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

3–7 APRIL 2006

IZMIR, TURKEY

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

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Contents

1 Executive summary

Key findings

1. Size and species selection issues with pelagic trawls (Section 9)

- There are indications that considerable mesh escapement occurs in commercial pelagic trawls. Methodology to study escapement and escapee mortality in pelagic trawl is not adequate, and needs to be developed.
- If escapee mortality is identified as a problem, investigations should be carried out to reduce mesh escapement of target fish. If it is identified not to be a problem, investigations should be carried out to control size selectivity.
- Research of the behaviour of target and non-target species should be conducted to assist in the development of devices to reduce bycatch without corresponding losses of target species.
- Where bycatch of megafauna is identified as a problem, research should be continued to reduce this.
- There are indications of mesh selection in survey trawls; this should be quantified to reduce potential bias in estimates.

For the attention of **WGMHSA, HAWG, PGHERS**

2. WGFTFB Advice for assessment working groups and ACFM (Section 10)

WGFTFB has collated and reported on fleet information that may be relevant for fishery and fleet based advice. The information includes the following:

- *External factors*
  - High fuel costs are causing changes in fleet behaviour in several ways: gear, area and target species changes and other operational parameters
  - Effort management measures may be more difficult to control and effort data more difficult to interpret.
- *Enforcement changes*
  - In a number of fisheries the effectiveness of enforcement has improved considerably, particularly in pelagic and anglerfish fisheries.
  - VMS systems are now fitted to smaller vessels that may lead to changes in behaviour and reported effort distribution.
  - Assessment WGs should be aware that this may result in substantial reductions in illegal landings and should be accounted for in stock modelling and predictions.
- *Management measures*
  - The combined effect of high fuel costs, management measures and market conditions are causing substantial and rapid shifts between metiers.
  - EU effort regulation 26/2006 allows more effort for vessels using smaller mesh sizes than larger.
  - Vessels have reverted from using 100 mm+ to 10–99 mm to target mixed fish/*Nephrops* fishery, these shifts have been dramatic and rapid
  - There is no incentive for fishermen to increase mesh size in fisheries that have high discard rates and the catch composition regulations encourage increased discarding through high grading.
  - Large numbers of vessels have been removed through decommissioning. It is unclear what this may have on real effort as it is often older, less efficient vessels that are removed and in some cases replaced with fewer, more efficient vessels. The impact on capacity utilisation should be investigated.

- *Vessel power*
  - Vessel power is falsely under declared in many fleets to fulfil fleet capacity figures. With the shift to effort-based management discrepancy between "apparent" and "real" engine power has significant implications for the estimation of actual levels of fishing effort and fishing mortality.
  - There are indications from some countries that fishermen have now 're-aligned' there vessel power declarations in order to increase fishing entitlements under national programmes.
- *Technological creep*
  - Technological creep is evident in a number of fisheries, with vessels becoming more efficient and targeted in their approach
  - Technological creep, however, is still largely ignored in assessments as in reality it is hard to quantify and has probably little impact on overall official landing statistics.
  - There is increasing evidence of almost "negative" technological creep driven by increasing fuel prices as vessel owners strive to reduce their operating costs.
- *Ecosystem Effects*
  - In several countries there has been major fleet re-structuring and fleets have moved from being composed of a large number of relatively inefficient vessels to a smaller number of highly efficient boats. It has not been properly assessed whether these switches have positive or negative implications on the marine habitat.

For the attention of **AMAWGC, WGNSSK, WGNSDS, WGSSDS, WGHMM, WGBFAS, AFWG, WGMHSA, HAWG, WGNPBW, WGDEEP, WGECO, WGMME**

3. Alternative fishing gears (Section 11)

- No universal alternative gear or practice exists; suitable alternatives are likely to be specific to a fishery.
- Increased fuel costs are increasing the incentive to investigate and develop alternative gears.
- Currently, many alternative gears do not offer an economically viable solution. These gears require innovation or modification before wider application beyond current use. Inventive and imaginative concepts for responsible fishing methods should be actively encouraged, using study of fish behaviour, especially reaction to alternative stimulation.
- Tradition, management measures as well as market conditions and other socio-economic concerns, may affect the adoption of alternative gears by fishing fleets
- The development of alternative gears is likely to be a long-term effort and will need to be supplemented with immediate measures to target existing problems.

For the attention of **WGECO**

4. Multiple size selection devices in towed gears (Section 12)

- For a given *l50*, the combined selectivity of the cod-ends with the Bacoma panel had sharper selection (*lower sr*) for cod than the traditional diamond mesh cod-ends.
- There is no evidence of sharper size selection of cod for the combination of grid and diamond mesh codend in comparison to what is obtained for a diamond mesh codend only.
- There is no evidence of sharper size selection of haddock for the combination of square mesh panel and cod-end in comparison to what is obtained for a diamond mesh codend only.

- There are many other issues, which inform whether a device is appropriate for a fishery. These relate to the variability of selective performance, on-board handling, legislation and enforcement, rigging and material strength, damage to and survival of escaping fish and acceptability to fishermen.

5. The WGFTFB also addressed to other terms of reference relating to issues affecting Turkish Fisheries **(Section 14)** and the revision of the FAO Gear Classification system **(Section 13)**.

The Gear classification work is ongoing and the revised classification will be published as a joint FAO-ICES document in 2007.

2 Directive

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.

3 Introduction

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Venue: Izmir, Turkey
Date: 3–7 April 2006

3.1 Terms of Reference

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

Terms of Reference:

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 focused 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 WGFTFB meeting in 2006. The Co-Chairs will invite members to the group representing important FAO regions to assist in the revision process.

3.2 Participants

A full list of participants is given in Annex 1.

3.3 Explanatory note on meeting and report structure

During the 2003 WGFTFB meeting, the mini-symposium format previously used by the WG for the exchange of technological information was discussed. The WG noted that there were certain limitations to this approach. While providing information on individual pieces of ongoing or recent work, it did not readily facilitate a more in-depth analysis or review of the general themes. The format also made it difficult to provide more holistic recommendations for future actions.

In the run-up to the 2004 meeting an alternative approach to the way specific Terms of Reference (ToRs) were considered by the WG was proposed by the Chair. For the ToRs (Topics) selected at the 2003 meeting individual convenors were appointed to oversee and facilitate work by correspondence throughout the year. The Chair asked the convenor of each

ToR to prepare a working document, 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 conveners and members of the individual Topic Groups to meet, finalise their reports and findings, and produce a presentation to the WG and prepare a final report for inclusion in the FTFB report. 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 convener 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**.

4 WGFTFB advice during 2005–2006

4.1 *Ad hoc* Group dealing with request from the European Commission on electric beam trawls

Convenor: Norman Graham (IMR, Norway)

4.1.1 General overview and presentation of principal findings

This ToR was introduced by Norman Graham.

In November 2005, ICES received a request from the European Commission Directorate General for Fisheries and Maritime Affairs regarding the current regulation that bans the use of fishing techniques that use electrical stimulus for fish capture. In the Netherlands, a commercial company has developed a commercially viable electric fishing gear that can be used as alternative to tickler chains fitted to beam trawls targeting sole and plaice. It has been operational on an experimental basis for one year. There are several advantages. As the system needs to be towed slower in comparison to the existing gears, fuel consumption is reduced by ~40% and the area swept for a given time is reduced by ~22%.

The Chair of WGFTFB was asked to formulate a multi-disciplinary *ad hoc* Expert Group (Table 1) to consider the request. The Expert Group will report to ACFM by mid-May 2006.

Three members of the Expert Group continued to work on the draft report during the WGFTFB meeting. A draft version of the conclusions and recommendations were presented to the WGFTFB for comment.

4.1.2 Terms of Reference

i) What change in fishing mortality could be expected following the adoption of such gear in the commercial fishery, assuming unchanged effort measured in KW-days at sea?

ii) What effect would such a widespread introduction have in terms of (i) the mixture of species caught; (ii) the size of fish caught?

iii) What, if any, effects would such introduction have on non-target species in the marine ecosystems where this gear was deployed?

4.1.3 Current status

For evaluation and review of the state-of-the-art concerning the use of electrical stimulus for beam trawling, the Expert Group was given seven reports on research conducted by the national fisheries laboratory of The Netherlands (RIVO). The group has worked over the past few months and has reached some preliminary conclusions and a draft report has been produced outlining the group's analysis. The evaluation of the system has been hampered by lack of detailed information on the pulse characteristics used (pulse shape, height, frequency etc) all of which are known to affect fish in various ways. In freshwater systems, if inappropriate stimulus is used, it can cause a variety of injuries including internal bleeding, including snapping of the spine and punctured swim bladders (Snyder, 2003). There is some anecdotal evidence to suggest that the stimulus used in the proposed system is excessive and causes damage. At this stage, it appears that further work is needed on a range of species (particularly vertebrates) and length classes in order to determine whether this is indeed the case. During the WGFTFB meeting more detailed information about the electrical pulse was provided, but due to lack of appropriate expertise during the meeting, it was not possible to evaluate the pulse setting and possible negative impacts. This information has been forwarded to the appropriate members of the Expert Group for consideration.

Table 1: *Ad hoc* Expert group participants.

EXPERT GROUP PARTICIPANT	AFFILIATION	ROLE
Dr Norman Graham Institute of Marine Research Bergen Norway	Chair ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB)	Coordination of contributions and preparation of report
Dr Andrew Revill CEFAS, Lowestoft, England	WGFTFB	General contribution and evaluation of report
Prof. Ian Cowx University of Hull, Hull, England	Director Hull International Fisheries Institute	Leading expert on electric fishing
Dr Mike Breen FRS Marine Laboratory, Aberdeen, Scotland	Chair ICES Study Group on Unaccounted Fishing Mortality (SGUFM)	Evaluation of survival studies
Dr Leonie Robinson University of Liverpool, Liverpool, England	ICES Working Group on Ecosystem Effects of Fishing (WGECO)	Evaluation of benthic impact studies
Bob van Marlen RIVO Netherlands Fisheries Laboratory Ijmuiden, The Netherlands	WGFTFB	Provision of data, reports and technical specifications of the gear
Mr. Coby Needle FRS Marine Laboratory, Aberdeen, Scotland	Chair ICES Working Group on Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)	Estimate on the stock effects of electric beam trawls
Mr Olafur Ingolfsson Institute of Marine Research Bergen Norway	WGFTFB	Statistical analysis of catch comparison data
Dr. P.A.M. Stewart Aberdeen	Invited expert	Leading expert on electric fishing (marine environment)

4.1.4 Recommendations

The final recommendations and conclusions of the Expert Group will be contained in their report.

4.1.5 Discussion

A lengthy discussion evolved around the suggested recommendations and conclusions:

- The comment was made that FTFB did not have the expertise to assess the conclusions of the expert group, as it did not have the necessary expertise or access to the data supplied.
- It was noted that the guiding principles in giving advice are the Precautionary Approach in ecosystem and fisheries management; and the principles of Responsible Fisheries laid down in the FAO "Code of conduct for Responsible Fisheries" of 1995. The FAO code states that it is important to promote the development and implementation of more environmentally friendly, but economically viable, fishing gears, and fishing operations can only be maintained when ample profitability is achieved.
- Concerns were raised on the effects on elasmobranchs, and a report was given of a recent ban on electric fishing in China. It was emphasized that the use of heavy tickler chains in beam trawling was heavily criticized for its effects on benthic communities, and the new technology provides potential to reduce these effects.
- One of the main points was the perception that the recommendations would inhibit innovation. The request to evaluate the electric pulse to greater detail than already done was thought to be too difficult. It was, however, replied that a study of roughly 6 months should suffice to carry out the work. It was not the intention of the expert group to expand the injury study to all animal species present in the trawlpath but to present a reasonable mix of species over the different taxa present in the trawlpath in the study.
- The WGFTFB Chair remarked that the request of ACFM was a "fast track" type of request, directed towards an expert group and not to the WGFTFB. Presenting this to FTFB was more a gesture of courtesy. This implies that the conclusions and recommendations should not be changed to a great extent, also because not all members of the expert group are present and some expert group members are not a member of WGFTFB or a member of WGECO. A minority disagreed and thought that the WG should be involved and the comments taken into account. In the end, the recommendations were slightly reworded.
- The suggested recommendation states that the electro-trawl as presented should not be promoted to a wider fleet level than is the case now before more information is available. The request was made to change the text so that the electro-trawl trials could be extended to more vessels. The reason for this was to allow the fleet to convert to fuel saving fishing methods. The reply was made that the experiments requested should not take more than 6 months and therefore should not limit any swift introduction, if the stimulus is not harmful.

Bob van Marlen, as a member of the expert group, disagreed with the recommendation made to limit the use of electro-trawls to one vessel. He also asked for a list of topics to address in further work and a definition of the conditions under which a positive recommendation for introducing the technology in the beam trawl fleet might be made, to give clear guidance to the developers and avoid that requests for further study can be extended forever.

