatch at some shrimping grounds (Isebor, 1999).

In 2004 BRD experiments has been conducted with Square-mesh window codends, full square mesh codends and 90° turned meshes codend with good results.

## Current legislation

Nigeria's efforts to ensure responsible inshore fishing practices and proper management of the living marine fish and shell fish resources date back to 1971 when the first comprehensive marine fisheries legislation came into force under the Sea Fisheries Decree No 30 of 1971. In order to further promote the sustainability of the inshore fisheries and the fisheries of the Exclusive Economic Zone of Nigeria, the old decree was repealed in 1992 and replaced by the Sea Fisheries Decree No 71 of 1992. The main Decree contains the general provisions for the conditions for issue of 'Motor Fishing vessel Licenses', duties and powers of Authorized Persons and penalties for offences committed under it. The supplements of the Decree namely 'The sea Fisheries (Fishing) Regulations' and the 'Sea Fisheries (Licensing) Regulations' contain specific provisions which guide and control investment in industrial marine fishing business and mode of operating such a venture in Nigeria. The current sea fisheries licensing and fishing regulations which impact on shrimp trawling, its bycatch and discard are:

- i) Obligatory pre-purchase assurance in writing by the licensing authority that any procured vessel entering into Nigerian shrimping business would be licensed after due process. This is a measure to control, before investment, fishing effort and for preventing over-capitalization.
- ii) Vessels survey and tonnage measurement in Nigeria by the Federal Ministry of Transport's Government Inspector of Shrimping (GIS) to ensure that only suitable and permissible vessels enter into the Nigerian shrimping or fishing fleet.
- iii) Restriction of size of a shrimp trawler to 23.2-m LOA and 130 GT to prevent over-sized vessels from entering into the trawl shrimp fishery.

- iv) Delimitation of a 5 nautical mile non-trawling zone which places restrictions on trawling in a sea water area covering about 7898.78 km<sup>2</sup> of the Nigerian continental shelf essentially to protect the nursery ground from indiscriminate fishing. It is also to protect the artisanal fishermen who operate within the zone, as well as to reduce conflict between them and trawler operators.
- v) Codend mesh size specification, 44mm (1¾ ins.) stretched, for any shrimp trawl net to promote sustainability of inshore trawl fisheries through rational exploitation.
- vi) Prohibition of the use of the same vessel licensed to trawl for fish from trawling for shrimps in order to limit the efforts to trawl for shrimps.
- vii) Prohibition of dumping (i.e., discard) of edible and marketable sea products and transshipment at sea of bycatch. The immediate purpose is to encourage vessels, by bringing all catches back to the home port, to increase supply of fish to the domestic market; indirectly this should also discourage non-compliance with mesh size regulation which lead to catching small-sized or juvenile fish. By the side, when this provision is complied with by the industry, it will allow for easier study of the bycatch problem.
- viii) Regulation concerning a minimum size of fish for sale to discourage the catching of undersized fish and ensure the use of legal mesh size in the codend.
- ix) Prohibition of single and pair trawling by motorized vessels less than 20 GT and in waters shallower than 18m to protect the juvenile fish and biodiversity in fishing grounds which also happen to be the nursery grounds in some areas.
- x) The installation of Turtle Excluder Device (TED) on shrimp trawl nets is a requirement from 19 September 1996.

### **Recommendations for future research or legislative intervention**

In 2004 the export to USA were closed because of non-compliance with the American demand for the use US specified TED's in the shrimp fishery.

Although the export to the US only constituted a minor part of the total Nigerian shrimp export before the closure, the Industry seemed very anxious to have the US export reopened. The largest concern seems to be that the EU will follow US in adapting the same TED conditions as the US has set up.

The issue of closed areas and/or season is major concerns for the stakeholders in the Nigerian Shrimp trawling industry and the fisheries authority. Researches are being intensified in order that concrete decisions are based on scientific knowledge and evidence. There are periodic meetings among the members of Nigerian Trawler Owners Association, the Federal Department of Fisheries, the Nigeria Institute of Oceanography and Marine Research (NIOMR) and all other fisheries law enforcement agents i.e., the Nigerian Navy, The Marine Dept. of Nigeria Police, Nigerian Customs Service, surveyors or examiners appointed under the provisions of the Merchant Shipping Act. At these consultative fora, matters relating to legislation or any issue of interest to the inshore fishing industry, such as the management of the finite marine fisheries resources are exhaustively deliberated upon.

Constraints to better participation of stakeholders in the management of resources mainly relate to the fear of profit loss through perceived reduction in catches when gears with better selectivity are used. The lack of basic, essential, infrastructures on landing places or harbour to fulfil the needs of fishing operators and the generally not too conducive atmosphere may also

constitute hindrances to a more cooperative attitude of the industry to the compliance with fishery management measures.

Even though, trawling for shrimps within the first five nautical miles of the Nigerian continental shelf and in waters shallower than 18 m are prohibited and the codend of a shrimp trawl should have more than 44 mm mesh size, yet observations of fish landings and activities at sea suggest that these statutory provisions of the fishing regulations are not being strictly complied with.

**Recommendations:**

- i) Research on attractive, environmentally friendly, cost effective, adoptable by-catch reduction devices should involve all the stakeholders.
- ii) Research on alternative fishing gear and responsible fishing methods for catching shrimps should be conducted/promoted.
- iii) Investigation of bycatch trades and implications of reduction of bycatch should proffer recommendations for ameliorating the impacts on various beneficiaries.
- iv) Research on stock assessment and the issue of closed areas and /or season which is a major concern to all the stakeholders in the Nigerian Shrimp should be given due consideration.
- v) Appropriate legislation (laws and regulations) for the adoption of the BRD technology should be enacted.
- vi) Monitoring, control and surveillance capabilities should be strengthened for effective performance.
- vii) Capacity building and skills acquisition as well as short term (2–4 weeks) professional/technical training on design, construction and operation of BRD are desirable.
- viii) Series of out reach sessions and awareness programmes for the adoption and implementation of the BRD technology on national and sub-regional levels should be conducted.

## South Africa

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### Overview of individual fisheries

The South African prawn trawl fishery is relatively small, catching about 300 tonnes of target species per annum, with a value of about \$ 1 million. There are shallow (< 50 m) and deep (> 100 m) water components, and the fishery is managed by means of input controls, i.e., there are no quotas. It is a wasteful fishery, with about 1 000 tonnes of discards per annum.

The deep water component currently has about four vessels operating, and catches about 250 tonnes of pink prawns (*Haliporoides triarthrus*), crabs (*Chaceon mcphersoni*), rock lobster (*Palinurus delagoae*) and langoustines (*Metanephrops mozambicus*) per annum. There is a retained bycatch of about 30 tonnes per annum, mostly comprising fish and cephalopods, and a discarded bycatch of about 1 000 tonnes. The composition of the discards is not well known, although the fish component is dominated by greeneyes (*Chlorophthalmus punctatus*), coffin fish (*Chaunax pictus*) and rattails (Family Macrouridae). The shallow water fishery comprises four trawlers, targets penaeid prawns (mostly *Penaeus indicus* and *Metapenaeus monoceros*) and catches about 100 tonnes per annum. The retained bycatch (mostly fish and cephalopods) is about 25 tonnes per annum and the discarded bycatch is diverse, but mostly consists of fish and crustaceans, and is about 400 tonnes per annum. The fish component of the bycatch mostly consists of *Otolithes ruber*, *Johnius dussumieri*, *Johnius amblycephalus*, *Trichiurus lepturus* and *Thryssa vitirostris*.

## Target and non-target species

There are no historical data for the deep water trawl fishery, and collection of observer data only commenced in 2002, although there are data on retained bycatch which have been collected (via skipper's logbooks) since 1985. Consequently it is not possible to determine whether there are ecological impacts by deep water trawlers because of the lack of detailed information. Based on the current knowledge of deep water bycatch composition (Fennessy and Groeneveld, 1997), there is no obvious impacts of the deep water prawn trawl fishery on other fisheries sectors.

In the shallow water fishery, there are user conflict impacts between trawlers and hook and line fishermen. The work by Fennessy (1994a) showed that trawlers were catching about 800 000 juvenile individuals of the sciaenid fish *Argyrosomus thorpei* per annum (mostly in January and February), while commercial hook and line fishermen were catching about 400 000 individuals of this species annually, albeit larger individuals. Per-recruit modelling demonstrated that the trawl catches were impacting on yield and spawning biomass of this species and, since about 1997, the shallow water Tugela Bank trawl fishery has been closed in January and February each year. The economic viability of the prawn fishery was also not good during these months, so it made economic sense not to trawl at this time and the trawlers had the possibility of trawling on the deep water grounds during these months. Good data is required to be able to undertake user conflict assessments of this type, specifically data on catch quantities, sizes of the relevant species caught by the different sectors, and information on age, growth and maturity of the relevant species. Currently, a similar assessment is underway for *Otolithes ruber*.

## Review of previous studies to improve catch composition

During September 2000, a study was done on the effects of a square mesh panel on the bycatch of a twin net boom trawler operating on the Tugela Bank shallow water prawn grounds. The panel was inserted in the codend of one trawl net while the other net served as a control. The objectives of the study were to reduce the bycatch, but without reducing the prawn catch. Catches of prawns, retained bycatch and discards in panel and non-panel trawls were compared. The panel was successful in reducing overall discarded catch quantities, without reducing prawn catches (Table 18). In fact, on 10 occasions, prawn catches in the panel trawl were greater than in the non-panel trawl. Catches of retained fish (mostly *O. ruber*) were reduced in the panel trawl. Other retained catch categories (crabs, cuttlefish) did not appear to be affected by the insertion of a panel. Differences in catch rates of discarded fishes appeared to be species specific, with catches of *J. amblycephalus*, *O. ruber* and *P. olivaceum* being lower in the panel trawls. For *A. thorpei* and *P. sextarius*, differences in catches between panel and non-panel trawls were not apparent.

**Table 18: Numbers of Tugela Bank trawls incorporating a square mesh panel; with catch quantities either greater than, less than or equal to a non-panel (standard) trawl.**

CATCH CATEGORY	PANEL > NON-PANEL	PANEL < NON-PANEL	PANEL = NON-PANEL
Prawns (weight)	10	5	2
Crates of discarded catch	3	13	3
Retained fish (no.)	3	15	1
Retained crabs (no.)	8	9	2
Retained cuttlefish (no.)	8	6	5
<i>A. thorpei</i> (no.)	5	6	0
<i>A. nibe</i> (no.)	4	4	3
<i>J. amblycephalus</i> (no.)	2	9	0
<i>J. dussumieri</i> (no.)	4	7	0

CATCH CATEGORY	PANEL > NON-PANEL	PANEL < NON-PANEL	PANEL = NON-PANEL
<i>O. ruber</i> (no.)	2	9	0
<i>P. olivaceum</i> (no.)	2	9	0
<i>P. sextarius</i> (no.)	4	4	3

Catch rates of discards and retained fishes were significantly higher in trawls without a square-mesh panel, while prawn catches by weight were not affected (Figure 18). Mean catch rates of the main discarded fish species were all lower in trawls with a panel and, in the case of three species, significantly so.

It was anticipated that the size distributions of fishes caught in panel and non-panel trawls would be different, because of the potentially greater ability of smaller fish to escape through the panel relative to larger fish. However, this does not appear to be the case, as there was not much difference in size. The panel therefore appeared to permit the escape of all sizes of the most common fishes encountered. This contention is supported by the much reduced catch rates of retained fishes in panel trawls on the Tugela Bank. Most retained fish were *O. ruber* that, despite being much larger than discarded *O. ruber*, were still able to escape through the square mesh, largely accounting for reduced catches of the retained fish component in panel trawls.

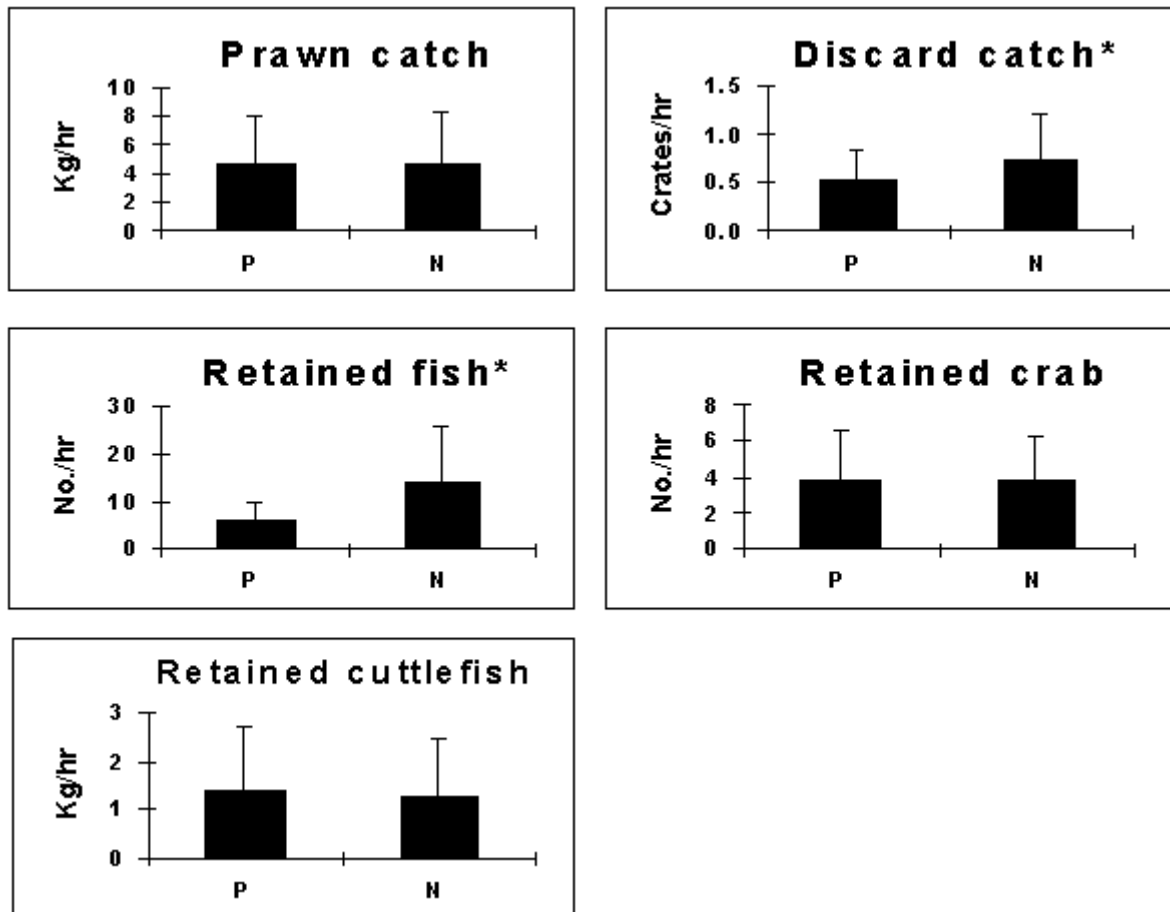


Figure 18: Comparison of mean catch rates (plus one standard deviation) by panel and non-panel prawn trawls on the Tugela Bank. P = Panel, N = Non-panel; an asterisk\* indicates a significant difference (Wilcoxon paired signed-rank test: P < 0.05).

The results of this work show that the square-mesh panel holds considerable potential for the reduction of fish bycatch in the South African prawn trawl fishery. However, several aspects need further investigation. Firstly, the panel needs to be tested during the main prawn season, i.e., when prawn catches are greatest (April to June), in order to determine whether prawn

catches will be compromised beyond the viability of the fishery. Secondly, variances associated with the mean catch rates are high, so greater numbers of replicates are required. Thirdly, the square-mesh panel that was used in this investigation does not allow the release of larger fishes such as *P. commersonii*, sharks or rays. The importance of individual species' behaviour is indicated by the differential catch rates of some fishes relative to others.

Although implementation of legislation requiring South African prawn trawlers to utilize square-mesh panels is feasible, based on these results, it is apparent that additional experimental work is required to optimize the application of bycatch reduction devices. However, such research is also dependent on the cooperation of the industry and the availability of suitable vessels

## Current legislation

Specific regulations or permit conditions relevant to bycatch in the South African prawn trawl fishery include:

Any spotted grunter (*Pomadasys commersonii*) caught may not be sold.

Closed seasons and areas: "Fishing is prohibited on the Tugela Bank from November to February".

Gear limitations: "The mesh size on trawlnets may not be less than 50 mm, measured centre knot to centre knot".

Only five trawlers are allowed within seven nautical miles of the coast at any one time.

## Recommendations for future research or legislative intervention

Levels of discarded bycatch remain unacceptably high (Figure 19) and contrary to policy.

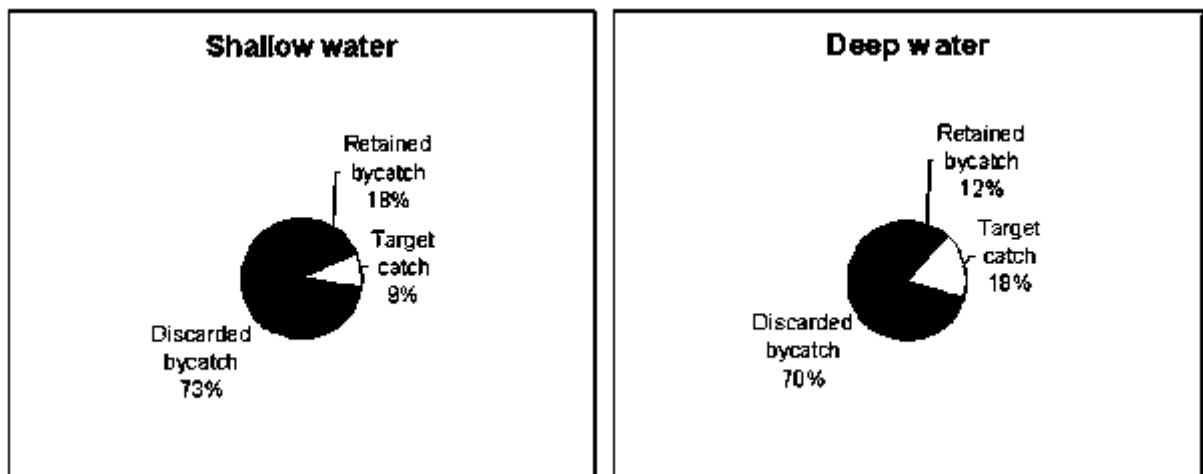


Figure 19: Composition of prawn trawl catches in South Africa (Fennessy and Groeneveld, 1997).

However, there is a need for research before regulation. In this regard, a long-term observer programme started in 2002, which aims for 15 to 20 percent coverage of all trawls. The programme:

- collects data on retained and discarded bycatch and target species;
- focuses on discarded bycatch;
- collects samples for further analysis in the laboratory;
- discarded bycatch are identified and quantified (by numbers and mass) at sea. A key (field guide) for species identification at sea has been developed for the fishery.

- e) further initiatives to reduce discarded bycatch in the prawn trawl fishery include:
- f) trials with bycatch reduction devices (BRDs) to take place in 2003;
- g) policy to address bycatch and discarding by demersal trawlers in early stages of development.

These initiatives will, in the near future, provide a scientific basis for the management of bycatch in the South African prawn trawl fishery.

## Tanzania

### Abstract

The shrimp catch reported by trawlers in 1998 was almost 1 000 t. The white prawn (*Penaeus indicus*) makes up 66% of the catch, giant prawn (*P.monodon*) and tiger prawn (*P. semisulcatus*) 18% and brown shrimp (*Metapenaeus monoceros*) 15 %.

By regulation all the fish caught are supposed to be retained for local sale. However, the total amount of discards is unknown.

In 1998, 17 industrial trawlers, mostly foreign owned, were licensed. A recent regulation limits the power of the engine and the tonnage of shrimp vessels. The mesh size in the codend is 50 mm.

The fishing season is from March to November only and night trawling is prohibited.

Most of the time the vessels operate within 1–6 nautical miles from the coast; three zones were demarcated for spreading the fishing effort on the fishing grounds on a monthly rotational basis.

The artisanal fishers consider trawling, in particular in coastal areas, is a serious problem: large catches of juvenile fish which are the basis for the recruitment of resources exploited by the non-industrial sector and a decline has already been observed in the artisanal catches in areas where trawlers have operated.

### Overview of individual fisheries

Five penaeid species contribute to the Tanzanian shrimp fishery. The white prawn *Penaeus indicus* makes up to 66% of the catch, 18% are giant prawn *Penaeus monodon* and the tiger prawn *Penaeus semisulcatus*, 15% are brown shrimp *Metapenaeus monoceros* and the flower shrimp *Penaens japonicus* makes up 1%.

The maximum sustainable yield i.e., potential annual catch has been estimated for shrimp at between 1 050 and 1 400 metric tonnes.

**TABLE 19: Shrimp and fish catches (in tonnes) by trawlers during the period 1988–1998.**

YEAR CATCH	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Shrimp (t)	650	688	960	669	663	597	1014	812	769	699	995
Fish (t)	988	978	647	460	462	398	575	765	598	610	537

The shrimp fishery is located in three major areas namely Bagamoyo area extending from 05<sup>0</sup> 30'S to 06<sup>0</sup> 30'S; Kisiju area from 07<sup>0</sup> 05' to 07<sup>0</sup> 45'S and Rufiji area from 08<sup>0</sup> 00' to 08<sup>0</sup> 40'S

Kisiju area is the most productive shrimp fishing ground, contributing 45% of the annual catch. Bagamoyo fishing ground contributes 25% and Rufiji area contributes 30% of the shrimp annual catches

### **Industrial shrimp trawl fishery:**

#### *The vessels*

The majority of the shrimp trawlers are double rig, outrigger trawlers. The outriggers/booms are normally made of steel and are 8–12 metres long. The side booms, center boom and center mast are located at mid-ship. The vessels are usually single-decked with crew quarters in the fore body and fishing activities being carried out on the main deck in the aft.

Colour video sounders are popularly used as a fish finder on the vessels. All trawlers carry SSB and VHF radios. The vessels have no shrimp sorting machines. Almost all vessels possess blast freezers and freezing hold. The holding temperatures in the fish hold range from -21°C - 35°C.

Most of the time, the vessels operate within 1–6 nautical miles from the coast at depths ranging between 3 and 20 metres.

The engine power of the vessels is ranging from 220 HP to 992 HP and the lengths from 17.6 to 38.1 m while the Gross Registered Tonnage is between 45 GRT and 296 GRT.

To date the engine horsepower has been by regulation limited to not more than 500 HP and the Tonnage of the shrimp trawlers not more than 150 GRT.

About 20 industrial trawlers are operating in Tanzanian waters.

The shrimp trawlers operate within 1–6 nautical miles from the coast at depths of 3–20 metres. The vessels are rationally divided into three groups and made to fish on the three fishing grounds on monthly rotational basis.

Both industrial and artisanal fisheries share the shrimp resource in the same waters.

#### *The trawls*

Floridian rigging commonly known as double rig trawling or outrigger trawling is the predominant method used by shrimp trawlers: two similar trawls are towed at the same time, one of each side of the vessel. More than 80% of the trawlers use the 4 seam semi-balloon net designs. The net webbing material for the body of the shrimp trawls is PE 360d - 400d/3. The wings and the body have mesh sizes ranging from 50 to 55 mm. Most vessels shoot a try-net before shooting the standard shrimp trawls. The try-nets have 3–5 metres head rope and are used with miniature otter boards of 0.3–0.6 metres. Most of the trawlers use rectangular, flat, wooden, otter boards.

The boards are directly attached to the wings. Four chain bridles are then used to attach the otter board to a wire bridle that runs to the main towing warp. The bridles are, in general, 16mm in diameter and 60–70 m in length. The main warps are 18–20 mm diameter wires. Eighty five percent of the trawlers use combination wires for their ground ropes, sizes ranging from 16–18 mm in diameter. The rest use steel wire covered by PP rope.

Ballasting is done by chain. Short link chains are used to tie loops along the ground rope at 30–45 cm intervals. The loops constitute 9–12 links of chain. The fleet popularly uses tickler chains.

There are no bycatch reduction devices on the trawls.

Catches from the industrial trawlers are processed on board, including sorting by species and commercial size, grade, packaging into 2kg boxes and freezing. Most exports are made to the European Union countries and Japan

The bycatch is sold to fish collectors at sea or auctioned at open market at Dar Es-Salaam port, after a fishing trip, which usually lasts for about 30 days. However, logistics involved in collecting the bycatch at sea is a limiting factor. Transport costs are high

*The Artisanal shrimp fishery:*

The dugout canoe, locally known as mtumbwi is the most commonly craft in use in small-scale fisheries; it is propelled by oars and poles or, if operated in the open waters, occasionally equipped with sails. Planked boats equipped with sails and/or outboard engines are employed as well.

“Mesh nets” and seine nets are the predominant gears. Both mesh nets and seine nets are made of nylon yarn with mesh sizes ranging from 1 to 2 inches and 1/16 to 1/2 inches respectively. Mesh nets are usually two ply and the seine nets range between six and eight ply.

There are two types of “mesh nets” with different mean lengths of 113 yards (103 metres) and 378 yards (344 metres). The former is mainly operated from dugout canoes while drifting with one end attached. The latter is set across channels within the inter-tidal zone. “Mesh nets”, held between two mangrove poles are frequently towed by two persons operating on foot.

Other nets very similar to the above mentioned ones, small seine nets locally known as “chandalua” or “tandio”, 10 and 20 yards (9 and 18 metres) long, are also very common; larger seine nets, “nyavu” are often more than 50 yards (46 metres). Such seine nets are most of the time operated by two persons either on foot or with a dugout canoe. Wooden bars are attached at each end and the fishermen drag the nets in the shallow waters during low tide.

## Target and non-target species

The shrimp species from the industrial fishery are:

<i>Penaeus indicus</i>	(white shrimp)
<i>Penaeus monodon</i>	(Giant prawn)
<i>Penaeus semisulcatus</i>	(Tiger prawn)
<i>Penaeus japonicus</i>	(Flower shrimp)
<i>Metapenaeus monoceros</i>	(Brown shrimp)

According to surveys in 1985 and 1990, the percentage of *P. indicus* would vary between 60 and 65.9%; *P. onodon* would be around 15% and *P. semisulcatus* 4% or in another report *P. monodon* and *P. semisulcatus* together would be 11%; the percentage of *Metapenaeus monoceros* would be 15 to 20%; finally *P. japonicus* would be 1 to 7% (Concerning this species, it was observed that it consisted mainly in small sized individuals, making insignificant contribution to the total catch and suggesting some over exploitation of the resource).

An analysis of the trawl total bycatches showed that the highest, 116 kg/hr, were in the north (Bagamoyo area) and 85 kg/hr further south, in Kisiju area.

The shrimp to bycatch ratio vary widely from one haul to the other, between areas and period of the year. As already mentioned, there is more bycatch in the north and, consequently, the shrimp to bycatch ratios are much higher in the Kisiju area than in the Bagamoyo area, with averages of 1:3 to 1:4 in the former against averages of 1:9 to 1:14 in the latter. In both areas there is a general decrease in ratios towards the end of the year.

The major bycatch species: *Trichiurus lepturus*, *Hilsa kelee*, *Pellona ditchela*, *Thrissa*, *vitrostris* and *Leiognathus leuciscus* are all discarded. Generally all the small pelagic species are discarded, as well as the fishes of the family *Leiognathidae*. On the other side, *Otolithes ruber*, *Johnnieops sina*, *Terapon theraps*, *Sphyræna obtusata* and *Gerres filamentosus* are kept.

More rare species, which are normally kept, are *Carangidae*, *Haemulidae*, *Serranidae*, *Nemipteridae*, *Lethrinidae*, *Lobotidae*, *Scombridae*, *Sillaginidae*, *Arridae* and *Muraenesocidae*, sharks and rays.

Five species inhabit the Tanzanian marine waters. These are:

*Caretta caretta*, the Pacific loggerhead turtle  
*Chelonia mydas*, the Pacific green sea turtle  
*Eretmochelis imbricatta bissa*, the hawkbill turtle  
*Lepidochalis olivacea*, the Pacific ridley turtle and  
*Dermochelys corriacea schlegelli*, the pacific leatherback turtle

The sea turtles have occasionally been cited as caught in trawls, few dead but, most of them, alive. Sea turtles are protected by law and fishermen are called upon to set sea turtles free whenever they are caught. This seems to be the practice.

## Review of previous studies to improve catch composition

The Tanzania Fisheries Research Institute (TAFIRI) has conducted a survey on the prawn fisheries of Tanzania. The aim of the survey was to analyse the composition of the catch and bycatch. It is observed that most of the catches include both juvenile of prawns and fish. The juvenile prawns are always thrown over-board as they do not fetch good market. Off the fish bycatch, the crew members usually keep a small portion of it, mainly table fish and, as room to keep prawns is needed, the rest of the bycatch is discarded.

The survey carried out confirms that a good percentage of prawns caught by trawlers are sub-adults and most of the small fishes are either juveniles or considered trash (while they are consumed by local communities). The report recommends the use of "fish rejection/excluder devices" that should separate prawn from fish and allow small fish to escape.

Very little work has been done on such devices for the Tanzanian shrimp trawling fisheries. The ratio of bycatch/shrimp mixtures is high. Separation of shrimp from fish is still a problem to the trawlers. Separation is done manually on deck and hence time consuming with some risk that prawns be spoiled before a long sorting.

However, the Tanzania's Mbegani Fisheries Development Centre carried out some studies on prawn selectivity by applying a large separator panel with two codends.

Results showed that there was a drop of up to 30 percent of the total fish bycatch. The prawn catch was also low comparatively (no figures available). Some fishes (especially the pony fish *Leiognathus* spp. managed to filter along side the prawns.

## Current legislation

Management actions aimed at the conservation of the prawn resource include:

- Limitation on the number of vessels
- Limitation of the engine power to 500 HP and the Gross Registered Tonnage to 150 GRT
- Prohibition of trawling between 6.00 p.m. and 6.00 a.m. (No night fishing)
- 3 zones delimited where vessels are assigned to fish designated in on monthly rotational basis
- Closed season from December to February
- Minimum codend mesh size of 50 mm.

It is specified to shrimpers that all the fish caught is to be retained on board the vessel for local market.

A licensed fishing vessel may at any time be required to accommodate an observer. At any one time, there is an observer in each of the fishing ground who is able to communicate with the other fishing vessels in the area.

All fishing vessels are required to submit fisheries statistics including catch effort data, fishing locations, etc. on special forms which have been designed for this purpose.

### **Recommendations for future research or legislative intervention**

To meet acceptable standards of environmentally friendly shrimp exploitation, the Fisheries Sector is facing a number of problems which require actions: including, among other:

- Insufficient information on the resource available
- Lack of capacity to carry out research
- Poor handling and inadequate processing methods and technologies
- Poor transport and distribution network leading to high levels of post-harvest losses
- Inadequate national capacities and infrastructure for training
- Environmental degradation and inability to integrate environmental protection with development
- Insufficient empowerment of the local communities
- Lack of discussion on issues and action from fisheries communities
- Unfavourable credit condition from money lending institutions

## Bycatch reduction technologies in shrimp trawling in Latin-American fisheries

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Compiled by:                      Andrés A. Seefoó Ramos<sup>1</sup>  
                                             Sául Sarmiento Náfate<sup>2</sup>  
                                             Alejandro Balmori Ramírez<sup>3</sup>

<sup>1</sup>Instituto Nacional de la Pesca. Dirección General de Investigación Pesquera en el Pacífico Sur. Prolongación Playa Abierta S/N, Col. Miramar, C.P.70680, Salina Cruz, Oaxaca, México. E-mail: sdt\_inp@prodigy.net.mx.

<sup>2</sup>Instituto Nacional de la Pesca. Dirección General de Investigación Pesquera en el Pacífico Sur. Prolongación Playa Abierta S/N, Col. Miramar, C.P.70680, Salina Cruz, Oaxaca, México. E-mail: cripsc@prodigy.net.mx.

<sup>3</sup>Instituto Nacional de la Pesca. Dirección General de Investigación Pesquera en el Pacífico Norte. Calle Sur, No. 605, Colonia Cantera, C.P. 85400, Guaymas, Sonora, México. E-mail: abalmori@gys.megared.mx.

### Summary

The present document shows some of the main efforts made to transfer and develop bycatch reduction technologies by all Latin American Countries participating in global project EP/GLO/201/GEF: *Reduction of environmental impact from tropical shrimp trawling, through the introduction of bycatch reduction technologies and change of management.*

Among other technologies, the document includes Bycatch Reduction Devices (BRD's), modification of trawl designs, inclusion of new rigging elements, etc., for both industrial and artisanal shrimp trawling.

*Key words:* Bycatch, Bycatch Reduction Devices (BRDs), shrimp trawls.

### INTRODUCTION

Shrimp fishing is a very important activity for Latin American countries due to its great economic and social value. In most countries, shrimp exports are the main source of income from the fishing industry, and it provides many direct and indirect jobs.

Although its importance, it is well known that when trawling for *Peneids* in tropical regions, there is a significant incidental catch of non-target species, many of which are discharged and returned to sea. The amount of bycatch and its taxonomic composition varies according to fishing ground conditions, operating depth, trawl design/rigging/speed, climate, etc., and shrimp/bycatch ratio may vary from 1/3 to 1/30.

Commercial shrimp trawling for *Peneids* in Latin American countries is done mainly from 2 to 120 m., by catch composition includes, among other organisms and debris, crustacean, molluscs, turtles and especially small juvenile fish of poor economic instant value, which may represent an important source of income for other fisheries if allowed to fully grown.

Another associated problem to shrimp trawling industry is the high consumption of fuel and the constant increase of it's cost in the last decades, as well as the low prices of shrimp in the international market, due to increase of offer from shrimp farming.

Both issues, bycatch/discharges and fuel consumption, have been addressed as significant problems in the **Code of Conduct for Responsible Fisheries**, and to minimize their impact have become a main goal for some of the countries participating in the EP/GLO/201/GEF project.

The present document only deals with information on bycatch reduction technologies transferred or developed by Latin American countries participating in the global project EP/GLO/201/GEF.

Basic documents used by compilers include publications, internal technical reports, national projects progress reports, etc. In most cases, particularly on those referred to other countries but Mexico, the information presented has been gathered from national projects reports and no further information or modification has been added to them.

Countries achievements are presented in alphabetical order and do not include all research results obtained on the subject of reduction of unwanted bycatch, such as TED research prior to their mandatory use in shrimp exporter countries to USA.

Most of the studies have been made onboard commercial vessels, due either to lack of research platforms or to facilitate technology transfer to the fishing industry, which has proven to accomplish better results.

## Costa Rica

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### General overview

Shrimp trawl fishing is done in both coasts, Pacific and Atlantic, by means of a significant number of artisanal boats, 65 semi-industrial and 2 industrial outriggers fishing vessels.

Main *peneid* species aimed for by the first two fleets are *Litopenaeus occidentalis*, *L. stylirostris* and *L. vannamei*. There is also a shrimp trawl fishery of deep water shrimp such as *Solenocera agassizii*, *Heterocarpus affinis* and *H. vicarious*, which are targeted by the industrial fleet.

### Bycatch reduction technologies

All boats aiming for *peneid* shrimps are subject to mandatory use of TEDs. Main results for bycatch reduction have been accomplished through TED introduction in shrimp trawls.

At present time the Instituto Costarricense de Pesca y Acuicultura, have collected preliminary information regarding technical characterization of all fishing fleets (vessels and fishing gear), as well as taxonomic composition of shrimp bycatch in traditional fishing grounds.

Future research work includes developing joint research with Mexico on modification of shrimp trawl designs (for peneids only) and testing of BRDs for later introduction in commercial shrimp fishing in order to develop a certification process of sustainable fishery.

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## Colombia

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### General overview

Commercial shrimp trawl fishing started in Colombia at the end of the 50's in the Pacific coast and in 1968 in the Atlantic.

Since then, many efforts have been made in general fisheries research through joint ventures with international institutions, such as the former Bureau of Commercial Fisheries from the U.S.A. (1954), PNUD-FAO-INDERENA (1969), JICA-INDERENA (1981), FAO-NORAD/PNUD (1989); as well as through national research institutions such as UNIMAG-UNAL(), INPA-VECEP/UE, INVEMAR-COLCIENCIAS and lately INPA-COLCIENCIAS.

Apparently, there is not an artisanal fishery; all shrimp trawlers are outriggers of steel and GRP hull. Fleet composition includes shallow water shrimp trawlers, deep water shrimp trawlers and combined trawlers for both type of fishing.

There are 47 shrimp trawlers in the Pacific coast all of them using two trawl nets, bycatch constitute 40% of the total revenues. In the Atlantic coast, operate 53 trawlers all of them use four trawl nets (twin trawls), 30 are Colombians and 23 operate under foreign flag.

Length overall of trawlers varies from 13 to 25 m., and main engine power ranged from 165 to 525 hp.

In the Pacific coast peneid species aimed for are *Litopenaeus occidentalis*, *L. vannamei*, *Farfantepenaeus californiensis*, *F. brevirostris*, *Trachipenaeus birchy*, *T. faoea* and *Xiphopenaeus riveti*; deep water shrimp main target species are *Solenocera agassizii* and *Heterocarpus spp.* In the Atlantic coast, main species caught are *Farfantepenaeus notialis* and *F. brasiliensis*.

## Bycatch reduction technologies

All boats aiming for peneid shrimps are subject to mandatory use of TEDs. Main results for bycatch reduction have been accomplished through TED introduction in shrimp trawls.

At present time under framework of Colombian project have been collected all information regarding technical characterization of fishing fleet (vessels and fishing gear), as well as taxonomic composition of shrimp bycatch in traditional fishing grounds.

Future research work includes introduction of new netting materials, modification of shrimp trawl designs (for peneids only) and testing of BRDs for later introduction in commercial shrimp fishing.

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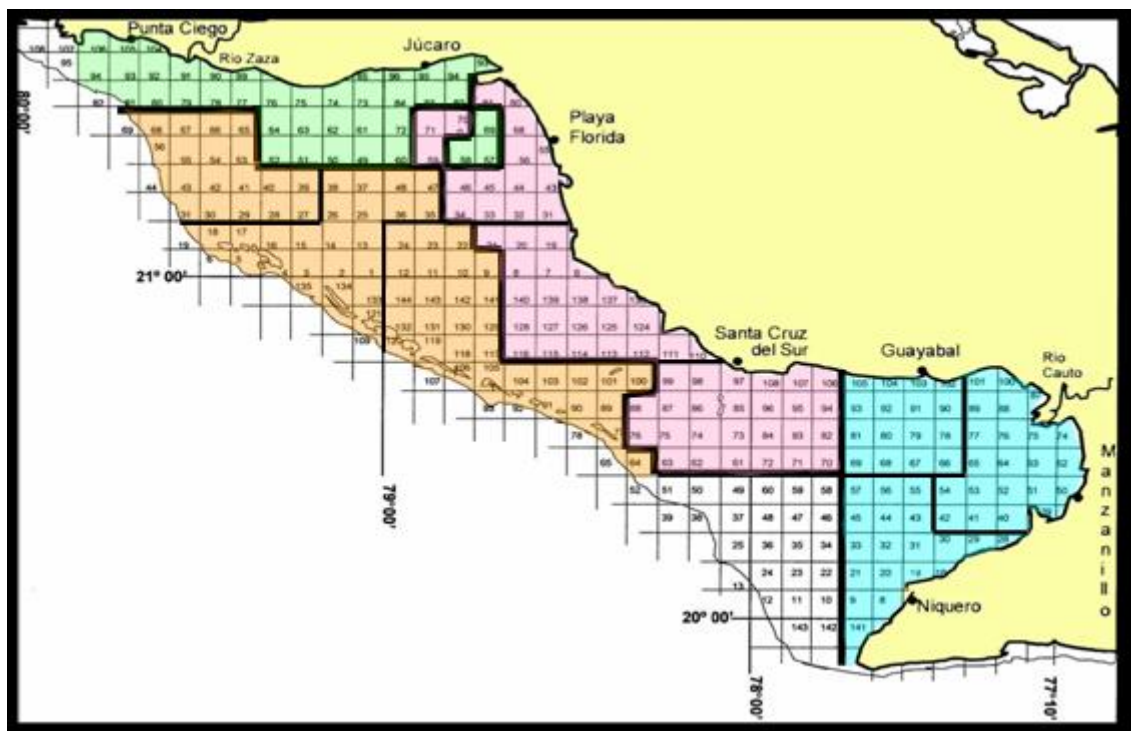
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## Cuba

### General overview

The Cuban shrimp fishery takes place in the southeastern shelf of the country (Figure 20). After reduction of 37% of fishing effort in 1999, average shrimp catch for the period 2000–2003 was 1417.5 metric tons per year, meanwhile bycatch amounted to 3774.2 metric tons per year, all of which is landed and there are not discards.

Shrimp fleet for 2004 season was composed of 50 outrigger trawlers, of Ferro-cement hull (69%), steel (24%) and GRP (7%). Length overall varies between 18 to 23 m., main engine power ranged from 300 to 480 hp. They tow four trawl nets (Twin trawl), of 52 mm mesh size in net body and 40/48 mm in codend.



**Figure 20: Shrimp fishing grounds.**

There are not artisanal shrimp fishing, trawlers main shrimp targets are *Farfantepenaeus notialis* and *Litopenaeus schmitti*.

Although bycatch does not seem to constitute a complex problem in the shrimp fishery of Cuba, taking into account that no discards occur at sea, studies on the impact of the shrimp fishery on commercial valuable finfish species, such as Lane Snapper (*Lutjanus synaris*), have been performed.

Analysis of fishing log data and port landing samplings of length frequency from the 1984–2001 period, show a reduction in the mean length of *Lane Snapper* catches, as well as an increase on the number of immature individuals caught.

## Bycatch reduction technologies

### MODIFICATION OF TWIN TRAWL DESIGN

Based on practical experiences performed in Mexico, (bycatch reduction of 20% was accomplished by decreasing 49% of trawl-body length in a *Flyier* trawl net), a twin net was reduced 30% of total length of trawl-body, by means of using a combined taper of 1N5B in upper and lower body panels. Also, head-rope length was increased from 9.9 to 10.3 m., as well as 30 meshes increase in codend length, to keep hauling and discharge of catch maneuver conditions.

Paired fishing trials under experimental and commercial conditions were done, the modified experimental trawl net was placed at the starboard side and conventional control net was placed at port side, after a number of sets they were switched. Results show that modified twin trawl had an increase of 2–3% of shrimp catch, and no significant differences of bycatch catches between both trawls.

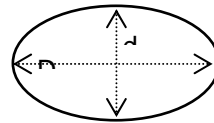
### BYCATCH REDUCTION DEVICES (BRDS)

Since no background was available in Cuba regarding appropriate size of fish-eye BRDs, three different sizes were tested, all of them made of 6 mm galvanized steel bar:

FE<sub>1</sub>: D/d =225/125 mm

FE<sub>2</sub>: D/d =485/250 mm

FE<sub>3</sub>: D/d =530/325 mm



In all cases, paired fishing trials were conducted, comparing traditional twin trawl against modified trawl with fish eye.

During FE<sub>1</sub> testing a total 10 trawl sets were made, each of two hours trawling time at a trawling speed of 3.1 knots (1.54 m/s); fish eye was installed in two different places of the codend and five trawl sets were made in each position. Results show similar figures of shrimp catches, although no significant fish escape was observed.

For FE<sub>2</sub> and FE<sub>3</sub> BRDs trials were conducted under experimental conditions, speed was standardized to 3.1 knots and trawling time to 30 minutes. Results are shown in Table 20.

**Table 20: Results of BRDs tests.**

BRD	No.	TRAWLING	SHRIMP (KG/HR)		BYCATCH (KG/HR)		SHRIMP	BYCATCH
	Sets	Time (hr)	Traditional	Modified	Traditional	Modified	Loss (%)	Reduction (%)
FE2	14	7	5.23	5.22	43.33	37.64	0.3	13.1
FE2	30	15	2.77	3.01	45.64	38.46	-8.8	15.7
FE3	30	15	2.72	2.91	18.81	16.84	-7.0	10.5

Even though testing effort was not enough to obtain definitive results, It can be observed that some variations occur between trawls, which may be influenced by some diverse factors as: fish eye position and specially fishing ground conditions (depth, bottom characteristics, and trawling time) which determine the fish composition and also their reaction inside fishing gear.

Despite that fact, preliminary results indicate that the BRD increase the trawl's selectivity on fishes, allowing a escape that should be higher, if trails were made on a commercial basis (2–3 hours duration), due to the codend saturation effect.

Future research work includes trials under commercial conditions of FE<sub>2</sub> BRD, (due to its apparent higher efficiency) made of stainless steel or hard aluminium rod, to avoid bending of bars and device deformation.

Also in cooperation with Mexico, modification of Twin trawl designs will take place, along with introduction of a bigger codend in order to install two FE<sub>2</sub> BRDs.

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- Font-Chávez, L., and Valdés, E. 2004. Cuba National report January-June 2004. III National Coordinators Workshop for Latin America and the Caribbean. EP/GLO/201/GEF "Reduction of Environmental Impact from Tropical Shrimp Trawling, through the Introduction of By-catch Reduction Technologies and Change of Management. Port of Spain, Trinidad and Tobago.

## Mexico

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### General overview

Shrimp trawl fishing takes place in the Pacific, Gulf of Mexico and Caribbean, both by artisanal and industrial fleets. Although trawling for shrimp started in the late twenties, shrimp has been a fished since Pre-Colombian times with fishing gear and methods that prevail nowadays.

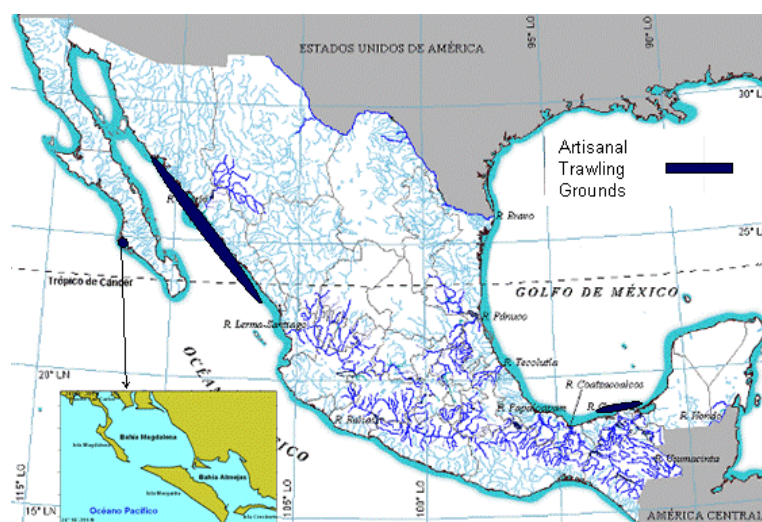
In 2003 total shrimp landings were 122,307 t. Participation of shrimp farming, industrial and artisanal fleet are given in Table 21.

**Table 21: Composition of 2003 shrimp landings.**

ORIGIN	PACIFIC COAST	ATLANTIC AND CARIBBEAN
Artisanal landings (t)	13,559	7,024
Industrial landings (t)	23,503	16,938
Aquaculture (t)	58,305	2,978

Artisanal shrimp trawling fleet is about 300 to 350 small fiberglass boats of 6 to 9 m length overall, with outboard engines of 40 to 100 hp. They tow only one trawl net, made of mono or multifilament PA, 9 to 15 m headrope length and it is mandatory the use of a hard or soft TED.

In the Mexican Pacific, artisanal trawling is only allowed in Bahía Magdalena in the West coast of Baja California (*Farfantepenaeus californiensis*, *Litopenaeus stylirostris* and *Sicyonia Spp*) and coastal marine zone of Sonora and Sinaloa States (*Litopenaeus vanamei* and *L. stylirostris*). In the Gulf of Mexico, this activity takes place in the coastal marine zone of Tabasco and Campeche States and shrimp target is *Xiphopenaeus kroyeri* (Figure 21).



**Figure 21: Artisanal trawl fishing areas.**

Industrial shrimp fleet is composed of 2,412 (Table 22) steel hull outrigger trawlers and a few GRP and wooden units, of 10 to 30 m. length overall and 150 to 625 hp main engine.

**Table 22: Industrial fleet distribution and main shrimp species.**

FISHING AREAS	VESSELS	MAIN SHRIMP TARGET SPECIES
<b>Pacific</b>	<b>1674</b>	
West Coast of Baja	71	<i>F. californiensis</i> and <i>L. stylirostris</i>
Gulf of California	1456	<i>F. californiensis</i> , <i>L. stylirostris</i> and <i>L. vanamei</i>
Gulf of Tehuantepec	147	<i>L. vanamei</i> , <i>F. californiensis</i> and <i>L. stylirostris</i>
<b>Gulf of Mexico</b>	<b>703</b>	
Tamaulipas	293	<i>Farfantepenaeus aztecus</i> and <i>L. setiferus</i>
Veracruz	72	<i>F. aztecus</i> and <i>L. setiferus</i>
Tabasco	20	<i>F. aztecus</i> and <i>L. setiferus</i>
Campeche	311	<i>F. aztecus</i> , <i>L. setiferus</i> and <i>F. duorarum</i>
Yucatán	7	<i>Farfantepenaeus aztecus</i>
<b>Caribbean</b>	<b>35</b>	
Quintana Roo	35	<i>F. brasiliensis</i>

Trawlers tow mostly two trawl nets in the Pacific coast and four trawl nets in the Gulf of Mexico and Caribbean; minimum mesh size is 44.5 mm (inside measure) in wings/net body and 38.1 mm (inside measure) in codend. There are two major areas where fishing is restricted (Figure 22), in Upper Gulf of California, fishing must be done in a way that target/bycatch ratio must be 1 to 1.

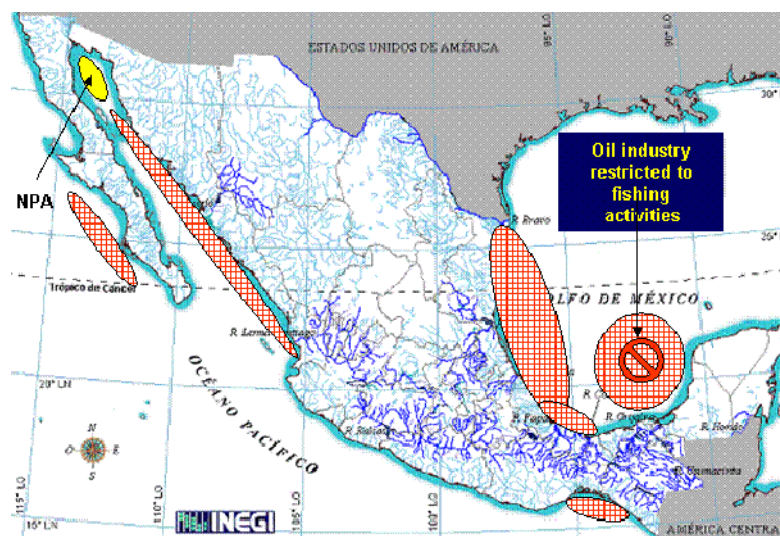


Figure 22: Industrial trawl fishing areas.

## Bycatch reduction technologies

### Turtle Excluder Devices (TEDS)

The use of hard TED's is mandatory in all industrial fleet vessels, in 2004 a new regulation required to increase the escape opening of TEDs and the possibility to use single or double cover for the escape opening.

Assessment of new regulation through paired fishing trials conducted under experimental and commercial conditions in the Gulf of Tehuantepec, showed that new TED with single cover has similar catch efficiency of shrimp, and increased 3.3% bycatch reduction compared with former TED used. Double cover TED trials showed increases of 2% in shrimp catch efficiency and 11% in bycatch reduction.

### Bycatch Reduction Devices (BRDS)

Research on the use BRDs started in Mexico in 1992, at this stage the main goal was to make a qualitative assessment of species feasible to escape from fishing gear through a Fish Eye (Torres *et al.*, 1992 a).

In 1993 in the framework of the *Technical Committee for Preservation and Protection of Vaquita and Totoaba*, endangered endemic species of the Gulf of California (Figure 23), a research program was developed to assess efficiency for reduction of bycatch of juvenile totoaba (*Totoaba macdonaldi*) of three sizes of Fish Eye (Figure 24) onboard commercial shrimp trawlers. Paired fishing trials were conducted under experimental conditions achieving more than 65% exclusion of totoaba juveniles (Torres-Jiménez and Balmori-Ramírez, 1994).

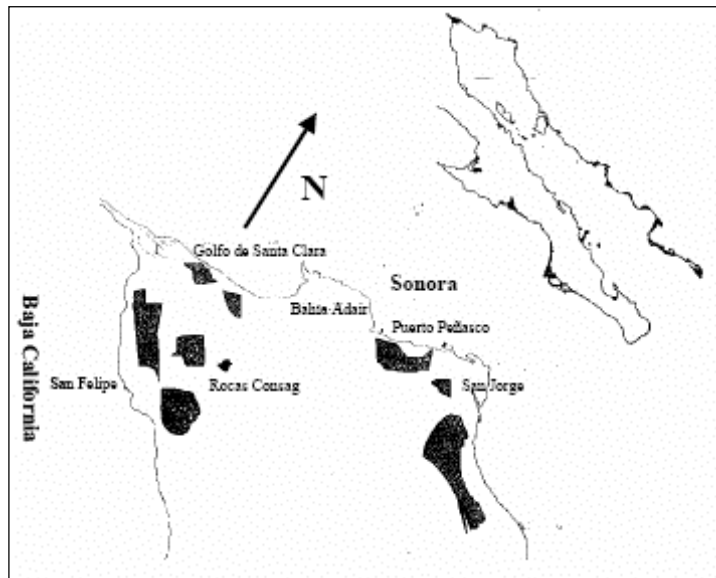


Figure 23: Working area and location of trawl sets.

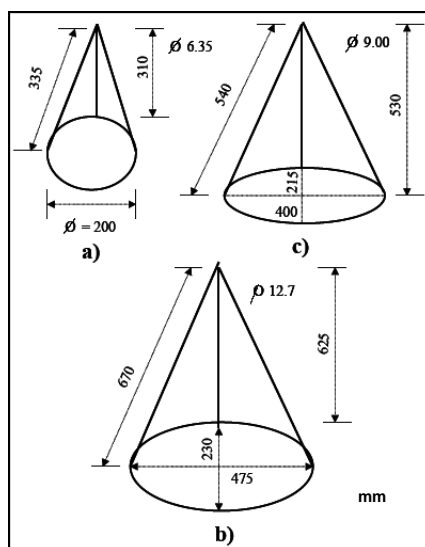


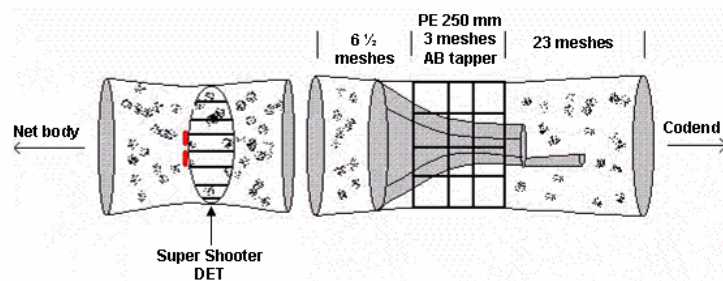
Figure 24: Fish Eye TESTED

Research on BRDs continued in 1997, previously indicator species were chosen according to their importance (either commercial or ecological) and abundance as bycatch in shrimp trawling (Table 25).

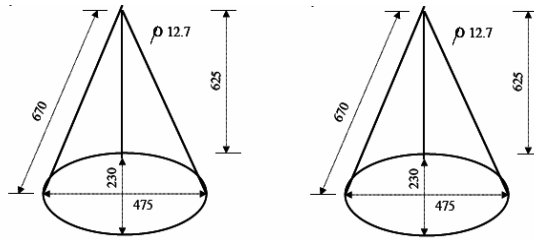
**Table 23: Fish species used as indicators.**

FAMILY	SPECIE	MAIN CHARACTERISTIC
Balistidae	<i>Balistes polylepis</i>	Commercially important
Batrachoididae	<i>Porichthys analis</i>	Secondary consumer in trophic chain
Lutjanidae	<i>Lutjanus peru</i>	Commercially important
Paralichthyidae	<i>Paralichthys aestivalis</i>	Commercially important
Rhinobatidae	<i>Rhinobathos productus</i>	Commercially important
Scianidae	<i>Micropogonias altipinnis</i>	Commercially important
Scianidae	<i>Cynoscion reticulatus</i>	Commercially important
Scianidae	<i>Totoaba macdonaldi</i>	Endemic specie of Gulf of California
Scorpaenidae	<i>Scorpaena sonorae</i>	Endemic specie of Gulf of California
Serranidae	<i>Diplectrum pacificum</i>	Secondary consumer in trophic chain
Synodontidae	<i>Synodus scituliceps</i>	Secondary consumer in trophic chain

From 1997 to 2002 two campaigns in BRD assessment in the Gulf of California were carried out, either onboard INP research vessel (R/V BIP XI) or commercial shrimp trawlers. Through these campaigns, BRDs assessed were Extended Funnel (Figure 25), single Fish Eye Florida type and double Fish Eye Florida Type (Figure 26).

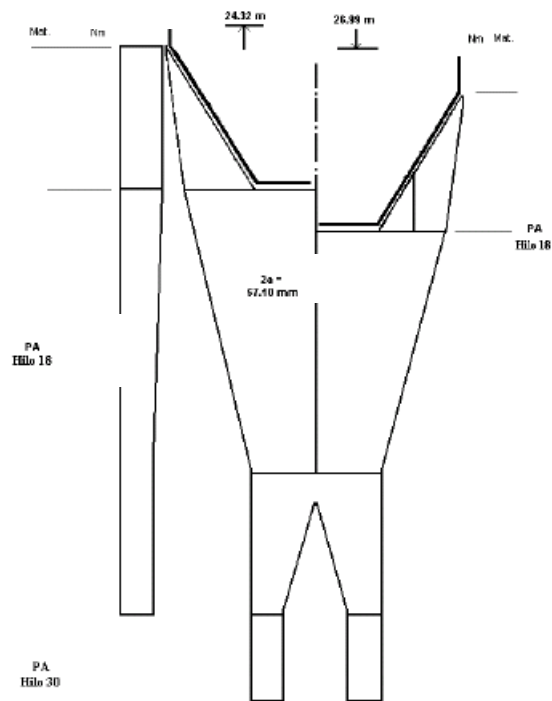


**Figure 25: Extended Funnel BRD.**



**Figure 26: Florida type Fish Eyes.**

In first campaign using INP vessel, since out rigs were not available at that time onboard BIP XI, only one trawl net was towed and codend was splitted in two parts (Figure 27); half of trawl sets were made with BRD in the starboard section of split codend and the other half in the port section. BRDs tested were Extended Funnel and single Fish Eye Florida type.



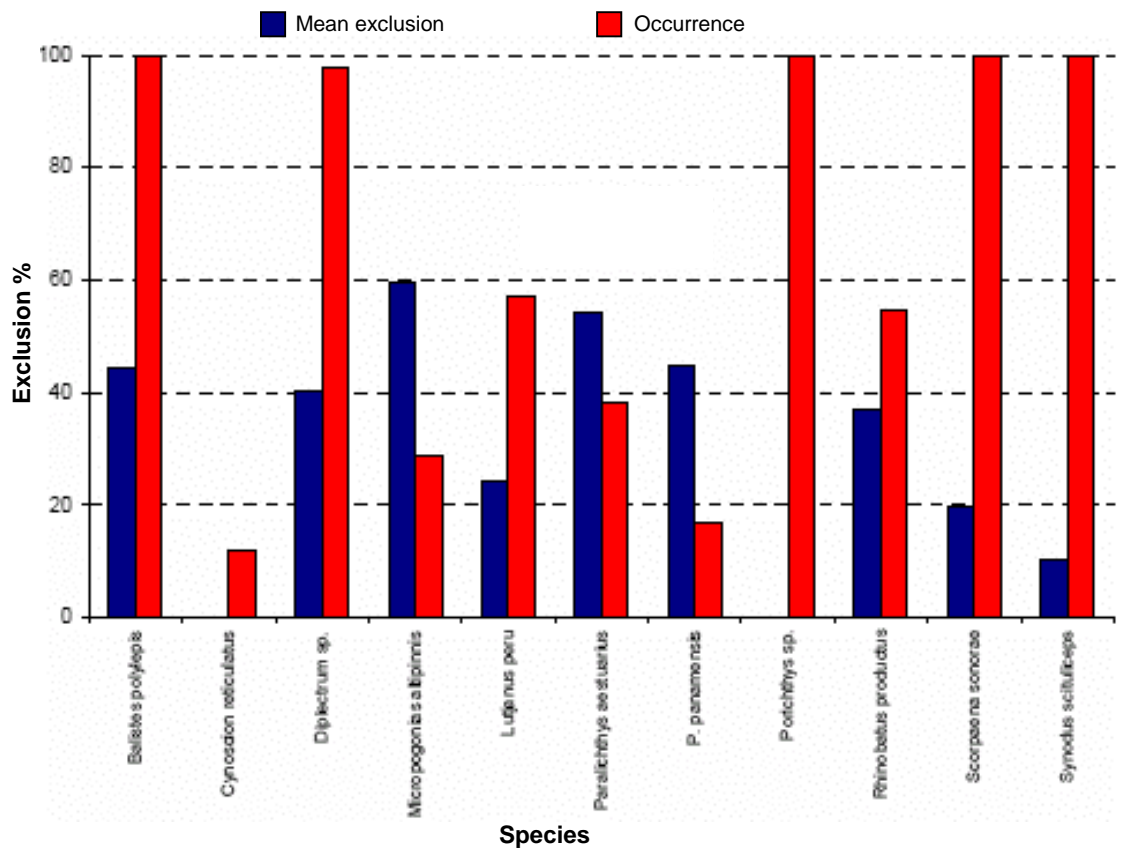
**Figure 27: Split codend.**

Results show that Extended Funnel BRD presented a shrimp loss of 7.3%, juvenile fish exclusion of 37.4% and invertebrates reduction of 54.8% (Table 24). The average total bycatch reduction of this device was 40.2%.

**Table 24: Extended Funnel results during first campaign.**

ORGANISM	EXCLUSION	
	kg/h	%
Shrimp	0.36	7.3
Fishes	22.7	37.4
Invertebrates	28.6	54.8

Five species were present in 100% of trawl sets (*Balistes polylepis*, *Diplectrum pacificum*, *Porichthys analis*, *Scorpaena sonorae* and *Synodus scitificeps*); *Balistes polylepis* had the highest exclusion of all fishes with more than 40%. On the contrary, catches of *Cynoscion reticulatus* and *Porichthys analis* were bigger in BRD (Figure 26).



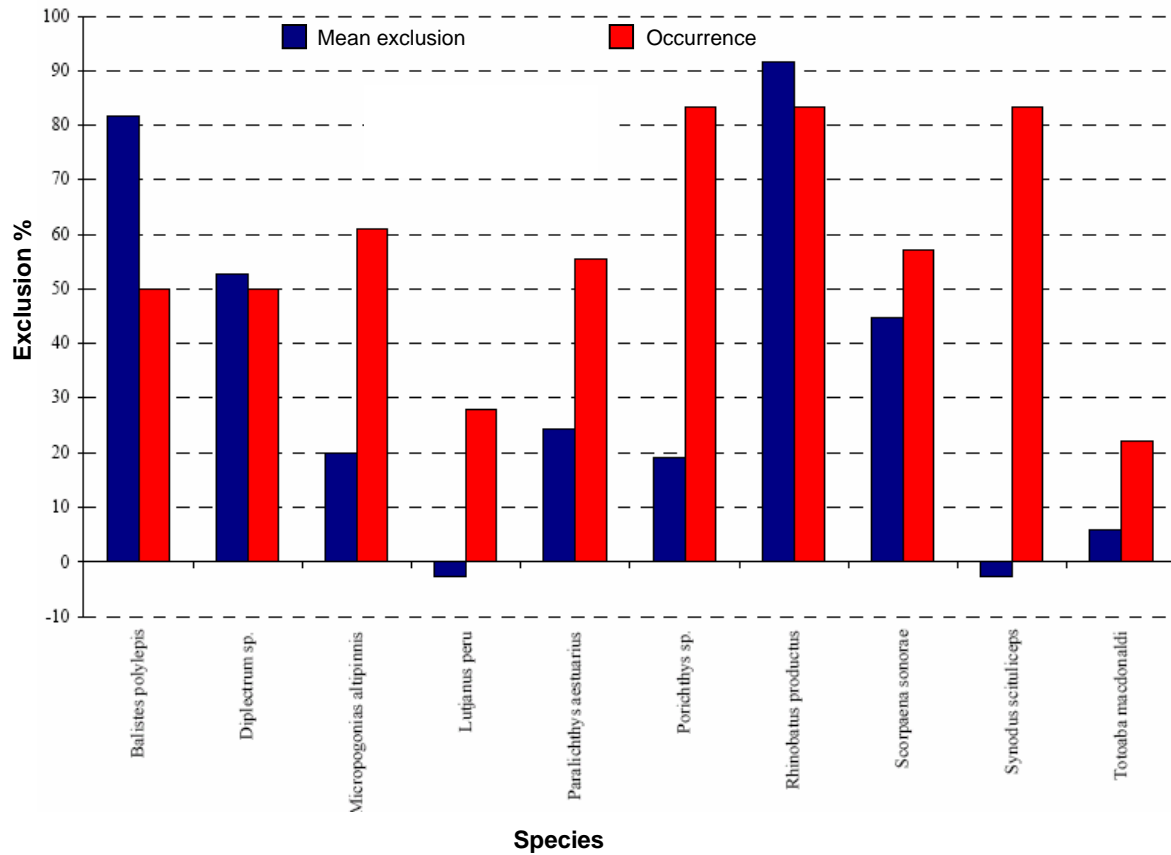
**Figure 28: Exclusion efficiency of fish of Extended Funnel BRD.**

Fish Eye results indicate a negative shrimp loss of 10.14% (shrimp gain), 23% of exclusion of juvenile fish and 14.72% of invertebrates. Total bycatch average reduction of this BRD was 10.14% (Table 25).

**Table 25: Fish Eye Florida type results during first campaign.**

ORGANISM	EXCLUSION	
	kg/h	%
Shrimp	0.21	-10.14
Fishes	6.86	23.00
Invertebrates	3.50	14.72

Major occurrence was presented by *Porichthys analis*, *Synodus scituliceps* and *Rhinobathos productus*. The highest efficiency in bycatch exclusion of fish eye was for *Rhinobathos productus* (Figure 29).

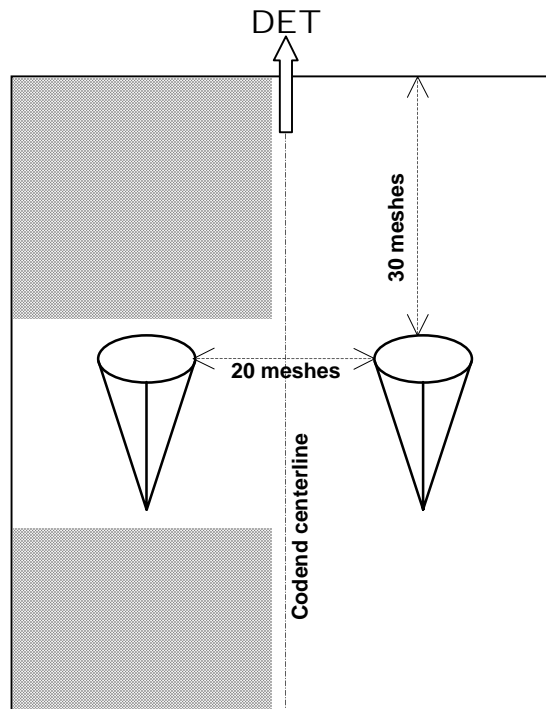


**Figure 29: Exclusion efficiency of fish of Fish Eye BRD.**

Second campaign was done onboard outrigger commercial shrimp trawler, with traditional trawl nets (Table 26); paired trials were carried out using Extended Funnel and two 475 x 230 mm Fish Eyes (Figure 30).