4.2 Issues raised by the FTC Chair

4.2.1 Discussion on scientific committees

One of the main problems considered in ICES is the communication between the different groups within ICES (expert groups, WGs, committees). The main question was whether the

structure of ICES is appropriate to the current role of ICES Scientific committees have not been transformed yet and the question was raised as to whether this was considered necessary and if so what should be changed in FTC?

4.2.1.1 Summary of the discussion

- One fundamental point is that many WG participants don't attend the committee meetings and in fact are unaware of the function of the committee. It was suggested that national delegates should be more active in communicating with WG members.
- There was a general feeling that the FTC and its WGs are functioning well, but there needs to be a continuous effort to improve the functioning of FTC and its WGs. The setup of the WGFTFB meetings as a tool for formulating advice and a forum for exchange of scientific information between members is considered to be a good formula.
- There was general agreement that FTC should think more strategically. Generally issues are considered usually over a one-year timeframe (under the system of ToR's). FTC should, though adopt a longer-term approach and, be proactive and generate new ideas. The FTC Chair replied that the business meeting should be used for this longer-term approach, which is not the case now. Last year the FTC meeting consisted of only a series of reports and the ToRs for the next year, but no strategic discussions.
- A problem was identified in accessing the FTC report. FTC also has an action plan but not many members are aware of its existence. The strategy is there, but not well communicated. This could be changed by posting the strategy on the FTFB website in the short term although a wider circulation is probably required.

4.2.2 WG meetings in non-ICES countries

- There is general consent that FTC should enhance contacts with non-ICES countries, exchange information and stimulate discussion between ICES and non-ICES nations, given that WGFTFB is an ICES-FAO joint working group.
- One of the main clients of ICES is the European Commission. This client and the FAO's General Fisheries Commission for the Mediterranean (GFCM) have a desire to set up a common fisheries policy for the Mediterranean. WGFTFB has expertise in fishing technology which could be of value to fishery managers in both EU and non-EU countries of the Mediterranean for the purposes of developing technical conservation measures related to fishing gear design and operation. WGFTFB is affiliated to FAO with a remit to cover all world fisheries. If ICES keeps acting within member countries, the client might not get the information needed because non-ICES Mediterranean countries are excluded.
- WGFTFB has received an invitation to host a future meeting in Bangkok (Thailand).

4.2.3 Organisation FTC – Joint WG Session:

- The FTC Chair suggested there was a need to formalise the joint session and to appoint an independent Chairperson as opposed to the current system where the joint session is Co-Chaired by the Chairs of WGFAST and WGFTFB.

5 Presentation of the Activities of Study group on Unaccounted Fishing Mortality's

5.1 Executive Summary

Fishing mortality is an important variable in fisheries science and is the key to the effective management of a fishery. However its estimation remains imprecise because, in addition to the reported catch, there are other unaccounted sources of fishing mortality. In an ecosystem–based approach to the management of fisheries, the lack of such information may lead to

erroneous conclusions and recommendations, which if uncorrected could threaten the sustainability of the affected stocks and undermine global food security. In addition to the direct impact upon the stocks, unaccounted fishing mortality also leads to lost economic opportunities for the fishers and may detrimentally impact the ecosystem as a whole. Having a clear view of the effect of unaccounted fish mortality on a fishery therefore remains a priority for fisheries managers.

A joint report was presented summarising the work of the ICES Study Group and Workshop on Unaccounted Fishing Mortality [SGUFM and WKUFM]. It provided an overview of the major sources of unaccounted fishing mortality and reviewed the level of understanding that the ICES Stock Assessment Working Groups currently have about these potential sources of bias to fishing mortality in the fisheries upon which they advise. Recommendations from WKUFM were presented and a work-plan for SGUFM proposed – to gather relevant information on UFM and assess the impact of this information upon the management of selected stocks.

Mike Breen (Marine Laboratory (UK)

6 SELDAT Database status and future needs

6.1 General overview

During the period 2005/2006 a number of WGFTFB members raised a number of questions (by e-mail) relating to the use and future of the selectivity database (SELDAT), which was developed in two EU-projects in the 1990s by institutes in several EU countries and Norway, coordinated by Bob van Marlen. The aim was to make a central database of selectivity data on towed fishing gears to be used in research and management advice. The database is currently hosted by CEFAS. It appears that the system is underutilised by the gear technology community despite a need for such a database being identified in earlier WGFTFB meetings. The Chair of WGFTFB was asked to allocate agenda time to allow for some discussion.

6.2 General Discussion

There are a number of key issues: in its current form, does the database work? Can we enter data or carry out analysis and can we maintain the database? The general feeling was that if the answer is no, it should be modified or abandoned. From the discussion, it was clear that the concept is still considered very useful for a number of reasons – single location of data, standardised format and that such selectivity data is needed for management purposes. For example, if SELDAT was populated, the *Nephrops* selectivity data recently requested for an ICES workshop on *Nephrops* stocks could have easily been extracted from the database.

From the discussion it became clear that there are some well defined problems:

- The level of complexity in the database is too high. This has been discussed in the projects but opinions seem to differ. Some members felt that simple data output is really all that is required, but it was argued at the time the database was being constructed that this simple set-up would reduce the functionality of the database. The project ultimately went for a moderately complex system designed to maximise the benefit of the results from selectivity research for all gear technologists and provide good quality data for management advice.
- Data entry into the database is currently too time consuming.
- There are still some errors in the database.
- Selectivity data without parameterised output cannot be entered into the database.

Due to these problems, consequently, very little data has been inputted and the database is not being used. It was pointed out that much work was put into the setting up of the database and

this should not be wasted. The question was raised as to whether the original objectives for setting up the database be revised and the structure simplified. The comment was made that a simple list of selectivity parameters would probably be sufficient for assessment WG's, which only really need to know the data, exists. Maybe a simple Excel table, along the lines circulated under ToR b), identifying available selectivity data by gear type/area and species would suffice. The FTFB website could be used to store this data.

In concluding it appears that the main issue remains, if no one is prepared to enter data and maintain the database, it will never work. Currently given the time constraints on most institutes it was considered high unlikely that data would be entered into SELDAT in its current complex format. The suggestion was made that *ad hoc* group should be set up to deal with the problem and come up with a workable alternative.

7 WGFTFB Website and mailing list status and future

7.1 General overview

The FTFB website and mailing list is generally seen as a useful tool and the website has been expanded with additional information. Up till now, the FTFB website and mailing list has followed the FTFB Chair. This is, according to the Chair, not a good approach, as the workload for the Chair and IT department of the institute involved in maintaining the website are too high.

There seems to be agreement that somebody should be nominated to handle the site but finding a permanent host for the website remains a problem. Firewall restrictions imposed on the intranet facilities in most institutes restrict that number of potential hosts. ICES and FAO were put forward as the most suitable alternatives although problems with both were identified.

The FTC Chair suggested that FTFB Chair produce a summary document of the content and the justification for the continued development of the website. This document should be presented to ICES. The comment was added that the website could also be used to edit documents and that ICES has the technology to implement this. Norman Graham and Wilfried Thiele will take the initiative to present a report to ICES and FAO and look for possible solutions.

8 WWF Smart Gear Competition

By March 2006, 83 entries from 23 countries were received. Of these, 43 passed the first selection. The main issue from the entries is "endangered species" susceptible to fishing activity (e.g. turtles, dolphins, albatrosses…). The previous winner was a design of deep setting of longlines to avoid turtle bycatch. The competition is open to everybody and the prize is $25.000. The 2006 judges will meet in Washington, USA 19–21 April to select the winners and runners up for the 2006 competition.

9 ToR a): Size and species selection issues with pelagic trawls

Conveners: Haraldur Einarsson (MRI, Iceland)

9.1 General overview and presentation of principal findings

This ToR was introduced by Haraldur Einarsson (MRI, Iceland) at the 2005 FTFB meeting in Rome. An overview of the topic was given at to the whole FTFB at the start of 2006 meeting.

9.1.1 Terms of Reference

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 out 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.

9.1.2 Abstract

Generally speaking, no part of a pelagic trawl should be in contact with the seabed during normal fishing situations, but the group recognised that in various situations parts of the trawl may be on the bottom. Pelagic trawls target species living off the seabed.

There are two main categories of species targeted with pelagic trawling. In some fisheries, size selection is not encouraged. In other fisheries there may be minimum landing size/ minimum catch size, and size selectivity is in interest of the industry and the management.

Considering the importance of the pelagic trawl for harvesting pelagic species, research on gear performance and selectivity is far from adequate. After the development of the large mesh trawls and associated increase in gear size in the late 1970s and early 1980s, there has been only limited development and research effort within the ICES community on pelagic trawling. Recent research includes the following four main areas:

1) Model testing

Gear manufactures have been developing trawl design in the last decades, but the ICES members have conducted little research on this topic. Scottish researchers have reported on geometric measurements and dynamics from flume tank testing of pelagic trawls (Ferro *et al*., 1996; Ward and Ferro, 1993).

2) Species and size selectivity

Size selection devices are introduced in some pelagic fisheries. In the Alaska pollock fishery, some vessels are using a modified "Swedish exit window" (developed for and used in the Baltic cod trawl fishery 1995 – 2002) to reduce bycatches of small pollock (P.O. Larsen, pers comm.). In the Icelandic redfish fishery, a 135 mm mesh size codend is used to improve species and size selectivity. In Norwegian mackerel pelagic trawl fisheries, a grid with 42 mm bar spacing was developed to reduce small mackerel, but was not introduced into regulation due to suspected high mortality of the escaping fish (Kvalsvik *et al*., 2002). Square mesh codend have been tested in the English Channel mackerel fishery, but this did not improve size selectivity of mackerel (Casey *et al*., 1992). A grid system has been tested for size selectivity in the Baltic herring fishery (Suuronen, 1993), although, this has also had limited uptake by industry and not implemented into regulation An EU funded project (SELMITRA) was carried out in the 1990s with the objective to improve species and size selection in midwater trawls through behaviour studies and gear modification. This study, however,

showed that separating pelagic species was difficult (van Marlen, 1995). In addition, some projects on the efficiency and selectivity of pelagic trawls have been carried out in the Black Sea (Zengin *et al*., 1998).

In the Norwegian herring fishery, a grid system for large pelagic trawls was developed to reduce catch of saithe and cod (Isaksen *et al*., 2005). The device is now being used by vessels of 40 m long and 2000 HP on a voluntary basis. However, large losses of herring have been observed with the use of the device when targeting dense schools of herring, and there is concern over the mortality rates of these escaping fish. More recently, similar grid systems have been tested in Faroe Islands and Iceland to reduce saithe and cod in the blue whiting fisheries (Zachariassen 2006; H. Einarsson, pers comm.). This grid system has been proven to reduce round fish catch significantly; however, technical improvements for easier handling of the grid are still needed for industry acceptance.

3) Mortality of escaping fish

Little work in this area has been done some experiments in pelagic trawl fisheries in the Baltic Sea for herring and vendace (Suuronen *et al*., 1995; Suuronen *et al*., 1996 a; b) have been conducted. These experiments were made with small trawls and may not be comparable with large-scale fisheries, although they do provide a potential methodology for the conducting of future experiments in large-scale offshore fisheries.

4) Bycatch of Megafauna by pelagic trawls

Megafauna refers to marine mammals, turtles, large sharks, seals and other protected species. Bycatch and associated mortality of megafauna is currently considered as a problem in several pelagic fisheries (Morizur *et al*., 1999; Zeeberg 2006; Zellott and Rosenberg, 2006). An EU funded study called NECESSITY, is currently developing and testing several types of net barriers, excluder devices and Acoustic deterrent devices, specifically to reduce bycatch in pelagic trawl fisheries.

Pelagic survey trawls

Pelagic survey trawls are in most cases used to verify acoustically recorded fish. Except for catch comparisons between different pelagic survey trawls (Bethke *et al*., 1999), no experiments have been reported to estimate the catching efficiency for different species and sizes of fish.

Based on the above findings, the following issues regarding pelagic trawl fisheries have been identified:

- Bycatch of nontarget species of the same size.
- Loss of target species in dense concentrations when using sorting grids.
- Limited knowledge of the mortality of escaping target species.
- Potential bycatch of megafauna in some fisheries.
- Limited knowledge of the catching efficiency of pelagic survey trawls.
- A protocol for survival of escapees from pelagic trawls is needed.

9.1.3 Participants

Gabriele Buglioni	CNR-ISMAR	Italy
Haraldur Einarsson Chair	IMR	Iceland
Arill Engås	IMR	Norway
Pingguo He	Univ. of New Hampshire	USA
Irene Huse	IMR	Norway
Mustafa Zengin	Central Fish. Res. Inst. Trabzon	Turkey

9.1.4 Recommendations

i) Methodology to study escapement and escapee mortality in pelagic trawl is not adequate, and needs to be developed.