**Table 26: Mesh size of main sections of trawl nets**

NET SECTION	TRADITIONAL NET
Wings	44.4 mm/PA Ø 1.8 mm
Body	44.4 mm/PA Ø 1.8 mm
Last body section	44.4 mm/PA Ø 1.8 mm
Codend	41.0 mm/PA Ø 2.5 mm



**Figure 30: Layout of double Fish Eye installation.**

Experimental cruise was carried out in May 2002 in the Upper Gulf of California at Sonora and Baja California coasts. The double Fish Eye was tested during first part of cruise through paired trawls, and afterwards the Extended Funnel.

Results show that shrimp loss observed in double Fish Eye BRD is 0% and 12.0% in the Extended Funnel compared with control trawl net. Bycatch reduction was 30.0% by double Fish Eye and 47.0% in Extended Funnel, compared to control trawl net without BRD (Table 27).

**Table 27: Double Fish Eye Florida type and Extended Funnel results during second campaign.**

ORGANISM	EXCLUSION			
	DOUBLE FISH EYE		EXTENDED FUNNEL	
	kg/h	%	kg/h	%
Shrimp	0.40	0.00	0.55	12.00
Fish	70.76	30.00	92.21	47.00

### Modification of net designs

#### *Industrial shrimp trawl*

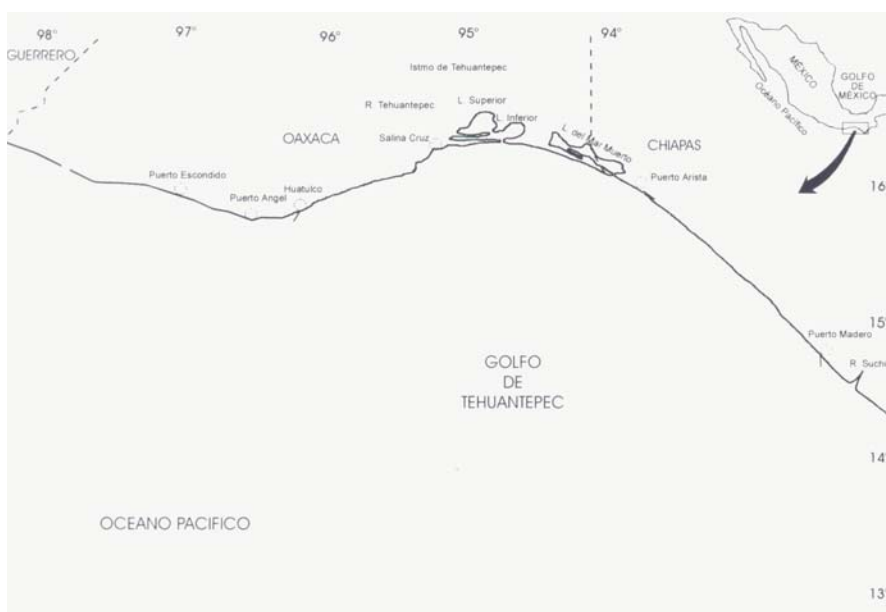
Modification on conventional design was based on the concept of fish behavior, although there are some behavior similarities between fish and shrimps, fish has a stronger reaction to stimulus (Okonski and Martini, 1976), this is specially noted in fish trying to escape form a trawl net and codend when the trawling process end.

The behaviour pattern described above becomes more evident in threatening circumstances, having more varied reactions, depending on the species, and even on the situation. Within the range of a trawl net, small fish have few escape possibilities, as the trawling speed most of the time is bigger than fish speed, once being caught, whereas bigger fish succeed in the escape process (Boddeke, 1970).

Based on these criteria, if we change the traditional taper pattern used in last panel when trawling for fish (Bucki, 1981), there will be a higher possibility for fish to escape.

According to that, changing the taper of upper and lower body panels (1N4B) in traditional shrimp trawl by an all bars taper (AB), we can reduce funnel length. This modification has not been used as a rule, final length reduction depends on type of net design, net size, array of panels sections, manoeuvre requirements, etc.

For modification of fishing gear, two conventional trawl net designs were selected: “Flyer”, most commonly used in shrimp fishery of the Gulf of Tehuantepec (Figure 31), and “Cholo” type, second in importance.



**Figure 31: Working area of “Short Flier Trawl”.**

The fishing trials were carried out onboard nine commercial shrimp trawlers willing to participate, technical characteristics of fishing vessels are given in Table 8.

**Table 28: Technical characteristics of participating vessels.**

VESSEL	YEAR	L (M)	W (M)	D (M)	HP	GTR	NTR	HULL MATERIAL
F/V 1	1982	20.26	6.6	3.6	375	123.24	73.24	Steel
F/V 2	1974	21.6	6.0	3.26	365	93.82	28.96	Steel
F/V 3	1964	21.0	5.4	4.2	170	96.01	62.28	Steel
F/V 4	1980	21.0	6.0	3.35	365	115.64	62.95	Steel
F/V 5	1976	21.0	6.79	3.35	365	96.96	62.08	Steel
F/V 6	1966	21.3	6.16	3.1	370	113.34	84.73	Steel
F/V 7	1971	19.8	5.41	3.6	380	65.00	32.50	Steel
F/V 8	1974	21.6	6.0	3.26	375	93.82	28.96	Steel
F/V 9	1972	22.87	6.1	3.45	380	100.01	65.37	Steel

**L= Length W= Width D= Draft hp= Horse power GTR= Gross Tonnage record NTR = Net Tonnage Record**

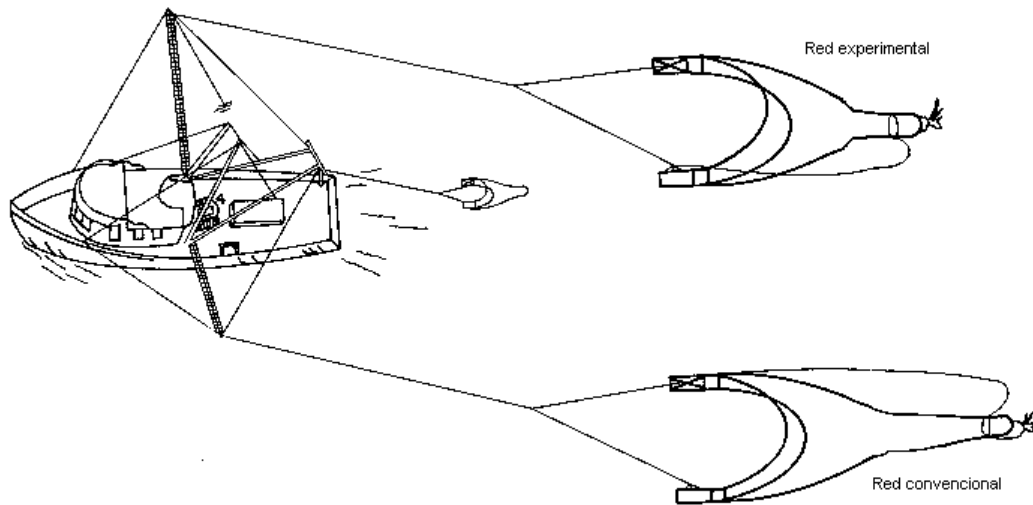
Experiments took place in 1998 and 1999, and it was possible to operate during fishing season and in the shrimp ban period. Type and characteristics of trawl nets used by all nine fishing vessels are given in Table 29.

**Table 29: Characteristics of trawl nets used during trials.**

VESSEL	NET TYPE	HEADROPE LENGTH (M)	MESH SIZE (MM)
F/V 1	Flyer	24.4 (80')	44.45
F/V 2	Flyer	24.4 (80')	44.45
F/V 3	Flyer	22.9 (75)	44.45
F/V 4	Flyer	24.4 (80')	44.45
F/V 5	Flyer	24.4 (80')	44.45
F/V 6	Flyer	24.4 (80')	44.45
F/V 7	Flyer	22.9 (75')	44.45
F/V 8	Flyer	24.4 (80')	44.45
F/V 9	Cholo	24.4 (80')	44.45

Paired fishing trials were done in each vessel, the modified experimental trawl net was placed at the starboard side and conventional control net was placed at port side (Figure 32), after a number of sets they were switched. Capture obtained from both nets was separated by means of a wooden panel to enable an adequate classification and quantification of the catch.

Trawls operated within a range of 11 to 69 m (6 to 38 fathoms); trawling time varied from 32 up to 360 minutes, with a mode value of 60 and mean value of 85 minutes.

**Figure 32: Paired Trawling Layout.**

A total of 480 control trawl sets were made, equivalent to a trawling time of 483.4 hours. Total catch was 95, 214 kg (3.3 % shrimp and 96.7 % bycatch).

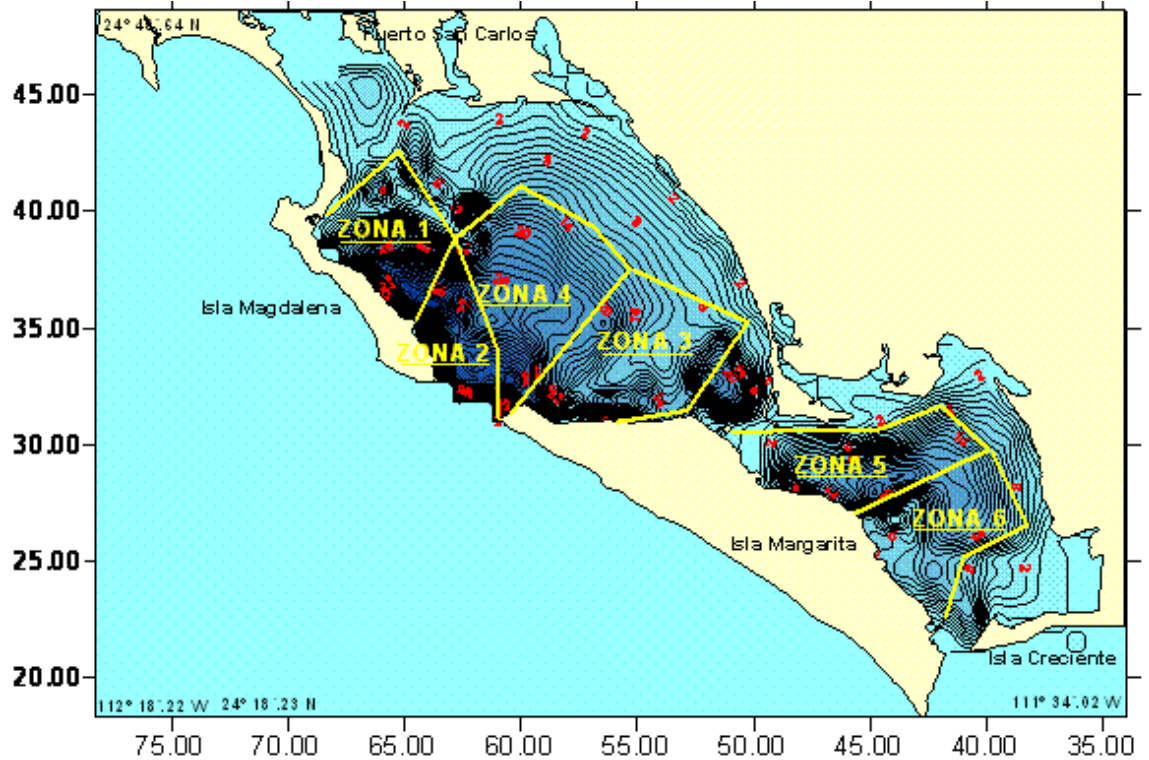
**Table 30: Catches during fishing trials.**

	CATCHES (kg)		
	MODIFIED	CONVENTIONAL	TOTAL
Camaron	1,596	1,557	3,153
Bycatch	40,746	51,315	92,061

Shrimp catches with both nets were not statistically different, however, a slight shrimp gain between 2 and 3% can be observed in the modified net. CPUE of bycatch with modified trawl was 59.42 kg/hr and conventional net 74.84 kg/hr. Bycatch reduction observed in modified trawl compared to conventional trawl was 20.5%.

***Artisanal shrimp trawl***

During 1998–1999, two experimental campaigns took place in Bahia Magdalena and Bahia Almejas in Baja California Sur, Mexico (Figure 33). Main goals were to assess catch efficiency and multispecific selectivity of two artisanal shrimp trawls (Monkey Vs Angel’s Wing) proposed by local fishermen, and develop a new environmental friendly trawling system.



**Figure 33: Traditional fishing grounds of Magdalena and Almejas bays.**

During first campaign, all preliminary data were collected (boats, fishing gear, fishing ground conditions, bathymetry, etc.).

Fishing trials were done under commercial regime through parallel trawls using simultaneously *Ala de Angel* (Angel's Wing) as experimental trawl and Chango (*Monkey*) as control trawl net.

Both trawl had the same netting design (Figure 34) main difference was the rigging of ground-rope, since *Ala de Angel* included a second ground rope, as shown in Figure 35.

Fishing trials were done onboard 63 small boats with outboard engine; 715 cruises (one night duration) were made, equivalent to 3,031 trawl sets, total trawling time was 5,067 hours and 16,057.4 ha were swept in whole campaign

Although paired parallel trawls were planned, occasionally some boats went to sea without its partner boat and at the end trawl sets were not even. General results are given in Table 31.

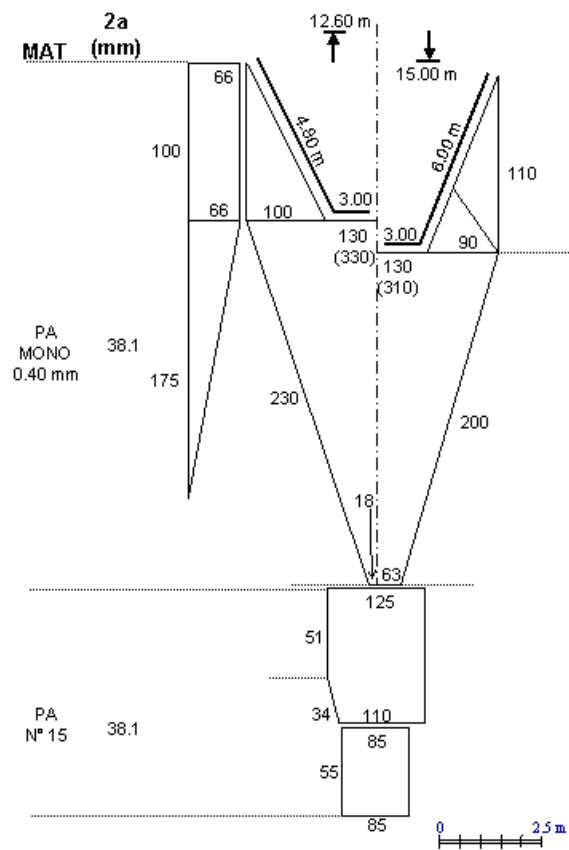


Figure 34: Chango (Monkey) and Ala de Angel (Angel's Wing) design.

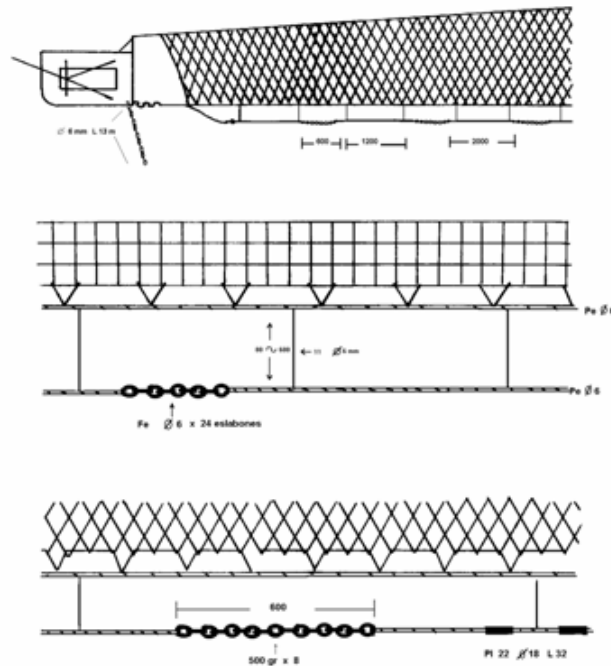


Figure 35: Second ground rope in Ala de Angel (Angel's Wing) trawl.

Table 31: Catch and CPUE by trawl net (first campaign November-December 1998).

	CHANGO		ALA DE ANGEL		TOTAL	
	(N = 1,311 trawl sets)		(N = 1,900 trawl sets)		(N = 3031 trawl sets)	
	(kg)	(kg/ha)	(kg)	(kg/ha)	(kg)	(kg/ha)
Blue shrimp	684	0.1304	2,240	0.2878	2,924	0.2302
Brown shrimp	8,321	1.3651	12,377	1.3025	20,698	1.3256
Commercial fishes	1,457	0.2606	2,033	0.2286	3,490	0.2403
Non commercial fishes	3,919	0.7604	3,720	0.3889	7,639	0.5254
Crustacean	696	0.1363	583	0.0655	1,280	0.0915
Mollusks	316	0.0838	198	0.0222	514	0.0448
Invertebrates	255	0.0397	237	0.0272	492	0.0318
<b>TOTAL SHRIMP</b>	<b>9,005</b>	<b>0.7506</b>	<b>14,617</b>	<b>0.7953</b>	<b>23,622</b>	<b>0.7789</b>
<b>TOTAL BY-CATCH</b>	<b>6,645</b>	<b>0.2567</b>	<b>6,770</b>	<b>0.1466</b>	<b>13,415</b>	<b>0.1870</b>

Blue shrimp: *Litopenaeus stylirostris*      Brown shrimp: *Farfantepenaeus californiensis*

In sandy bottom, the *Ala de Angel* trawl has a reduction of 42.9% of bycatch compared to the *Chango* trawl; however, this difference tends to disappear when trawling over muddy bottom.

Mean catches of brown shrimp were statistically equal for both trawls; however, mean catches of blue shrimp, showed similar differences to bycatch (in favour of *Ala de Angel*).

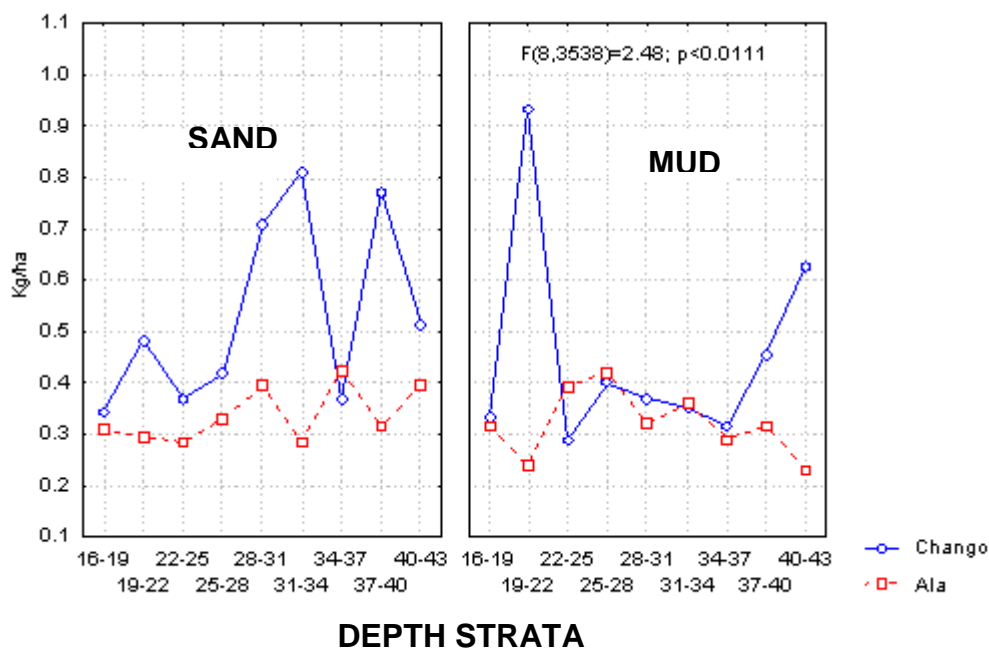


Figure 36: Effects on fish CPUE of type of trawl, trawling depth and bottom type.

From the above, it was concluded that differences in bycatch between both trawls were only significant in sandy bottom; moreover, overall shrimp/bycatch ratio 1:0.60 (1:0.74 for Monkey trawl and 1:0.46 for Ala de Angel) is the lowest registered for shrimp fisheries in Mexico, and this might be an indication of decline of communities present in bycatch.

On that basis, and in order to obtain better results, a new trawl system was expressly designed for fishing conditions in those bays, having as main goal to improve bycatch reduction in all bottom conditions, and keep, as much as possible, similar shrimp catch efficiency to those assessed before.

New trawl system included, among other features, the following (Figure 37):

- New net design with four different mesh sizes (Table 32):
- Elimination of the tickle chain,
- Inclusion of a double ground-rope (Figure 38 a), rigged in the central section with 100 mm rubber discs (from used car tires),
- Introduction of reduced (780 x 1,080 mm) Super Shooter Turtle Excluder Device to avoid bycatch of sea turtles and juvenile sea lions, when present, and
- Introduction of Fish Eye BRD (Figure 38 b)

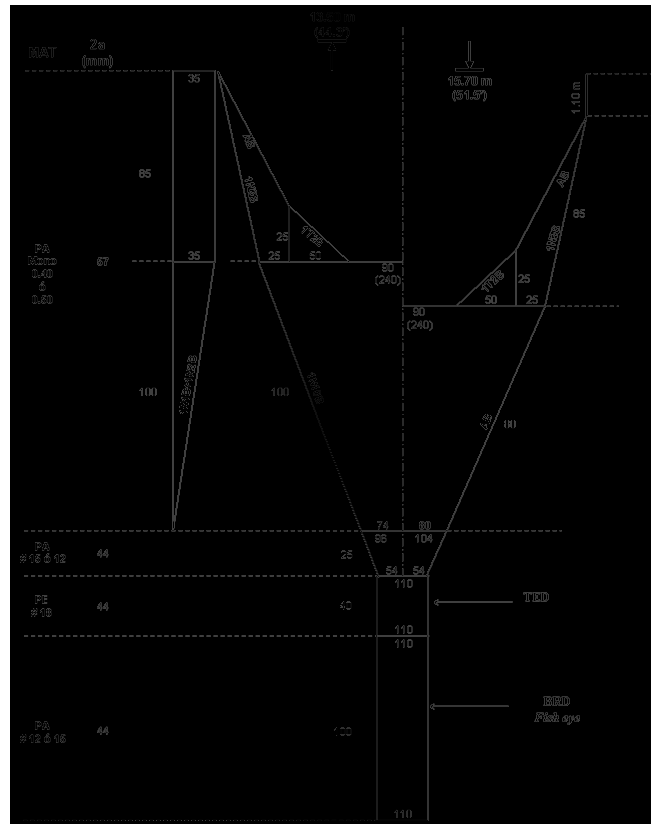


Figure 37: New shrimp trawl 13.50/15.70: RS-INP 1 (57 mm version).

**Table 32: Netting characteristics of three Magdalena 1 versions.**

SECTION	RS-INP 1		RS-INP 2		RS-INP 3		RS-INP 4	
	TWINE	MESH SIZE (mm)	TWINE	MESH SIZE (mm)	TWINE	MESH SIZE (mm)	TWINE	MESH SIZE (mm)
Wings	PA mono Ø 0.4/0.5	57.2	PA mono Ø 0.55	50.1	PA mono Ø 0.55	44.5	PA mono Ø 0.55	41.2
Side panels	PA mono Ø 0.4/0.5	57.2	PA mono Ø 0.55	50.1	PA mono Ø 0.55	44.5	PA mono Ø 0.55	41.2
Upper body panel	PA mono Ø 0.4/0.5	57.2	PA mono Ø 0.55	50.1	PA mono Ø 0.55	44.5	PA mono Ø 0.55	41.2
Lower body panel	PA mono Ø 0.4/0.5	57.2	PA mono Ø 0.55	50.1	PA mono Ø 0.55	44.5	PA mono Ø 0.55	41.2
Pre-codend	-o-	-o-	PA multi # 15/12	50.1	PA multi # 15/12	44.5	PA multi # 15/12	41.2
TED extension	PE multi # 18	44.5	PE multi # 18	41.2	PE multi # 18	41.2	PE multi # 18	38.1
Codend	PA multi # 15/12	44.5	PA multi # 15/12	41.2	PA multi # 15/12	41.2	PA multi # 15/12	38.1

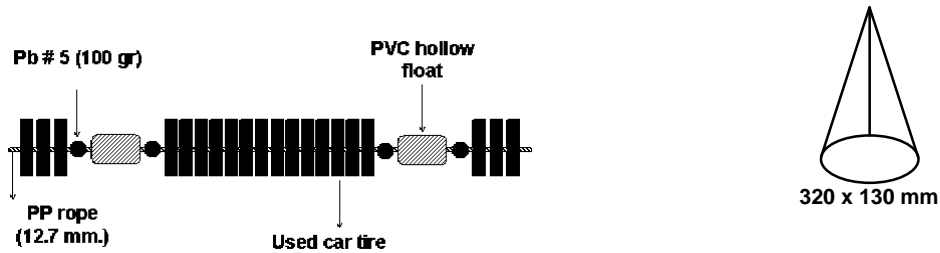


Figure 38a: Central section of 2<sup>nd</sup> ground rope.

Figure 38b: Fish Eye.

Prior to fishing trials, underwater observations took place to make adjustment and final calibration of all trawls. These observations allowed making changes in flotation/weight, wing netting tapers and TED.

Central section with rubber discs of the second groundrope, worked accordingly to plans, since it could be observed the smooth displacement of discs over bottom, with low sea floor disturb.

Fishing trials were carried out during shrimp ban season; normally in this period (June to August), “hard shell” shrimp (*Sicyonia penicillata*) is observed in great concentrations in both bays, practically displacing blue shrimp and affecting in a lesser way brown shrimp concentrations.

As the former campaign, fishing trials were done under commercial regime through parallel trawls using simultaneously RS-INP as experimental trawl, and *Ala de Angel* as control trawl net. General results for each trawl net are given in Table 33.

Best brown shrimp catch efficiency was achieved by RS-INP 4 (4.59 kg/ha) and hard shell shrimp by ALA 41 (8.65 kg/ha). Best bycatch reduction was achieved by RS-INP 3 (3.63 kg/ha).

Statistical analysis of brown shrimp (main target specie) mean CPUE, showed similar catch results for trawls ALA 41, ALA 44 and RS-INP 1.

**Table 33: Catch and CPUE by trawl net (second campaign June-August 1999).**

TRAWL	SETS	TRAWLING TIME (HR)	AREA (HA)	BROWN SHRIMP		HARD SHELL SHRIMP		BYCATCH	
				(kg)	(kg/ha)	(kg)	(kg/ha)	(kg)	(kg/ha)
ALA 44	57	76.75	209.80	676	3.15	746	4.94	1,416	7.27
ALA 41	47	74.85	180.39	769	4.15	1,314	8.65	1,745	9.44
RS-INP 1	48	78.19	197.43	742	3.98	1,023	5.05	805	5.03
RS-INP 2	50	71.98	208.92	364	1.73	904	4.52	806	4.08
RS-INP 3	43	73.42	207.16	198	0.89	332	1.64	713	3.63
RS-INP 4	44	74.62	185.02	879	4.59	1,290	7.28	1,382	7.15
TOTAL	289	449.81	1,188.72	3,628	3.09	5,609	5.37	6,867	6.24

Comparison of bycatch CPUE between trawls ALA 44 and RS-INP 1, which have same mesh size, show that RS-INP 1 had achieved 34.2% more exclusion, especially of small juvenile fish of 150 mm length.

Based on both research campaign results, a modification of the general shrimp fishing regulation was made, authorizing as only trawling system that can be use in Magdalena and Almejas bays the RS-INP 1, which has been included in the corresponding Shrimp Fishing Standard on 9 August 2001.

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## Trinidad and Tobago

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### General overview

Trinidad and Tobago, along with Venezuela, Guyana, Suriname, French Guiana, and Brazil, conform the Western Central Atlantic Fishery Commission (WECAFC), through this commission, they collaborate in the management of shrimp and groundfish fisheries.

The shrimp trawl fishery of Trinidad and Tobago is considered to be one of the country's more valuable fisheries, accounting for approximately 20% by value of the country's total annual production.

Estimated landings for the entire trawl fleet in 2002 were 940 metric tonnes of shrimp valued at TT\$23.9m and 1,005mt bycatch valued at TT\$4.8m

Trawl fleet at present comprises about 126 vessels:

- 95 artisanal (includes 41 outboard and 54 inboard engines)
- 9 semi-industrial
- 22 industrial

Main shrimp fishing grounds are located at Gulf of Paria, Columbus Channel and North Coast in the area West of S'aut D'eau Island (Figure 39).

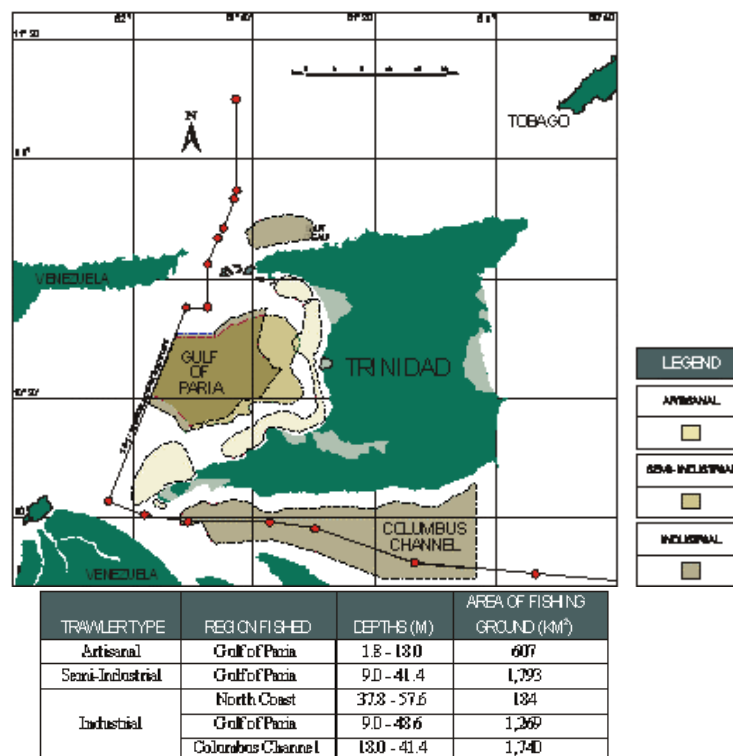


Figure 39: Shrimp trawling fishing grounds.

Shrimp trawlers ranged from 7.9 (artisanal) to 23.6 (industrial); fleet composition and characteristics of units are given in Table 1. Main shrimp targets are *Litopenaeus schmitti* and *Farfantepenaeus subtilis* and

Table 34: Characteristics of trawlers.

Length (m)	GRT (tonnes)	Engine Power (Hp)	Onboard facilities/Storage	Gear	Deck equipment
<b>ARTISANAL</b>					
<b>7.9-18.4</b>	-	<b>46-110</b>	Potable barrels with ice with an average capacity for 31 kg fish/shrimp	1 stem trawl net 1.3 x 0.5 m doors net headrope length 10.7 m mesh size 3.5cm.	-
<b>SEMI-INDUSTRIAL</b>					
<b>9.3-12.1</b>		<b>165-230</b>	Ice hold with storage capacity for 5 tonnes fish/shrimp	1 stem trawl net 1.9 x 0.9 m doors net headrope length 12.9 m mesh size 3.5cm. TED	Winch communication equipment
<b>INDUSTRIAL</b>					
<b>18.9-23.6</b>	<b>30-96</b>	<b>365-425</b>	Vessels with ice hold have storage capacity for 8 tonnes fish/shrimp Vessels with refrigerated hold have storage capacity for 12 tonnes fish/shrimp.	2 trawl nets on outriggers 2.7 x 1.2 m doors net headrope length 15m mesh size - 3.5cm. TEDs bycatch	Winch GPS Depth sounder communication equipment.

Bycatch to shrimp ratio by fleet is 12.2:1 for artisanal, and 9.1:1 for semi-industrial (data for industrial trawling was not available). Artisanal fleet lands approximately 9.8% of their bycatch, and semi-industrial 28.6%.

In terms of weight, most common fish landed are croakers, weakfish, lane snapper, snook and blinch. Most common discards are sardines, herrings, and juveniles of commercially important fish.

## Bycatch reduction technologies

Semi-industrial and industrial trawlers aiming for penaeid shrimps are subject to mandatory use of TEDs. Main results for bycatch reduction have been accomplished through TED introduction in shrimp trawls.

At present time under framework of Trinidad and Tobago project have been collected all information regarding technical characterization of fishing fleet (vessels and fishing gear), as well as taxonomic composition of shrimp bycatch in traditional fishing grounds.

Future research work will be done in cooperation with Venezuela and México for the Gulf of Paria and Columbus Channel. It includes and Observer Programme for the industrial trawl fleet, testing of alternative fishing gear, modification of shrimp trawl designs (for penaeids only) and testing of BRDs for later introduction in commercial shrimp fishing.

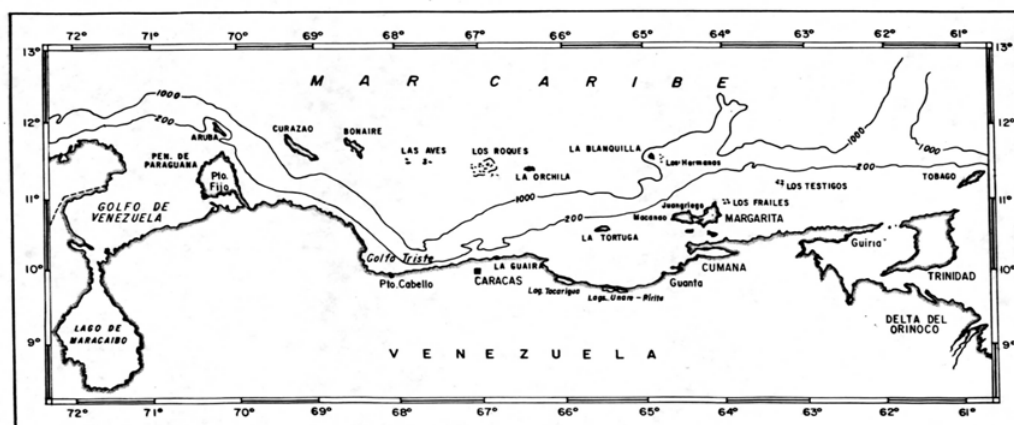
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## Venezuela

### General overview

Shrimp fishing in Venezuela is carried out in many geographical areas, being the most important Marine Coastal areas around the continent and islands, Lake Maracaibo, Orinoco Delta, Gulf of Paria and Coastal Lagoons disseminated along the country (Figure 40). Industrial trawling is allowed 6 miles outside the continent and 10 miles outside the islands.



**Figure 40: Shrimp trawling fishing grounds.**

Main shrimp target is white shrimp (*Litopenaeus schmitti*), which is caught during day time. Shrimp fleet is composed by artisanal, semi-industrial and industrial boats. Landings for 1998 are given in Table 35.

Main fishing gears used are: PE shrimp trawl nets (industrial trawlers), small PA trawl nets (semi-industrial and artisanal boats) and beach seine nets (known as jala pa'riba) operated manually. Bycatch in industrial trawling represent about 96% of total catch, from which 30% is landed and amounts to 50% of income.

**Table 35: Landings by main fishing areas.**

FLEET/FISHING AREAS	SHRIMP LANDINGS (T)	BYCATCH (%)	BYCATCH VOLUME (T)
Industrial Trawlers	3,231	70	38,000
Orinoco Delta	166	56	200
Lake Maracaibo	2,646	29	1,100
Gulf of Paria	216	82	1,000
Coastal Lagoons	614	47	550

## Bycatch reduction technologies

Industrial trawlers aiming for penaeid shrimps are subject to mandatory use of TEDs. Main results for bycatch reduction have been accomplished through TED introduction in shrimp trawls.

At present time under framework of Venezuela project information regarding technical characterization of fishing fleet (vessels and fishing gear), as well as taxonomic composition of shrimp bycatch in traditional fishing grounds is being collected.

Future research work will be done in cooperation with other countries (Mexico and Trinidad and Tobago) include, among other subjects the following:

- Training of observers (Manual of species in by catch),
- Agreements for sharing experiences with project participants, testing of alternative fishing gear, and transfer of technology from previous experiences validated elsewhere (Mexico),
- TED optimization, according to turtle structure and commercial by catch,
- Mesh size selectivity,
- BRD's in industrial trawl gear (section of square mesh, ring of square mesh, fish eye,
- BRD's in artisanal gear (Nordmore grid in zones with high debris, section of square mesh or ropes in areas with low debris), and
- Transfer of technology to local fishermen communities (industrial and artisanal), and project participants in neighbor countries.

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## Australia

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### Overview of individual fisheries

The Northern Prawn Fishery is Australia's largest and most valuable shrimp fishery, landing approximately 10 000t of shrimp per year valued at A\$100 - 200 million. The fishery covers a large geographical area of some 700 000 square kilometres extending across much of the northern coastline, from Queensland to Western Australia. The fishery presently supports about 95 steel-hulled boats each with an average length around 24m. The number of boats permitted to operate in the fishery is limited by Statutory Fishing Rights (SFRs). A Class B SFR is required for each boat in the fishery and so-called gear SFRs are required to cover the amount of net used on each boat. Gear SFRs are a specified length of headrope and footrope. In 2002, a single gear SFR was equivalent to 7.5 cm of headrope and 8.6 cm of footrope.

All boats are permitted to tow two trawls simultaneously, and headrope length of each trawl measures between 11 – 29 m. The mesh size in the main part of the trawl is typically around 63 mm and the codend mesh around 50 mm. The fishery has two fishing seasons, April to May and September to December; during the first season fishing can occur during the night and day while only night operations are permitted in the second season. Fishing depth is typically less than 40 m.

## Target and non-target species

The main target species are *Penaeus semisulcatus*, *P. esculentus*, *Fenneropenaeus merguensis*, and *F. indicus*. In addition to this a range of valuable not-target species (called by-product) is also landed, including some finfish species (e.g., mackerels, snappers, emperers), squid, crabs and other crustaceans, although catch limits are in place for many of these species to safeguard against overfishing.

The capture of juvenile animals, including shrimp, fish or other animals by the trawl fleet does not appear to be a problem in this fishery. This is mainly because most areas frequented by these animals are either closed permanently or for some of the fishing season. Temporary fishing closures are lifted when juvenile animals are large enough to be recruited into the fishery or have reached sexual maturity. In addition, the mesh size used in both the main body of the trawl and codend is about 63 mm and 50 mm respectively; this allows many small animals to escape.

At present two species appear to be under threat by shrimp trawling in the NPF; sawfish and sea snakes. The exclusion of sawfish is possible through the escape opening of the TED however the toothed bill of the shark readily fouls the trawl netting or bars of the grid. The exclusion of sea snakes is problematic because their morphology and swimming performance hampers their ability to orientate and swim through the escape openings of existing BRD designs. Both species are currently protected under State and Commonwealth legislation.

## Review of previous studies to improve catch composition

Improving catch composition in the Northern Prawn Fishery can be achieved either by increasing the prawn catch or decreasing the bycatch. There have been few if any scientific studies to improve the prawn catch as the fishery is already deemed to be fully exploited and studies of this type are not encouraged. However, several studies have been undertaken to reduce bycatch. For a review of this work see Eays (2004) and Brewer *et al.* (1998).

## Current legislation

With respect to bycatch reduction and protection of sea turtles, all fishermen are required to attach an approved TED and BRD to each trawl net. A TED is defined as any device that allows turtles to escape immediately after capture in the net and: 1. has a grid of inclined bars to guide turtles to an escape opening immediately forward of the grid; 2. is attached to the entire circumference of the net; 3. has one or more escape openings measuring at least 760mm across *and* at the same time measures 380mm in length, and; 4. has a distance *between* the bars not exceeding 120mm.

A range of bycatch reduction devices are legislated for use in this fishery, including a modified TED, square-mesh codends and windows, two types of fisheye, and a radial escape section. The specifications for these devices are as follows:

### **Modified TED**

A modified TED has the following characteristics:

- An escape opening the same size as for a TED but located in the *top* of the codend.
- A distance between the bars no more than 60mm.
- An escape flap over the escape opening if required (no part of the flap may be closer than 150mm to any part of the grid or barrier, when the TED is fitted to a codend and hung vertically).
- A guiding funnel or flap inside the codend if required (no part of the funnel or flap may be closer than 150mm to any part of the grid or barrier, when the TED is fitted to a codend and hung vertically).
- No pieces of netting or other material covering the escape opening during the fishing operation.

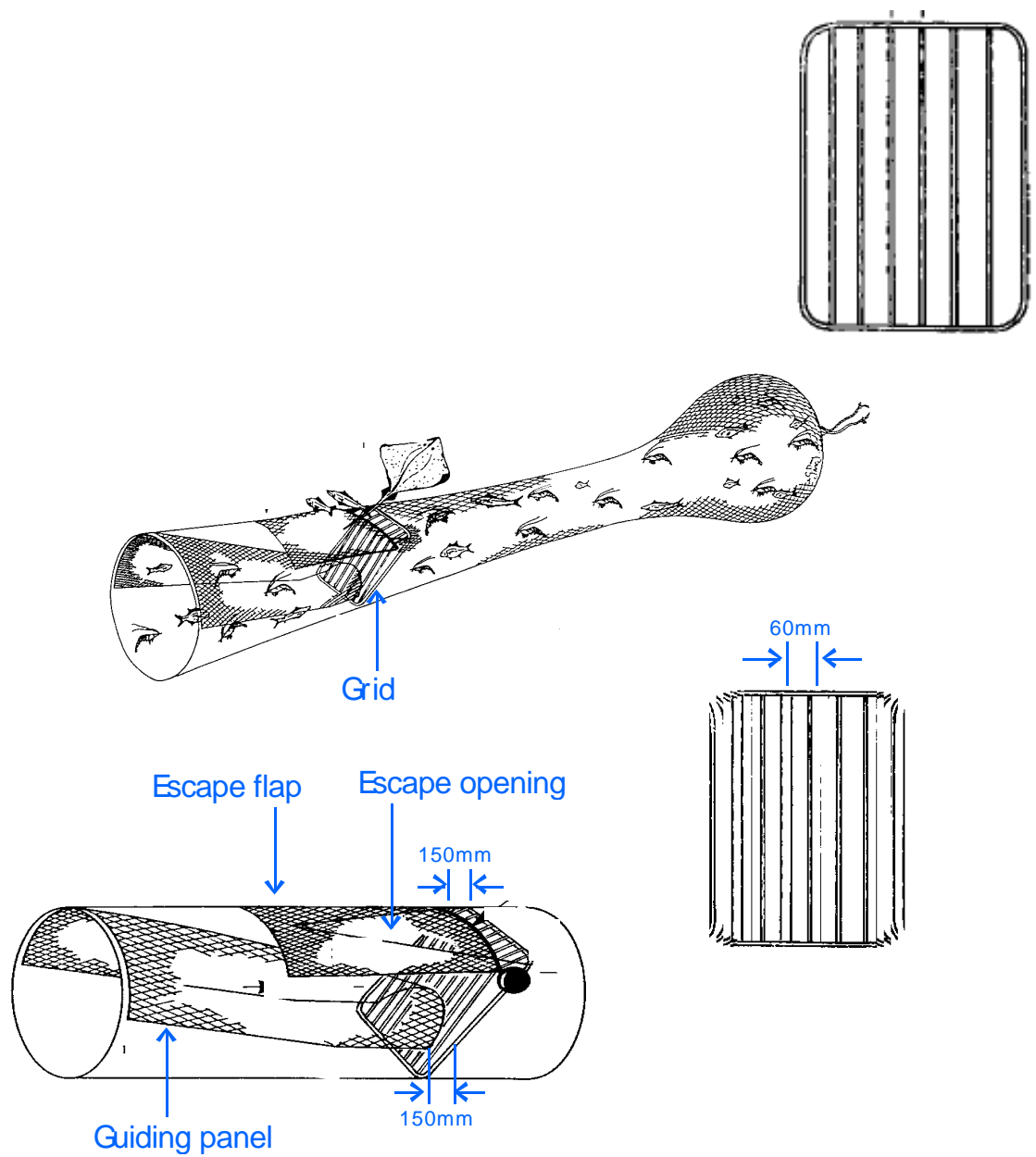


Figure 41

## Square-mesh codend

A square mesh codend has at least half the circumference of the codend with the following characteristics:

- A nominal mesh size no less than 45mm (22.5mm bar length).
- Netting orientated so that the direction of twine is longitudinal and transverse to the length of the codend.
- An overall continuous length measuring at least 75 meshes (3.375m) long.
- No pieces of netting or other material covering any square meshes during the fishing operation.

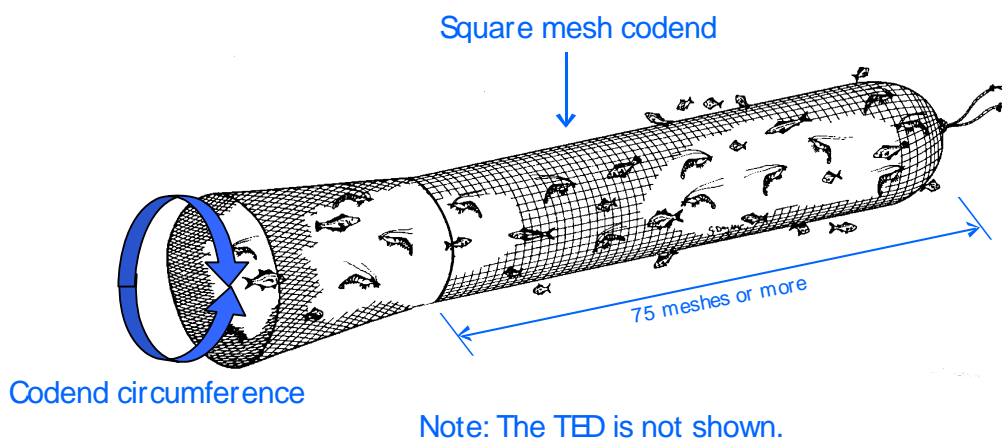
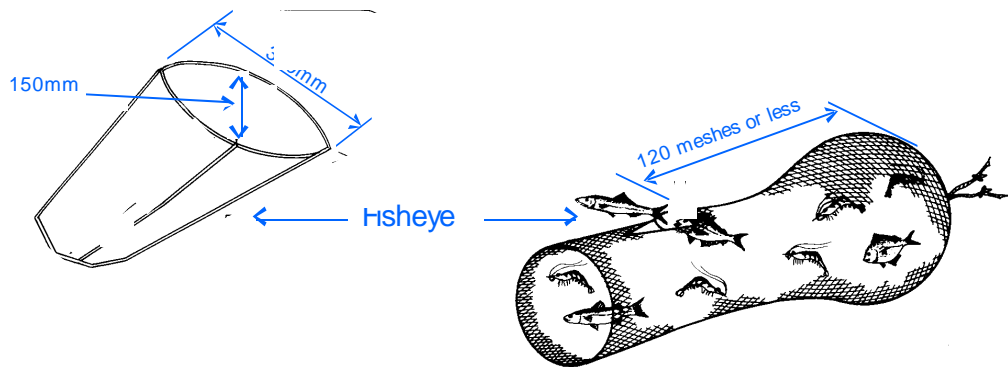


Figure 42

## Fisheye

A fisheye is a device with the following characteristics:

- A vertical escape opening held open by a rigid frame.
- An escape opening measuring no less than 350mm wide x 150mm high.
- The escape opening located no further forward than 120 meshes of the codend drawstrings.
- No pieces of netting or other material covering the escape opening during the fishing operation.



Note: The TED is not shown

Figure 43.

### Square-mesh window or panel

A square mesh window or panel is a continuous panel of netting that has the following characteristics:

- A nominal mesh size no less than 101mm (50.5mm bar length).
- An overall size measuring at least 400mm wide and 600mm long.
- The aft edge of the panel located no further forward than 120 meshes of the codend drawstrings.
- No pieces of netting or other material covering any square meshes during the fishing operation.

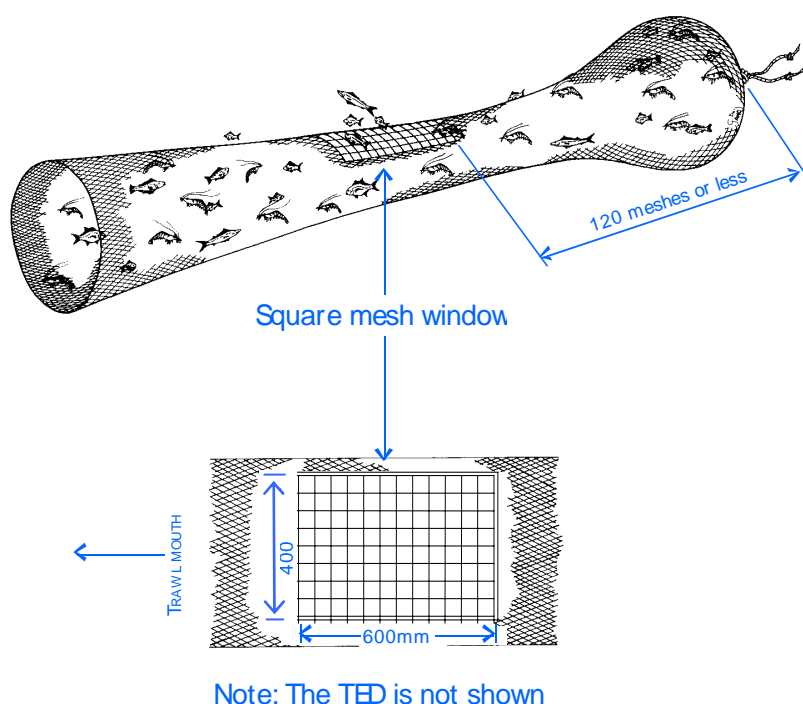
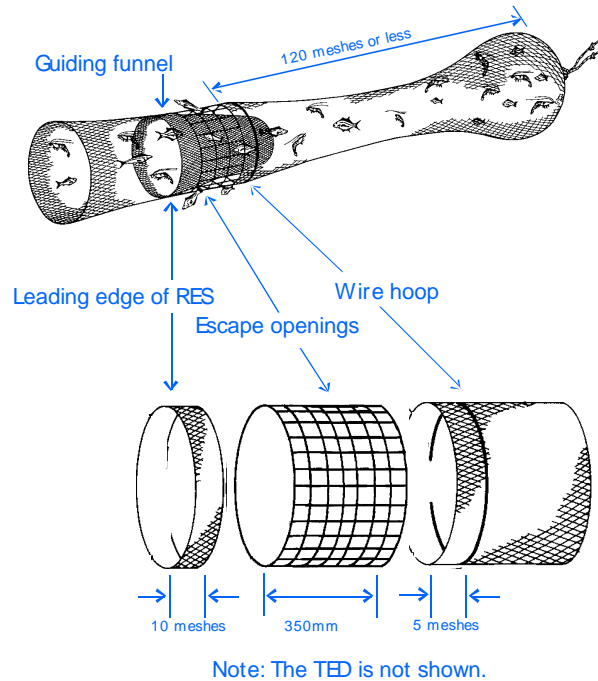


Figure 44

### Radial Escape Section

A Radial Escape Section (RES) is a device with the following characteristics:

- A funnel of netting or other material located within the codend.
- The circumference of the leading edge of the funnel must be of equal length to the circumference of the codend (the circumference of the codend is equal to the mesh size x the number of meshes around the codend).
- The leading edge of the funnel must be attached to the codend no more than 10 codend meshes ahead of the escape openings.
- The circumference of the trailing edge of the funnel is no more than 60% of the circumference of the codend.



**Figure45.**

Individual escape openings no less in size than a square mesh size of 100mm (50mm bar length).

Overall escape openings no less than a panel of netting measuring 350mm long (7 bar lengths) and at least half the circumference of the codend wide.

The trailing edge of the funnel extending no more than 500mm past the aft edge of the escape openings.

The aft edge of the escape openings located no further forward than 120 meshes from the codend drawstrings.

The forward edge of the RES located within 900mm of the TED grid or barrier, or if greater than 900mm from the grid, a wire hoop must be attached to the leading edge of the RES (where the funnel is attached to the codend).

A rigid or semi-rigid wire hoop with a minimum diameter of 650mm located no more than 5 meshes behind the escape openings.

No pieces of netting or other material covering any escape openings during the fishing operation.

## Recommendations for future research or legislative intervention

The 5-Year Research Plan for the Northern Prawn Fishery lists and prioritises research requirements. Listed as a high priority is the need to assess the status of major byproduct species including squid and crustaceans. Also given a high priority is the effects of fishing on the seabed, the effects of discarding practices, the survival of discard species, and the development of alternative fishing practices. A medium priority in the fishery is research into increased utilisation of bycatch species.

Given that the current range of bycatch reduction devices specified for the fishery are excluding only modest amounts of fish, there is clearly a need to improve their performance. The performance of these devices is influenced by a range of operational factors, including rigging, location in the codend, catch composition and volume, fishing ground characteristics and towing speed. However, quantifying the magnitude of these influences is difficult, and has not satisfactorily been achieved.

Another option to improve bycatch reduction is to design devices that take advantage of behavioural differences between shrimp and bycatch. To achieve this there is a need to evaluate the natural behaviour of shrimp and fish bycatch and their response to trawl stimuli. This knowledge is currently scant. For example, the escape swimming speed and endurance of shrimp has not been evaluated, nor has it been determined for bycatch species. This information is important because it can be used to develop species selective bycatch reduction devices to further reduce bycatch.

There is a need to explore the potential of innovative options to exclude bycatch. These options may include the use of electricity, light, sound and specialised trawl modification such as ultra-low opening trawl designs. Little work has been done applying these options to tropical shrimp-trawl fisheries. Most work has been done in other fisheries and/or applied to shrimp fisheries many years ago, and given the speed of technological development, it is now appropriate to re-evaluate the potential of these options.

There is also a need to develop BRDs that exclude protected species from the catch such as sawfish and sea snakes. Current BRD designs appear to perform modestly and further improvements are required. Limited video footage indicates that square-mesh windows can exclude sea snakes and perhaps further modification to this BRD would be a good starting point for future research.

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## Appendix 1: Working Documents

### Selective shrimp trawl development using behaviour differences between fish and shrimp

by

John Willy Valdemarsen

Institute of Marine Research,

Bergen, Norway

E-mail: John.Valdemarsen@iMrno

#### Introduction

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Shrimp and fish behave quite differently in the capture process during trawling (Isaksen and Valdemarsen 1994). While fish normally swim away from approaching netting, shrimp are generally non-directional in their reaction pattern. By studying these basic behaviour differences, ideas to develop technical solutions to separate fish from shrimp in the capture process are emerging. This paper describe three recent studies conducted in Norway that verify the behaviour differences, followed by a discussion on how such differences can be implemented technically in developing selective shrimp trawls.

#### Experiments

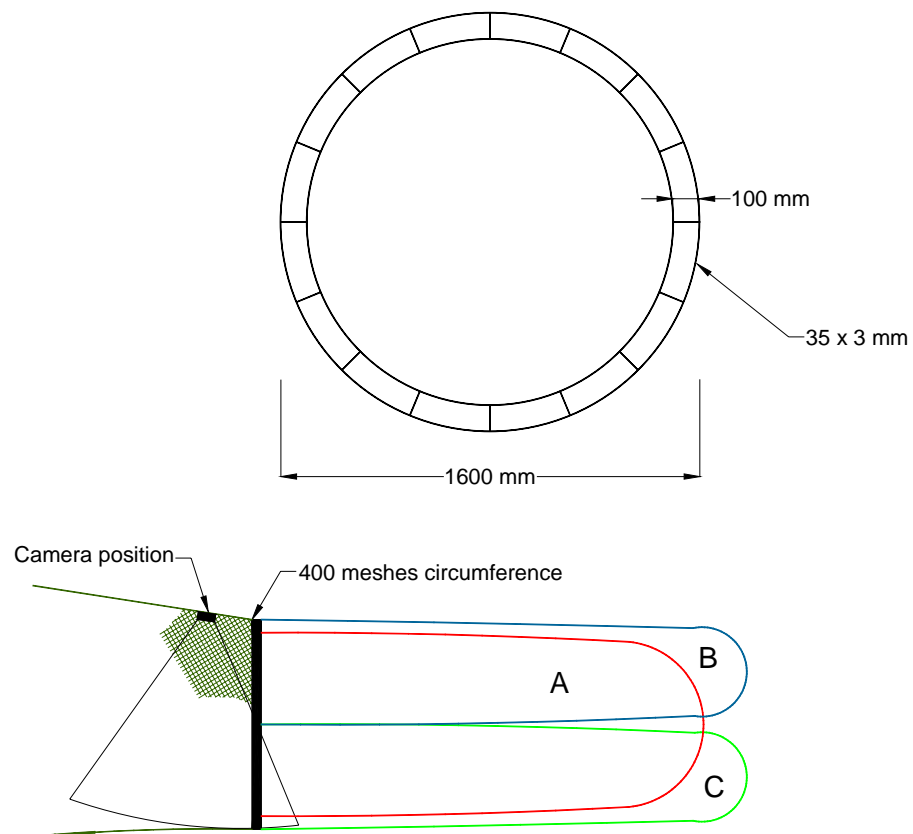
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Three experiments were conducted on two cruises in 2003 and 2004 using a smaller shrimp trawler (M/S “Fangst”) in a fjord in northern Norway. The first experiment was aimed to verify distinct behaviour differences between shrimp and fish while passing through the aft belly into the codend. The study was a combination of direct observations using an underwater camera and collecting bags. The second study during the same cruise was aimed to study the selectivity properties, particularly for 0-group cod by a modified Nordmøre grid. Observation of shrimp and fish behaviour with an underwater camera system in combination with catch comparisons in a divided trawl, equipped with a traditional and a modified Normøre grid were conducted. The third study in November 2004 was to some extent based on the 2003 experiments. The difference in behaviour of shrimp and fish passing through a 1 by 1 m squared section of square meshes in front of a two level codend was observed using an self recording camera. The catch composition in an upper and a lower codend was documented as well. Details about the designs of three devices and results from the various tests are described below.

#### Study no 1. A selective ring device

The basic idea behind this experiment was an assumption that nearly all shrimps that enter a trawl mouth will hit the netting, and thus be guided along it towards the codend, whereas fish will react to an approaching netting by trying to avoid it, and thus stay at some distance away from the netting when they are on their way towards the narrow aft belly of the trawl.

Figure 1 illustrates the ring device inserted in the aft belly of a shrimp trawl used in the experiments. The ring with a 1.6 m diameter was mounted in a position of the belly where it was assumed that the netting in front was continuously sloping inwards



**Figure 1: An illustration of the selectivity ring used in the experiments.**

towards the ring position. The 10 cm slot around the ring perimeter was divided into a lower and upper half, each covered with a collecting bag. The central hole was covered with a third collecting bag. The sloping of the netting in front of the ring was controlled by two methods; one was to measure the belly diameter 1 meter in front of the ring, and the other was to continuously record the sloping angle of the lower belly netting 30 cm ahead of the ring. The camera was positioned below the upper panel approx. 50 cm in front of the ring viewing downwards.

The diameter and angle measurements indicated that the ring should have been positioned further forward in the belly, as the diameter 1 m in front of the 1.6 m dia. ring was slightly less, approx. 1.5 m. The slope angle of the lower panel varied between  $-15$  and  $+2$  degrees, which also confirms that the ring should have been positioned further ahead to perform optimal.

The catch composition in the various codends varied in the 10 experimental hauls, which could be explained by the ring position (as described above), and its floatation. To illustrate the entrance to the three codends, only two valid hauls are presented. Table 1 clearly shows that most of the shrimp passes through the lower half of the ring slot, whereas particularly round fish passes through the central hole of the ring. It is, however, clear that some of the smallest cod also passes through the lower slot into the lower codend, together with flatfish. These results were also verified by the camera observations. Shrimp seem to be passively guided along the bottom panel whereas fish were more active and often kept some distance away from the panels.

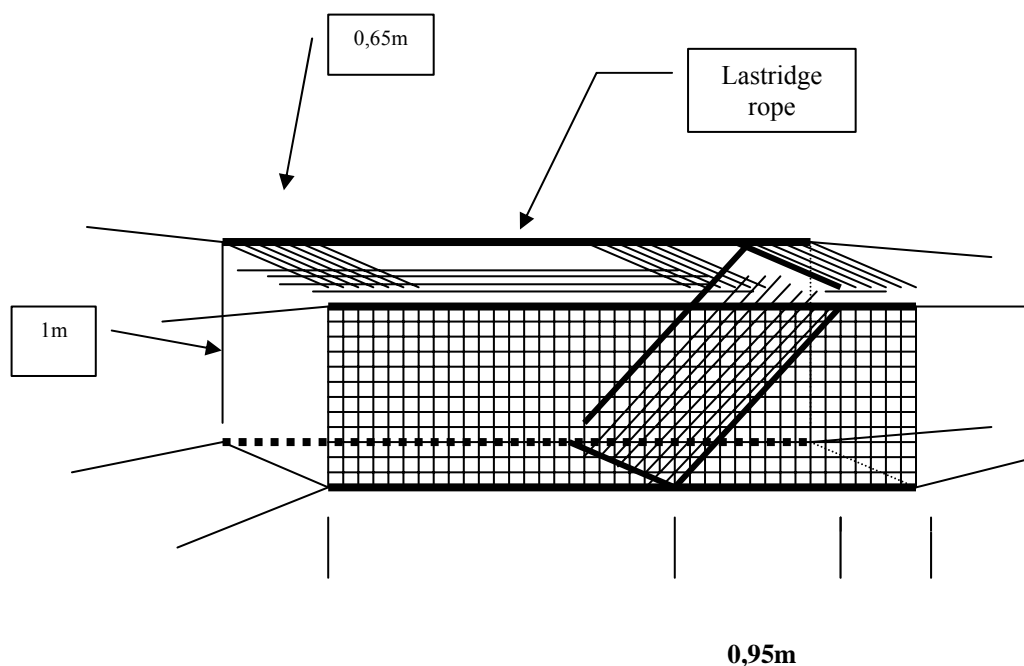
**Table 1: Catch composition of shrimp and some fish species in the three collecting bags behind the ring.**

Tow NO.	CODEND	SHRIMP (KGS)	SHRIMP (%)	COD (NO)	HADDOCK (NO)	BLUE WHITING (NO)	NORWAY POUT (NO)	FLATFISH (NO)
8	Upper	0,05	0,2	22	2	18	24	0
	Centre	0,4	1,9	56	192	108	91	0
	Lower	20,6	97,9	44	8	3	57	3
9	Upper	0,05	0,1	7	7	8	62	0
	Centre	1	2,9	66	276	115	82	0
	Lower	33	96,9	43	7	8	102	1

Beside the differences in reaction pattern of shrimp and most fish species, this study also indicated that the shrimp on this particular fishing ground was distributed close to the bottom as very few shrimp were caught in the upper codend. Although some shrimp entered the centre codend in some of the tows, probably because of reasons as explained above. The nearly zero catch of shrimp in the upper bag was confirmed in all 10 tows.

## Study no 2. The modified Nordmøre grid

Based on some of the observations in the study described above, an idea of removing the guiding panel in front of the sorting grid emerged. The main function of the guiding funnel in front of the sorting grid is to reduce loss of shrimp, which might follow along the upper panel towards the grid, through the fish outlet positioned in front of the top part of the grid. When shrimp is distributed close to the bottom it will, however, be guided along the bottom panel towards the sorting grid, and in such circumstances the guiding funnel have no positive function. In fact it might reduce the wanted fish release, as all fish are forced to pass the lower slot below the funnel in front of the grid. To assure that the lower edge of the sorting grid was the highest point along the rising bottom panel, a section of square meshes was designed for inserting the Nordmøre grid without a guiding funnel in front of it (Figure 2).



**Figure 2: Modified Nordmøre grid inserted in a squared section of square meshes without a guiding funnel in front of the grid.**

Besides observations with a camera in front of the grid two other methods to study the effect on shrimp loss and fish release were included in the trials. One study was to compare the catch composition in each codend of a divided trawl belly with a belly equipped with the modified sorting grid whereas the other had a standard Nordmøre grid device (with a guiding funnel in front). The other independent but linked method, was to compare the catch in the codend behind the modified grid with that of a collecting bag covering the fish outlet. All tows were carried out with a divided trawl belly, out of which 4 hauls were with the collecting bag over the fish outlet.

The catch composition in the two codends in each of the 9 comparisons is shown in table 2. These results clearly show that more of the small sized fish (0-group) cod and Norway pout escape with the modified grid compared with the standard grid device, whereas there is no sign of increased shrimp loss with the guiding funnel removed.

The experiments with the collecting bag over the fish outlet confirm the low shrimp loss with the guiding funnel removed, shown in table 3. These data also indicate that as much as 65–70 % of 0-group cod might be released when the guiding funnel is removed compared with a nearly zero escape of these small fish with the traditional Nordmøre sorting grid device. The data also show that less than 1% of shrimp were lost with the guiding funnel removed.

These results clearly indicate that shrimp is following the bottom panel towards the sorting grid, and that an arrangement where the lowest grid edge is the highest point of a rising bottom panel can be utilized to retain shrimp. Fish and also small sized cod will keep some distance above the bottom panel if allowed. The application of these findings will be further discussed later in the paper.

**Table 2: Catch in the two codend of shrimp and indicator species (cod < 15 cm and small sized Norway pout).**

HAUL NO	COD (NO)		NORWAY POUT (NO)		SHRIMP (KG)	
	Without funnel	With funnel	Without funnel	With funnel	Without funnel	With funnel
11 (A)	21	127	99	440	14,2	19,6
12 (A)	50	103	134	391	26,5	28,4
13 (A)	84	253	230	443	48	52
14 (A)	70	240	292	848	41	48,7
15 (B)	106	164	830	2042	31	26,8
16 (B)	160	185	355	491	35,1	32,3
17 (B)	70	141	470	1581	21,8	21,1
18 (B)	70	103	822	1285	32,1	16
19 (B)	145	217	523	1048	28,1	21,5
<b>Total</b>	<b>776</b>	<b>1533</b>	<b>3755</b>	<b>8569</b>	<b>277,8</b>	<b>266,4</b>

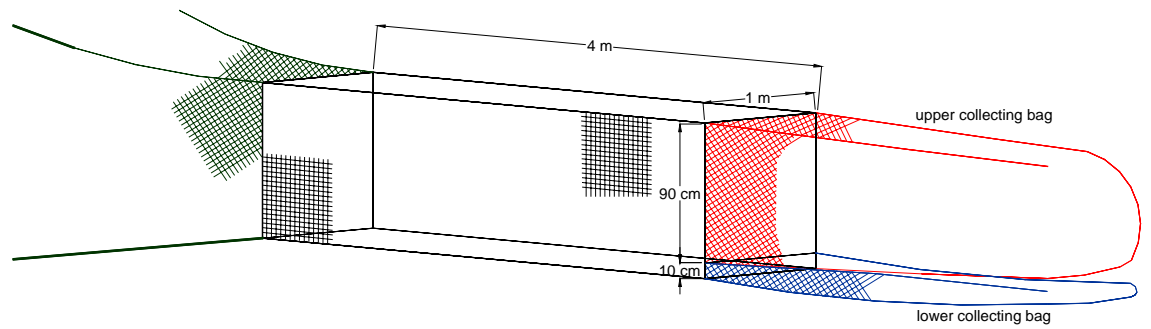
**Table 3: Catch composition of 0-group cod in the main codend and in a collecting bag in four experimental hauls with the modified Nordmøre grid.**

HAUL NO	MAIN CODEND			COLLECTING BAG			ESCAPEMENT IN %		
	Cod (no)	N. Pout (no)	Shrimp (kg)	Cod (no)	N.Pout (no)	Shrimp (kg)	Cod	N.Pout	Shrimp
13 (A)	84	230	48	164	330	0,3	66,1	58,9	0,6
14 (A)	70	292	41	149	602	0,3	68,0	67,3	0,7
15 (B)	106	830	31	67	296	0,01	38,7	26,2	0,03
16 (B)	160	355	35,1	61	315	0,4	27,6	47,0	1,1
<b>Total/average</b>	<b>420</b>	<b>1707</b>	<b>155,1</b>	<b>441</b>	<b>1543</b>	<b>1,01</b>	<b>51,2</b>	<b>47,4</b>	<b>0,6</b>

### Study no 3. Passage of fish and shrimp through a 1X1 squared section in front of the codend

The results from the experiments described above initiated an idea to study the passage of shrimp through a horizontal narrow slot arranged above the bottom panel in front of the codend. A 4 m long unit of square meshes, 1 m wide and 1 m tall, to which was attached an 1 by 1 m aluminium frame as shown on Figure 3. The basic idea was that shrimp would follow a rising bottom panel towards a 10 cm slot, whereas fish would stay higher above the bottom panel when approaching the frame, and thus be released through some kind of a fish outlet above. In addition to observation with camera of the passage of shrimp and fish through the squared frame, organisms passing through the 10 cm lower slot compared with those passing the upper part of the frame were captured in two attached to each of the two passages. The

experiments also included the use of a grid (40 mm bar distance) in front of the 10 cm slot, as well as successive removal of netting on the top of the squared section and parts of the side panels.