There are limited observations of meshing in trawl panels in several pelagic fisheries; however, there are no estimates of the actual amount of fish escaping. Whenever escapement is encouraged (size selectivity) or unwanted, the mechanism behind escapement in different fisheries needs to be investigated. Previous studies on pelagic fisheries have shown high mortality of escaping pelagic fish. The initial estimates of escapee mortality of demersal species are also high but have later been reduced due to improved protocols for estimating mortality.

ii) If escapee mortality is identified as a problem, investigations should be carried out to reduce mesh escapement of target fish.

Both from the management point of view and from the industry perspective, meshing (and the resulting increased drag) of target fish is a problem. Escapement of target species is in most cases not desirable in pelagic trawling.

iii) If escapee mortality is identified not to be a problem, investigations should be carried out to control size selectivity.

From the management point of view, selectivity of target species can be used as a mechanism to control fishing mortality.

iv) Survival experiments should be conducted on the species targeted in pelagic trawl fisheries.

Currently there are only a few estimates of escape mortality of pelagic species.

v) Research of the behaviour of target and non-target species should be conducted to assist in the development of devices to reduce bycatch without corresponding losses of target species.

Bycatch of nontarget species of similar size has been identified as an issue in several fisheries, and there are currently no proven methods to resolve this problem.

vi) Where bycatch of megafauna is identified as a problem, research should be continued to reduce this.

The work that is started in this area is encouraged, and should be extended to other areas and fisheries. The behaviour of the species during entrance and once inside the net is required.

vii) Reduce species and size selection and estimate the level in pelagic survey trawls.

There are indications of mesh selection in survey trawls.

9.1.5 Discussion

Avoiding bycatch of marine mammals is complex and difficult and worthwhile investigating and a topic that should be continued to be monitored by FTFB.

The comment was also made that as most pelagic trawls have small meshes codends to avoid the meshes filling up with gilled fish, using larger mesh is not necessarily to b encouraged given that it could be wasteful and dangerous in extreme cases. Cleaning gilled pelagic fish from trawls is also problematic and time consuming. There are also questions about the survival of escaping fish through meshes regardless of mesh size, and so larger meshes may not necessarily be desirable from a stock perspective if large meshes lead to high mortalities.

9.2 Individual presentations

9.2.1 Recent research into pelagic trawling in Iceland

Haraldur Einarsson (MRI, Iceland)

Abstract

Fishing with large mesh size (1 – 60m) pelagic trawls in Icelandic waters started in 1989 with the deep-sea red fish fishery in the Irminger Sea. During the last years, these large trawls have been more extensively used in the capelin and herring fishery, substituting the use of conventional purse seines. In addition this gear type is now used in the blue whiting fishery, which started in Iceland 1996 after a closure of several years. The use of large-mesh trawls has raised questions amongst fishermen, scientists and management people in Iceland, regarding, in particular, possible unaccounted mortality due to extensive escapement of fish through the larger mesh panels. It is also felt that pelagic trawling may disturb the migration patterns of mature capelin.

A research program for addressing these issues was initiated in 2005. Initially sample bags covering certain net panels in areas of the trawls, where escapement was suspected as being highest where used in order to collect escaping fish. In addition measurements of the vertical profile of the trawls where made with DST -fish tags.

Later in 2005 the Marine Research Institute began using a new remotely operated towed vehicle, and direct observations of the pelagic trawls where carried out from December 2005 to the beginning of March this year. Due to exceptionally small spawning capelin stock migrating this year, considerable effort was spent in searching and stock size assessment activity, and therefore observations were less intensive than previously planned. Despite these conditions, a total of 16 observation hauls where made during the period, revealing important factors concerning escapement, mesh size/enmeshing, and capelin behaviour during the catching process. As a result some gear modifications particularly with respect to the mesh sizes in the belly of the trawl are being considered.

As a separate task, observations where made on two types of selection grids used in the blue whiting fishery, revealing some major faults in the designs tested.

Discussion

The question was raised whether it is difficult to calibrate the tags? It's very easily done by lowering the tags to the same depth. The tags are then tuned using a constant derived from the sum of square method.

The gilling problem is similar for capelin and blue whiting. For herring it is different, because they all hit the trawl netting in more or less the same position. The new gear design has, however, not been tried yet, so it is not known if it solves the gilling problem

9.2.2 Bycatch reduction in the Norwegian herring fishery

Arill Engas (IMR, Norway)

Abstract

In 2000 high by catch of saithe and cod was encountered during the trawl fishery for herring in the fjords of Northern Norway. This happened at the same time, as there was no saithe quota left for the small coastal vessels up to 21 m length.

The Directorate of Fisheries immediately closed some areas, and asked the Institute of Marine Research to look into the possibility of developing a selectivity device that could solve the

bycatch problem. Both the fishermen as well as the Fishermen's organization were very eager to support this work. The herring trawlers were initially not allowed to fish cod and saithe, and due to the prohibition of discarding in Norway, the bycatch meant that they did not get access to the herring fishery.

On request from the fishermen, the first device tested was a sorting panel, very similar to that developed for shrimp trawl in Norway in the late 1970s (HH-Panel, Ludvig Karlsen, 1978). This device gave poor results, and the same result was obtained for a device similar to the Nordmore grid (Isaksen *et al.,* 1992) Video observations revealed that herring were actively swan to the fish release opening resulting in huge losses of target fish.

The next and last device that has been worked on is a grid system with a fish release opening in the bottom panel of a four-seam extension piece. The fish release opening is placed aft of the grid and is impossible for a fish swimming in front of the grid to detect (Figure 1).

This device has been tested and modified on a yearly basis during the autumn herring trawl fishery from 2001 up to 2005, giving mixed results.

The device started out with two grids and an angle of attack of the grids of 35 degree. Due to low sorting capacity, one more grid was included, at the same time as the grids were given a 45 degrees angle of attack. Later on a guiding panel in front of the grids was removed, given better water flow through the grid system.

The device is now regarded as acceptable and has proved to have a good effectiveness when trawling in herring layers with catch rates of 200 tons per hour. The device has been used for 2–3 years on a voluntary basis. Final technical description of the system is now being written up, and hopefully this device will be allowed on a permanent basis during the autumn trawl fishery for herring by the smaller and medium sized pelagic trawlers.

From 2003 there has been a close contact and discussion on this device between the Faroese, the Icelandic and the Norwegian marine research institutes in order to improve the system as a whole. The three institutes have concentrated on different materials for the grid, mostly due to the need for capacity and handling characteristics.

In 2006 the selectivity work in Norway was shifted towards bigger pelagic trawlers (5000+Bhp). The steel grids were divided into 6 shorter grids, which turned out to be less curved than the longer ones, when taken onto trawl drums. Trawling on migrating herring spawning shoals gave catch rates up to 430 tons, with herring entering the trawl for ten minutes (as detected by Simrad FS-sonar).

This catch rate resulted, not surprisingly, in a high loss of target fish. A grid device is therefore not regarded as a convenient selectivity device when fishing on dense shoals, in its present form. During the years with selectivity work on pelagic trawls, numerous hours with video observations has indicated that there is a major difference in distribution of target and by catches species when fishing on dense or thin marks of pelagic fish.

In thin layers, the by catch species (which predate on the herring) will be distributed along with its preys, and a selectivity device has to be working the whole time. In shoals, very, very few by catch species will be found inside the shoals, but they will be found between the shoals. This consideration should be taken into account when and if the work on selectivity device for pelagic trawls continues.

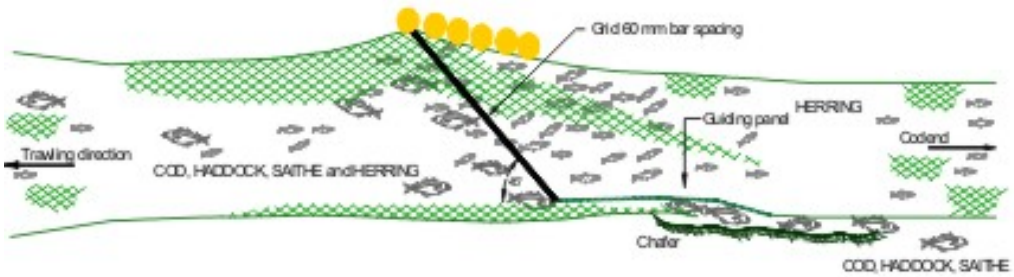

Figure 1: Illustration of the grid device used for reducing by catch of saithe, cod and redfish in the pelagic trawl fishery for herring.

Discussion

The author was asked whether other means to estimate the escaping herring have been used. This was the case, with collection bags.

If fishing on layers gives a better species selectivity, why should commercial fishing not always be carried out on layers? Fishing on dense shoals results in better fish quality and needs far less time, and thus costs, to attain the same catch rates.

Did you consider building an escape box in the grid to estimate the survival of the herring? No, no survival experiments were carried out but it is clear from the high amount of scales observed on the video that many fish will be injured and die. The methodology of survival experiments is complicated and determining the survival rate is still difficult.

The comment was made that the greatest concern in terms of survival is haddock. Herring escaping will probably have large mortality, due to scale loss. Cod survival is probably not a problem, based on our experience but maybe worthwhile investigating.

It was concluded that pelagic fishing is apparently not such a "clean" fishing method.

9.2.3 Bycatch reduction in the Faroese pelagic trawl fishery for blue whiting

Bjarti Thomson (FRS, Faroes)

Abstract

The fishery for blue-whiting (*Micromesisus poutassou*) is one of the most important pelagic fisheries in the North East Atlantic. In Faroese and Icelandic waters this fishery is sometimes hampered by bycatch of cod (*Gadus morhua*) and saithe (*Pollachius virens*).

In cooperation between the Faroese fishing industry and the Faroese Fishery Ministry a project was carried out with the aim to reduce this bycatch problem. In 2004 and 2005 a range of rigid and flexible sorting grids have been tested in commercial pelagic trawls to reduce bycatch.

Underwater video techniques have been used to observe the function of the different grids. Rigid steel grids had good selecting properties, but could not withstand the huge forces in play in large pelagic trawls. Rigid plastic grids seemed to have less selective efficiency presumably because of reduced water flow through the grid. The best overall results have been obtained using flexible grids made of plastic tubes on ropes. Bycatch has been reduced by 95% without losing more than 1% of the targeted fish. The use of such grids will allow vessels to operate in areas that otherwise would have been closed due to bycatch problems.

Discussion

The author was asked whether the flexigrid is made of the same material as in salmon farms (Shetland). This is indeed the case. The material is thin plastic tubes with a diameter of 1 cm and with rope through it to hold it together. There is no frame to keep it open – the forces in the netting suffice.

It is remarkable that the flexigrid systems still functions well with very high catch rates. The sorting for the steel and flexigrid is the comparable, but handling on deck is better with the flexigrid.

9.2.4 Marine Mammal bycatch reduction – EU Necessity project

Dominic Rihan (BIM, Ireland)

Abstract

The main objective of a 3-year EU funded study entitled NECESSITY, is to develop effective and acceptable gear modifications (bycatch reduction devices or acoustic deterrents) to reduce the bycatch and mortality of cetaceans in pelagic trawl fisheries. A considerable amount of work has been completed to date on the cetacean part of the project. Evaluation and selection of appropriate gear modifications for testing at sea has been completed, following a workshop held in the Flume Tank in Boulogne-sur-mer, and a number of designs have already undergone preliminary experimentation. The results have been largely inconclusive, although t of rigid grids and vertical net barriers seem technically feasible solutions with respect to net geometry and minimal loss of target species. Despite considerable efforts, little underwater footage of cetacean behaviour in and around pelagic trawls has been recorded. Of the limited observations that have been made, it would seem that cetaceans do not show uniform behaviour within pelagic trawls. Further trials will be carried out during the first half of 2006 with rigid grids and net barriers, although it has been agreed by the partners to concentrate efforts in fisheries where bycatch rate is reportedly highest i.e. the bass fishery.

An interactive acoustic deterrent device has been developed and tested on captive animals in a dolphinarium in Sweden and also on bottlenose dolphins in the Shannon Estuary, with positive results. Further sea trials in early 2006 with common dolphins on the south coast of Ireland gave less encouraging results and have shown differences in behaviour between different cetacean species. In addition to the interactive device, IFREMER in France have looked at adapting gear monitoring equipment commonly used on pelagic trawls to emit deterrent noises. This device was initially tested in 2005 and gave encouraging results with a very significant deterring effect observed with common dolphins at a distance of more than 500m. Further testing of this device is planned for 2006. A limited amount of behavioural work on the reaction of cetaceans to acoustic deterrent devices and the different excluder devices has been completed, but given that the frequency of interactions of cetaceans with trawls appears sporadic, this has proved very difficult. Several of the partners have resorted to carrying out experiments in more controlled environments, where the presence of cetaceans is well known and the frequency of encounter is high. This project is due to be completed in March 2007.

10 ToR b): WGFTFB Advice for assessment working groups and ACFM

Conveners: Dave Reid (Marine Laboratory, UK), Dominic Rihan (BIM, Ireland), and Norman Graham (IMR, Norway)

10.1 General overview and presentation of principal findings

ToR b) On Provision of WGFTFB expertise to assessment working groups and ecosystem based advice

10.1.1 Terms of Reference

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 creep and changes in fishing practices, implementation of regulations and other fleet adaptations, ecosystem effects of fishing and potential mitigation measures. This advice will be focused on the North Sea and address the assessment WG tasks as identified in the report of AMAWGC.

10.1.2 Abstract

This ToR was introduced by Dominic Rihan (BIM, Ireland). The Chair of WGFTFB, Norman Graham had attended the WGNSSK meeting in September 2005, at which he presented information on of technical issues relating to fishing and survey trawl technology that may impact on fishing mortality and more general ecological impacts. On this basis it was decided to broaden the ToR for the WGFTFB meeting of 2006 to include all areas for which ICES provide stock advice.

10.1.3 General Issues

The convenors issued a circular questionnaire to the appropriate WGFTFB members in EU as well as Norway, Iceland and the Faroe Island during February 2006. This questionnaire was split in two parts. Part 1 contained a series of questions relating to recent changes within the fleets observed and also highlighting gear/fleet/fishery related issues that are important but are not currently recognised by Assessment WG's. Specifically FTFB members were asked to comment under the following:

- Fleet Dynamics
- Technology Creep
- Technical Conservation Measures
- Ecosystem Effects
- Development of New Fisheries
- Any other comments or remarks

The second part related to selectivity data. A series of Excel tables, created, designed to provide information as to whether selectivity data was available for the key stocks and fisheries in different regions, based loosely on the Regional Advisory Council Areas. This table was not designed to be a definitive review of available data but merely to identify gaps in knowledge and also provide an indication of the species composition in different fisheries.

Responses to the questionnaire were received from:

IMR, Norway	RIVO, Netherlands
IMR, Sweden	DIFRES, Denmark
FRS, Scotland	IFREMER, France
BIM, Ireland	SFIA, UK
RvZ, Belgium	ISMAR, Italy

The Group then met in Izmir from 4–6 April during the WGFTFB meeting to discuss the findings from the individual questionnaires and review the selectivity data. A number of general issues were identified that were common to most countries, as follows:

10.1.3.1 Direct implications for management

External factors – Fuel costs

The main impact on fleet dynamics in 2005 is the substantial increase in fuel costs. The broad picture emerging from all countries is that fuel prices are causing vessels to change behaviour in many ways; by gear, by area, by species and by operational parameters such as steaming speed. The main impacts on assessment and management are felt to be that effort management measures may become more difficult to control and assess, while the distribution of fishing effort will be hard to interpret. Specific examples of such changes in fleet dynamics include the following:

- Switch from multiple (mostly twin) rigs to single rigs e.g. in Scottish mixed whitefish and mixed whitefish/*Nephrops* fisheries in IVa & Irish anglerfish fisheries in area VII.
- Some Irish twin-rig vessels targeting anglerfish are now using nets with 200mm top and bottom wings and belly sheets with 160 mm codends. These are low drag and do not reduce monkfish catch.
- Norwegian offshore demersal fish trawling fleet are targeting aggregated fish to increase CPUE and are either switching to the shrimp fishery or even remaining in port to maintain viability.
- General reports of boats operating on grounds closer to homeports, and steaming to and from fishing grounds at reduced speeds to conserve fuel e.g. Scottish and Irish pelagic vessels. Implications for days at sea measures and distribution of fishing effort in such shifts in operating practices need to be considered.

Enforcement changes

There have been a number of measures taken in 2005 to increase the effectiveness of control and enforcement measures. The lack of enforcement has regularly been cited at ACFM as a causative factor in poor data quality and stock decline. However, when enforcement is more stringent, it can change many aspects of fleet dynamics. Assessment WG's should be alert to the likelihood that there may be substantial reductions in illegal landings over a very short time period, and that this needs to be accounted for in stock modelling and prediction. Specific examples cited include the following:

- Enforcement and revenue authorities, investigating systematic mis-reporting of landings of fish, particularly mackerel, have recently targeted Scottish and Irish pelagic fleets. In both countries this has led to shorter fishing season at the end of 2005, and beginning of 2006. It will almost certainly likely result in much lower catches in 2006, and logbook data are likely to be a much better reflection of actual landings than previously. In the longer term, illegal landings maybe expected to be much reduced, thus improving data quality. There are, however, reports that fishers may well discard more (grading or slippage) to maximise profits from landed catches, while some vessels may leave the industry. Timing

and effort distribution are likely to change in response to increased control and enforcement.

- Greater enforcement of anglerfish catches in Ireland has again led to landings that more accurately reflect catches but it will also lead to effort being moved to other fisheries, e.g. mixed whitefish or *Nephrops* to remain legal.
- Extension of VMS to smaller vessels as well as greater use of VMS by European agencies is expected to lead to changes in vessel behaviour and effort distribution.

Skills shortages

Although not a major factor in assessment or management so far, there are general reports of skills shortages in many N. European fleets driven mainly by high fuel costs. This is leading to the use of smaller crews, loss of skilled personnel to other industries e.g. oil and gas due to reduced income and an increase in the use of unskilled personnel. In the longer term this may impact on the ability of fleet sectors to change capture method.

Changes in fishing metier

A combination of factors (fuel costs, management measures as well as market issues) is leading vessels to make significant changes in fishing method and target fisheries. The overall impression is that many vessels and/or fleet components are willing to make substantial changes in fishing methods, target species and area in response to a variety of drivers. Net manufacturers and in some cases fishermen's organisations are promoting new gear designs or fisheries to fleets experiencing difficulties. However, the important point is that many vessels can and do switch very fast from one fishery to another. Again this has major implications for effort control and fleet/fishery based management. Examples are provided in the detailed comments for particular Assessment WG but specific cases include the following:

- Irish dual RSW/demersal trawlers switching to trawling for *Nephrops* SW of Ireland in 2005 after the mackerel fishery finished in early March.
- Irish demersal vessels are expected to switch to pair trawl for hake using Spanish style VHO trawls.
- Scottish demersal boats (large and small) are switching to the squid fishery in the Moray Firth using high headline trawls with 40mm.
- French anchovy trawlers in Biscay have switched to the tuna and sea bass fisheries following the closure of the anchovy fishery in Area VIII.
- Belgian beam trawlers are investigating switching to other fishing methods including gillnetting, twin-rig trawling and even handlining for bass to improve fuel efficiency
- Shift from both longline and gill net fisheries to seine nets in North Western and Northern Norway, particularly of vessels in the 16–27 m category due to increased bait prices and better flexibility with seine net gear.

10.1.3.2 Indirect implications for management

Decommissioning

National institutes report a broad perception that large numbers of vessels have been removed from the fleets either through official decommissioning schemes, e.g. UK, Denmark and Ireland, voluntary withdrawals from the fishery or the merging of quotas, from numbers of vessels to a single one. What is less clear is whether this has had any major impact on *real* effort. In many decommissioning schemes, inefficient, old, small vessels are removed, but often smaller numbers of new, more efficient and often more adaptable vessels enter national fleets. In many fleets owner/operators will merge their allocations and replace two or more vessels with one newer one. In both cases this can be seen as a reduction in effort i.e. in terms of hours or days fishing, but in terms of capacity utilisation the reduction is much less clear.

Even unilateral withdrawals from the fishery do not provide a clear picture, as these are often the least effective fishers, i.e. those with lowest CPUE.

Technical Conservation Measures

FTFB members were asked to report on any new technical conservation measures introduced in 2005 and these responses are provided in the detailed Assessment WG sections. However, the list should not be regarded as definitive, or exhaustive. For most of the fisheries the competent authority is the European Commission. It is proposed that DGFISH be asked to produce a definitive list of any new measures introduced at December Council. This list could be circulated to FTFB members for feedback on likelihood of observation, adoption and impacts on the fleets. This feedback could then be collated and provided to the assessment WG. The feedback from FTFB members should also include any national TCM legislation that is different from that of the EU Commission.

Management Rules

As has been pointed out regularly the current provision of the EU effort regulations (Annex IV of Regulation 56/2006) allows more effort for vessels using towed gears of smaller mesh sizes than larger mesh sizes, on the basis that trawlers/seiners using 100 mm mesh generally catch more cod in the North Sea and to a lesser extent in the Irish Sea and West of Scotland. This is counter-productive in that it has resulted in many vessels reverting from using 100 mm + to 70–99 mm mesh sizes, targeting *Nephrops* or a mixture of *Nephrops* and mixed demersal species including squid. Effort displacement in some fleets in this regard has been quite dramatic; with large offshore trawlers switching to twin rigging for *Nephrops* in inshore waters e.g. Scotland. There is absolutely no incentive now for *Nephrops/*mixed demersal fishermen to increase mesh size in fisheries that are regarded as having high discards and the need for fishermen now to stay within catch composition regulations to allow them to use 70–99 mm mesh size and thus fish 227 days, leads to high grading and discarding of haddock and cod. In the amended regulations for 2006, the Commission has also tried to introduce an incentive for fishermen to use selective gears through increased effort allocation. However, the Swedish grid is identified in the regulation as currently the only acceptable device. This is based on limited data and while they state that other selective devices could be used, they must have equivalent selectivity parameters to the Swedish grid, but no such data exists. Due also to issues relating to the handling of this grid and high losses of marketable *Nephrops*, there has been no take-up of this grid in *Nephrops* fisheries in the UK or Ireland. Similarly in Belgium, with the increased cost of fuel and pressure to use gears that have less bottom impact, beam trawlers are looking at alternative gears, particularly gillnets. The current regulations, however, provide little incentive to switch to such gears, as the current effort levels contained in the regulation are the same for both gears.

Horsepower

In many European countries there is well-documented evidence that vessel owners have falsely under declared engine power to meet EU and national legislation fleet capacity figures. With the move to an effort based approach to fisheries management in the EU, using kW days as the main measure of fishing effort, this discrepancy between “apparent” and “real” engine power has significant implications for the estimation of actual levels of fishing effort and fishing mortality. There is evidence of this in the pelagic fleets e.g. Scotland, Ireland and the Netherlands where the discrepancy is reportedly extremely large. Whether all of this mis-reported power directly equates to increase fishing efficiency has never been assessed. There is also evidence in some countries, e.g. Belgium that fishermen have now re-aligned their engine horsepower to increase their fishing entitlements, allocated under national management measures.

Technological Creep

The effects of technological creep are still evident in many fisheries, with vessels becoming more efficient and targeted in their approach e.g. the use of three-dimensional plotting systems such as Olex, allowing trawlers to work in previously uncharted grounds. Similarly in Norway there has been an increasing trend in the past few years to use thicker rope in the seine net fisheries typically from 32mm to 42mm; it is believed that this 'thicker' rope has better fishing power. It has also opened up more areas to exploitation. More vessels are now using the triplex system as opposed to the power block for hauling the seine net, this system is easier to operate and allows for continued fishing in periods of bad weather. Adoption of T90 cod ends in Baltic & Irish pelagic nets to increase water flow, which also increases CPUE and reduces meshing. Technological creep, however, is still largely ignored in assessments as in reality it is hard to quantify and has probably little impact on overall official landing statistics. Recently there is also increasing evidence of almost "negative" technological creep driven by increasing fuel prices as vessel owners strive to reduce their operating costs e.g. switching from twin-rig trawling to single rig trawling in monkfish fisheries in Ireland or vessels in Scotland reverting back to pair trawling or seining instead of twin-rigging.

10.1.3.3 Ecosystem Effects

Bottom Impact

In several countries there has been major fleet re-structuring e.g. Ireland and Belgium, and under such programmes, which are usually government driven, fleets have moved from being composed of a large number of relatively inefficient vessels to a smaller number of highly efficient boats. It has not been properly assessed whether these switches have positive or negative implications on the marine habitat. In Belgium, vessel owners have been encouraged to replace smaller beam trawlers with one large vessel but it is debatable whether the fishing operations of these larger vessels, using heavier gear but over a narrower area, has a greater or lesser effect on benthic habitats than a larger number of smaller boats fishing over a wider area.

Marine Mammal and Seabird Bycatch

The bycatch of cetaceans, pinnepeds and sea turtles in fishing operations, is an issue of growing concern globally to organisations such as the European Commission and FAO, under pressure from NGO's and the general public. There are a number of fisheries where marine mammal and seabird bycatches are documented but in most cases the extent is not well defined and given the lack of accurate data, the impact of bycatches on population sizes cannot be properly assessed. There are also currently very few effective mitigation measures to reduce bycatch, with technical and practicality issues reported for several such measures included in legislation i.e. the mandatory use of acoustic deterrent devices ("pingers") in gillnet fisheries. Simpler solutions such as sinking the headline of pelagic trawls or setting surface longlines at deeper depths in some cases have been reported to reduce bycatch e.g. the Albacore tuna pair pelagic fishery. In some cases it is also reported that predation by marine mammals, particularly seals and seabirds in small scale fisheries may have an impact on fish stocks, which is usually not taken into account in the assessments. In several cases this problem has escalated to quite alarming levels e.g. Irish pelagic vessels report an increasing seal predation in mackerel fisheries off the west coast of Ireland.