**Figure 3: An illustration of the 1X1 m frame inserted in a square mesh aft shrimp trawl belly.**

**Table 4.: Catch composition in the upper and lower codends in the 19 tows.**

HAU L NO	TES T CON F.	OBS.	SLOPE ANGLE	COD- END	SPECIES						%SHRIMP IN LOWER CODEND	
					Cod (no)			Haddock (no)				Shrimp (kg)
					<20cm	20- 50cm	>50 cm	<20cm	20- 50cm	>50 cm		
1	1	0	11,9	Upper	2	53	25	12	114	4	2,9	
				Lower	1	2	1	0	4	1	11,4	79,7
2	1	+	12,6	Upper	38	44	13	49	212	5	0,9	
				Lower	20	26	10	7	27	0	13,7	93,8
3	1	0	11,4	Upper	8	84	14	416	69	8	20	
				Lower	7	24	0	23	5	0	72,2	78,3
4	1	+	12	Upper	4	54	27	285	58	13	5	
				Lower	6	19	6	39	17	3	27	84,4
5	1	+	15,7	Upper	0	12	17	245	30	17	17	
				Lower	0	2	3	93	3	5	83	83,0
6	1	0	15	Upper	1	90	45	4	1	2	5,2	
				Lower	1	3	1	0	0	0	38,4	88,1
7	2	0	16,2	Upper	5	64	9	5	0	0	1,4	
				Lower	8	32	5	1	0	0	32,9	95,9
8	2	0	-1,4	Upper	5	59	25	6	0	0	9,7	
				Lower	0	12	4	0	0	0	27,4	73,9
9	3	0	10,4	Upper	23	65	16	3	0	0	8	
				Lower	5	15	2	0	0	0	48,9	85,9
10	3	+	7,3	Upper								
				Lower							89,2	100,0
11	3	+	2,9	Upper	3	10	13	427	51	32	20	
				Lower	0	2	4	27	5	3	61,7	75,5
12	4	+	13,3	Upper	4	8	11	292	27	14	1,3	

HAU L NO	TES T CON F.	OBS.	SLOPE ANGLE	COD- END	SPECIES						%SHRIMP IN LOWER CODEND	
					Cod (no)			Haddock (no)				Shrimp (kg)
			degree		<20cm	20- 50cm	>50 cm	<20cm	20- 50cm	>50 cm		
				Lower	0	3	7	48	7	3	54,6	97,7
13	4	0	20,4	Upper	2	22	35	517	58	32	7,4	
				Lower	2	2	11	23	1	2	78,9	91,4
14	5	+	13	Upper	4	8	19	116	21	11	7,8	
				Lower	0	2	0	21	1	1	67,7	89,7
15	5	0	12- 14,5	Upper	1	10	21	109	25	22	13	
				Lower	0	0	1	5	0	0	44,1	77,2
16	5	0	12,6	Upper	38	127	16	449	40	8	5,6	
				Lower	15	16	0	11	2	0	32	85,1
17	6	0	12,3	Upper	27	143	4	49	4	5	18,5	
				Lower	8	21	0	4	0	0	115,3	86,2
18	7	0	19	Upper	36	103	9	36	1	2	0,5	
				Lower	19	49	2	5	0	0	41,7	98,8
19	8	+	20-15	Upper	11	40	3	173	0	0	0,1	
				Lower	33	27	5	70	1	1	55	99,8

Test configurations: 1=10 cm lower slot, 2= 20 cm lower slot, 3= 10 cm slot including 50 cm on the sides, 4= As 4 + 5 kg extra floatation, 5= Grid with 38 cm bar spacing in front of lower slot, 6=As 5 with upper panel in square mesh section removed, 7= As 6 with the grid removed, 8= As 7 with half side netting removed.

The slope of the bottom panel in front of the squared frame was measured with an angle sensor that continuously transmitted measured values acoustically to the vessel (a Scanmar prototype sensor).

Table 4 is a summary of the 19 experimental hauls with these arrangements. Besides catch composition of various size groups of cod and haddock as well as shrimp in the two collecting bags (when used), information about average bottom panel slope angles and whether camera with light in front of the frame were used are included in the table. The various gear modifications are also explained.

The general observation from this experiment was that shrimp to a large extent follows the bottom panel towards the codend, as long as the bottom panel is rising. The same also happened for other passive organisms like jellyfish. Large jellyfish sometimes blocked the 10 cm narrow slot of the frame and thus forced some shrimp into the upper collecting bag. A 30 degrees sloping grid in front of the slot removed the blocking problem, but some shrimp were observed to slide along the grid bars into the upper bag (hauls 14–16). It was also observed that some shrimp came along the lower parts of the side panels. This was the reason why the 10 cm slot was extended to the lower half of the side.

Fish was observed to be very active in front of the frame. The data clearly show that most of the haddock passed through the upper part of the frame, whereas some cod also passed through the narrow bottom slot. In fact it seems as more cod passed the slot while using light for observations.

In the last three hauls the top netting in front of the frame was removed. It was obvious that many fish that came into this area escaped through these openings. This particular experiment does not, however, provide exact data for this fish escapement, neither for shrimp loss.

## Discussion

The key assumption that shrimp that hits a netting panel will be guided along the netting when tapered inwards was confirmed in all three experiments. This behaviour can thus be the basis for a trawl design that is guiding the target shrimp along netting towards a narrow slot in front of a collecting bag (codend). For shrimp, which is distributed in the vicinity of the bottom, this implies that the bottom panel can be the main guiding panel. A similar narrow slot in the aft part of a rising bottom panel might therefore become a solution that can be further technically developed.

Before discussing technical solutions, however, some comments regarding the observed fish behaviour in the trawl belly is of interest. In the first study using the ring, the space was larger than in the two last studies inside squared funnels of 1 by 1 meter. The extra space seems to result in more “relaxed” movement of fish into the observation area. Most of the larger (>20 cm) fish obviously kept some distance away from the netting when approaching the ring. The catch distribution in the three bags confirmed that active fish passed the central parts of the ring indicating such behaviour.

The second study with the modified Nordmøre grid, was an interesting experiment in the sense that removal of the guiding net in front of the grid released more 0-group cod than a standard Nordmøre grid. A possible explanation of this promising result is that fish, including the smallest cod, came towards the grid at some distance from the bottom panel and thus could easier escape through the fish outlet in the top panel in front of the upper edge of the grid. And as seen from the result, minor loss of shrimp occurred with the guiding funnel removed.

The third study had some obvious weaknesses regarding fish escape behaviour. The narrow passage combined with light when observing with camera seems to trigger some “panic” behaviour when passing the 1X1 m frame. This might explain why so many fish also passed the narrow slot above the bottom panel in some of the hauls. But the most interesting observation was the relaxed escape of fish through the large opening in front of the frame in the very last haul of the study.

A technical solution, which utilizes the observed shrimp and fish behaviour differences, is most likely a combination of untraditional trawl design and the use of proper monitoring instrumentation. A first challenge is to design a bottom panel that is continuously rising towards a slot, independent of the codend catch weight. This rising feature should, however, be monitored with an instrument so that haul back can be initiated when the rise of the bottom panel disrupted. The next challenge is to design a trawl where most of the upper netting panel is removed. Removal of such netting will first of all reduce the trawl drag significantly, but probably as important the fish escape through the open “roof” will be significant.

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## Annex 4: Topic group report on review of technical measures

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### Introduction

During the past 5 years many changes have been made to fisheries legislation relating to gear design and applying to North East Atlantic fisheries. The European Commission has adopted several recovery plans and is scheduled to review technical conservation measures (tcm) legislation. The International Baltic Sea Fisheries Commission has adopted new measures to control fishing gear in their area over the past few years. The EU has made agreements with third countries (and other bodies such as NEAFC) on technical measures to be applied in jointly managed or international waters.

Legislators, scientists and the fishing industry recognise however, that there are inconsistencies in the current range of legislation. In 2004 ICES approved a recommendation put forward by the Working Group on Fishing Technology and Fish Behaviour (WGFTFB) to address some issues relating to legislation on technical conservation measures, which have a bearing on fishing gear design. The aim is to inform the debate which will be generated during the European Commission's review.

While the current exercise aims to inform the review of EU legislation and therefore concentrates on EU fisheries, there may be a similar worthwhile task to be done in other areas of the world.

### Terms of Reference

- a) To review issues relating to legislation on technical conservation measures relating to fishing gear design;

(Topic leaders: [Dick Ferro](#), FRS, Aberdeen and [Dominic Rihan](#), BIM, Dublin).

### Participants

Ludvig Ahm Krag (DIFRES, Denmark)	Terje Jorgensen (IMR, Norway)
Ana O. Amodo (FAO)	Pascal Larnaud (IFREMER, France)
Paolo Belcari (DSUA, Italy)	Per Olov Larsson (IMR, Sweden)
Eckhard Bethke (BFHFI/IFF, Germany)	Alessandro Lucchetti (ISMAR-CNR, Italy)
Asta Hron Bjorgvinsdottir (Univ. of Atureyr, Iceland)	Waldemar Moderhak (SFI, Poland)
Bong-Jim Cha (NFRDI,)	Charlotte B. Mogensen (WWF)
Dick Ferro (FRS, Aberdeen)	Michael Pol (Massachusetts Div. of Mar. Fish., USA)
Ronald Fonteyne (CLO-DvZ, Belgium)	Dominic Rihan (BIM, Ireland)
Ulrik Jes Hansen (SINTEF, Denmark)	Jacques Sacchi (IFREMER, France)
Rene Holst (DIFRES, Denmark)	Antonello Sala (ISMAR-CNR, Italy)

Mats Ulmestrand (IMR, Sweden)

Arill Engås (IMR, Norway)

## Issues identified

The Conveners issued a circular letter (See Appendix I(a) to appropriate WGFTFB members in European countries in December 2004 inviting participation in the Group and suggesting that they contact their respective enforcement agencies to ascertain their views on the current legislation. The EU was also contacted with a view to engaging in dialogue on assistance that WGFTFB could provide (See Appendix I(b)). The Group worked by correspondence in early 2005 and several members were present at another meeting in Lorient at which the opportunity was taken to identify some initial tasks in the review process. The agreed action points arising from this meeting were as follows:

1. To make a list of any relevant national measures which are additional to EU Technical Conservation Measures in Regulation 850/98 and associated regulations To make a list of the current Technical Conservation Measure issues, which are of highest priority or give the greatest difficulties to respective national industries e.g., including areas where there is perhaps a need for better Technical Conservation Regulations or the existing regulations are ineffective from a gear selectivity perspective. To identify inconsistencies in Technical Conservation Measures between adjacent areas in national waters e.g., mesh change from northern to southern North Sea, North Sea to Skagerrak/Kattegat or North Sea to West coast of Scotland; or where there are inconsistencies between scientific advice and/or stock management areas and the current Technical Conservation Regulations e.g., Northern Hake stock where several different mesh sizes apply within the same management area.

The Group then met in Rome on April 18 2005 during the WGFTFB meeting to discuss these issues.

### Item 1. National legislation

This information was compiled to act as a useful reference and provide information on areas where more stringent legislation was in place with a view to assessing its wider applicability. The full list of legislation identified by country is presented in Appendix II.

### Item 2. Priority issues

The Group was clear that its remit extended only to consider technical issues relating to legislation on fishing gear design and operation. It was not the intention to consider biological or management issues unless these required input of technical information that the Group could provide nor was it the intention to make judgements on which regulations or methods of controlling fisheries are more effective. In view of this, the Group first drew up a list of criteria, which helped to identify whether an issue was of a technical nature as shown in Table 1.

**Table 1: Criteria to distinguish technical problems.**

<b>Characteristic of legislation</b>	<b>Examples of technical problem</b>
Ineffective, unnecessary or complex	Extension length, codend circumference
Unenforceable	k-netting
Inappropriate for a fishery	Heavy steel grid on small vessel
Inadequately defined in regulation	Square mesh panel position
Difficult for fishermen to implement	Loss of strength due to thin twine
Inadequate for control	No restriction on multi-rigs

After considerable discussion, the Group selected a range of priority issues relevant to fisheries throughout Europe (Table 2).

The ultimate aim in this task was not only to identify the issues but also the technical information which could help to solve the problems and whether some additional work might be needed e.g., in collating and analyzing existing data to provide justification for a change in a particular technical measure. Within the time available, the Group has not been able to complete this aspect of the job although it considers that it would still be very worthwhile. This point is discussed further under consideration of the future work of the Group under the aegis of WGFTFB. Potentially gear technologists also have a role to play in assessing the effects (intended and unintended), which regulations may have on fisheries. Gear technologists, similar to enforcement officers, often have practical experience of how fishers conduct fishing operations and could potentially circumvent technical measures. Again future work would be needed to complete this exercise.

**Table 2: Summary of Priority Issues.**

ISSUE	COMMENTS	SUGGESTED ACTION
Twine Thickness	Twine thickness is regulated because thicker twine has an adverse effect on selectivity. However, reducing twine thickness may compromise strength and hence safety. New types of stiff twines are coming onto the market having characteristics, which may reduce selectivity.	Assess whether there is a need to take account of limitations in twine strength in certain fisheries and also investigate whether twine stiffness influences codend selectivity.
Twine Construction	A new regulation (129/2003) has recently been introduced to control twine thickness but the instrument for testing compliance is not yet available.	Review the application of the new regulation.
Codend/Extension Construction	There are a number of anomalies in the current regulations regarding dimensions and construction of codends/extensions, which could be rationalised. For example, the rules limiting meshes round the codend could be simplified, while those on codend and extension length also seem unduly complex and unnecessary.	Review and summarise appropriate selectivity data, with a view to advising on the need to simplify the current legislation.
Square Mesh panels	Some aspects of regulations on square mesh panels are poorly defined e.g., on panel position, width or joining ratio. With single or four selvedge codends there are also potential difficulties in defining panel width. The availability and description of materials for panels is poorly specified in the legislation.	Review available selectivity data on square mesh panel position. Better define materials and construction of square mesh panels.
Headline Panels	The regulation on headline panels for trawls appears to be based on relatively little data and no assessment has been made of the effects of such panels.	Review any available selectivity data testing this concept as well as data from trials planned for later in 2005 under the EU funded NECESSITY Project, which will test similar headline panels.
Strengthening Bags	Strengthening bags, which are widely used in many countries have been shown to have an adverse effect on codend selectivity. These effects, however, are not well documented	Review available data to assess the benefits of restricting the use of strengthening bags.
Top Side Chafers	The use of top side chafers is potentially detrimental to codend selectivity. It is questionable whether such devices should be permissible.	Assess the effect of the use of top side chafers on selectivity.
Strengthening Ropes	Under the current gear attachment regulation there is no restriction on the number or specification of strengthening ropes. By attaching multiple strengthening ropes, codend selectivity could be potentially reduced.	Review work in this area, with a view to amending the regulation. To define the number and specifications of strengthening ropes.
Gillnets	In a number of sea areas e.g., The Baltic there are specific regulations (both national and EU) governing the length, soak time and hanging ratio of gillnets. No such re-	Assess the effect of additional technical conservation measures.

ISSUE	COMMENTS	SUGGESTED ACTION
	<p>strictions apply in Western waters or in the North Sea. Studies have shown excessive soak times caused by the use of unmanageable gear lengths in gillnet fisheries result in very high discards.</p>	
<p>Asymmetric Meshes</p>	<p>Under Article 9 (1) of Regulation 850/98 the use of mesh shapes other than diamond or square mesh is prohibited. The use of hexagonal mesh to improve selectivity through improved water flow has been tested but the legality of using hexagonal meshes is unclear under this regulation.</p>	<p>Check the legality of the mesh shape</p>
<p>Bycatch Regulations</p>	<p>Under the current EU Days at Sea legislation the maximum permitted bycatch of cod increases when using an 80mm mesh size compared to 100mm or greater. This actively encourages use of the smaller mesh size.</p>	<p>Carry out a technical analysis of changes in fishing pattern as a result of this regulation.</p>
<p>Multiple Rigs</p>	<p>The use of multiple rigs i.e., more than two nets has increased significantly in recent years but the increase in level of fishing power associated with the use of such gears has not been properly defined.</p>	<p>Assess data on the difference in fishing power associated with multiple rigs compared to conventional gears.</p>
<p>Pelagic Trawls</p>	<p>Pelagic trawls are used in some fisheries close to the sea bed resulting in bycatches of non-target demersal species.</p>	<p>Examine the potential of gear modifications such as raised footropes.</p>
<p>Trouser Codends</p>	<p>Current regulations limit the number of meshes allowed in the circumference of codend/extensions. This regulation prevents the effective use of trouser codends, which are used by some vessels, particularly in the North Sea, to enhance fish quality and also reduce the effect of codend damage.</p>	<p>Assess the need for a change in legislation onto accommodate trouser codends</p>

### Item 3. Inconsistencies in legislation

Typical inconsistencies are seen where a single stock management unit covers two areas where the tcms differ. Also it is common for adjacent sea areas to have similar fisheries but again to be covered by different technical measures. To discuss the inconsistencies brought forward by different members, the Group split into 3 sub-groups, each dealing with sea areas which were considered to have similar fisheries. They were:

- Baltic (ICES areas IIIb,c and d);
- North Sea, Norwegian Sea, Skagerrak, Kattegat, West of Scotland (II, IIIa, IV, V, VI);
- Western waters (VI, VII, VIII, IX).

Comprehensive lists identifying the inconsistencies in the legislation are given for the three areas in Annex III. It should be noted that issues have been included in these lists that the Group considered may require gear related information to help in the amendment or formulation of regulation, even if the subject maybe superficially a biological or a management issue, e.g., the need to harmonise minimum landing sizes has a connection with the need to match mls with codend selectivity. WGFTFB could potentially provide much of this information.

By way of illustration of the complexity and differences in current EU and national legislation, in the *Nephrops* fishery in the area from the Skagerrak (IIIa) to West of Scotland (VIa) no less than ten different pieces of legislation currently exist between EU and national legislation as shown in Table 3. Codend mesh size can range from a minimum of 70mm to 120mm diamond while twine thickness ranges from 4mm single to 6mm double. Depending on the area, 80mm or 90mm Square Mesh Panels are required or a grid with 35mm bar spacing can be used. Additionally the maximum number of meshes in the codend circumference is 120 meshes in some areas but no restrictions apply in others.

**Table 3: Inconsistencies in legislation relating to *Nephrops* fisheries in ICES areas IIIa+b, IVa+b+c, VIa+b.**

AREA	LEGISLATION (EU OR NATIONAL)	CODEND MESH SIZE	ADDITIONAL REQUIREMENTS	TWINE THICKNESS	CODEND CIRCUMFERENCE
Skagerrak/Kattegat	Sweden	70mm Square	35mm Grid	none	none
		90mm Diamond	none	6mm double/8mm single	none
Skagerrak/Kattegat	Norway	70mm Square	(> 60m depths)	none	none
		90mm Diamond	none	5mm double/8mm single	none
North Sea Norwegian Sector	Norway	120mm diamond	none	none	none
North Sea and West of Scotland North of 56° N and west of 7° 30' W	EU	80mm diamond	80mm square mesh panel and 140mm headline panel	5mm double/8mm single	120 meshes
North Sea and West of Scotland North of 56° N and west of 7° 30' W	UK	80mm diamond	90mm square mesh panel and 140mm headline panel	4mm single	120 meshes
West of Scotland South of 56° N and east of 7° 30' W	EU	70mm diamond	80mm square mesh panel and 140mm headline panel	6mm single/4mm double	120 meshes
West of Scotland South of 56° N and east of 7° 30' W	UK Single Trawl	70mm diamond	90mm square mesh panel and 140mm headline panel	4mm single	120 meshes
West of Scotland South of 56° N and east of 7° 30' W	UK Twin Rig	80mm diamond	90mm square mesh panel and 140mm headline panel	4mm single	120 meshes

**Note 1.** There is a difference between Scotland and the rest of Europe in the catch composition of *Nephrops* which defines a vessel fishing for *Nephrops* in the 80–99mm mesh range. Scottish vessels anywhere and British vessels in Scottish waters are required to have at least 35% *Nephrops* by weight whereas other vessels are required to have 30%.

**Note 2.** Square mesh panel position is defined differently in European legislation compared to Scottish and UK law.

A fourth sub-group was charged with compiling an initial list of topics relevant to the Mediterranean. At present very few technical measures regulations at either EU or national level exist for the Mediterranean. The current goal of the EU for fishery management, though, is to develop a communal policy for the Mediterranean for implementation by all EU and non-EU Mediterranean nations. The sub-group prepared a document listing current EU, national and local regulations for each gear type used in the Mediterranean, and commenting on possible problems, improvements or uncertainties in these regulations. For instance, under EU legislation, bottom trawling requires a minimum codend mesh size of 40mm and is forbidden within the 3 mile coastal limit and in less than 50m depth. France however, mandates by national regulation a minimum stretched mesh length. This creates a misunderstanding because the EU regulates on mesh opening and not minimum stretched length. Therefore it is suggested the

regulation of mesh measurement should be harmonised between France and the EU. The full document is contained in Appendix IV.

It is also important to note that a STECF Sub-group, SGMED, has been set up to look at all aspects of the fisheries, techniques and legislation that currently exists in the Mediterranean, and the review of legislation produced by the Mediterranean scientists at the TCM topic group should be useful for this STECF Sub-Group.

## **Future work**

Items 1 and 2 highlight specific issues where legislation may be considered for revision. In many cases, detailed technical information is available which will inform these discussions. Gear technologists should be involved in collating and interpreting such information, as indicated in the right hand column of Table 2, for use by fishery managers leading the review process. Linkage with the ICES Study Group on Management Strategies (SGMAS) would also be useful and the 2005 report from SGMAS identifies the need for technical input as to the effectiveness of gear regulations in the development of management strategies.

The work on item 3 involved defining very carefully the legislation, which was in place in each sea area. This proved to be very difficult and it is clear that a comprehensive job could only be carried out with much effort from appropriate experts from enforcement and legal departments. Having said this, the Group can see that there is an important role for gear technologists at the following stage after the legislation has been defined and the differences between areas identified. For example, gear technologists could then estimate the selectivity of inconsistent gears and thus provide a quantified assessment of the significance of the inconsistency to management of the fishery.

## **Recommendations**

The WGFTFB Chair has been invited to discuss with the EU Commission progress in the Group's work at an early opportunity. If the Commission considers that further work would be beneficial then it is recommended that WGFTFB consider how to take the matter forward.

## **Appendix I(a) Circular sent to FTFB members**

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### **ICES Review of Legislative Issues Related to Technical Conservation Measures**

During the past 5 years many changes have been made to fisheries legislation relating to gear design and applying to North East Atlantic fisheries. The European Commission has adopted several recovery plans and is scheduled to review technical conservation measures legislation. The International Baltic Sea Fisheries Commission has adopted new measures to control fishing gear in their area over the past few years. The EU has made agreements with third countries (and other bodies such as NEAFC) on technical measures to be applied in jointly managed or international waters.

Legislators, scientists and the fishing industry recognise however, that there are inconsistencies, uncertainties and inadequacies in the current range of legislation. The Fishing Technology and Fish Behaviour Working Group (WGFTFB) of ICES proposes to undertake a technical review of the issues. The aim is to inform the debate which will be generated during the European Commission's review by providing information of relevant fishing practices and operations, reviews of technical data and technical assessments of fishing gear performance. The Working Group will finalise a report for circulation by June 2005.

The table below provides an initial list of issues that could be considered in detail by a sub-group of ICES WGFTFB. A further table identifies the principal EU legislation. We would be grateful if you would consider the list of issues and give an initial reaction on the relevance and importance of each and on the action proposed to be taken by the Sub-group. We would also be grateful for suggestions for other items to add to the list. If your response could be returned by 31<sup>st</sup> January the sub-group would have time to complete its review in time for the ICES Working Group meeting in April 2005.

## Appendix I(b) Correspondence sent to EU

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Mr Ernesto Penas  
European Commission  
Directorate-General for Fisheries  
Management of Stocks  
Rue Joseph II  
B-1049 Brussels

Tuesday, 25 January 2005

Dear Mr Penas,

RE: Technical information helpful for review of technical conservation measures pertaining to fishing gear.

During the past 5 years many changes have been made to fisheries legislation relating to gear design, mainly through amendments to Council Regulation 850/98. It is however, perceived by many legislators, scientists and the fishing industry that there may be scope for rationalisation across the current range of gear regulations. This has been recognised in the recent communication from the Commission, '**Perspectives for simplifying and improving the regulatory environment of the Common Fisheries Policy – SEC (2004) 1596**'.

The Fishing Technology and Fish Behaviour Working Group (WGFTFB) of ICES is a source of expertise on technical aspects of fishing gear design and operation. In the light of a possible review of technical measures, the WGFTFB has identified a need for re-examination of some of the technical issues relating to Reg 850/98 as well as associated regulations such as those of the IBSFC and NEAFC. A small group is being set up to produce a report which will be discussed by the Working Group in April, with a final report due for circulation by June 2005.

The main aims are to provide technical and practical information relevant to the regulation of fishing gear design, which might be helpful to clarify technical issues and assist with any future rationalisation of legislation. The views and advice of Fisheries Inspectors in different Member States are being sought and ultimately we hope our findings will inform the debate on any future review of the regulations carried out by the Commission.

We have prepared the attached document setting out some of the issues which we feel could be tackled in our review. We would welcome having initial discussions with yourself and others in the Commission, in order to ensure that we do not duplicate work already ongoing and also to identify areas in which gear technologists might usefully provide input. Perhaps you could indicate if you would be interested in having a meeting and suggest a possible date, hopefully within the next month.

Yours sincerely,

Norman Graham

Dick Ferro

Dominic Rihan

Chair of ICES WGFTFB

Co-conveners of the review group

cc. John Farnell  
Alain Laurec  
Willem Brugge

## Appendix II: National measures additional to EU technical conservation measures

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NOTE: The information contained in this Annex is provided in good faith but must not be used to assess the legality of fishing gears. The only authoritative source is the legal text published in the country of origin.

### Ireland

Sea Fisheries (Regulation of Nets) Order, 1993. S.I. No. 264/1993.

Prohibits Irish vessels fishing with 70–79mm mesh size in Area VIIa unless using a 75mm square mesh panel (S.I. rescinded)

Lobster (Conservation of Stocks) Order, 1994. S.I. No. 304/1994.

Imposes a conservation measure whereby all lobsters containing a V notch are returned to the sea.

Crawfish (Fisheries Management and Conservation) Order, 2002. S.I. No. 179/2002.

Introduces a ban on the taking of Crawfish by means of nets in two specified areas off the Galway and Kerry coast.

Bass (Conservation of Stocks) Order, 1990. S.I. No. 128/1990.

Prohibits fishing for bass by Irish vessels with nets and also prescribes a mls for bass of 40mls for bass caught by any other method.

Drift nets. Fisheries (amendment) Act, 1997 and Associated Bye-Laws (794/2004).

Limits maximum length of drift nets for salmon and sea trout to 732 metres in the Southern South Western, Shannon and Western Fisheries Regions and 1,372 metres in the North Western and Northern Fisheries Region. Minimum mesh size of 17.8cm/7” in the round (8.9cm/3.5” stretched mesh). Maximum depth allowed of 45 meshes. Other provisions regarding effort, seasons and areas.

### Scotland

#### Whitefish [SSI2001/250]

- a) The attachment of a strengthening bag is prohibited for nets having mesh size of 70mm or more unless the net is carried in or used by a boat for the purpose of fishing for *Nephrops* (i.e., at least 35% by weight of *Nephrops* in the catch).
- b) Any net which has a mesh size of 70mm or more but less than 119mm shall have incorporated in it as part of the net a square mesh panel which is of not less than 90mm and is positioned so that the rearmost row of meshes of the square mesh panel is no more than 9m from the codline.

#### *Nephrops*

Any net carried in, or used by a boat for the purpose of fishing for *Nephrops*,:

- a) having a mesh size of between 70 and 94mm, shall have the codend, extension and square mesh panel (if fitted) constructed of single twine that shall not exceed 4mm. [SSI2001/250, SSI2003/167]

- b) having a mesh size of 70mm or more but less than 119mm, shall have incorporated in it as part of the net a square mesh panel which is of not less than 90mm and is positioned so that the rearmost row of meshes of the square mesh panel is no more than 15m from the codline [SSI2001/250].

### Scallops [SSI2003/371]

Restrictions have been placed on the gears used for fishing for *Pecten maximus* (Scallop). The type of dredge is restricted. Depending on the type of dredge, the number of dredges per side is restricted depending on sea area being fished.

### Multiple trawls [SSI2000/405, SSI2003/166]

Multiple trawls are banned on Scottish boats or British boats in Scottish waters unless:

- they are used on beam trawls
- they have a mesh size of at least 80mm in the Fladen area, in area VI south of 56°N, in area VII or in area IV south of 53°N
- they have a mesh size of at least 95mm.

## Belgium

Shrimp trawls (K.B(Royal Decree) of 14.08.1989 amended by K.B. 11.03.1996, K.B. 12.04.2000 & K.B. 31.05.2001)

A sieve net has to be inserted to protect juvenile flatfish from 1<sup>st</sup> Nov until 30 Apr.

Fishing in the 3-mile coastal zone is restricted to vessels of less than 70 GRT

Larger minimum landing sizes are required for a number of species:

SPECIES	BELGIUM REGULATION (2004)	REGULATION 850/98
Cod	40 cm	35 cm
Turbot	30 cm	No size
Brill	30 cm	No size
Lemon sole	25 cm	20 cm
Dab	23 cm	No size
Flounder	25 cm	No size
Gurnard	20 cm	No size
Monkfish (whole)	500 gr landing weight	No size
Monkfish (beheaded)	250 gr landing weight	No size

The following restrictions on recreational fisheries with towed gear apply:

- Only allowed in the shrimp fishery
- One beam trawl with a beam of 3 m maximum or
- One otter trawl with maximum length of headline + upper bridles of 4.5 m
- Twin trawls are prohibited
- Can only fish within the 3-mile zone
- May not have on board or land species subjected to TAC or quota regulations

- g) This does not apply to non-mechanised pole fishing as long as the quotas are not exhausted. However, the maximum landing per person is restricted to 20 kg of cod and bass with a maximum of 15 kg cod.

## Sweden (Skagerrak and Kattegat)

Extract from the National Board of Fisheries regulations on fisheries in Skagerrak, Kattegat and the Baltic Sea (FIFS 2004:36).

### General provisions for handling of gear

When fishing no measure should be taken that in any way counteracts the purpose of a regulation regarding minimum mesh size, sorting grids, escape openings or any other arrangement for increased selectivity.

### Protected species

It is not allowed to fish or land sea lamprey, lesser spotted dogfish, porbeagle, basking shark, common (blue) skate, thornback ray, allis shad, twaithe shad, ziege, three-bearded rockling and northern bluefin tuna. This rule is applicable for Swedish fishermen in all of Skagerrak/Kattegat.

### Closed seasons

Fishing and landing the species listed below is forbidden during the following time periods:

Species	Period	Area
Salmon and Trout	1/10 – 31/3	Inside 4 Nm
Salmon and Trout	all year	Outside 4Nm
Lobster	1/5 – 1st Monday after 20/9	All Skagerrak/Kattegat
Lobster (berried females)	all year	All Skagerrak/Kattegat
Cod	1/1 – 31/3	Inside 4 Nm
Pollack	1/1 – 31/3	Inside 4 Nm
Haddock	1/1 – 31/3	Inside 4 Nm
Plaice (mature females)	1/1 – 31/5	Inside 4 Nm

### Protected areas

Over 90 estuaries in Skagerrak/Kattegat are protected in order to preserve local trout (and salmon in some cases) populations. The rules for each area vary somewhat. The most common set of rules are that fishing is forbidden 1 October to 31 March, except when fishing with lobster pots and eel fyke nets with a ring diameter of less than 60 cm. The gear use is restricted also during the open period (1 April to 30 September).

There are three no-take zones in the Skagerrak for lobster protection. All are closed to all kinds of fishing operations all year round

1030 km<sup>2</sup> of sea bottom is closed for trawling inside the 4 Nm border in Skagerrak and 3 Nm Kattegat (Figure 1) to protect habitats sensitive to trawling disturbance (mainly rocky bottom habitats).