Development of New Fisheries

There are very few examples of new fisheries being developed given that most species are exploited to some degree, but there are documented cases of fleet displacement into fisheries for species not traditionally exploited by vessels of particular countries. For example, there has been a large expansion in the Moray Firth squid fishery in Scotland by small < 10m vessels, as

well as larger whitefish vessels. In this case, given that these vessels use small codend mesh size (40 mm); this will result in high bycatch and discarding of haddock, cod and whiting.

10.2 Information for Individual Assessment Working Groups

Specific information relating to different areas and fisheries by Assessment Working Group are shown below, detailed by the relevant Assessment Working Group. Information is provided for the following WG's (see Annex 3):

- AMAWGC
- WGNSSK
- WGNSDS
- WGSSDS
- WGHMM
- WGBFAS
- AFWG
- WGMHSA
- HAWG
- WGNPBW
- WGDEEP
- WGECO
- WGMME

10.3 Selectivity Data

The second part of the questionnaire circulated related to selectivity data and through a series of excel tables was designed to provide information as to whether selectivity data was available for the key stocks and fisheries in different regions, based loosely on the Regional Advisory Council Areas. This table was not designed to be a definitive review of available data but merely to identify gaps in knowledge and also provide an indication of the species composition in different fisheries. It is intended that the collated information will be placed on the WGFTFB website and updated on a regular basis. It was also felt that the information should be cross-referenced with the SELDAT database.

The results of this review showed that selectivity data is sporadic and restricted to a few species e.g. haddock and cod and for a few gear types e.g. *Nephrops* trawls with mesh sizes 70 –89 mm. Very little selectivity data exists for pelagic species or for important demersal species such as monkfish or megrim.

10.3.1 Participants

Dave Reid	FRS	UK
Norman Graham	IMR	Norway (PT)
Francois Gerlotto	IRD	France (PT)
Hendrik Stouten	RvZ	Belgium (PT)
Dominic Rihan	BIM	Ireland
Bob van Marlen	RIVO	Netherlands (PT)
Jochem Depestele	RvZ	Belgium (PT)

PT – Part time

10.3.2 Recommendations

i) The topic group will continue to collate this information on an annual basis, based on the issues related above and subject to a revision of the questionnaire by the convenors.

ii) WGFTFB should continue to receive feedback from the different WG's and AMAWGC, to assess the usefulness of the information supplied.

iii) DGFISH should be asked to produce a definitive list of any new technical conservation measures introduced at December Council for comment by WGFTFB members.

iv) WGFTFB members of relevant countries should provide information on proposed national TCMs

v) The Chair of WGFTFB should continue to participate in the AMAWGC meeting annually and present findings of ToR on WGFTFB advice to assessment working groups and ACFM.

10.4 STECF Sub Group on Fishing Effort – a connection to gear technology

Dick Ferro (Marine Laboratory, UK)

The European Commission's Scientific, Technical and Economic Committee on Fisheries (STECF), has formed a Study Group on Fishing Effort Management (SGRST). The Study Group will have three meetings during 2006 with the objective of preparing databases on catch (landings and discards) and effort for the period 2000–2005 in EU fisheries. The objective is to inform the European Commission on how effort management is affecting the activities of individual metiers and how they may be responding. Métiers are being defined by area, for a range of gear types, mesh sizes and target species, taking account of the special conditions defining gears that are permitted under recent regulations. At the first meeting in March 2006, there was a preponderance of stock assessment biologists who provide the catch and effort data. It became clear that there was a role for gear technologists with knowledge of fleet operations and trends in fishing gear use in helping to interpret the changes in effort between the identified metiers. The author was alerting the gear technology community to the possibly helpful role they could play.

10.5 Continued WGFTFB input in Assessment Working Groups

The WGFTFB were presented Terms of References from Assessment Expert Groups that are of direct relevance to the WG:

- Plan further implementation of fisheries-based advice by the Assessment Working Groups and integration of fisheries technology expertise
- Make a road map of where the individual WGs should be moving in the medium and long term. This should include issues like assessment methods, surveys, basic scientific work, data collection, proactive development of management strategy options, mixed fisheries issues, ecosystem impacts and impacts on ecosystem analysis.
- In mixed fisheries where mixed catches are an important feature of the fisheries, there is a need to assess the influence of individual fleet activities on the stocks and the technical interactions;
- Update the description of fisheries exploiting the stocks, including major regulatory changes and their potential effects. Comment on the outcome of existing management measures including technical measures, TACs, effort control and management plans.

10.5.1 Discussion

The suggestion was made to meet with the assessment WG Chairs to define what they consider important. The Chair pointed out that there has been considerable dialogue already and the Term of Reference on Advice for assessment working groups and ACFM was specifically set up to address the key issues required by assessment expert groups. The members were informed that, according to ACFM, if possible, a gear technologist should be present at all ICES regional assessment working groups, as the recent experience of the Chair has been that this has been very productive.

One of the main problems is that not every institute is willing to provide staff to participate at such meetings and some members felt that participation should only occur when there is a

specific request from the Assessment Working Group Chair. It was felt that this process could be further encouraged by the allocation of travel funds by ICES for such participation. It was concluded that there are better forums available to maintain a workable link with the assessment groups. The Chair of WGFTFB should continue to participate in the AMAWGC and possibly present the findings of the Topic Group on Advice for assessment working groups and ACFM at each meeting, which is now proposed as an annual ToR for WGFTFB. It was noted that feedback from ACFM and the individual assessment working groups is necessary to demonstrate how the information is being used and how it can be refined and/or modified in the future.

The WGFTFB national reports present a useful mechanism for obtaining the type of information needed and the questionnaire provided to the individual members of the WGFTFB should be seen as an integral part of their national report in the future, although it was agreed the questionnaire needs to be revised and simplified.

10.5.2 Conclusions

i) In order to meet the requests of the individual assessment working group, the WGFTFB will continue to provide information through the annual ToR on WGFTFB advice to Assessment Working Groups and ACFM as defined.

ii) The Chair of WGFTFB will participate in, and present the finding at AMAWGC

iii) It may not be feasible for WGFTFB to provide participants to all regional assessment working group meetings due to lack of resources and other work commitments. Participation should be on an *ad hoc* basis to deal with specific issues

11 ToR c): Alternative fishing gears

Conveners: Bjarti Thomsen, (FRS, Faroes)

11.1 General overview and presentation of principal findings

This ToR was introduced by Bjarti Thomsen.

11.1.1 Terms of Reference

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

Abstract

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

> "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 or the ICES Symposium on Fishing technology in the 21st Century"

At the FTFB 2005 meeting in Rome, 21 scientists met and worked on the topic. Summary of this work is given in the FTFB 2005 report.

At the FTFB 2006 meeting in Izmir, 19 scientists participated in the topic group work with convener Bjarti Thomsen and Mike Pol as Rapporteur.

Presentations were made in plenary session to the WGFTFB on characteristics of the ideal gear, field experiments with cod pots in USA and Faroe Islands, and modifications of salmon traps in Sweden to make them 'seal safe'. Summaries are included elsewhere in the WGFTFB report.

The group decided that it was more appropriate to report to the present FTFB meeting rather than the ICES Symposium later this year.

Text has been prepared from some of the presentations given in 2005 and these will be collated into a final report.

The group identified reasons to seek alternative gears, methods to identify traditional gears, and also obstacles to the development and implementation of alternative gears.

The group developed tools (see Annex 4) to conduct a qualitative assessment of common fishing gears. Using these tools individual group members assessed common fishing gears in relation to ideal gear characteristics that were modified from the list initiated by Mike Pol.

The group devoted the remaining time in this session to developing conclusions and recommendations for presentation to the plenary session.

Conclusions

i) Existing codes provide guidance for use of alternative gears, for example, the FAO Code of Conduct for Responsible Fisheries.

ii) No universal alternative gear or practice exists; suitable alternatives are likely to be specific to a fishery.

iii) The use of alternative gears in a particular fishery should address various responsible fishing issues including:

- Minimizing environmental impacts
- Improvements to fish quality
- Reducing unaccounted mortality
- Optimising both species- and size-selectivity

This list should not be looked upon as exhaustive.

i) Increased fuel costs are increasing the incentive to investigate and develop alternative gears.

ii) A valuable initial step to identify alternative gears is transfer of knowledge and technology from other areas of the world. For example, translation of foreign language publications was identified as valuable, particularly publications from Asia and the former Soviet Union.

iii) A qualitative assessment by the group, reviewing common fishing gears, identified certain gears as best meeting ideal gear characteristics as defined by the group; for example pole and line, diving and pots.

iv) Currently, many alternative gears do not offer an economically viable solution. These gears require innovation or modification before wider application beyond current use. Inventive and imaginative concepts for responsible fishing methods should be actively encouraged, using study of fish behaviour, especially reaction to alternative stimulation.

v) Tradition, management measures as well as market conditions and other socio-economic concerns, may affect the adoption of alternative gears by fishing fleets

vi) The development of alternative gears is likely to be a long-term effort and will need to be supplemented with immediate measures to target existing problems.

11.1.2 Participants

Bjarti Thomsen (Convener)	Fish. Lab.	Faroe Islands
Michael Pol (Rapporteur)	MA Div. of Marine Fisheries	USA
Benoît Vincent	IFREMER	France
Els Vanderperren	ILVO – Visserij	Belgium
Esteban Puente	AZTI	Spain
Fabio Grati	CNR-ISMAR	Italy
Gary Dunlin	SFIA	UK
Gérard Bavouzet	IFREMER	France
Gianna Fabi	CNR-ISMAR	Italy
Håkan Westerberg	SBF	Sweden
Hans Polet	ILVO – Visserij	Belgium
Jochen Depestele	ILVO – Visserij	Belgium
Michael Breen	Fisheries Research Service	Scotland, UK
Pingguo He	Univ. of New Hampshire	USA
Rikke Frandsen	DIFRES	Denmark
Svein Løkkeborg	IMR	Norway
Tories Bők	Univ. of Istanbul	Turkey
Benal Gűl	Ege University	Turkey
Gőktuğ Dalgıç	Rize University	Turkey

11.1.3 Recommendations

The work from this topic group will be submitted for publication as an *ICES Cooperative Research Report*. The Topic Group conclude that the use of fish traps for commercial fisheries needs to be considered in more detail, including a review of the latest research and development into fish behaviour and fish pot design. The Topic Group conclude that this would be best achieved with the formation of a Study Group. The proposed terms of reference for this are given in Section 18.1.4 of this report.

11.2 Individual presentations

11.2.1 The *ideal* gear

Mike Pol (Ma. Div. of Marine Fisheries, USA)

Abstract

A list of characteristics of the ideal fishing gear was developed in response to discussions and presentations during a meeting of a topic group on alternative fishing gears held at the ICES-FAO Working Group on Fishing Technology and Fish Behaviour in 2005. The ideal gear: should be highly species-selectivity, and knowable size-selectivity; does no unnecessary harm to fish have low impact on the physical environment; is durable and constructed of sustainable

materials; have high efficiency and changes it's fish capture process randomly; is safe to humans; has no impact on non-target species e.g. megafauna; and be low cost. The list was presented as a starting point for discussion.

Michael Pol (mike.pol@state.ma.us), Massachusetts Division of Marine Fisheries

11.2.2 Cod potting in Massachusetts, USA

Mike Pol (Ma. Div. of Marine Fisheries, USA)

Abstract

Pots demonstrated to catch Atlantic cod *Gadus morhua* in Newfoundland successfully caught cod during two seasons (May/June 2005 and Dec 2005 – Feb 2006) off Boston Harbour, Massachusetts. Pots were seen as a means of reducing wastage of fish due to overcatch by gillnets and longlines during a seasonal concentration of cod. Pots were 183 mm2 x approx. 100 mm with additional volume added by codend webbing (30 M of 10 cm diamond PE with a float) on top. Three construction types were used, but no difference was found due to construction. Traps were primarily baited with squid *Loligo* sp. and surf clams *Mya* sp. and fished from a conventional lobster *Homarus americanus* 13 m LOA vessel. Catch quantities were insufficient to support commercial effort, although catches are the highest known to date in the region and costs were low. Cod sizes in pots were compared to sizes caught in two multimesh gillnets (nine panels each in two strings; sizes: 114–229 mm by 13mm increments (except 190 mm)). Gillnets caught larger fish on two catch dates (means; pots: 48.5; gillnets: 80.8 and pots: 42.0; gillnets: 65.0). Observed mortality and bycatch were low. Underwater video showed fish entering and exiting the pot. Other video suggested that cod did not aggressively seek to enter the pot despite being drawn to bait. Further work on seasonal components of this fishery, especially matching to longline success, was emphasized over alteration of pot characteristics.

Michael Pol (mike.pol@state.ma.us) and Mark Szymanski, Massachusetts Division of Marine Fisheries

Philip Walsh, Marine Institute, Memorial University

Discussion

The author was asked what type of bait had been used. He replied that they used herring and salted herring (as used in lobster fishery), scallops, clams (good bait for cod) and squid. The bait used mainly depended on availability.

The author was asked if predation by seals was observed. This could be a problem, but it was not observed.

The comment was made that in Norway it was never succeeded to make pots work for cod. Variables like the season or the bait could be the problem. It would be logical to assume that for the same species, pots should have a comparable efficiency in different areas. This is, however, not the case, as has been observed in the commercial fishery. Fishermen claim e.g. that for lobster, in one area you should use yellow pots and a few miles further offshore, another colour.

Although pot fishing is a good fishing practice there are many unknown factors about pot fishing and far too little effort has been put into this fishery whereas for trawling a huge amount of research was invested. There is a tendency (politically, worldwide) to reduce or even ban bottom trawling. The pot fishery will become more important, so the work with pots or passive gear in general is very important.

11.2.3 Observations of cod pots in the Faroe Islands

Bjarti Thomsen (FRS, Faroes)

Abstract

Development of fish pots for traditional species (cod and haddock) was initiated in the Faroe Islands in 2005. The aim was to increase efficiency of this gear to make them an alternative to other gear in use. The work focused on tests of different design of pots, development of a long-lasting bait, and the use of alternative stimulation to guide fish into the pot.

The equipment used included an underwater camera with transmitter at the surface and wireless link to a boat or ashore. The depth used was in the range 20–50 m.

Underwater observations showing fish arriving upstream underlined the importance of the entrance facing downstream or entrance access from all sides. Most fish kept 1–2 m distance to the pot and were not aggressively seeking to enter the trap. Examples of fish swimming in and out of the pot underlined the need to develop an effective entrance. Cod were also seen to be territorial, guarding the entrance and chasing fish away. A container containing frozen bait soup was found to be reasonable long lasting bait. Experiments with running light (chasing light) showed no apparent reaction of fish. This work will continue in coming years.

Discussion

The comment was made that during trials with pots on the East coast of England, the bait used did not appear to attract fish. If, however, small, codling were caught in the pot, catch rates increased. A similar phenomenon has been seen with lobster and cuttlefish. The author added that the correct and long lasting bait is important. Seal safe salmon traps.

Håkan Westerberg (Swedish Board of Fisheries, Sweden)

Abstract

Traditionally the coastal fishery for salmon, trout and whitefish in the Baltic region uses traps, either entangling traps or floating traps with a fish chamber. This type of gear is very vulnerable to seal damage. Entangling traps are no longer used due to excessive damage. With the protected status of the Baltic seal population and a population growth of 5–10%/year the coastal fishery is in need of alternative fishing methods that are usable in the presence of seals. Work on this has been going on for a decade with government funding.

The result is a salmon trap with two properties that minimises the reward to the seal. One is an entrance section with a large mesh size, allowing the fish but not the seal to pass, and a design to avoid sharp corners where a seal can trap fish on their way into the trap. In traditional traps a large part of the seal interaction is predation on salmon being concentrated in the entrance sections of the trap. The other property is a fish chamber that protects the fish when captured. The main ingredients are a rigid frame and double netting which separates the fish and the seal and a mechanism for emptying this rigid gear. This is made by inflating pontoons under the fish chamber, lifting it completely out of the water. The trap is called the "pushup" trap and the lifting method is patented. The separation between the inner and outer net is 20 cm minimum. At this distance the grey seal don't try to attack a fish.

An important advantage in addition to the seal protection is that the "pushup" trap makes handling of the trap much easier than with the traditional design. The trap has been well accepted by the fishermen and has now replaced more than 1/3 of the traditional traps. Seal damages still occur but there is a significant reduction with the "pushup" trap. This type of trap is now being modified and tried as replacement for gillnets in the coastal fisheries for whitefish, pikeperch, eel and other Baltic fisheries.

Discussion

The question was raised whether there is a safety problem if the weather conditions are bad when harvesting. The author replied that trap fishery presented has the advantage that fish can stay alive in the trap for a long time, so good weather conditions can be awaited before harvesting. It would be interesting, however, to find ways to harvest while the trap stays on the seafloor.

The author was asked if he noticed differences in behaviour between the different seal species. Yes, the grey seal tears thing apart. Ring seals are more discrete and are also much smaller, which make it more difficult to keep them out of the trap.

12 ToR d): Multiple size selection devices in towed gears

Convenors: Norman Graham (IMR, Norway) and Barry O'Neill (Marine Laboratory, UK)

12.1 General overview and presentation of principal findings

This ToR was introduced by Barry O'Neill (Marine Laboratory, Aberdeen)

12.1.1 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 bycatch 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.

12.1.2 Abstract

The topic group met to review the use of 'additional' selection devices for improving size selectivity in demersal trawl fisheries and to consider their effectiveness in comparison to conventional diamond mesh codends. An inventory of the fisheries where these devices are being used, their design specification and date of introduction was compiled. These were partitioned into three categories as follows:

- the cod fishery in the Barents Sea and the cod and haddock fishery in Iceland where the *Sort – X, Sort – V and Flexigrids* are used;
- the cod fishery in the Baltic where the *Bacoma square mesh panel* is used;
- the round fish fishery in the North Sea, Skagerrak and Kattegat where a *square mesh panel* can be (has been) used.

A review of the associated literature was carried out. Most available data pertain to diamond mesh codends with Bacoma panels in the Baltic cod fishery. There are also smaller but useful data sets relating to the use of grids in Norway, and square mesh panels in the North Sea.

It is often claimed that when these devices are fitted in a gear (i) the selective performance of the gear is less variable and (ii) the selection range is sharper. The first of these claims was not examined in sufficient detail by the group and still needs to be addressed. The second claim was examined in depth and for appropriate data sets *sr* was plotted against l50. For given *l50* values this type of graph permitted the examination of how *sr* varied when an additional

selection device was used. There is strong evidence to support the view that the selection range for cod of a diamond mesh codend fitted with a Bacoma panel is sharper (lower). No evidence was found of a sharper selection range of cod for the combination of grid and diamond mesh codend in comparison to that of a diamond mesh codend only. Similarly, no evidence was found for sharper selection of haddock in North Sea diamond mesh codends when a square mesh panel is inserted in the codend.

Many other issues must be considered with regards to additional size selection devices and may influence their appropriateness in a given fishery. These relate to on-board handling, legislation and enforcement, rigging and material strength, damage to and survival of escaping fish and acceptability to fishermen.

The experimental and statistical methodologies used to measure the selectivity of these devices were also considered.

Conclusions

The available *l50* and *sr* data for a range of diamond mesh codends and a range of codends with a Bacoma square mesh panel were reviewed and it was found that, for a given *l50*, the combined selectivity of the codends with the Bacoma panel had sharper selection (*lower sr*) for cod than the traditional diamond mesh codends.

A review of published studies on the performance of size selective grids presented no evidence of sharper size selection of cod for the combination of grid and diamond mesh codend in comparison to what is obtained for a diamond mesh codend only.

A review of the published studies on the performance of square mesh panels inserted in the diamond mesh codends of the North Sea found no evidence of sharper size selection of haddock in comparison to what is obtained for a diamond mesh codend only.

There are many other issues, which inform whether a device is appropriate for a fishery. These relate to the variability of selective performance, on-board handling, legislation and enforcement, rigging and material strength, damage to and survival of escaping fish and acceptability to fishermen.

12.1.3 Participants

Frandsen, Rikke	DIFRES	Denmark
Jørgensen, Terje	IMR	Norway
Larnaud, Pascal	IFREMER	France
Larsson, Per-Olov	IMR	Lysekil, Sweden
Moderhak, Waldemar	MIR	Poland
O'Neill, Barry (Chair)	FRS	Scotland
Özbilgin, Yeliz	Ege University	Turkey
Sala, Antonello	CNR-ISMAR	Italy
Meke Soung, Pierre N.	MINEPIA	Cameroon
Wienbeck, Harald	BFA	Germany

12.1.4 Recommendations

The topic group recommends that:

i) when conducting experiments, the priority should be to test the combined selectivity of the codend and selective device.

ii) estimates of the combined selectivity of codend and selective device should be obtained over a range of catch sizes that are typical of the fishery and

that full consideration should be given to the seasonal and environmental conditions throughout the year.

iii) the selective properties of the additional devices should be monitored to ensure that they do not deteriorate significantly with usage.

iv) in the absence of issues relating to other target species, the selectivity of the device and the codend in which it is inserted should be the same.

v) studies should be carried out to investigate the effect on long term yield of changes to selection range.

vi) when introducing a size selective device, consideration should be given to changes of discard and unaccounted mortality.

13 ToR e): Gear classification

Convenor: Wilfried Thiele (FAO) and John Willy Valdemarsen (IMR, Norway)

13.1 General overview and presentation of principal findings

This ToR was introduced by John Willy Valdemarsen.

13.1.1 Terms of Reference

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.

Task for this meeting:

i) Discuss and propose classification structure as for the present level,

ii) Revise text of gear categories

iii) Discuss needs and prospects for better estimates fishing effort by gear categories

iv) How to complete the ToR

13.1.2 Abstract

The Topic group on Gear Classification met for two days during the meeting, the following objectives and actions were agreed upon. A new draft of the original FAO Technical Paper 222 on gear classification was produced. New gear categories were added to reflect the changes in fishing gears over the past 30 years, for example twin and multiple otter trawls, which have been widely introduced in many regions. Additionally, it was agreed that the new report should reflect the co-sponsorship of the WGFTFB by FAO and the new report will be a

joint FAO-ICES publication. The group developed a new draft FAO/ICES classification based on an FAO proposal, agreed on structure of gear definitions (Brief and concise definitions and *additional description about the gears*) and developed an **Action plan** for completing the classification and definitions

Action plan

Finalise definition and classification of fishing gear categories

Definitions of gears (1 October 2006)

Drafting group:	Wilfried Thiele, FAO, Italy
	John W. Valdemarsen, IMR, Norway
	Ulrik Jes Hansen, SINTEF, Denmark
	Francois Theret, European Commission, Belgium
	Dick Ferro, FRS, Scotland

Circulate for comments by the group (1 December)

Editing of the text (FAO)

Illustrations of main gear categories (1 February) FAO

Prepare the draft version for approval by FTFB (1 March 2007)

A draft of the fishing gear definitions and an example of the hierarchal system used is given in Annex 6. Note that the text included in this annex is in draft form and as such should not be used as a replacement for the existing 1971 FAO Technical Paper 222.

13.1.3 Participants

John Willy Valdemarsen	Norway (Co-Chair)
Wilfried Thiele	FAO (Co-Chair)
Andrés Antonio Seefoó Ramos	Mexico
Ignacio Mendez	Mexico
Bundit Chokesanguan	SEAFDEC
Alessandro Lucchetti	Italy
Ulrik Jes Hansen	Denmark
Steve Walsh,	Canada (NAFO appointed)
Celal Ates,	Turkey
Gøkhan Gøkge,	Turkey
Francois Theret,	EU
Dick Ferro,	UK
Mats Ulmestand,	Sweden

13.1.4 Recommendations

i) The Topic Group on Definitions and classifications of fishing gear categories should continue and will follow the agreed Action Plan timetable

ii) Identify in consultation with management bodies gear parameters that should be monitored to provide better estimates of commercial CPUE

13.1.5 Discussion

It was noted that there was no expert from the Mediterranean in the drafting group. However, the presenter stated that the drafting group should be kept small in order to ensure that the work is carried out as quickly as possible and including representatives from every fishery region would make result in a very large group. One member of the drafting group represents the FAO, therefore ensuring global coverage. This text will become available for comments to the topic group, which has a wider geographical coverage.

It is stated in the original ToR that inconsistencies between adjacent areas should be identified; this has not been achieved in the past year. The Chair suggested that managers should be included in the process, because these are important users. It was noted that the European Commission is represented.

The identification of gear parameters that affect gear efficiency and commercial CPUE could be used in stock assessment for refining CPUE estimates, which is particularly important with the shift in some regions to area and fleet based management. There was a general consensus that this should be done, that work in the EU has begun to deal with these refinements, but there is a need to continue. Also, as ICES provides advice for several client commissions, work outside the EU arena should continue and it is likely that there will be commonality for all management regions.

There is a need for this Topic Group to continue its work over the next year and the outgoing Chair of WGFTFB will work to identify appropriate gear parameters for refining CPUE estimates and will begin by reviewing existing initiatives e.g. EU data collections regulations.

14 ToR f): *Ad hoc* group on Issues affecting Turkish Fisheries

Convenor: Huseyin Ozbilgin (Turkey) and Dick Ferro (Marine Laboratory, UK)

14.1 General overview and presentation of principal findings

This ToR was introduced by Huseyin Ozbilgin.

14.1.1 Terms of Reference

An *ad hoc* topic group will be formed to identify and review fishing technology matters affecting the fisheries of Turkey. This group should consider issues such as recent developments in fishing technology that may affect fishing mortality, an appraisal of current fishing gear and vessel legislation and identify possible sources of unaccounted mortality.