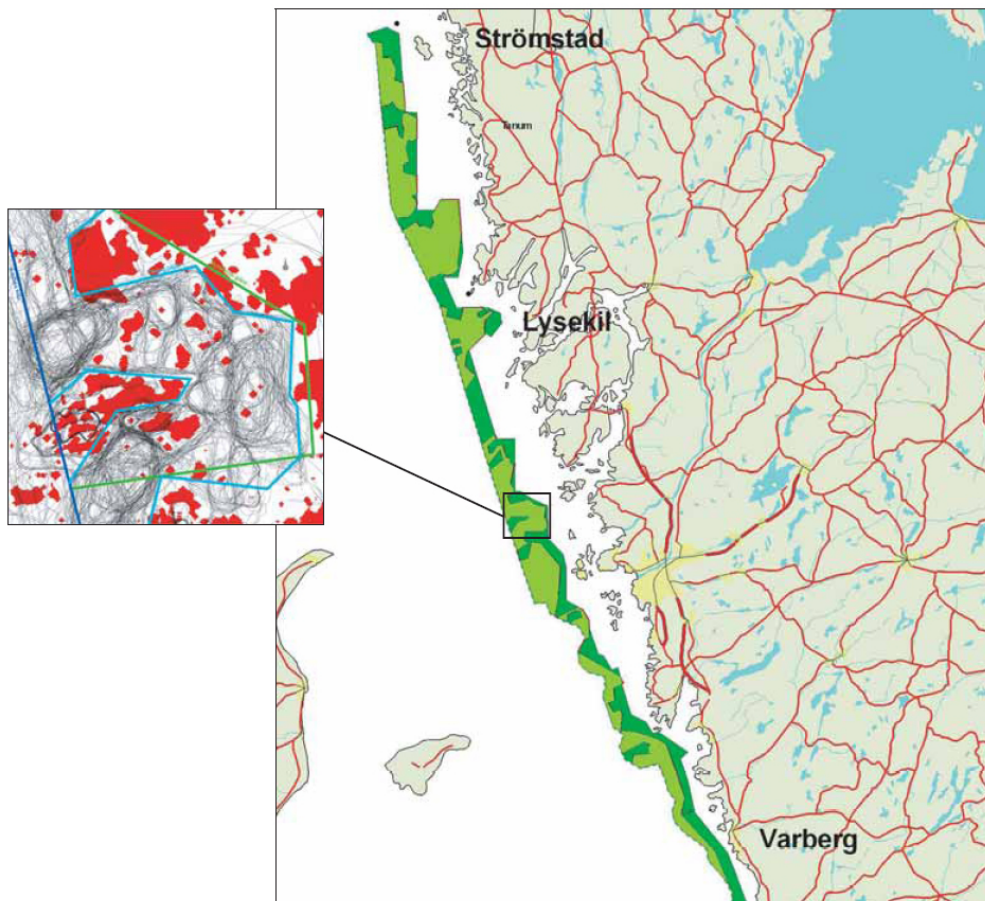
## Fishing methods

### *Fishing with pots*

Lobster (*Homarus gammarus*) pots are defined as having at least two circular escape openings with a minimum diameter of 54 mm in each compartment. Crab (*Cancer pagurus*) pots are defined by having at least one circular escape opening with a minimum diameter of 75 mm in each compartment. Professional fishermen may fish with 50 lobster pots while non-professionals may use 14 lobster pots. Lobster may only be fished with pots.

### *Trawling*

Trawling is not permitted inside the trawling border (4 nm in Skagerrak and 3 nm in Kattegat).



There are however three exceptions to this general rule:

1. Trawling for *Nephrops norvegicus* is admitted in specially designated areas (Figure 1) and in accordance with the following conditions:

The trawl gear shall be a single trawl, trouser trawl or twin trawl. Each extension/codend shall have a species selective sorting grid with 35 mm bar spacing (Nordmøre grid design, grid specifications are given below). At least 8 m full square mesh codend with a minimum mesh size of 70 mm. Codend circumference shall not be more than 100 open meshes and shall be constructed of maximum 3 mm single

twine. A protection bag is allowed (240 mm mesh size and 40 meshes circumference). Maximum ground gear diameter is 10 cm (discs, bobbins etc.).

Figure 1. (a) A graphical presentation of areas open to species selective *Nephrops* trawling (lighter green areas). Dark green areas- trawling prohibited. Red line- earlier trawling limit. All areas to the east of green areas are closed to trawling.

(b) An example of how detail adjustments were made considering both sensitive habitats and how the *Nephrops* trawl fishery was carried out earlier. Red areas represent rocky bottom areas, black lines are plotted trawl hauls, dark blue- the trawling border at 4 Nm, light blue lines- adjusted areas for species selective *Nephrops* trawling.

2. Trawling for *Pandalus borealis* is admitted in waters deeper than 60 m and in accordance with the following conditions:

One single trawl per vessel allowed. Each trawl door shall not weigh more than 350 kg and not exceed 2.7 m<sup>2</sup> in area. Species selective Nordmøre grid is mandatory (19 mm bar spacing, grid specifications are given below). Minimum mesh size is 35 mm. Maximum ground rope length of is 50 m (between arm ends). Maximum head rope length is 38 m. Maximum circumference at ground rope center is 130 m.

3. Pelagic trawling is allowed outside 2 Nm between the latitudes 57 00 N and 58 00 N between October 1<sup>st</sup> and February 28<sup>th</sup> for vessels with an engine power of less than 700 kW.

### Specifications for sorting grids

Species selective sorting grids mandatory for trawl fisheries inside the trawling border in Skagerrak and Kattegat for *Nephrops norvegicus* and *Pandalus borealis* shall be designed and mounted in accordance with following specifications:

- Grid bar spacing may not exceed 19 mm when fishing for *P. borealis*.
- Grid bar spacing may not exceed 35 mm when fishing for *N. norvegicus*.

Common for both is that the grid shall be mounted upwards backwards so that all sides of the grid are attached to the trawl. There shall be an unblocked fish outlet immediately in front of the upper bar of the grid in the top panel of the trawl. The fish outlet shall on the aft side have the same with as the grid and shall be cut out along mesh bars to a point.

### *Dredging*

Dredging is prohibited.

### *Purse seining*

Purse seining with light is allowed in restricted areas inside 4 Nm from 1 October to 31 December. Purse seining without light is allowed in restricted areas between 1 January and 31 March. The basis for area and light restrictions is to reduce the risk to bycatching demersal species.

### *Gill nets*

In fixed gears (annex VI in 850/98), the minimum mesh size for Dab, Whiting, Flounder and Sole is 90 mm compared to 100 mm in all of Skagerrak and Kattegat in Swedish regulations. Gill nets set at water depths shallower than 3 meters shall have a minimum mesh size of 120 mm Otherwise same rules as in 850/98 applies.

### Minimum sizes

The following list shows species for which the Swedish national legislation has a MLS other than 850/98 or where there is no MLS in 850/98. Minimum sizes according to 850/98 are indicated within parentheses.

Flounder ( <i>Platichthys flesus</i> )	20 (n.a) cm	Skagerrak/Kattegat
Witch ( <i>Glyptocephalus cynoglossus</i> )	28 (n.a) cm	Skagerrak/Kattegat
Lemon Sole ( <i>Microstomus kitt</i> )	25 (n.a) cm	Skagerrak/Kattegat
Brill ( <i>Scophthalmus rhombus</i> )	30 (n.a) cm	All Swedish waters
Turbot ( <i>Psetta maxima</i> )	30 (n.a) cm	All Swedish waters
Lobster ( <i>Homarus gammarus</i> )	8 (7.8) cm	Skagerrak/Kattegat
Oyster ( <i>Ostrea edulis</i> )	6 (n.a) cm	All Swedish waters

#### *Special provisions for Skagerrak and Kattegat*

Fishing with driftnets and anchored floating nets for salmon and trout is prohibited.

Fishing with gillnets, fyke nets and pots is prohibited inside 4 Nm from 15 September until the start of the lobster season (i.e., the first Monday after 20 September). It is however allowed to use gillnets for herring and dogfish and fyke nets and pots aimed for eel at water depths less than 6 m and *Nephrops* creels at water depths exceeding 30 m.

Fishing for whelk (*Buccinum undatum*) using pots is only allowed with a special permit from the National Board of Fisheries. A whelk pot shall have the entrance on the top and shall have a smooth plastic surface with a vertical height of at least 30 cm. The pot sides and bottom may be perforated with drainage holes of maximum 25 mm.

Static gears higher than 1.5m may only be used on private waters and with a special permit.

Fishing with Danish seine is prohibited inside the trawling border (4 Nm outside the coast in Skagerrak and 3 Nm in Kattegat).

Fishing with fyke nets with a pot net mesh size smaller than 40 mm is prohibited from 1 January to 1 April. Fyke nets shall be serviced at least once every 72 hrs. When servicing the nets all undersized fish shall be handled in such a way that they can be returned alive at sea.

When fishing with fyke nets at water depths exceeding 10 meters, the nets shall have two circular escape openings with a minimum diameter of 75 mm placed on each side of each pot net.

Professional fishermen may fish with 600 fyke nets (1200 pot nets). Non-professionals may fish with 6 fyke nets (12 pot nets).

## Portugal

There are many laws governing fishing gears and some of the main differences from EU 850/98 regulation are listed here. Some laws apply to gears not contemplated in EU legislation

### Trawling

Trawling is not allowed within 6 miles of the coastline

### **Gill-nets and trammels**

Maximum height of the net panels is 3m for trammels and 10m for single panel nets. The maximum length of fleets is limited according to the vessel's overall length.

### **Drift nets**

Drift nets are forbidden except for small pelagics. No fishing is allowed within 0.25nm from the coastline.

## **Denmark (Skagerrak and Kattegat)**

### **Closed seasons**

There are no closed seasons for fishing in Kattegat and Skagerrak but some species are protected in connection with their spawning. Mature female plaice (*Pleuronectes platessa*) and female flounder (*Platichthys flesus*) are both protected in the period from the 15 January to the 30 April. Salmon (*Salmo salar*) and Sea trout (*Salmo trutta*) with spawning characters are protected from 16 November to 15 January.

### **Protected areas**

There are locally numerous closed areas in Denmark where fishing in general or specific types of fishing gear or fishing methods are forbidden. These areas are typically in fjords, bays or near river systems. There are however, also some more general restrictions. Fishing with bottom set gillnets is prohibited within 100m of the shoreline (low tide) to protect sea trout (*Salmo trutta*) and salmon (*Salmo salar*). All fishing is forbidden in an area of 500 meter in diameter in the sea where a stream or river (with a minimum width of 2 meters) runs out into the sea. The exception is fishing in August to November with fyke nets for eels (*Anguilla anguilla*). All trawling is prohibited from the shoreline (low tide) and 3 nautical miles perpendicular out.

### **Minimum landing sizes**

Table 1 shows species for which the Danish national legislation has a MLS other than 850/98 or where there is no MLS in 850/98.

**Table 1: Minimum landing sizes in Reg. 98/858 and in the Danish national Legislation.**

Species	MINIMUM LANDING SIZES (CM)		Area
	Reg. 98/850	Danish national Leg.	
Cod ( <i>Gadus morhua</i> )	35	40	North Sea
Cod ( <i>Gadus morhua</i> )	30	40	Skagerrak
Cod ( <i>Gadus morhua</i> )	30	35	Limfjorden, Kattegat
Plaice ( <i>Pleuronectes platessa</i> )	22	27	All Danish waters
Turbot ( <i>Psetta maxima</i> )	non	30	All Danish waters
Sole ( <i>Solea</i> spp.)	24	24.5	All Danish waters
Witch ( <i>Glyptocephalus cynoglossus</i> )	non	28	All Danish waters
Haddock ( <i>Melanogrammus aeglefinus</i> )	27	32	North Sea, Skagerrak and Kattegat
Haddock ( <i>Melanogrammus aeglefinus</i> )	30	35	Baltic and the Belt Sea
Saithe ( <i>Pollachius virens</i> )	35	40	All Danish waters
Hake ( <i>Merluccius merluccius</i> )	27–30	40	All Danish waters

## Norway (Skagerrak/North Sea)

It is prohibited to use more than two trawls per vessel in any trawl fishery in the North Sea and the Skagerrak. This prohibition does not apply to fishing operations by foreign vessels in the Norwegian Economic Zone in the Skagerrak.

### Shrimp

#### *Skagerrak*

It is prohibited to use a trawl if the mesh size of any part of the gear is smaller than 35 mm.

Restriction on the use of bobbins ground gear.

Specification and restriction on the use of devices which can affect selectivity

#### *North Sea*

It is prohibited to use a trawl if the mesh size of any part of the gear is smaller than 35 mm

Specification and restriction on the use of devices, which can affect selectivity

### Norway lobster

#### *Skagerrak*

It is prohibited to use a trawl if the mesh size of any part of the gear is smaller than 90 mm (diamond). If a square mesh codend is used, minimum mesh size is 70 mm.

Specification and restriction on the use of devices, which can affect selectivity

#### *North Sea*

It is prohibited to use a trawl if the mesh size of any part of the gear is smaller than 120 mm

***Skagerrak***

It is prohibited to use a trawl or Danish seine if the mesh size of any part of the gear is smaller than 90 mm. This prohibition does not apply to fishing operation for species listed below (minimum mesh size listed in brackets):

Whiting (70 mm); herring, mackerel, horse mackerel (32 mm); greater argentine (30 mm); sprat, Norway pout, blue whiting, greater weever, garfish, molluscs, sandeels, grey gurnard, eels (16 mm), sandeels (period 1 April-30 September) (16 mm), blue whiting (using pelagic trawls) (between 35 and 80 mm).

Specification on codends and extension piece in trawls and Danish seines during fishing operations using gear with a minimum mesh size of 90 mm

***North Sea***

It is prohibited to use a trawl or Danish seine if the mesh size of any part of the gear is smaller than 120 mm. In the trawl fishery for saithe in the EU zone minimum mesh size is 110 mm. This prohibition does not apply to fishing operations for species listed below (minimum mesh listed in brackets):

Mackerel, herring, clupeoids, greater argentine, capelin, sandeels, Norway pout, blue whiting, horse mackerel (between 16 and 80 mm); sandeels (period 1 April-30 September, in the EU zone, period 1 March-30 September) (less than 16 mm), blue whiting (pelagic trawls)(between 35 and 80 mm).

Specification on codends and extension piece in trawls and Danish seines during fishing operations using gear with a minimum mesh size of 120 mm

It is prohibited to use gill nets with a mesh size of less than 148 mm in fishing operations for cod, haddock, saithe, plaice, ling, pollack and hake (area specifications).

## Appendix IIIa: Inconsistencies in Technical Conservation Measures in the Baltic

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Issue	Areas	Regulation	Comment
Twine Thickness	III b, d	Proposal (2005/0014 (CNS) Appendix to Annex II, 1.b.ii) for a Regulation amending 88/98 and 1434/98. Most present rules appearing in the annual TAC and Quota Regulations	Twine thickness in cod trawls, single 6mm or double 4mm, different from Area IIIa.
Codend /Extension Construction		Proposal (2005/0014 (CNS) Appendix to Annex II, 1.b) for a Regulation amending 88/98 and 1434/98. Most present rules appearing in the annual TAC and Quota Regulations	The dimensions of the codend, extension piece and the rear end of the trawl are described in more detail than for adjacent areas.
Existing Mesh Size Regulations		Proposal (2005/0014 (CNS) Annex II and Annex III) for a Regulation amending 88/98 and 1434/98. Most present rules appearing in the annual TAC and Quota Regulations	Mesh sizes of species for towed and fixed gears in IIIb-d and IIIa are the same for most species appearing also in the former area. The mesh size for cod trawls are inconsistent, due to the special construction of the BACOMA codend mandatory in area III b and d. The mesh size in the BACOMA window is 110mm (105mm diamond meshes in the rest of the codend and the extension), the same as for gillnets. This implies a higher "L <sub>50</sub> " for gillnets than for trawls.
Square Mesh Panels		Proposal (2005/0014 (CNS) Appendix to Annex II) for a Regulation amending 88/98 and 1434/98. Most present rules appearing in the annual TAC and Quota Regulations	The BACOMA window is a square mesh panel, particular for the area IIIb and d (trawling prohibited in IIIc), and in detail described in the regulation (even conditions for the repair of a panel).

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## Appendix IIIb: Inconsistencies in Technical Conservation Measures between Areas VI, VII, VIII and IXa in National Waters

Issue	Areas	Regulation	Comment
Twine Thickness	VI vs VII, IXa	Reg. 850/98 Article 8(2) Amended by the following:  Reg. 2056/2001 (Article 1) and 1162/2001 2549/2000 and 1456/2001	Different twine thickness between area VI and VII and VIII. (Single 6mm and double 4mm in area VII compared to single 8mm and double 5mm in area VI). Regulations contradict each other (2056/2001 and 1162/2001) and also scientific advice for haddock, saithe, hake, pollack is given for both areas and TAC covers both areas. Twine thickness does not apply in IXa.
Codend /Extension Construction	VI vs VII, VIII, IXa	Reg. 2056/2001 Article 5(1(ii))  Reg. 2056 Article 5(1(iii))  Reg. 2056 Article 5(iv)	The length of any codend and extension to have maximum length of 36m (IV, VI and IIa, Vb/All towed gears with a mesh size >70mm) but does not apply to VII, VIII and IXa.  Codend or extension constructed of more than one sheet of netting such that the linear dimensions of the top and bottom sheeting are not equal is prohibited (IV, VI and IIa, Vb/All towed gears) but does not apply to VII, VIII, IXa.  Codend or extension or square mesh panel that is not constructed of the same material is prohibited (IV, VI and IIa, Vb/All towed gears) but does not apply to VII, VIII and IXa.

Issue	Areas	Regulation	Comment
Existing Mesh Size Regulations		Reg. 850/98 Article 4 and Annex I-V; Reg. 724/2001 Article 1(1); Reg. 1162/2001 Article 2(1) and 5(2); Reg. 2056/2001 Article 4; Reg. 254/2000 Article 3 (1);Reg. 494/2002 Article 2	Mesh sizes of species for towed and fixed gears in Area VII and VIII are different for most demersal species (general mesh size of 70mm in area VIII compared to 80mm in Area VII). There is an inconsistency in that the Scientific advice and TAC apply to the whole of Area VII and VIII yet different mesh sizes for hake apply. This is further confused by the introduction of a minimum mesh size for hake of 100mm in two Hake Recovery Areas. Other inconsistencies are apparent with the catch compositions allowed from area to area which again has been confused by Recovery plans for cod and hake. Reg. 2056/2001 contradicts a number of other regulations in this regard.
Days At sea	VI,VIIa and VII,VIII and IXa	Regulation 27/2005 Annex V	Days at sea restrictions apply in Area VI and VIIa but not in the rest of VII or Area VIII.  Differences between areas have caused displacement of effort from VI to VII.
Square Mesh Panels	VIIa and VIIg VIIa, VIII and IXa	Reg. 850/98 Article 3 (d,e,f) and 7; amended by Article 1 (4a)  Reg. 2056/2001 Article 4(5)	80mm square mesh panel of defined dimensions and positioning required in all towed nets in the range of 70–79mm in all areas although under the Irish Sea Recovery Plan this was extended to the mesh size range 70–99mm. This means there are different square mesh regulations for vessels bordering different ICES areas i.e., VIIa and VIIg, VIIa, VIII, IXa. Under Reg. 2056/2001 90mm Square Mesh panel of defined dimensions and positioning are required in all towed gears in the range 100–119mm (IIa, IV, Vb, VI) but not in VIIa,b,c, which border these areas subject to Catch composition. Provision allowing use of 80mm SMP in trawls 70–79mm mesh size and 70mm SMP in mesh sizes 32–54mm does not apply to VIII and IXa

Issue	Areas	Regulation	Comment
Headline Panels	VIa and VIIa and VII, VIII, IXa	Reg. 2549/2000 Article 2 (5); Reg. 2056/2001 Article 5 (2(iii))	Panel attached directly to the headline of the net extending towards the posterior of the net for at least 15 meshes of 140mm mesh size applies to VIIa, IIa, IV, Vb,VI/All towed gear in mesh size range 70–99mm except beam trawls but not in the rest of Area VII or in VIII, IXa. Similar regulation for beam trawls applies in all areas
UK measures	Mainly VI and VII	National measures	Scottish regulations currently require the use of significantly more selective gears than either UK or EU regulations. Some standardisation should be achieved.
Mesh sizes	IXa	Reg 850/1998 Annex 1	Adjacent areas either side of 7°23'48"W have significantly different mesh size ranges although the mls are the same (except for anchovy). MLS the areas are the same in both areas.
Anchovy	VIII and VIIIc	Reg 850/98 Article 23	Prohibits the use of pelagic trawls for fishing anchovy in Area VIIIc.
Minimum Landing Sizes	All Areas	Reg 850/98 Annex XII	A number of differences in mls for <i>Nephrops (VIIa and VII)</i> Anchovy (IXa east and west of 7° 23'48"W) Edible crab VIIId,e and VIII, IXa), Scallop (VIIa north and south of 52° 30'N, VIIId) Also differences with National Legislation.

## Appendix IV: Findings of Mediterranean sub-group

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Fisheries management in the Mediterranean Sea faces challenges, primarily based on geography and geopolitics. For example, bordering nations do not have exclusive economic zones and national waters also vary in distance (3, 12, 20 miles). Many nations are involved, only some nations are EU members. Some nations conduct fisheries in both the Atlantic and the Mediterranean, with vessels that may fish in different seas on different days. The current EU goal for fishery management is to develop a common policy for the Mediterranean for implementation by all EU and non-EU Mediterranean nations.

For each fishing method, existing EU legislation is listed. Additional national legislation is also given together with comments on any technical issue which may need further consideration. Finally there is a section on protected areas identified by Italy.

### Bottom Trawling

Minimum codend mesh opening: 40 mm (R. CE 1626/94);

Forbidden within the three-mile coastal limit or on bottom less than 50 m depth (R. 1626/94)

*France mandates, by national regulation, a minimum stretched mesh length. This regulation creates a misunderstanding because the EU regulates mesh opening. The regulation of dimension should be harmonized between France and the EU.*

*Twine thickness and diameter should be regulated, but face the same measurement and enforcement problems as in other EU fisheries.*

### Purse seine (target species: small pelagic species)

Minimum mesh opening: 14 mm (R. CE 1626/94);

Maximum length of net: 800 m mounted (R. CE 1626/94);

Maximum height: 120 m stretched (R. CE 1626/94);

Forbidden within the three-mile coastal limit or on bottom less than 50 m depth (R. 1626/94)

*The minimum height necessary to close an 800 m purse seine is at least 130 m. The regulations should be adjusted in consideration of the specific geometry of purse seines.*

### Purse seine (target species: large pelagic species)

None

*Spain limits vessel and net length in a fishery protection zone in international waters. This action should be encouraged because it combines technical and management measures, and establishes protection for a shared stock.*

### Gillnet, trammel, and combined net

Maximum length of net: 5000 m (R. CE 1626/94);

Maximum height: 4 m stretched (R. CE 1626/94);

*Italy: Minimum mesh opening: 20 mm*

*No practical method exists for measurement of maximum length.*

*The height limit is too short generally, and not justified by any research, and is not appropriate for all three gear types.*

*New proposed regulation under discussion specifies the overall surface area that can be fished, allowing increased heights overall, while limiting effort. The proposed regulation also prohibits targeting of large pelagic species.*

*Soak time is currently unlimited; effort reduction could be effective if soak time was limited.*

*Hanging ratio has been shown to be an important factor in size and species selectivity of static gears and should be defined in technical measures.*

### **Pelagic trawl (target species: small pelagic species)**

Minimum codend mesh opening: 20 mm (R. CE 1626/94)

*In Italy, pelagic trawling must be done by pairs of vessels. Spain bans pelagic trawling. In general, the EU definition of pelagic trawl presents problems in Mediterranean fisheries because the definition is based on catch contents and gear specifications are not adequate.*

### **Hydraulic dredge**

Maximum horizontal opening: 3 m (DM 22/12/2000)

Maximum weight: 600 kg

Maximum pressure of the dredge at bottom: 1.8 bar

*Currently, the only measurable pressure is the pressure onboard. No practical method exists to measure pressure at the bottom.*

### **Longline**

Maximum length: 7000 m for bottom longline (R. CE 1626/94);

Maximum length: 60000 m for pelagic longline (R. CE 1626/94);

*No accurate method exists for measurement of maximum length.*

*New proposed regulation limits crew size, and defines hook size using hook length. While hook gap might be a more effective measure, no studies have established the relationship between hook gap, hook length, and hook size.*

### Italian Minimum Landing Size

SCIENTIFIC NAME	MLS	REFERENCE
<i>Engraulis encrasicolus</i>	9 cm	R.(CE) 1626/94
<i>Thunnus alalunga</i>	40 cm	DPR 1639 (2/10/1968)
<i>Anguilla anguilla</i>	25 cm	DPR 1639 (2/10/1968)
<i>Mugil</i> spp.	20 cm	D.M. 5/6/1987
<i>Epinephelus</i> spp.	45 cm	R.(CE) 1626/94
<i>Polyprion americanus</i>	45 cm	R.(CE) 1626/94
<i>Zosterisessor ophiocephalus</i>	12 cm	D.M. 5/6/1987
<i>Scomber japonicus</i>	15 cm	DPR 1639 (2/10/1968)
<i>Merluccius merluccius</i>	20 cm	R.(CE) 1626/94
<i>Sparus aurata</i>	20 cm	R.(CE) 1626/94
<i>Pagellus</i> spp.	12 cm	R.(CE) 1626/94
<i>Pagrus pagrus</i>	18 cm	R.(CE) 1626/94
<i>Sarda sarda</i>	25 cm	DPR 1639 (2/10/1968)
<i>Platichthys flesus</i>	15 cm	D.M. 5/6/1987
<i>Xiphias gladius</i>	140 cm	DPR 1639 (2/10/1968)
<i>Lophius</i> spp.	30 cm	R.(CE) 1626/94
<i>Diplodus</i> spp.	15 cm	R.(CE) 1626/94
<i>Scomber scombrus</i>	18 cm	R.(CE) 1626/94
<i>Solea vulgaris</i>	20 cm	R.(CE) 1626/94
<i>Dicentrarchus labrax</i>	23 cm	R.(CE) 1626/94
<i>Acipenser sturio</i>	FORBIDDEN	D.M. 3/5/1989; (Rett. G.U.8/7/1989); DPR 357 (8/9/1997)
<i>Acipenser naccarii</i>	FORBIDDEN	DPR 357 (8/9/1997)
<i>Huso huso</i>	100 cm	DPR 1639 (2/10/1968)
<i>Trachurus</i> spp.	12 cm	R.(CE) 1626/94
<i>Euthynnus alletteratus</i>	30 cm	DPR 1639 (2/10/1968)
<i>Thunnus thynnus</i>	80cm (10 kg)	R. (CE) 27/2005
<i>Mullus</i> spp.	11 cm	R.(CE) 1626/94

### **Protected areas**

In Italy more than 20 areas are protected in order to preserve local bio-diversity and sensitive habitats. All are closed to all kinds of trawling operations all year round. In each area three types of protected zones are defined:

- zone A: no acts of making the zone of land or water profitable, productive or useful;
- zone B: artisanal fishing and recreational activities are permitted under controlled conditions;
- zone C: antropic activities are allowed under sustainable conditions

## Annex 5: Topic group report on topic c: interaction between fishing gear and structures related to oil and gas exploration and production

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### Contents

- 1 ) Introduction
- 2 ) Present regime governing fisheries and offshore activity interactions
- 3 ) Sources of information on fishing gear and seabed installations
- 4 ) A review of available information on interactions
- 5 ) Gaps in knowledge
- 6 ) Conclusions

Table 1. References on work relating to interaction between fishing gear and sub-sea structures - with brief abstract

Table 2. List of trials undertaken on the interaction between fishing gear and sub-sea structures

Appendix 1. Current situation in Europe and North America

### Introduction

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The offshore oil industry facilities include platforms, sub-sea wellheads and modules and pipelines. The structures are frequently located in areas of high importance to the fishing industry. Moreover, the structures are known to act as fish aggregation devices (FADs) because they act as shelter or a beneficial environment (e.g., through raised ambient temperature) and generate their own marine ecosystems. Fishermen therefore frequently target areas close to these installations. Fishing activities near oil platforms are restricted by the introduction of security zones, normally prohibiting fishing activities within a radius of 500 m from the platform and enforced by standby vessels.

Pipelines are protected against the impact of fishing gears by coating, gravel or burial. Large diameter pipes (e.g., more than ca 45 inch) are laid on the seabed without burial or trenching. Fishing activities near oil structures incur the risk of damage to both fishing gear and the oil structures. Apart from the economic considerations, hooking of the gear may represent a safety risk to fishing vessels especially in bad weather. The likelihood of such events depends on characteristics of the pipeline, its position on or in the sea bed, gear dimensions, such as weight, the shape of gear components, and the angle of incidence between gear and pipeline.

Other sub-sea facilities may provide special hazards to fishing gears, due to their shape and elevation above the seabed. Examples are: well heads, storage facilities, compression stations, and protection devices for suspended well heads. Larger units may have a safety zone, although abandoned well heads are not protected this way. Significant hazards to fishing gear may also be caused by anchor mounds created by pipe-laying barges or berms resulting from pipe-trenching operations.

The interaction between underwater telecommunications and power cables and fishing gear is also considered in this report as a significant hazard.

There are currently ca 12000 km of pipeline in the UK zone in the North Sea alone. There are recent proposals to install larger diameter (bundled) pipelines, which, over substantial distances, may not be buried or trenched. Work has been done and is planned on interaction of

fishing gear and these pipelines. Mitigating measures have also been devised for many sub-sea structures on the basis of model or full-scale trials but the information is not easily available.

The oil/gas industry has matured and abandonment of structures at the end of their useful life is being considered. Drill cutting piles, which have accumulated under drilling platforms, may be of order of 10m high and may contain hydrocarbon and heavy metal residues. These cuttings could be left on the seabed after removal of abandoned drilling platforms. The interaction of fishing gear with them is unknown. There are issues of dispersal of the pile material and the effect of impacts with fishing gear components. Policies and strategies for abandonment which need to be formulated by national governments should be informed by knowledge of interactions with both structures and cuttings piles in order to assess potential problems such as loss of fishing opportunities, damage to gear, safety of fishermen and fishing vessels and pollution. ICES is an appropriate body to collate existing knowledge and review the need for further work.

ICES has previously been involved in reviewing the interaction between the fishing and offshore industries. In 1977 a special joint session of the Gear and Behaviour Committee with the Fisheries Improvement Committee was held and a Cooperative Research Report was written (McIntyre and de Groot, 1980 – see 1.1.4 of table 1). An update of this earlier work is overdue.

Following a recommendation made by ICES in 2004 a topic group was formed to work, initially by correspondence, on the following terms of reference:

To review work done, identify information gaps and recommend research priorities on interaction between fishing gear and

- Pipelines and other sub-sea structures
- Cuttings piles

Information was collected on studies on the interaction between fishing gear and sub-sea structures. A reference list of published reports was compiled with a brief abstract of each. A more detailed description of some model and full-scale trials results on fishing gear interaction with structures was also prepared.

The group then met in Rome on 19 April 2005 during the meeting of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WFTFB). This report was drafted and recommendations agreed with the WGFTFB.

## **Present regime governing fisheries and offshore activity interactions**

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In the Norwegian sector, all sub-sea installations and pipelines should be designed to be over-trawlable, causing minimum obstacle to the fishing industry. In the UK sector the requirement is for 'fishing friendly' structures, without the specific need for over-trawlability. To meet these requirements, and to minimise potential risks, both for the fishing and the offshore industry, the design of sub-sea pipelines and structures needs to comply with:

- a) Authority requirements for the proposed shelf / location,
- b) Specifications from the operator of the installation,
- c) Governing design standards.

In the Norwegian and UK sector, one of the following design standards is used:

*Pipelines:*

- Det Norske Veritas (DNV) Guideline 13, “Interference between trawl gear and pipelines, 1997.
- OTH561: Guidelines for trenching, design of submarine pipelines, Trevor Jee Associates and HSE UK.

*Sub-sea installations:*

- ISO 13628 part 1, Petroleum and gas industries – Design and operation of sub-sea production systems.
- NORSOK U-001 Sub-sea production systems, October 2002 (equivalent to ISO 13628, but includes supplementary national requirements for the Norwegian sector).

These design standards and guidelines are based on trawl equipment and interference tests existing before 1996. However, trawl gear and fishing vessel equipment have developed in recent years to include new types (*e.g.*, ‘twin’ trawling with clump weights), and the sizes and weights of the equipment have increased. Furthermore, there is growing operational experience on damage to offshore installations and trawl gear and this new information could be incorporated into the guidelines.

To account for these changes and experiences gained, a Joint Industry Project (JIP) has been initiated by DNV to issue an updated recommended practice to replace the current DNV Guideline 13 applying to the Norwegian sector. The work is being performed as a JIP with Statoil, Norsk Hydro and DNV, to be issued in October 2005, as DNV RP-F111.

In addition a pre-study has been initiated to identify gaps in current design standards and guidelines for offshore sub-sea structures, to be completed in 2005, and if considered valuable, to continue as a JIP with the objective to develop a design standard for trawl interference with sub-sea structures.

## Sources of basic information on fishing gear and seabed installations

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### Fishing gear

For the UK sector there is a general publication by Fisheries Research Services – Marine Laboratory Aberdeen (FRS) describing the main fishing methods used in Scotland: An introduction to commercial fishing gear and methods used in Scotland (Scottish Fisheries Information Pamphlet 25, 2004).

A more detailed reference work was prepared in 2001 by the Scottish Executive (SEERAD) at the request of the Fisheries and Offshore Oil Consultative Group (FOOCG) in conjunction with Fisheries Research Services – Marine Laboratory Aberdeen and the Ministry of Agriculture, Fisheries and Food. It is entitled: A Fishing Industry Guide to Offshore Operators. Electronic copies are available on the website of the UK Offshore Operators’ Association (<http://www.ukooa.co.uk>) or on the following Scottish Government website (<http://www.scotland.gov.uk/library3/fisheries/figoo-00.asp>). As well as a description of the gears in use, it includes useful information on the types and sizes of fishing vessel operating in the UK sector and the maximum dimensions and weights of fishing gear components and maximum towing speeds employed.

## Sub-sea obstructions

An electronic system was developed as a joint initiative within the UK by the fishing and off-shore industries to warn fishing vessels when they were approaching known seabed obstructions. A description of the system is available at <http://www.oilandgas.org.uk/issues/fishsafe/>

Fish safe works by taking position from the onboard GPS receiver and using that to interrogate a comprehensive database of all pipelines, wellheads and cables throughout UK waters to find any nearby obstructions. An audible warning is output on close approach to one of these obstructions.