14.1.2 Abstract

The Group met during the afternoon of 4th and morning of 5th April 2006 in Izmir. A total of 27 Turkish gear technologists participated under the Chairmanship of Dr Ozbilgin with Dr Ferro acting as Rapporteur. Additional drafting was undertaken on 6th April.

Prior to the meeting, data were compiled summarizing the structure of the main Turkish fleets by fishing method and landings. A start was also made on gathering information on recent research in the gear technology field in the approximately 20 research institutes and Universities throughout the country. A reference document containing this information will be produced by Ege University, Izmir.

During the meeting the main work of the Topic Group was to consider each main gear category represented in Turkish fisheries. The key technical issues and problems were summarized. These were associated with technical measures related to gear design, technological creep, ecosystem effects, gear conflicts and unaccounted mortality. Until the

reference document detailing current research is complete, it will not be possible to consider potential solutions to these problems fully nor to identify what prior research may be needed.

Purse seining is a major fishery for anchovy, particularly in the Black Sea. There are significant discards of juveniles at times and light fishing can attract juveniles, mammals and non-target species in the Aegean and Mediterranean Seas. Significant technical creep is evident due to improvements in equipment, more efficient fleet operations to catch live tuna, higher power/larger size of vessels allowing a wider operational area. Legislation on closed areas, closed seasons, depth limitations, restrictions on light fishing and limits on catch composition already exist.

Beam trawl fisheries for shrimp and sea cucumber exist in the Sea of Marmara and for Rapa whelk (during daylight only) in the Black Sea. Shrimp selectivity has been studied but bycatch, discards (of both fish and benthos) and habitat damage are major concerns and further research is needed. Discards and unrecorded landings are common. There are beam and mesh size regulations and seasonal and area closures.

Demersal otter trawls form a major fishery that has poor size selectivity. There are many papers on the effect on selectivity of the design of codends and other selective devices and post-escape survival has been studied for some species but the main problem is the multi-species nature of the fishery. Although studies on fish swimming have been conducted to improve understanding of the fish capture process, there is a need for further behavioural studies. While gears are unselective, there is less discarding than expected because of illegal landing of undersize fish. Technological creep is clear in the development of electronics and vessel design but not in gear design yet. Increases in effort by this fleet are evident. There are a range of regulations on gear design and closed areas and seasons.

A midwater pair trawl fishery for small pelagic species has developed recently in the Black Sea. Gear designs are still developing. Studies have been done on bycatch, selectivity and catch composition. There are concerns about the effect of bottom contact in this fishery, which has seasonal, and area closures.

Twin trawling does not exist in Turkey but gives potential for unregulated increases in fishing effort.

There are major fisheries involving a great variety of gillnets and entangling nets in both marine and fresh waters. Size selectivity of these gears has been studied extensively but bycatch (including mammals) and discard levels are generally unknown and of concern. Technological creep is shown by the increasing use of net-haulers and GPS and echosounders, and continuous deployment of nets is a concern. Gear conflicts and ghost fishing are known to exist.

Trap fisheries using pots, fyke nets and aerial traps are established in both fresh and marine waters but only a few studies have been done on efficiency, catch composition and selectivity, with some concern over the latter.

Small-scale handline fisheries and both pelagic and demersal longline fisheries exist but only limited knowledge of their extent is available.

Hydraulic dredges are used in the striped Venus clam fishery. Technology is continuing to develop and overfishing may occur in some areas.

There are other fisheries such as beach and boat seines, boat and hand dredges, cast and lift nets and spear fishing.

A full report of the topic group's findings is given in Annex 5.

14.1.3 Participants

Okan AKYOL
Celal ATEŞ
Celalettin AYDIN
İsmet BALIK
Tomris BÖK
Göktuğ DALGIÇ
Aydın DEMİRCİ
Sevil DEMİRCİ
Cengiz DEVAL
Cemal DİNÇER
İbrahim Tamer EMECAN
Mustafa ERDEM
Didem GÖKTÜRK
Raşit GURBET
Akın İLKYAZ
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14.1.4 Recommendations

The WGFTFB should form an internal group of experts from Mediterranean countries and expand on the work done by the *ad hoc* group on Turkish Fisheries.

14.1.5 Discussion

There was consensus that this is a useful recommendation. Topic Group participants noted that this has been a very useful exercise for gear technologists working in Turkey as it gave them the first opportunity to meet and discuss the various issues. Following the success of this, it was noted that a meeting of Turkish gear scientists would now be held each year.

A proposed Term of Reference for the formation of a Topic Group dealing with technology issues affecting the Mediterranean has been submitted for consideration by ICES (Section 18.1.2).

15 Other requests to WGFTFB

15.1 WGEF (Elasmobranch fisheries)

- Measures to reduce bycatch of sharks, especially in tuna and swordfish fisheries should be evaluated by WGFTFB.

The FTFB Chair has provided a state of the art overview to the Chair of WGEF.

15.2 Workshop on *Nephrops* Stocks (WKNEPH)

In January 2006, an ICES workshop on *Nephrops* stocks was held at ICES headquarters, Copenhagen, Denmark. One of the ToRs related to size selectivity of *Nephrops*:

- Evaluate the effects of mesh size regulations on the catchability of small *Nephrops*.

Information was provided on the state of the art of *Nephrops* selectivity by Dominic Rihan (Ireland), Dick Ferro (UK) and Norman Graham (Norway). The FTFB recognizes the need for evaluation of recent *Nephrops* selectivity data and has proposed holding a workshop to consider the issue in more detail (see Section 18.1.4)

Discussion

A remark was made on the need for a workshop on the latest information on *Nephrops* selectivity. A review was made in the mid 1990s but more recent experiments have been done by individual countries and many new data will be collected in the Necessity project. A problem is that for several experiments, data exist but there are problems with fitting standard selection curves. Research is needed to find appropriate models to fit the data. In Scotland a review is made of Marine Laboratory (Aberdeen) data, using smoother techniques but a more comprehensive review, to include all new international *Nephrops* data is needed.

16 Summary of posters and other presentations

16.1 Investigation of the paired gear method

Frandsen, R. P., Herrmann, B. and Holst, R.

Danish Institute for Fisheries Research

This study was initiated when single hauls from a paired gear experiment showed estimates for selection range (SR) that were much lower than expected (< 1 cm). Selection parameters were obtained by the SELECT method as recommended in Wileman *et al*. (1996) and neither "goodness of fit"-values nor confidence limits gave cause for concern.

In a parametric simulation study, Cadigan and Millar (1992) likewise found extreme values for the SR estimate, but always in association with small sampling sizes (<250 fish/haul). In the present study, the structural simulation programme PRESEMO (Herrmann and O'Neill, 2005) was used to generate multiple sets of "covered codend" and "paired gear" – data. Simulated catch data of the covered codend type are used as a reference as they are free of the experimental deficiencies of real experiments and therefore assumed to be unbiased. The found differences in results between the two methods can therefore not be attributed to physical or biological mechanisms.

In accordance with the findings by Cadigan and Millar (1992) analysis of the simulated catch data using the SELECT method (Millar, 1992), showed that extreme values of SR are more frequent when the number of fish is low. In addition to this, we found that mean estimates of the selection parameters displayed a bias that was independent of both the number of fish and the number of hauls. Furthermore, results indicate that bias, in particular on the SR estimate, partly can be explained by a poor estimation of the split.

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Wileman, D. A., Ferro, R. S. T., Fonteyne, R., and Millar, R. B. 1996. Manual of Methods of Measuring the Selectivity of Towed Fishing Gears. ICES Coop. Res. Report No. 215.

16.2 Selectivity of the large mesh trawl codend in the Gulf of Maine

Pingguo He (Univ. of New Hampshire, USA)

Abstract

Selectivity properties of five codend types were evaluated using the covered codend method during the spring and summer of 2003. The codends tested were 152, 165 and 178 mm (6", 6.5" and 7") diamond mesh codends, and 165 and 178 mm (6.5" and 7") square mesh codends. A new hydrodynamic codend cover, which was expanded by twelve water-borne kites, was developed, tested and used during the codend mesh selectivity studies. Eighty-two successful tows were completed for the five codends. This paper reports data and results for Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Results for four flounder species will be reported in a subsequent paper. The results indicate that larger codend mesh sizes retained larger fish for both species for both diamond and square mesh codends, but the mesh shape (diamond or square) has no significant effect on the 50% retention length (L50) for both species. The square mesh codend, however, has a narrower selection range (SR) than the corresponding diamond mesh codend.

Keywords: Codend selectivity, trawl, Atlantic cod, Gadus morhua, haddock, Melanogrammus aeglefinus

Discussion

The remark was made that it is remarkable that there is no difference in selectivity for cod for the diamond and square meshes. The author was also asked whether the catches were high and whether the catch size was taken into account. He replied that no clear trend on catch size was observed and that the catch amount was not huge but still reasonable.

16.3 Results of preliminary investigation of cod trawl with belly made of T90 meshes netting

Waldemar Moderhak (Sea Fisheries Institute, Poland)

Abstract

The project regarding use of T90 netting to constructing trawl belly is on going from the middle of May 2005. The aim is to create a trawl gear for fishing cod on Baltic Sea that will be environmentally friendly and simultaneously save income for fisherman.

For this purpose two similar trawl gears were prepared. The first is commonly used in Baltic Sea for commercial cod fishing and the second replaced diamond netting by turned netting (T90) in two last segments of the belly. On December 2005 first sea trials were conducted. The limited results obtained are very interesting and should be spread widely among fishing technologists.

Investigation shows a very stable mouth opening (both horizontal and vertical) over a wide range of towing speed of the experimental gear in comparison to the standard one. Observation of angle of attack of the blade of vessel's CPP (controllable pitch propeller) did not show substantial differences in „towing load" between both gears. To utilise the lower drag of T90 netting it is necessary to make major changes in the rigging of the experimental gear- such as lighter gear and smaller otter boards. The investigation will continue in subsequent years.

Discussion

The author was asked whether he has plans to do field trials with drag sensors to confirm the theoretical results. This is not the case because of lack of resources. There may be a possibility in cooperation with German colleagues and the subject may gain interest because of a possible reduction in fuel consumption.

16.4 The influence of some netting material properties on PA codend size selectivity of Mediterranean bottom trawl

Antonello Sala, Gabriele Buglioni, Alessandro Lucchetti, Vito Palombo

Abstract

In Italy the minimum mesh size of trawl codends is fixed at 40 mm stretch by the Regulation (EC) 1626/94, therefore the capture of undersized fish and discards are significant. Peak effort in the Adriatic bottom trawl fishery coincides with large concentrations of juvenile whiting, red mullet, poor cod, hake and blue whiting on the fishing grounds. Consequentially, large numbers of these fish are discarded as too small even for Mediterranean consumers. Improvement of trawl net selectivity is therefore of prime importance.

Italian bottom trawls are made generally with knotless polyamide netting and have a low vertical opening (around 1.5 m). Previous studies on codend selectivity compared the selectivity of different mesh sizes, while others were more devoted to comparing the selectivity of different trawl gears.

Until now no experiments have been conducted on Mediterranean fish species to verify the effect on selectivity of some additional parameters, such as mesh resistance to opening, mesh structure and the netting twine properties of the thicker and stiffer netting materials, which are currently used by the fishing industry.

In this paper, the effect of material properties on codend selectivity of some commercially important fish species in the Mediterranean Sea has been investigated.

Two codends were made by meshes with the same mesh opening (around 44 mm) but different twine thickness (Soft: R3644tex and Stiff: R5312tex). The two codends had the same nominal circumference and were daily alternated on the same trawl.

Discussion

What is the status of the square mesh legislation in the Mediterranean? There is no legislation yet, but there is a proposal for a square mesh panel.

There were two cruises at different times of year: did you see a change in selectivity depending upon the season? Seasonal variability was not studied because species caught in the first trip were not caught in the second trip and vice versa.

The remark was made that if a T90 codend would be used, the problem of stiffness could be overcome.

16.5 An overview of commercial fisheries in Turkey

Adnan Tokaç (Turkey)

An extensive overview of the fisheries of Turkey was presented, full details can be found in Annex 4.

16.6 Technical and operational overview of fishing vessels dredging striped Venus clam in Turkey (Full WD in Annex 7)

Goktug Dalgiç (Turkey)

Abstract

Technical and operational features of fishing vessels dredging striped Venus (*Chamelea gallina L., 1758*) in Turkey were investigated by conducting surveys in 2004 and 2006.

Thirty-nine vessels equipped with hydraulic dredges for fishing striped Venus were recorded in Turkey in 2006. The fleet consisted of vessels with size range of 12 to 28 m and employing 4 to 9 crew depending on size of vessels. It was also found that there isn't any regulation about the sieves in Fishing Circular (Turkish national fishing regulations).

In the paper we have analyzed findings of the survey, compared Turkish and Italian style hydraulic dredged vessels and presented recommendations for sustainable clam fisheries in Turkish waters.

Keywords: Chamelea gallina, striped Venus, bivalve fishing, hydraulic dredge, Black Sea.