Fish safe uses information originally collected by:

Kingfisher Information Service  
Sea Fish Industry Authority  
St. Andrew's Dock, Hull, HU3 4QE.  
Tel: 01482 327 837

This division of SFIA (<http://www.seafish.org/sea/kingfisher.asp>) can provide up-to-date electronic chart information on cables (KIS-CA) and all sub-sea obstructions (KIS-UKCS).

## National offshore liaison groups

In Norway, matters concerning the interaction between fishing and oil exploration are discussed by the Norwegian Oil Industry Association (OLF), OLF Oljeindustriens Landsforening, Postboks 8065, 4068 Stavanger, Norway (<http://www.olf.no>). A compensatory scheme is administered by OLF which guarantees the economic compensation to fishermen for loss due to lost fishing gear or loss of fishing grounds due to oil exploration activities.

In the UK, a similar task is undertaken by the Fisheries and Offshore Oil Consultative Group (FOOCG). The Secretariat is provided by Scottish Executive Environment and Rural Affairs Department (SEERAD) – Environment Group, Water Division – Marine Branch, Area 1-H(N), Victoria Quay, Edinburgh, EH6 6QQ, Tel 0131–244–6233.

The Fisheries Liaison with Offshore Wind Group (FLOW) aims to provide a UK forum for the exchange of information on general matters concerning the fishing and offshore renewable energy industries around the United Kingdom, to discuss broad principles and to keep under review developments in connection with renewable operations. The Group meets under the Chair of the Department of Trade and Industry. More information is available at [http://www.dti.gov.uk/renewables/renew\\_2.1.3.7.htm](http://www.dti.gov.uk/renewables/renew_2.1.3.7.htm).

The International Cable Protection Committee (<http://www.iscpc.org>) is based in the UK and aims to promote the safeguarding of submarine telecommunications cables against man-made and natural hazards. The Committee also serves as a forum for the exchange of technical and legal information pertaining to submarine cable protection methods and programmes. The Cable Industry, Fishing Industry Consultative Group (CIFICG) is a UK liaison group under the Chair of the Department for Environment, Food and Rural Affairs. It is equivalent to FOOCG (above) but with responsibility for the interaction of fishing gear and sub-sea cables.

The fishing and petroleum industries in Newfoundland and Labrador have joined forces in an effort to work together on issues of common concern. The organization ONE OCEAN was formed in 2002 to promote cooperation and understanding between the fishing and petroleum industries. It is an advisory board consisting of representatives from both industries, the Fish, Food, and Allied Workers Union, the Fisheries Association of Newfoundland and Labrador

(FANL), and the Canadian Association of Petroleum Producers (CAPP). The offices of ONE OCEAN are located at the Fisheries and Marine Institute of Memorial University in St. John's.

## **A review of available information on interactions**

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A bibliography (Table 1) has been compiled on studies of the interaction between fishing gear and structures on the seabed related to the offshore oil, gas and telecommunications industries. A short abstract of many of the reports is included. A brief summary of the range of information follows.

### **Pipelines**

A large body of research has been done at model scale on the interaction mechanisms between pipelines and both beam and otter trawl fishing gear. The experiments studied the impact, sliding and pull-over phases and measured maximum loads during these stages. Much of the work was done initially in Norway in the 1970s. Full-scale trials were also conducted again in Norway but also in other countries, notably in the Netherlands on beam trawls. These data were used to validate theoretical analyses which are used by pipeline engineers for pipeline design and protection. Modifications to fishing gear to reduce impact have also been developed. The trials, on a range of pipeline diameters and trawl gear types, provided the basis for developing standards (see section 2). The maximum diameter of pipe on which most tests have been done is 36" although more recently limited studies at full-scale have been made on larger sizes up to 46". In the late 1980s and early 1990s there were some trials which considered primarily the effect on the fishing gear and fishing operation, rather than the pipeline. The issue of snagging under free-spanning pipelines was given greater prominence in the 1990s.

### **Protection frameworks**

Many tests using physical models in tow tanks and flume tanks have been conducted in recent years to assess the mechanisms of interaction of fishing gear with offshore seabed structures such as well heads, pipeline terminations and manifolds. This has become of greater importance with the tendency to locate such installations away from platforms and without surface markers or guard vessels. A wide variety of designs of protective framework has been tested but reports are often unavailable for some years after completion of the trials because of commercial confidentiality. A list of such confidential trials undertaken by organizations in Norway and Denmark) is given in table 2. A limited number of full-scale trials on protective structures have been carried, e.g., in the Netherlands. The effectiveness of safety zones in preventing towed fishing gear interacting with structures have been studied using mathematical models.

### **Rock dumps**

Limited information exists on the interaction of fishing gear with rock dumps, mainly used to protect vulnerable pipelines where they cannot be trenched or buried; in particular the effects on the fishing gear have been recorded.

### **Cables**

The vulnerability of cables to damage by fishing gear has been well known for many years and early experiments were conducted in the 1960s. Simple modifications to beam trawl shoes have been introduced successfully to reduce the likelihood of hooking. Many fishermen have adopted these measures. Trawl doors can still be a problem, however and the authorities are still active in promoting awareness of cable positions.

## Gaps in knowledge

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One of the major obstacles in this review process has been confidentiality. Information in the oil industry about over-trawlability of sub-sea structures is often the result of a comprehensive design and testing process, sometimes involving many different companies and suppliers. The companies designing sub-sea structures may not be willing to distribute this information freely since it has considerable commercial value. Even though the main contractors funding the work might be prepared to share information, it is often the case that there is reluctance to release reports detailing either the structure itself or the results of tests in order to protect the commercial interests of subcontractors and suppliers. Even in the case where a publicly funded research organisation has been involved in the tests, the results may remain confidential. Table 2 lists work done (mostly at model scale) in flume tanks and towing tanks where there is no publicly available report describing what was done or the findings.

There was considerable discussion on this and other issues regarding the information provided by the literature review. Views were formed on the areas where there was inadequate information or where the means to access the information were inadequate. The Group also appreciated the need for both offshore industries to be more aware of what can be done to mitigate the damaging effects of interaction between fishing gear and offshore structures. This applies not only to the design of the pipelines and structures but also to the fishing gear.

## Conclusions

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The main conclusions by the topic group are summarized under six headings. The topic group hopes that appropriate national bodies, such as fishing/offshore industry liaison groups, will take up these issues and initiate solutions for the benefit of both the fishing and offshore industries to improve safety, speed up and improve offshore design processes and inform government policy on abandonment.

### Dissemination of information on fishing gear

Oil industry engineers designing sub-sea structures make use of information on dimensions and weights of, and loads generated by fishing gear equipment. In the experience of the group members, sources of such information are not well-known by oil industry personnel who may have limited knowledge of the operation of fishing gear. The sources are poorly advertised although an example source of information on North Sea fishing gear is given in section 5. Improved dissemination of this information would be helpful. As fishing techniques develop there is also a need for this information to be updated regularly, perhaps every 3 years. Furthermore there is a need to prepare versions of the information on an area basis (e.g., North Sea, Norway, North America), in order to take account of differences in fishing techniques and gear and vessel sizes. This task might be undertaken by the WGFTFB.

### Dissemination of information on sub-sea structure design

Based on experience of collaborating with oil and fishing industry in projects on interaction, it is clear that confidentiality restricts the availability to other potential users of the results of trials on interaction. To preserve confidentiality and yet provide designers with important information affecting safety, a means should be found to compile generic, non-specific information on the requirements for design of seabed structures and of fishing gear to mitigate the risks associated with interaction. Potential sources of information for providing such generic data are: responsible authorities who may record interaction incidents, offshore operators, fishing industry organisations, trials reports of model or full-scale tests as well as designers of sub-sea structures themselves. This compilation of generic information on design practice at international level will help design companies and individual engineers to learn from the ex-

perience of others and develop more sophisticated designs whereas at present basic lessons often have to be relearned through the repetition of model trials towing similar gears over similar designs of structure.

### **Effect of rigging and gear design on interaction**

Mitigating measures need to be developed by both sectors e.g., by engineers designing ‘over-trawlable’ or ‘fishing friendly’ structures but also by gear manufacturers and technologists redesigning or re-rigging fishing gear to reduce snagging risk. Quite simple changes to rigging may reduce the severity of impacts between gear and seabed structures. At present gear manufacturers do not design fishing gear components with lower impact risk, mainly because they do not have access to information on what could be done to prevent snagging/hooksing. Competition could become an incentive to design low risk design characteristics for fishing gear. Specific studies to assess the potential benefits of gear alterations may be useful and a first step would be to define a series of model tests for this purpose.

### **Interaction with cuttings piles**

There is little information available on the interaction of gear and the cuttings piles created under drilling platforms. On abandonment the platform may be removed, exposing the cuttings pile to impact by fishing gear. As an element in determining abandonment policy there is a need to be able to assess potential hazards of interaction with fishing gear. While the issue of the potential spread of toxic or polluted cuttings material is an important aspect of abandonment policy there should also be consideration of the physical effects on fishing gear of impacting cuttings piles. Full-scale trials are needed to identify likely mechanisms of interaction between the piles and different gear components such as trawl doors, nets and in particular wires. The latter have the ability to cut through the base of the cuttings pile and are then likely to cause the net or a trawl door to wedge firmly in the material on impact.

### **Need for more trials on new gears and larger pipes**

Trawl gear designs are developing continuously, e.g., recently with the introduction of twin trawling and the use of heavy clump weights. There is also a trend towards larger, more efficient vessels in some fisheries towing heavier gear at higher speeds. More trials are needed on the interaction of offshore seabed structures and these new trawl systems and new trawling methods.

More trials are also needed on the interaction of fishing gear and large diameter pipes over 45” which are not buried or trenched

### **Risk analysis**

One of the main purposes of interaction trials is to assess the risk of hooking or damage for a particular combination of sub-sea structure and fishing gear or to identify the lower risk solution between two design options. The power of the experiment to estimate the significance of the result depends on the number of test runs. The Group recognizes that the number of runs is often limited for many reasons and that the fewer runs, the greater the uncertainty of the estimated risk. Application of appropriate techniques for assessing risks to structure, fishing gear and vessel from trials results is needed to increase confidence in the conclusions.

**Table 1: Available references on work relating to interaction between fishing gear and offshore structures - with brief abstract.**

INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
<b>Pipelines - Model scale</b>				
1.1.1 and 1.1.2	1977	Carstens T., Kjeldsen, S.P. and Gjorsvik, O.	The conflict between <i>pipelines</i> and bottom trawls - some results from laboratory and field tests. Bull. Norwegian Inst. Technol., River and Harbour Lab., (no.16E), 187–214, (1977)	Pipelines laid in deep water are left unburied, but in water shallower than a 'crossover' depth, they are buried. The crossover depth depends on factors such as wave and current statistics, bottom material, costs of burying and weight coating, etc. However, there is always a period of up to a year between laying and burying when the pipeline rests exposed on the seabed. Mutual damage may occur if a bottom trawl hits the pipeline. In tests using a 975 kg trawl-door (half maximum weight in use), impact force of 30 000 kg flaked off a 30 x 30 cm piece of concrete coating from the pipeline, down to the reinforcement. Apart from damage to the trawl-doors, dangerous strain develops in the towing warps, which snapped twice in tests, creating a very dangerous situation for the crew.
1.1.1 and 1.1.3	1987	Guijt, J. and Horenberg, J.A.G.	Recent Investigations Concerning the Effect of Bottom Trawl gear Crossings on Submarine Pipeline Integrity. Offshore Technology Conference, Houston, Texas. Paper OTC 5616.	Testing and engineering analysis, i.e., impact testing and pull-over calculations, to assess this response are discussed, specifying the appropriate boundary conditions imposed by the heavy beam trawls used in the Southern North Sea. Typical results are highlighted. It is concluded that the present approach of a combination of impact tests and pull-over calculations is very useful in determining pipeline integrity during trawl-gear crossings, but includes some conservative elements. This conservatism may be reduced by devising more realistic, beam-trawl impact tests and a more accurate description of pipe-seabed interaction for pull-over calculations. This will be of special interest for evaluating the integrity during trawl-gear crossings of small diameter pipelines.

INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.1.1 and 1.1.2	1980	Moshagen H. and Kjeldsen S.P.	Fishing gear loads and effects on submarine pipelines. Offshore Technology Conference Houston Texas USA 1980	Extensive laboratory and field studies on the conflict between pipelines and trawl gear. Beam trawls and otter-trawls with oval, rectangular and V doors were tested over 16" and 36" pipes. Results are presented for impact and pullover loads. Hooking is concluded to be a possible event and trawl improvements are recommended.
<b>1.1.2 Pipelines – Full-scale</b>				
1.1.2	1997	Fyriiliev, o., Spiten, J., Mellem, T. And Verley, R.	"DNV"96, Acceptance criteria for interaction between trawl gear and pipelines". OMAE, Yokohama, Japan:pp91-98	
1.1.2	1983	Gill, R.A. and Woodbury-Eggins, R.	Report of seine net fishing trial on Frigg Pipelines October 1983. Total Oil Marine plc.	No gear damage of any kind was sustained during the trial. The results indicate that the pipelines (trenched 32") do not cause an obstruction to seine net fishing in the areas tested.
1.1.2	1975	Groot, S.J. de	The possible effects of beam- and otter trawls on submarine pipelines. ICES CM 1975/B:4, 8 pp.	Over-trawling sub-sea pipelines with otter trawls and beam trawls may cause substantial damage to submarine pipelines. This can be avoided by rounding the beam trawl shoes.
1.1.2	1977	Groot, S.J. de	The relation between beam trawling and submarine pipelines and possible of the fishing gear to reduce impact forces. ICES CM 1977/B:8, 7 pp	Beam trawls shoes can easily hook behind pipelines and cause serious damage. They can be adapted easily to avoid this problem.
1.1.2	1977	Groot, S.J. de	Dutch fishing activities in the North Sea and adjacent waters relevant to the safety of underwater pipelines. ICES CM 1977/B:9, 9 pp.	Over-trawling a 36" pipeline with adapted beam trawls resulted in no significant damage of the concrete pipe coating developed at the time (only scratches).

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INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.1.2	1982	Groot, S.J. de	The Impact of Laying and Maintenance of Offshore Pipelines on the Marine Environment and the North Sea Fisheries	This paper describes the coating, laying, burying and surveying of pipelines. Both natural hazards (water movement, corrosion, sediment movement) and man-made hazards (anchors, fishing activities) are discussed. A case history of a pipeline floatation is given in more detail. Other items are: fishery damage attributed to offshore activities, fishing activity in relation to pipelines, improvement of fishing gear to reduce the impact on pipelines and the biological effect of introducing structures on the bottom. It is suggested to base the requirements for each new projected pipeline on a combination of considerations and to assess these requirements case by case instead of applying standard requirements on e.g., burial depth, trenching, etc.
1.1.2	1986	Groot, S.J. de	Full scale tests on the interaction between bottom fishing gear and an 18-inch marine gas pipeline in the North Sea. <i>Ocean Management</i> , 10 (1986) 1–10.	Experiments on the impact of fishing gear on the NAM K7/K8 18" pipeline on the Netherlands Continental Shelf (area ICES F338) were carried out in 1984. It was confirmed that pipelines with the new type of coating can endure the impacts of fishing gear without ill effects on operation or safety. The impact forces can be reduced considerably by adding steel bars on trawl shoes.
1.1.2	1996	Groot, S.J. de	Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. <i>ICES Jour. Mar. Sci.</i> , 53: 1045–1050.	An overview is given of the development of the offshore oil and gas industry in the North Sea and the possible physical impact on the ecosystem in the short and long term. The order of magnitude of several activities (seismic exploration, drilling, platforms, pipelines, sub-sea facilities, and gas flaring) has been estimated on the basis of information from national authorities and the hydrocarbon industry.
1.1.2	1977	Groot, S.J. de, and McIntyre, A.D.	Literature references relative to the interaction between the fishing industry and the offshore gas/oil industries. <i>ICES CM 1977/B:10</i> , 7 pp.	This paper gives the major relevant references concerning the interaction between the fishing industry and the offshore gas/oil industries.

INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.1.2	1979	Groot, S.J. de and Dongen, F.A. van	Interaction of fishing gear and pipelines (Interactie vistuigen en pijpleidingen), RIVO Report CA-79-07 (RWS Report NZ-R-79.16), 33 pp <i>In Dutch</i>	Description of research carried out by VHL in the years 1973–1979 on the interaction of fishing gear and pipelines.
1.1.2	1984	Groot, S.J. de, and Hak, W. v.d.	Full scale tests on the interaction between bottom fishing gear and an 18-inch marine gas pipeline in the North Sea. ICES CM 1984/B:42, 8 pp.	Pipelines with the new coatings (concrete with various types of armour can endure the impact of beam trawls. The impact forces can be reduced considerably by adding steel bars on trawl shoes.
1.1.2	1984	Groot S.J., Hak W. van der	Full scale tests on the interaction between bottom fishing gear and an 18-inch marine gas pipeline in the North Sea. Ocean Management 10: 1–10	The paper describes experiments on the effects of the impacts of commercial bottom-fishing gear on a partially buried or unburied pipeline in operational use on The Netherlands Continental Shelf. It was confirmed that pipelines with the new type of coatings can endure the impacts of fishing gear without ill effects on operation or safety. The forces encountered by the fishing gear, especially the beam trawl, can be considerably reduced by specially designed adaptations of the trawl head (trawl shoes) on the lines such as those developed to avoid the hooking of marine telephone cables.
1.1.2	1999	Side J.	Issues Arising from the Westhaven tragedy concerning fishing gear and pipeline interactions. Journal of Society for Underwater Technology 24, 1:3–9	Reviews findings of 2 enquiries into the loss of a Scottish fishing vessel, describes relevant law and discusses implications for pipeline decommissioning and abandonment.
1.1.2	1979	Valdemarsen, J.W.	Behaviour aspects of fish in relation to oil platforms in the North Sea. ICES CM 1979/B:27, 11 pp	Fish density was higher around platforms, 3–10 times as much cod and saithe in the 200 m zone compared to the 500 m zone.
1.1.2	1988	Valdemarsen, J.W.	Trawling across pipelines. Underwater TV observations. (In Norwegian). FTFI-report 15.11.1988, Bergen Norway	Full-scale trawl experiments with shrimp and industrial trawls. 40 crossings over 28 and 30 inch pipelines at different angles of attack were observed with underwater camera. The pipelines could be crossed without any serious risk of gear damage.
1.1.2	1989	Valdemarsen, J.W.	Trawling across pipelines. Paper to the 1 <sup>st</sup> International Conference on Fisheries and Offshore Petroleum Exploitation, Bergen, Norway, October 23–25, 1989.	Same as above

INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.1.2	1993	Valdemarsen, J.W	Trawling across 40'' pipeline – effects on trawl gear. Fisken og Havet 11, 1993. ISSN 0071–5638. Institute of Marine Research. Bergen, Norway	Full scale tests with three trawl types: industrial fish trawl, and <i>Nephrops</i> trawl (rigged both as single and as twin trawl), on Zeepipe Phase I, which is a 40'' pipe on the seabed between the Sleipner A-platform and Zeebruegge.
<b>1.1.3 Pipelines – Mathematical models</b>				
1.1.3	1987	Guijt, J. and Horenberg, J.A.G.	An Analytical and Experimental Analysis of Trawl gear-Pipeline Interaction. Offshore Technology Conference, Houston, Texas. Paper OTC 5617.	To analyze the effect of unburied pipelines on fishing operations, the interaction between a beam trawl and a pipeline has been investigated. A numerical simulator of this interaction has been developed. In addition, model tests have been performed. The results not only confirm, but also explain, the significant reduction of the interaction forces resulting from fitting hoop-bars to the beam-trawl shoes or the use of shoes with a curved front. In addition, it has been established that the forces exerted on the pipeline are lower in magnitude and of shorter duration than the warp-line forces.
1.1.3	1991	Jiao G., Skallerud B., Soberg T.	Safety and integrity of submarine pipelines/flowlines under interaction of fishing trawl doors. The Proceedings of the Fourth (1994) International Offshore and Polar Engineering Conference. Volume 2, 1994, International Society of Offshore and Polar Engineers (ISOPE), Golden, Co (USA), 1994, pp. 378–385.	Safety and integrity of submarine pipelines/flowlines under interaction of fishing trawl doors are modeled for the 16'' and 36'' pipe. The trawl door pull-over loads are based on experimental results. Safety is assessed based on the results from global and local response analyses and realistic uncertainty measures.
1.1.3	1994	Verley, R.	Pipeline on a flat seabed subjected to <i>trawling</i> or other limited duration point loads. The Proceedings of the Fourth (1994) International Offshore and Polar Engineering Conference. Volume 2, 1994, International Society of Offshore and Polar Engineers (ISOPE), Golden, Co (USA), 1994, pp. 128–134	The paper describes through mathematical modelling the response (displacement and stress) of a long, straight pipeline lying on a flat seabed and subjected to a horizontally applied point load of limited duration, e.g., from trawling. The results of some 3000 simulations are presented. Conclusions are drawn concerning the protection of small diameter pipelines against trawl loads.

INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.1.3	1991	Verley R.L.P., Moshagen B.H.H., Moholdt N.C. and Nygaard I.	Trawl forces on free-spanning pipelines. The Proceedings of the Fourth (1994) International Offshore and Polar Engineering Conference. Volume 2, 1994, International Society of Offshore and Polar Engineers (ISOPE), Golden, Co (USA), 1994, pp. 273–280	Model tests investigating trawl forces for free-spans of up to 6 m height are described. Results are presented for maximum warp force, maximum force applied to the pipeline and shape of the force-time trace. Effects of tow velocity, span and warp flexibility and trawl door type are quantified. The effects of trawl forces in limiting allowable span lengths and heights are illustrated.
<b>1.1.4 Pipelines – Reviews</b>				
1.1.4	1984	Anon.	Submarine pipelines guidance notes. Pipeline Inspectorate, UK Dept of Energy	Gives guidance on applications for works authorization, design, construction and installation of pipelines and on safety aspects.
1.1.4	1997	Anon.	Interference between trawl gear and pipelines. Det Norske Veritas Guidelines No 13.	Comprehensive advice to pipeline engineers on analysis of pipeline and fishing gear interaction
1.1.4	1999	Anon.	The final disposal of disused pipelines and cables. Summary of the findings of Norwegian Assessment Programme. Section 7 – Impact on fisheries. Ministry of Petroleum and Energy, Norway	Discusses effects on fisheries of different disposal options. Summarizes studies on trawling over exposed and rock-dumped pipelines.
1.1.4	1980	McIntyre, A.D. and Groot, S.J. de	Interaction between the Fishing Industry and the Offshore Gas/Oil Industries. ICES Coop. Res. Rep., 94: 1–102	A summary of information available up to 1977 from both Europe and USA. A useful list of earlier references.
<b>1.2.1 Protection frameworks – Model scale</b>				
1.2.1	2004	Fyrileiv O. and Spiten J.	Trawl gear protection within platform safety zones. Proceedings of OMAE04. ASME. Vancouver, Canada. June 2004	When fishing vessels tow around the outside of a platform safety zone, trawl gear may snag installations in the safety zone. Options for reducing risks are discussed.
<b>1.2.2 Protective frameworks – Full-scale</b>				

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INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.2.2	1981	Armer GST, Garas FK. (eds)	Damage to sub-sea installations. Offshore Res. Focus, (no. 24), 8 (1981)	Describes an initial appraisal of the threat of damage to sub-sea installations. Some of significant points revealed by the survey were: installations situated within the 500 m safety zone around a surface facility appear to be no less vulnerable than those outside it; pipelines should be treated as a separate case since, despite their relatively low, rounded profile, the risk of damage is increased because of their length and this also influences the choice of suitable protection methods; wherever the damage was inflicted to the protection fitted to wellheads, the well-heads themselves remained undamaged; fishing activity was confirmed as the main cause of damage, with anchors and anchor chains responsible for most of the remaining instances of damage; estimates from the various sources differ as to the proportion of installations which have been damaged, but an average of in excess of 30% appears to be realistic.
1.2.2	1980	Foden, G.P., Fenimore, K.E. and Fraser, W.J.	A method of protecting sub-sea wellheads against environmental hazards. In: Europec '80: European Offshore Petroleum Conference and Exhibition. Proceedings. Volume I.	This paper presents the evaluation of the risk of damage to sub-sea wellheads from fishing gear and oil related objects. It lists the alternative forms of protection considered and the selection of the most cost effective type. Details are given of the design and installation of two protective covers in the North Sea. It presents the development of the design based on experience gained leading to the installation of a third cover in the same area.
1.2.2	1992	Groot, S.J. de, and Hak, W. v.d., Verhagen, W. and Knops, J.	Interaction between beam trawls and protecting constructions placed over temporary abandoned wellheads (Interactie boomkor – beschermende constructies van tijdelijk verlaten boorputten.) RIVO/DLO-report No MO 92-01, June 1992, 21 pp. <i>In Dutch</i>	Test were carried out in January 1992 in the North Sea on the impact of a beam trawl on sub-sea constructions meant to protect abandoned well heads. While the average increase in warp load was about 40kN, a maximum increase of 106kN was found in one occasion. The gear and the protection construction were not damaged, and neither the protection constructions nor the material around them displaced by the passage of the gear. Only in extreme cases did the passage cause vibrations on-board. These constructions were deemed acceptable to both the offshore and the fishing industry.

INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.2.2	1996	Groot, S.J. de	Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. ICES J. Mar. Sci., 53: 1045–1050, 1996	An overview is given of the development of the offshore and gas industry in the North Sea and the possible physical impact on the ecosystem in the short and long term. The order of magnitude of several activities (seismic exploration, drilling, platforms, pipelines, sub-sea facilities, and gas flaring) has been estimated on the basis of information from national authorities and the hydrocarbon industry.
<b>1.3.1 Rock dumps</b>				
1.3.1	1997	Soldal, A.V.	Trawling across rock covered pipelines in the North Sea (in Norwegian, English summary). Fisken og Havet 10 (1997), Institute of Marine Research, Bergen, Norway. pp. 46.	Describes a full-scale experiment to determine to what extent gravel dumped on pipelines obstructs bottom trawling. The results showed that gravel dumps increased the risk of damage to shrimp trawls and industrial fish trawls with light ground gears (grass rope) significantly, while trawls fitted with bobbins gears were less often damaged.
1.3.1	1997	Soldal, A.V.	Stone-filled pipelines damage trawl-gear. IMR Norway News no 1, 1997	Newsletter version in English of the report above.
1.3.1	1993	Valdemarsen, J.W.	Trawling across stone covered pipelines – a pilot study (In Norwegian) Fisken og Havet 23 (1993), Institute of Marine Research, Bergen, Norway.	
<b>1.4.1 Underwater cables</b>				
1.4.1	1977	Aitken, R.S.	Fishing interference with submarine telephone cables in the southern North Sea. ICES CM1977/B:32	Risks to underwater cables are discussed. The area of highest risk is defined and the contribution to cable faults by seabed formation and fishing gear is considered. Possible action to protect cables is indicated.
1.4.1	1971	Anon.	Trawling and submarine cables. International Cable Protection Committee	Provides the fishing industry with advice and information concerning the precautions which should be taken to avoid the fouling of submarine cables and the action which should be taken in the event of hooking.

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INDEX	DATE	AUTHORS	FULL REFERENCE	ABSTRACT/COMMENTS
1.4.1	1978	Bruin, A.C. de	Modified beam trawl shoe avoids damage to gear and underwater cables. (Gewijzigde uitvoering boomkor voorkomt schade aan tuig en kabels. <i>(In Dutch)</i> . De Visserijwereld, 37 (51/52), 3 pp.	Rounded steel bars added to beam trawl shoes ease the passage of these gears over underwater cables without causing damage.
1.4.1	1979	Groot, S.J. de	On the interference Between Beam trawls and Submarine Telephone Cables in the Southern North Sea – A Way out of the Problem. Ocean Management, 5 (1979) 285–294	This paper discusses the interference between beam trawls and submarine telephone cables in the southern North Sea. The developmental history is given of how a simple adaptation was developed to be welded at the front of existing beam trawl shoes, changing its shape in such a manner that passage of cables (and pipelines) cause less damage.

CODE	DATE	AUTHORS	REFERENCE	ABSTRACT/COMMENTS
<b>2.1 Interaction of fishing gear and cuttings piles</b>				
2.1	1998	Bell, N., Cripps, S.J., Jacobsen, T., Kjeilan, G. and Picken G.B.	Review of drill cuttings piles in the North Sea. Final report. A report for the Offshore Decommissioning Communications Project. Cordah Environmental Consultants	Wide ranging review. Deals briefly with trawling impacts and suggests a comprehensive study to examine the response of a pile to impact by trawling gear.
2.1	2002	Black K.S., Paterson D.M. and Davidson I.R.	Erosion of cuttings pile sediments: a laboratory flume study. Journal of Society for Underwater Technology 25,2:51–59	Discusses the composition of cuttings piles and the processes involved in their erosion.
2.1	1999	Carles L. and Bryden.I.	The Sensitivity of a dispersion model to cuttings settling speeds. Journal of Society for Underwater Technology 24,1:19–24	Identifies settling speed as an important parameter in dispersion models and proposes improvements.
2.1	2002	Tyler A.O., Sabour Z.A. and Hockley M.C.	Modelling the behaviour and environmental impact of cuttings piles during decommissioning. Journal of Society for Underwater Technology 25,2:39–50	Models effects of natural forcing and manmade operational disturbances during decommissioning. Ability being developed to predict longer term disturbance e.g., due to trawling.

**Table 2: A list of trials undertaken on the interaction between fishing gear and sub-sea structures. The associated reports and some of the location and client details are currently confidential.**

YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
		<b>Trials in association with Sea Fish Industry Authority, Hull, UK</b>	
2001		Flume tank over trawling tests on model protection structure (Cocoon). A range of model otter trawls and doors were towed over the structure. The structure was designed to stop the trawl gear but allow for smooth and easy gear retrieval.	Shell UK Exploration and Production
2001		Flume tank over trawling tests on model protection structure (tubular steel). A range of model otter trawls and doors were towed over the structure to test for over-trawlability and identify features in the structure which could be improved.	FMC Kongsberg Subsea
2003		Flume tank over trawling tests on model protection structure (tubular steel with and without cover panels). A range of model otter trawls and doors were towed over the structure to examine ways in which trawl gear could come fast and improvements made.	Subsea7

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YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
		<b>Trials in association with MARINTEK, SINTEF, Norway</b>	
2005	Norne Satel-lites.	Over trawling study. Model tests.	Stolt Offshore Systems.
2004	Kristin and Snøhvit	Pipelines in Free Spans. Over trawling by Clump Weights. Model Tests.	Statoil
2003	Nemo	Sub-sea Structures. Over trawling Study.	Nemo Engineering
2003	Snøhvit	Sub-sea Structures. Over trawling Model Tests.	ABB Offshore Systems
2002	Ormen Lange	Gas Pipeline. Over trawling Study. Model Tests.	Norsk Hydro
2001		Nugget Underwater Protection Covers. Design Evaluation Against Trawl-ing.	ABB Offshore Systems
2001	Vesterled	a) Over-trawlability Evaluation of the Vesterled Pipeline. b) Evaluation of Loads from Beam Trawl on Vesterled Sub-sea Protection Covers.	Nemo Engineering
2000		Evaluation of loads from trawls in sub-sea structures (Vurdering av trållaster på undervannsstrukturer).	ABB Offshore Systems
1995	Vigdis	Sub-sea Structures. Over-trawlability Tests of Protection Cover	Seanor Engineering
1995	Norne	Template. Sub-sea Protection Structures. Over-trawlability model tests.	Kongsberg Offshore
1994	Vigdis	Field Development. Evaluation of Loads from Fishing Gear on Sub-sea Protection Structures.	Saga Petroleum

YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
1993	Tordis	Sub-sea production system. Pre-study review and over-trawlability model tests of manifold jumpers.	Kværner Engineering
1993	Troll	Olje Sub-sea Protection Structures. Over-trawlability model tests of tied in lines.	Norsk Hydro
1993	Europipe	connection point – ship interaction	Aker Engineering
1992	Troll	Olje – Sub-sea Structures. Over-trawlability Model tests.	Kværner Rosenberg, Norsk Hydro
1992		Evaluation of Satellite Structure Design.	Cooper Oil Tool
1992	Lille-Frigg	Sub-sea structures. Over-trawlability model tests and fishing activity investigation	Aker Sub-sea
1992	Troll	Olje over-trawlability study. Fishing activity investigation and sub-sea protective structure design	Norsk Hydro
1991	Zeepipe	Z- Sub-sea Connection Point. Protective structure design evaluation	Statoil
1991	Tordis	- overtrawling tests. Model tests and fishing activity study.	Kværner Engineering
1989– 1991		Trawl-Pipeline Span Interaction. Model tests. A research study of a gas pipeline from Haltenbanken to the shore of Mid-Norway.	Statoil
1989– 1991		Protection of sub-sea flexible lines. Project in the research programme: Floating Production Systems (FPS) 2000.	NTNF + 7 oil-companies
1989– 1990		The KHEOPS System. A sub-sea protective structure. Model tests.	Seanor Engineering

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YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
1988–1989		Small diameter pipelines and trawls. An interaction study. Theoretical calculations.	Statoil, Amoco, Elf.
1986–1988		Interaction between sub-sea structures and fishing gear, phase I and II. Theoretical calculations, model tests and guideline report.	BP, Norsk Agip, Statoil, Norsk Hydro
1986		Interaction between sub-sea structures and trawl equipment. Pre-project for JIP. (MARINTEK, Snamprogetti, Barlindhaug).	Norsk Hydro
1985		Experimental and numerical investigation of accidental drops of drilling tubes.	NTNF

YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
		<b>Trials by FORCE – DMI, Denmark, often in association with SINTEF Fisheries and Aquaculture, Hirtshals</b>	
2004		Over trawling assessment of sub-sea structure including desktop evaluation, selection of relevant fishing gear and tests in the towing tank	
2003	Ormen Lange	Over trawling evaluation and model tests (in-air tests and in-water tests) of two sub sea installations	FMC Kongsberg
2003	Sleipner	Expert appraisal of over-trawlability of a sub sea installation	
2002		Over trawling investigation of offshore sub sea installation	Stolt Offshore A/S
2001	Visund Nord	Over trawling tests of sub sea installation	Kværner Oilfield Products
2000	Visund	Over trawling tests of sub sea installation	Kværner Oilfield Products
1998		Over trawling tests. Installation tests from a large Heavy lift vessel. During the tests the structure was lowered through the splash zone and where the loads on the structure and the crane was measured	Kværner Oilfield Products
1996		Over trawling tests of sub sea installation	Kongsberg Offshore AS
1996	Troll	Over trawling tests of sub-sea installation system	ABB Offshore Technology AS

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YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
1992	Draugen	Over trawling tests of sub-sea installation system	Seanor AS

YEAR	LOCATION	TOPIC AND NATURE OF STUDY	CLIENT
		<b>Trials in association with Det Norske Veritas, Norway</b>	
2005	Ormen Lange	Ormen Lange Pull-Over Loads for clump weights, DNV report 2005-0315	Norsk Hydro AS
2004	Ormen Lange	Trawl impact requirements study on Ormen Lange pipeline, DNV report 2004-1101	Norsk Hydro AS
2003	Kristin	Trawl Impact study, DNV report 2003-1314	Statoil
1996		Interference between trawl gear and pipelines, Guideline documentation report, DNV report 96-3466	Joint Industry Project (Norsk Hydro, Phillips Petroleum Company Norway, Saga, Statoil)
1993	Norne	GRP cover over trawling study model test report, report no C093-STOF-F-RD-012 (Norne satellites)	Statoil

## Appendix 1

A brief description is given here of the current situation regarding the interaction between the offshore and fishing industries in Europe and Canada.

### Europe

The North Sea has important deposits of oil and gas. Exploration and production of these resources started in the early 1960's, and rose to a complex level of activities. In the same time frame North Sea fisheries developed from herring (*Clupea harengus* L.) drift netting into trawling with relatively heavy gears for demersal species, e.g., sole (*Solea vulgaris* L.) and plaice (*Pleuronectes platessa* L.). Conflicts between these various users of the sea emerged, and several research programmes into the inter-action between the two industries were developed (De Groot *et al.*, 1975; 1977; 1984; 1992). In the present day oil and gas production in the North Sea is at its peak and likely to decline in the near future, and adaptations are needed to sub-sea structures thus avoiding either environmental damage or adverse effects of fishing gear. The experiences gained in the North Sea may be used in similar developments elsewhere.

**Table Years and major events in North Sea oil and gas production.**

YEAR	EVENT(S)
1959	Gas was discovered in Rotliegend Sandstone at Groningen in the Netherlands
1961	First drilling activities by the "Nederlandse Aardolie Maatschappij (NAM)"
1965	Leman field discovered off the Norfolk coast; North Sea gas was first discovered in the southern North Sea
1967	First oil reserve found in DK-sector; North Sea gas brought ashore
1969	Ekofisk field found in NO-sector
1970	Oil and gas found in NL-sector; Forties field discovered
1971	Ekofisk field on stream; Gas exploitation license given for NL-sector; Frigg field discovered; Brent field discovered; Argyll Field discovered in the Central North Sea
1973	Piper Field discovered
1974	Statfjord field discovered
1975	Oil (from the Argyll Field) came ashore
1977	South Brae Field discovered; Dutch offshore gas production started
1982	Oil production started in NL-sector
1988	Shearwater Field discovered
1980–1995	Booming period, with 50 production platforms during peak of activities
1998	Start of decline in activities

### Canada

Pacific Ocean: All oil and gas exploration is under moratorium in the Canadian sector since 1989 after the Exxon Valdez tanker accident. Apparently there are ongoing negotiations between the oil industry and the government of Canada on lifting the ban.

#### Atlantic Ocean

Newfoundland and Labrador Area. Oil exploration began in 1966 and up to present more than 190 wells tested. Hibernia oil field (producing since 1997) was discovered in 1979 with Terra Nova (producing in 2002) and White Rose (to start in fourth quarter of 2005) fields in 1984. All three fields are on the eastern portion of the Grand Bank continental shelf. Hibernia has a

gravity base platform while Terra Nova uses a FPSO (*Floating Production, Storage and Off-loading*) vessel. All of the oil is transferred to tanker.

The Canada-Newfoundland Offshore Petroleum Board (CNOPB) has the responsibility to ensure that offshore oil and gas industrial activities proceed in an environmentally acceptable manner and is the regulatory body. The Board reviews proposals for all physical activities offshore -- from seismic surveys to production projects -- to identify their potential effects upon the natural environment or upon other users of that environment (such as the fishery). It also evaluates measures that are proposed to prevent or mitigate these effects. Average daily oil production from the offshore in 2003 was 336,885 barrels, compared to 285,845 barrels in 2002. Production for the 2003 calendar year amounted to 122.96 million barrels, compared to 104.5 million barrels in 2002.

#### *Fishery*

The oil fields are located on historic fishing grounds and have displaced groundfish and crab fisheries out of that area of the eastern Grand Bank. The fishery exclusion zone takes in no fishing within 500 m from perimeter of drilling platform and 50 m from the anchor pattern for semi-submersible platforms. Wellhead abandonment follows the guidelines set out by CNOPB and heads are to be made flushed with bottom (cement casings) and debris removed.

### **Nova Scotia**

Oil exploration has been going on for over 30 years off Nova Scotia but the first producing field came on stream in 1992. The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) regulates including the Sable Offshore Energy Project (SOEP), The Cohasset – Panuke project and EnCana's [Deep Panuke Project](#). The Cohasset – Panuke project was Canada's first offshore oil project and operated from 1992 to 1999. The two production fields (Cohasset and Panuke) are approximately 8 kilometers apart and are located about 250 kilometers southeast of Halifax. The fields produced 44.5 million barrels (7.1 million cubic metres) of light oil during its life. The Board approved the start of the decommissioning in 2000 with the removal of the CALM Buoy, demobilization and removal of all mobile components, and the depressurization and de-energization of all platforms and sub-sea facilities. In May of 2004 EnCana Corp., which purchased the oil field in the mid 1990s, was asking regulators to allow it to leave more than 3,000 tonnes of pipeline that would stretch 25 kilometers on the ocean floor, says it has created an underwater oasis for starfish and lobsters that should not be disturbed. The SOEP consists of six major natural gas fields that lie 10 to 40 kilometres (6 to 25) miles north of the edge of the Scotian Shelf. The offshore side includes a central processing facility near Sable Island which will eventually be connected to six production platforms (three are currently connected and producing gas - the fourth field is Alma). A sub-sea pipeline is transporting the gas to a processing plant in Goldboro, Guysborough County, Nova Scotia. A new venture EnCana's [Deep Panuke Project](#) is under development and consists of the installation of production (and support) infrastructure to produce gas from reserves located in the Deep Panuke field. The Project also consists of the transmission of those reserves in the form of natural gas to the Nova Scotia mainland.

One of the CNSOPB's primary responsibilities is protection of the environment during all phases of offshore petroleum activities, from initial exploration to abandonment. The past fiscal year has been busy from an environmental perspective, with the introduction of the Canadian Environmental Assessment Act (CEAA), multiple environmental effects monitoring (EEM) programs, the continual review of many environmental assessments, and participation in environmental initiatives of other departments and agencies.

### *Fishery*

The production fields are located in historical fishing areas and have displaced some fishers. A fishery advisory committee is in place in Nova Scotia and membership includes representatives of various fishing groups, the Department of Fisheries and Oceans (DFO), and the Nova Scotia Department of Agriculture and Fisheries. This committee advises the CNSOPB.

### ***Environmental Regulation***

Both the Nova Scotia and Newfoundland Boards are a Federal Authority (FA) under the Canadian Environmental Assessment Act (CEAA) and are obliged to apply the environmental assessment review process set out in the Act. In July 2003, the federal government passed an amendment to the CEAA Law List Regulations, making all offshore oil and gas activities subject to the Act. Similar regulations regarding fishing activities, cleanup activities and well abandonment are generally joint regulations. No information on cutting pile regulations available at the time of this report.

### **Summary**

Oil and gas exploration is still a fairly new activity in the off-shores waters of Atlantic Canada. Very little information is available on fishing gear interactions with sub-sea structure and cutting piles so this may be a non issue at this point in time.

### **Sources of information:**

Nova Scotia: <http://www.cnsopb.ns.ca/>; <http://www.gov.ns.ca/energy/>

Newfoundland: <http://www.cnopb.nfnet.com/>

## Annex 6: The OMEGA protocol

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### ICES-FAO Working Group on Fishing Technology and Fish Behaviour

18–22 April 2005, FAO, Rome, Italy

#### Protocol for the use of an objective mesh gauge

Ronald Fonteyne  
Sea Fisheries Department  
Oostende, Belgium  
ronald.fonteyne@dvz.be

#### Abstract

The present document is an extract from the draft final report of the R&D and Demonstration Project “Development and testing of an objective mesh gauge”, known as the OMEGA project, within the Fifth Framework Programme of the European Commission (Contract No Q5CO-01335).

The main aim of the project was to design, build and test a new objective mesh gauge, suitable for fisheries inspection, fisheries research and the fishing industry. In support a Protocol for using the new gauge for fisheries inspection, research and netting manufacturing was drafted, taking account of legal aspects of mesh inspection. The Protocol specifies the mesh dimension to be measured on mesh types commonly found in use. Detailed instructions are given on how to prepare and operate the gauge, the number of meshes to be measured and how to select those meshes. Guidance is given on whether to accept or reject readings. Gauges used for inspection purposes must be calibrated annually and instructions are included for intermediate checking of force and length measurements.

#### 1.1. Introduction

A protocol for mesh measurement with an objective mesh gauge was prepared during the project and legal aspects of the methodology were investigated (Work packages 4.1 and 4.2). The protocol contains detailed instructions for the design, construction and operation of such a gauge, based on the experience gained during the project, and aims to ensure uniformity in the measurement procedure.

The first draft of the protocol was prepared by participants DVZ and AID and discussed by all the partners at the 3rd project meeting. This draft included sections dealing progressively with the background to the project as well as the operation of the new type of gauge. The partners considered that the instructions for using the gauge should be the first and main part of the text and that the background material should be included as annexes. The protocol was then re-drafted and discussed at the 4th and 5th project meetings. At the 5th meeting, in the light of results obtained during the project, it was decided to amend the stretching forces recommended in the protocol, for netting both above and below 55 mm. It was also agreed to include instructions for using an objective gauge to measure mesh sizes on static nets. The text was then re-edited and circulated to the partners for comment. The final agreed version of the protocol follows this introduction.

If an objective mesh gauge is widely adopted for fishery control and scientific purposes, the instrument will be used by fishery inspectors, scientists, net makers and fishermen. To ensure uniformity in mesh measurement the protocol sets out in detail how such a gauge is to be con-

structed and used. A brief introduction states the benefits to be obtained from using an objective mesh gauge, free of human influence. The essential features are then presented of an automatic mesh gauge, not only the OMEGA gauge, able to stretch a mesh to a pre-determined tension. Essential requirements for data recording, display and transmission are also given. The gauge developed during the project had one fixed and one movable jaw. As this design proved to be successful, it is recommended in the protocol. Gauges with two movable jaws are not recommended as it is not known whether such a design would be effective.

The measurement procedure set out in the protocol deals with the different types of mesh likely to be encountered, the preparation of the gauge, insertion into a mesh, operation, selection of meshes for measurement, acceptance or rejection of measurements and the determination of the mean mesh size. The placing of the jaws in a mesh relative to the knots conforms to the procedure set out in the standard EN ISO 1107, i.e., to measure the longest possible mesh opening. Netting can creep when force is applied and, to cope with this effect, an objective gauge must be able to re-apply the chosen force to obtain a valid measurement. The measurement algorithm used in the OMEGA gauge is described in Annex 6 of the protocol.

As mesh measurement procedures for enforcement purposes are set out in Commission Regulations, the text dealing with the selection of meshes for both active and static gears refers to the current regulation 129/2003 (Annex 7). This could be altered in future to refer to a new mesh measurement regulation, possibly specifying a smaller number of meshes to be measured (e.g., 20), based on the work done in this project. Acceptance or rejection of measurements is an important decision and a short list is given of cogent reasons for rejection. This list comes from the trials carried out during the project but may expand in the light of experience. Difficulties can be encountered when measuring static nets with very small forces. The mesh has to be stretched by hand to enable the gauge to be inserted and operated easily and there is a risk of excessive force being used.

The forces recommended for measuring set nets and codends are listed in the Protocol. These are based on ICES advice, amended in light of present test results. The 40 N force proposed for netting < 55 mm mesh size is not supported by the Spanish partner (see Discussion section 3.3.3.1).

Regular calibration of the new type of gauge is essential for enforcement purposes and this must be done by the respective standards authorities in each country. Techniques were developed during the project however, for intermediate checking of force and length measurements. Training in the use of such a gauge is essential.

The legal aspects of mesh measurement for enforcement of the regulations were thoroughly investigated during the PREMEGADEV project, in preparation for the OMEGA project. Guidance was given by lawyers, with experience of fisheries cases, on the essential requirements for evidence obtained with measuring instruments. The core of their advice is summarised in annex 5 of the Protocol. The need for a transparent method of calibration was recognised by the partners and the Protocol contains clear guidance.

The 2nd draft of the Protocol was sent to lawyers and the Commission for comment but no written responses have yet been received. One of the lawyers, who attended the 2nd workshop, noted the problem of creep under applied force and remarked that it may have legal relevance.

## 1.2. Protocol

### Protocol for the Use of an Objective Mesh Gauge

#### 1. Introduction

An objective mesh gauge measures the opening of a mesh by stretching it between two jaws until a set force is reached. The key feature of such a gauge is that manual force is not used to stretch the meshes. Force is applied by an internal mechanism. Thus the measurement made of the opening of a mesh is independent of the operator. Extensive trials of such a gauge showed it to be suitable for use on both active and passive fishing gears by:

- a) fishery inspectors to enforce the conservation regulations;
- b) scientists to study mesh selection;
- c) net makers to check mesh sizes during the manufacture of sheet netting;
- d) fishermen to check that their nets conform to the regulations.

An objective mesh gauge, suitable for use in all branches of the fishing industry, provides a common standard of measurement and assists the integration of the scientific, industrial and enforcement aspects of fishery management. It should ensure that all inspectors will obtain the same values of mesh size and that netting supplied to fishermen will not subsequently be found to be undersized. It will also be possible to manufacture netting with exactly the mesh sizes requested by customers. Fishermen will be able to check mesh sizes before and during fishing operations using the same objective method as the inspectors.

Detailed background information on the technical and legal aspects of objective mesh gauges is given in Annexes 1 to 5.

## *2. Specification of an Objective Gauge*

The gauge should have two jaws, one fixed and one movable, each 2 mm thick with rounded edges to ensure that the jaws slip easily over the twine. It may be electrically driven and must be able to apply selected longitudinal forces, in the range 5 to 180 N, to the meshes with a precision of 1 N. If the gauge is battery powered, it must be capable of making 1000 measurements, according to a typical pattern of use by a fisheries inspector, before requiring to be recharged. A built-in system for measuring the applied force is needed. A mesh should be stretched at a constant speed of  $300 \pm 30$  mm/min by the movable jaw. The gauge must be able to measure meshes from 10 to 300 mm and may have detachable jaws for use on small and large meshes. The measurement precision should be 1 mm.

The structure of the gauge must be rigid and not distort under load. The body must be light yet robust and should weigh no more than 2.5 kg. The gauge should be made of materials resistant to corrosion under marine conditions. It should be water resistant to standard IP56, be unaffected by dust and be stable in operation over a temperature range of -10 to +40 °C. The gauge should be able to withstand temperatures between -25 and +65 °C during storage and transportation.

Gauge operation should be controlled by software which should provide a menu of functions and enable the gauge to self-test the electronic and mechanical parts when started. It must be possible to operate the gauge with one hand and the functions should be accessed via external buttons. Data should be shown on an integral display able to present each measurement, the number of measurements made in a series and the mean value. A store should hold at least 1000 measurements and it must be possible to transmit data to a computer. Test procedures for checking the measuring force and the distance measured should be provided. Some netting will creep under load. The gauge should respond to this condition by re-applying the set force, requiring a suitable algorithm in the controlling software, as described in Annex 6.

## *3. Measurement Procedure*

- a) Mesh Type

The mesh dimension to be measured depends on the mesh type:

**Diamond mesh:** The netting is stretched in the direction of the long axis of the mesh, the N-direction (Figure 1). If, in knotless netting, the N-direction cannot be determined, then the longest axis of the mesh should be measured.

**Square Mesh:** The netting is stretched first in the direction of one diagonal of the mesh then in the other diagonal direction. The largest measurement is considered to be the mesh opening.

**Meshes Turned by 90°:** the same procedure as for square mesh.

#### b) Preparation of the Gauge

The operator selects the appropriate size of jaw for the meshes to be measured.

If small or large jaws are selected they are then fitted.

The operator ensures that the jaws are clean.

The gauge is then started by the operator and performs a self-check.

If functioning correctly, the gauge will show on the display that it is ready for use. If not, it will display an error message, close down and cannot be used.

The operator enters the gauge menu.

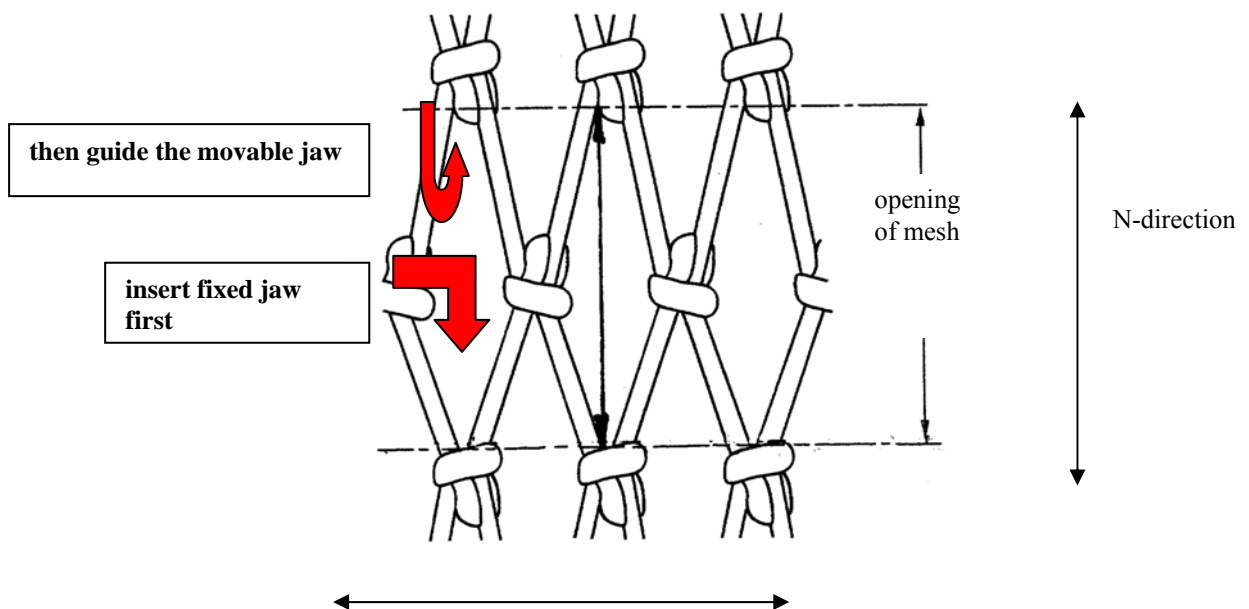
The operator selects the force to be applied. (The recommended forces are for set nets: 10 N for all mesh sizes; for codends: 20 N for mesh sizes < 35 mm; 50 N for mesh sizes  $\geq$  35 mm and < 55 mm; 125 N for mesh sizes  $\geq$  55 mm).

The operator enters the jaw type in the menu.

The gauge is then ready to make and record a sequence of mesh measurements.

#### c) Insertion and Operation of the Gauge

The operator holds the gauge in one hand and inserts the jaws into the mesh opening. The fixed jaw is located in the knot nearest to the operator, as shown in Figure 1:



**Figure 1: Insertion of the gauge.** T-direction

The gauge is activated and the jaws open until the movable jaw reaches the opposite knot and stops when the set force is reached. Care must be taken to ensure that the largest opening is measured with the jaws at the sides of the knots. The gauge should be held steady, until it has performed its measurement algorithm and obtained a final value of mesh size. A command is then given to accept or reject this measurement. The movable jaw is then retracted ready to make the next measurement.

On set nets, it may be more convenient to locate the movable jaw first in the knot furthest from the operator whilst stretching the twine gently by hand. This alternative procedure should be carried out with caution as excess force may be applied to the mesh and the twine must be released before the gauge applies the set force to the mesh.

d) Selection of Meshes

Selection of meshes to be measured must be in accordance with the appropriate regulation. (Annex 7 - Commission Regulation (EC) No 129/2003 Article 5 for active gear and Article 11 for passive gear.)

For scientific purposes 40 meshes in two or more parallel lines of up to 20 meshes are to be chosen for measurement.

e) Acceptance of Measurement

After making each mesh measurement, the operator must decide whether to accept or reject the measurement before saving it in the data store. Possible reasons for rejection are:

- the jaws did not locate in the longest opening position;
- the operator lost a firm grip on the gauge;
- the value is unrealistic.

If the measurement is deemed acceptable the operator then saves the reading. If a measurement is deemed unacceptable, but the operator accepts it in error, then the series of measurements must be cancelled and started again.

f) Determination of Mean Mesh Size

After measuring a series of meshes, the operator instructs the gauge to calculate the mean mesh opening. This is rounded to the nearest 0.1 mm and displayed. (For inspection purposes the measurement will subsequently be rounded to the millimetre above.) The operator then instructs the gauge to end the sequence. The saved data include all accepted measurements, date, time and a unique identifier. The gauge is then ready for another sequence of measurements.

For square meshes and meshes turned by 90°, the software shall contain a suitable function to select automatically the largest diagonal of each mesh to calculate the mean mesh size. The saved data however, must include all measurements made. This allows verification of the selection procedure.

#### 4. Calibration

Each gauge used for inspection purposes must be calibrated annually by an authorised organisation and a certificate obtained, for both applied force and length measurement. A calibration record must be maintained for each gauge.

Intermediate verification of length measurement is performed by inserting the jaws of the gauge into slots of different lengths in a calibrated rigid test plate. This can be done at any time.

Intermediate verification of force measurement is performed by hanging calibrated weights on the fixed jaw containing the load cell, with the gauge held vertical and secure. The weights can only be used under stable conditions.

#### *5. Training*

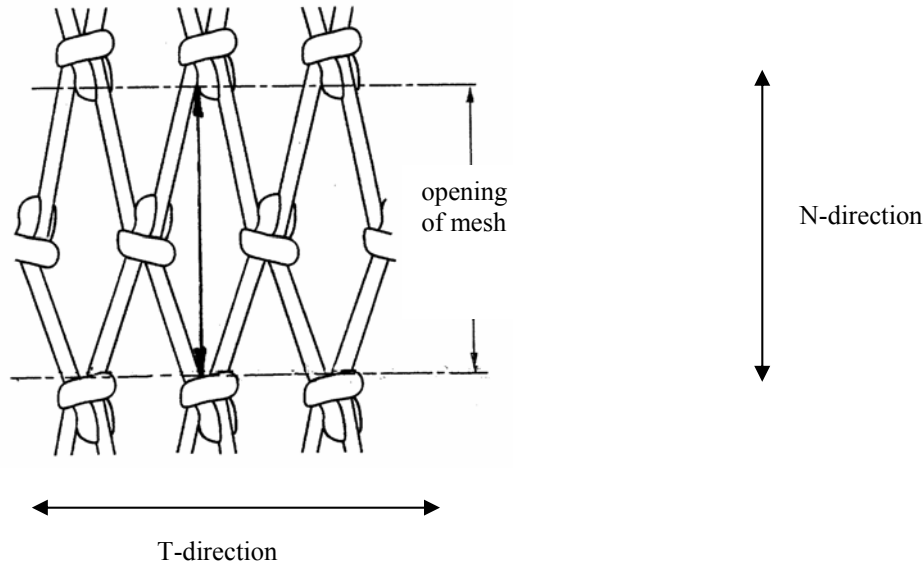
Operators should carry out several series of measurements to become familiar with the functions of the gauge before using it to make measurements for enforcement or scientific purposes. They should also practice the verification procedures.

It is strongly recommended that organisations using the gauge ensure that all operators receive adequate training in the use of the instrument.

## Technical and legal aspects of mesh measurement

### Annex 1: Mesh size

Fishery conservation regulations refer to the “mesh size” of a fishing net. This is defined as the “opening of mesh” in international standards (EN ISO 1107: 2003). For knotted netting, the size of a mesh is the longest distance between two opposite knots in the same mesh when fully extended in the N-direction<sup>1</sup> (Figure 2).



**Figure 2: Opening of mesh.**

For netting with square meshes or meshes turned by 90°, the netting is stretched first in the direction of one diagonal of the mesh (N-direction) then in the other diagonal direction (T-direction). The largest measurement is considered to be the mesh opening.

For knotless netting, the size of a mesh is the inside distance between two opposite joints in the same mesh when fully extended along its longest possible axis.

### Annex 2: Mesh measurement methods

On codends and attachments, mesh size opening is normally measured for control purposes with a wedge gauge. This is a 2 mm thick metal wedge with tapered edges. It is inserted vertically into the netting and manual force is applied to stretch the meshes horizontally. The mesh size is read off a graduated scale on the wedge, at the upper edge of the twine, regardless of twine thickness. The human factor can be significant when measuring with a wedge gauge and critical when the mesh size is close to the limit. If, during an inspection, the outcome is not acceptable to the fisherman, he may ask for re-measurement with a weight or dynamometer exerting 2 or 5 kgf, and the result is then conclusive.

<sup>1</sup> N-direction: the direction at right angles (Normal) to the general course of the netting yarn.

T-direction: the direction parallel to the general course of the netting yarn (Twinwise)

On set nets, mesh size opening is measured with a simple calliper gauge. The jaws of the gauge are inserted into a mesh and then pushed apart with light hand force until the mesh is firmly stretched. The mesh size is then read off a graduated scale on the gauge.

Scientists measure mesh opening when studying the size selectivity of fishing nets. They use the gauge developed for the International Council for the Exploration of the Sea (ICES); a device similar to a calliper gauge which applies a controlled spring force to the mesh. The recommended measuring force is 4 kgf. This gauge normally produces measurements smaller than those obtained with the wedge gauge.

Net makers measure mesh sizes during manufacture to produce sheet netting with mesh sizes as close as possible to customer requirements. They use the wedge gauge, the ICES gauge and also spring-loaded wedge gauges, such as the Utzon gauge. The international standard EN ISO 16663-1 specifies a method for the determination of the mesh opening using a flat wedge gauge.

Fishermen measure mesh sizes to ensure that their nets continue to conform to regulatory requirements after prolonged use at sea, as mesh shrinkage may occur due to wear or sand absorption. They normally use a wedge gauge.

### Annex 3: Stretching force

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Fishing nets are constructed from a variety of materials and twine types e.g., twisted or braided, woven in single, double or triple form. The mesh shape can be diamond or square. Thus the strength and stiffness of netting varies widely and different forces are needed to stretch the meshes fully for size measurement. In recent years, there has been a trend in the fishing industry to use codends constructed from much heavier and stiffer twine, e.g., double 6 mm braided twine. This requires a longitudinal force much greater than 5 kgf to stretch a mesh fully. Force requirements for mesh measurement were investigated during the EU OMEGA Project, using an objective mesh gauge on the types of netting used for active and passive fishing gears. Based on the extensive data collected during this work, the recommended forces are:

For set nets of all mesh sizes, 10 N;

For codends of mesh size <35 mm, 20 N; of mesh size  $\geq$  35 mm and < 55 mm, 40 N; of mesh size  $\geq$  55 mm, 125 N.

### Annex 4: The OMEGA project

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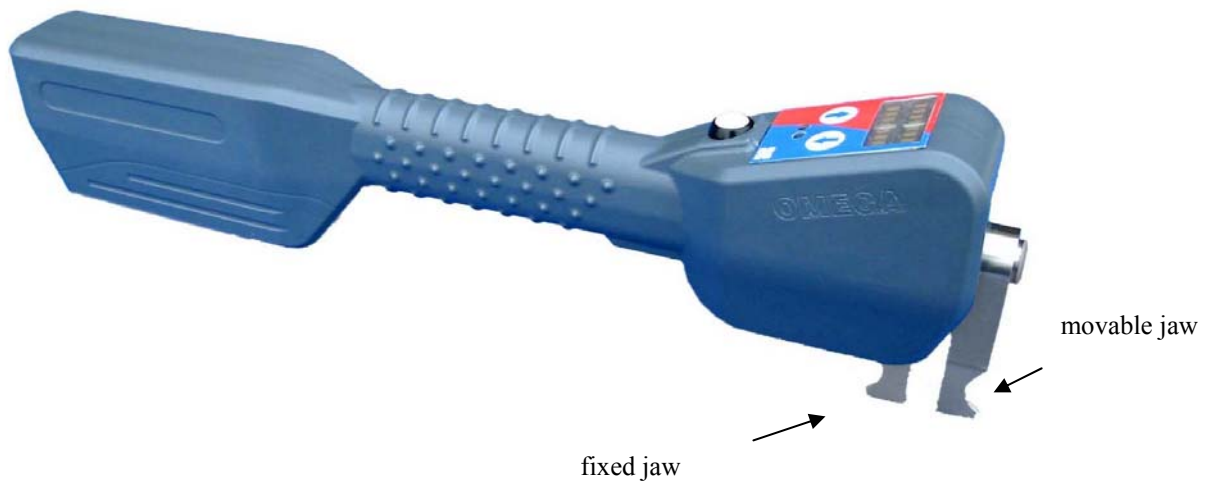
#### Development and testing of an Objective MESH GAUGE

The OMEGA project evolved from the perceived need for an objective mesh gauge for fisheries inspection, research and the fishing industry. Improving the methodology for mesh size measurement should contribute to better implementation of technical conservation measures and hence the effectiveness of fishery management.

An EU project evaluating mesh measurement methodologies (Fonteyne *et al.*, 1998) showed that the present EU regulation was not sufficiently precise and allowed variation in both the construction of the official wedge gauge and the operating procedure. It was recommended that a new, more objective mesh gauge be developed. The conceptual design of a new mesh gauge was produced during a further project (Fonteyne *et al.*, 2002). A proposal to build and

test an objective mesh gauge was then presented to the European Commission and was accepted for funding. The OMEGA project started in October 2002 and was completed in February 2005.

The design of the new gauge avoids the application of manual force by using a mechanism to apply a pre-selected force to stretch the mesh through extensible jaws. The mesh size measured is the calibrated extension distance of the jaws. The result is independent of manual force and of friction between gauge and twine. Force is applied with a precision of 1 N and mesh size is measured to an accuracy better than 0.5 mm. Figure 3 shows a prototype of the OMEGA gauge.



**Figure 3: OMEGA mesh gauge.**

The partners in the OMEGA project were fisheries research institutes, fisheries inspection agencies and a co-operative of two private companies. The latter were chosen from a group of interested European instrument makers following intensive consultation and a selection process (Fonteyne *et al.*, 2002). The coordinator of the project was the Ministry of Small Enterprises and Agriculture, Agricultural Research Centre – Sea Fisheries Department, Belgium.

The new instrument was tested and compared with existing mesh gauges in the laboratory, at sea, at harbours and in the netting industry. Future users were invited to evaluate the new gauge. As an integral part of the project, this protocol was written to guide operators in the design and use of such gauges.

## Annex 5: Legal issues

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A new regulation will be needed to permit the use of mechanised gauges for control purposes. The preparation of new regulations is the responsibility of the Commission.

There are several underlying principles and rights involved in the enforcement of regulations (Fonteyne *et al.*, 2002). It is essential that these are satisfied by the measurement protocol for the use of an objective mesh gauge to enforce regulations.

If an enforcing officer detects an infringement of a regulation and gathers evidence for a prosecution:

- a) A Fair Trial must be conducted subsequently, with procedures which are objective, honest, transparent and without unlawful practices to gather evidence;
- b) Equality of Arms requires that the enforcing officer and the fisherman can apply the same technique and equipment to obtain evidence, so the measurement method must be open and transparent and the equipment readily available;
- c) Equality of Inspection requires the same measurement method to be used by all inspectors to give the same outcome in the same circumstances;
- d) Approved Measuring Instruments must be used for obtaining evidence. They must either be accepted by experts as fit for the purpose or be type approved; be regularly calibrated and be operated by trained persons according to a defined protocol.

## Annex 6: Measurement algorithm

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To allow for creep in a stretched mesh:

- 1) Extend the jaw into the mesh at a constant speed of  $300 \pm 30$  mm/min, until the measurement force is reached
- 2) Stop the motor, and wait 1 second
- 3) If the force drops below 80% of the pre-set measurement force extend the jaw into the mesh until the measurement force is reached once more.

## Annex 7: Commission Regulation (EC) No 129/2003

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*Article 5: Selection of meshes - active gear*

- 1) Meshes to be measured shall form a series of 20 consecutive meshes chosen in the direction of the long axis of the mesh.
- 2) Except in square mesh panels, meshes less than 50 cm from lacings, ropes or codline shall not be measured. This distance shall be measured perpendicular to the lacings, ropes or codline with the net stretched in the direction of that measurement. Nor shall any mesh be measured which has been mended or broken or has attachments to the net fixed at that mesh.
- 3) By way of derogation from paragraph 1, the meshes to be measured need not be consecutive if the application of paragraph 2 prevents it.

*Article 11: Selection of meshes - passive gear*

- 1) The inspector shall select twenty meshes from the net. In the case of trammel nets, the meshes shall be selected from the part of the net having the smallest meshes.
- 2) The selection shall in no circumstances include the following meshes:

- a) meshes at the top and bottom of a net selvedge attached to a length of rope or a support frame, or other attachments;
- b) meshes within two meshes of lacings and ropes;
- c) meshes that have been broken or repaired.

## References

- EN ISO 1107: 2003. Fishing nets – Netting – Basic terms and definitions (ISO 1107:2003)
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