Discussion

The remark was made that the hydraulic dredge has a severe impact on the seafloor. Have you looked at the consequences on the benthos? The author replied that this was not the case but there are plans to do this in the future. The question was also raised whether survival studies had been done on the small clams going back in the sea after sieving? This was not the case but studies in other Mediterranean countries indicated that survival is not a problem. The author mentioned that there is no fish bycatch in the dredge.

16.7 Discard of rapido trawl fishery in the Adriatic Sea

Gianni Fabi

Abstract

The rapido trawl is a bottom towed gear employed in Italy to exploit flat fish and scallops. It resembles a toothed beam-trawl and consists of an iron frame provided with 3–5 skids and a toothed bar on its lower side. A nylon net bag is tied to the frame and its lower side is protected by a reinforced rubber diamond-mesh mat. These gears are usually towed at a speed of 10–13 km h^{-1}.

This fishing activity occurs along the Italian coast of the northern and central Adriatic Sea, while it is much less common along the western Italian coasts. On the basis of a census carried out in 2003, approximately 146 rapido trawl fishing vessels existed in the Italian maritime departments included inside GFCM Geographical Sub Area 17 (GSA 17: northern and central Adriatic sea): 127 of them targeted the common sole *Solea solea*, 6 spent a part of the year catching common sole and the remaining part targeting scallops (*Aequipecten opercularis, Chlamys glabra, Pecten jacobaeus*), while 13 caught mainly scallops. Their fishing grounds consisted of the soft, trawlable bottoms of the continental shelf between 6 and 36 km offshore and from 10 to 70 m depth.

Only the rapido trawl fishery for common sole has been considered in this context. Data come from a two-year study (2000–2002) funded by the EC (Study contract n. 99/051). The qualitative and quantitative catch composition in terms of both retained and discarded fraction was recorded at 20-day intervals by scientific personnel on board of professional vessels, without any interference in the usual fishing activity and in the "modus operandi" of the

fishermen. According to the fishing activity, data collection was carried out day and night and a total of 207 hauls were sampled in the overall sampling period.

Forty percent of the total catch biomass was made up by commercial species, 18% by discard of non-commercial species, primarily bivalves and decapods, (42%) by debris, mainly consisting of dead shells of gastropods and bivalves.

Besides *S. solea*, the commercial fraction included a pool of species some of which may be considered as "secondary" target species either for their high commercial value or their great amounts in catches. They were: *Sepia officinalis, Chelidonichthys lucernus, Melicertus kerathurus, Squilla mantis* and *Bolinus brandaris*. About 28% in biomass of this portion was retained, while the remaining was discarded (C discard). The observations on board allowed to further subdivide the species belonging to C discard into damaged, dead and alive on the basis of their conditions when rejected at sea after the sorting operations. Eighty percent of C discard biomass returned into the sea alive, mainly constituted by gastropods and bivalves, 18% was represented by damaged species, mostly crustaceans, and only 2% by dead organisms, above all fish. The tub gurnard *C. lucernus* dominated this last category accounting for 42% of the total dead C discard. The discarded biomass of this species changed seasonally ranging from 17% of its total catch in winter to 38% in spring, in correspondence with the recruitment. Discarded specimens fell into the size range 6–21 cm TL and they were rejected at sea because of no commercial value. Most of them were juveniles, as the size at first sexual maturity reported by literature is 24 cm TL in the Tyrrhenian Sea (Froglia, 1984) and 18 cm TL for males and 20 cm TL for females in the eastern Mediterranean (Ismen *et al*., 2002).

Discussion

One of the conclusions of the study was that there is a low impact on discards. This was based on the state of the animals when returned to the sea. The question was raised whether there had been a study on delayed mortality? No study was done on longer-term mortality.

Bit by bit pressure is increasing on bottom trawling, claiming it is the most destructive fishing method. The author was asked if there is a campaign to ban it in Italy? The author replied that in the west of Italy the rapido is forbidden. On the east coast, protest is less strong because there is a large continental shelf and it is considered that rapido has a low impact on ecosystem in that area. This is mainly because the communities are under a lot of stress due to other human activities, so the trawling will not make much difference. In the north Adriatic it's different, because in the past there were seagrass meadows that have probably been destroyed by the rapido.

Trawling speed is 7knots. Why such a high towing speeds? Fishermen say that especially sole will escape at lower towing speed. The main reason, though, is that they cover more area at high towing speed.

16.8 Relationship between critical and maximum sustainable swimming speed (Full WD in Annex 7)

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Abstract

Information on the Maximum Sustainable Swimming Speed (Ums) of fishes has significant value in our understanding of how fish reacts to towed fishing gears. However, it is rather difficult to measure Ums as it requires several days of swimming exercise. During these exercises swimming endurance needs to be measured at different speeds and experimental

animals should be rested at least 24 hours between the exercises. Each set of experiment some times continues as long as ten days during which all the factors influencing swimming performance, other than speed, need to be kept constant.

Critical Swimming Speed (Ucrit) experiments, on the other hand, are relatively easier way of measuring swimming performance. By using this methodology results can be obtained between one and five hours depending on the size of fish.

In this preliminary study we measured Ucrit of three commercially important species; *Mullus barbatus* (red mullet), *Pagrus pagrus* (red porgy) and cultured *Sparus aurata* (sea bream) from the Mediterranean. In addition, prolonged swimming speed and sustainable swimming speed data were collected and Ums values were estimated by a using inverse linear relationship for the same fishes. Mean Ums-Ucrit percentages for red mullet, red porgy and cultured sea bream were calculated as 73.7, 77.3, and 70.6, respectively. For red porgy Ums-Ucrit percentages have shown a decrease with increasing fish length. Ucrit measurements seem to have a great potential to be a short cut in swimming experiments. However, physiological mechanisms involved in these two types of swimming tests need to be better understood.

Keywords: Mullus barbatus, Sparus aurata, Pagrus pagrus, Ucrit, Ums, body length.

Discussion

The author was asked whether the result depend on the individual fish, are there big differences between individuals? The author replied that there is a great effect of the individual, especially because of the difference in behaviour if a fish is alone in the tank or in a group. If you have only one fish, it will not swim. If you have many fish they will all swim and when all but one are tired, the one fish will continue. The reason why is unknown.

Ucrit has been ignored for many years. This study is interesting, useful and the experiments are easy to carry out.

16.9 Maximum Swimming Speed Predictions for *Mullus barbatus* and *Diplodus annularis* (Full WD in Annex 7)

Huseyin Ozbilgin, Murat Pehlivan*, Fatih Basaran

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****Ege University, Medical School and Hospital, Biophysics Section***
İzmir, Turkey

Abstract

Maximum swimming speeds of red mullet (*Mullus barbatus*) and annular sea bream (*Diplodus annularis*) were estimated from muscle twitch experiments at Ege University, Fisheries Faculty, Urla –Iskele Fish Behaviour Laboratory in August and September 2005.

It was estimated that an average size of 16.9 cm red mullet had a maximum speed of 3.14 m/s or 18.6 bl/s at 26 ºC. At 20 ºC maximum speed was estimated as 16.7 bl/s for an average size of 11.5 cm annular sea bream. It was also observed that the maximum swimming speed decreased with decreasing temperature.

Keywords: Red mullet, Annular sea bream, Maximum speed, Muscle contraction, Temperature.

16.10 Comparison of the swimming performance of farmed and wild gilthead sea bream, *Sparus aurata*. (Full WD in Annex 7)

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Abstract

Farmed gilthead sea bream, *Sparus aurata*, frequently escape from the sea cages and interact with wild populations. The impact of these interactions on the wild populations will depend, in part, on differences in their performances. This study compared the swimming performance of the wild and farmed fish in a current channel.

It was found that the absolute U_{crit} increases with increasing size while the relative U_{crit} decreases. Even at the same length there can be noticeable performance differences between the individuals. The wild sea bream have significantly higher ($P<0.05$) CSS performance (0.86 ± ms^{-1}) than the farmed fish (0.79 ± 0.01 ms^{-1}).

Keywords: Gilthead sea bream, Critical swimming speed (U_{crit}), wild, farmed.

16.11 Swimming performance and deformity separation of juveniles of sea bass (*Dicentrarchus labrax* L.) by using current channels (Full WD in Annex 7)

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Abstract

To separate the abnormal sea bass juveniles, *Dicentrarchus labrax,* from the normal specimens, differences in their swimming performances were investigated. Firstly, Critical Swimming Speed (U_{crit}) tests were applied with 5 cms^{-1} increments and 5 min period, and then endurance tests were performed at a fixed water velocity of 50 cms^{-1}. Results of experiments were compared in 3 length classes of 6.1–7.0, 7.1–8.0 and 8.1–9.0 cm. Absolute U_{crit} (cms^{-1}) and relative U_{crit} ($B.L.s^{-1}$) values normal fish were significantly higher than those of the fish with lordosis ($P<0.05$). Both normal fish and those with lordosis showed increased endurance with increasing length during the exercise in the fixed water velocity of 50 cms^{-1}. At the end of 40 min exercise in this velocity, percentages of the normal fish maintained swimming in all three length classes were higher than those of deformities. Potential use of differences between the swimming performances of normal fish and deformities in hatcheries to sort the deformities is discussed. Results might have potential to be used in commercial hatcheries.

Keywords: deformity separation, sea bass, swimming performance, lordosis.

16.12 Effects of body length and water temperature on the critical swimming speeds (css) of red mullet and annualar sea bream (Full WD in Annex 7)

Yeliz Doganyilmaz Ozbilgin, Huseyin Ozbilgin, Fatih Basaran

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Abstract

Critical swimming speeds (U_{crit}) of *Mullus barbatus* L.1758 (red mullet) and *Diplodus annularis* L.1758 (annular sea bream), which are common commercial catch components in the Aegean Sea demersal trawl fisheries, were measured to investigate the effects of water temperature and fish length.

It was found that increasing water temperature and fish length increased the absolute CSS (m/s). Results were discussed in a way to improve our understanding of fish behaviour in relation to trawl operation.

Keywords: Mullus barbatus, Diplodus annularis, CSS, temperature, length.

16.13 Bycatch associated with shrimp trawling in the Eastern Mediterranean (Taşucu Bay)

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Abstract

The aim of this study is to determine the bycatch problem of shrimp trawling in the Eastern Mediterranean (Taşucu Bay). For this purpose, 32 hauls, on board 3 commercial trawl vessels using traditional shrimp trawl nets (Akamca ve Polat, 1997), which have a 400 mesh fishing circle, were carried out in legal fishing areas. Overall, the target catch was made up of 6 shrimp species, with a bycatch of 16 fish species and 3 cephalopod species and discards made up of 9 fish (6 were osteichtyes, 3 were chondrichtyes) species, 2 cnidarians, 2 crustacans, 3 echinoderms, 2 molluscs and algae. From a total of 33 hauls the target catch was 118.5 kg, with a bycatch of 317 kg and 1420 kg discarded. The total catch therefore was composed of 6% target catch, 17% incidental catch and 77% discard. As a result, to get 1 kg of target catch, 2.7 kg of incidental catch and 12 kg of discards were captured. Shrimp fishery in Taşucu Bay produces a bycatch to shrimp ratio of 14.7:1

Keywords: Taşucu Bay, Shrimp trawl, Bycatch.

16.14 Lunar periodicity of prawn (*Melicertus kerathurus*) and bycatch in trammel nets, Turkey

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Abstract

Bycatch and target species caught in commercial trammel prawn nets were counted and weighed over 39 nights during May-September 2002 in Izmir Bay (West of Turkey) to

measure the effect of lunar periodicity. The most dominant nine bycatch species and target species (by numbers per fishing day) were used for the analyses. To compare the differences by species and lunar period, the Kruskal-Wallis test was used. *Engraulis encrasicolus* was the dominant species during the study period. *Melicertus kerathurus* (p=0.011), *Bolinus brandaris* (p=0.001), *Squilla mantis* (p=0.041), *E. encrasicolus* (p=0.000) and *Mullus barbatus* (p=0.033) showed a strong significant differences in mean catch rates between the moon phases. However, *Goneplax rhomboides, Diplodus annularis, Arnoglossus laterna, Microchirus variegatus* and *Solea solea* had no difference regarding the moon phases. The results of this study suggest that the behaviour of some of the most dominant bycatch species relates to lunar cycle. Therefore, the catches of these species could be reduced with respect to the moon phases.

16.15 Gillnet size-selectivity for *Mullus barbatus* and *Diplodus anularis* by the direct estimation method

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Abstract

In this study, selectivity parameters of 36 and 44 mm mesh sized gill nets were calculated for red mullet (*Mullus barbatus* Linn., 1758) and annular sea bream (*Diplodus annularis* Linn., 1758) by using the direct estimation method. Live specimens were collected monthly with trawl nets during the period June 2004 – May 2005, from the Middle Aegean Sea.

Optimum catch lengths were calculated monthly, seasonally and yearly for both mesh sizes and species. Optimum catch length for red mullet for the 36 mm mesh size net was 14.7cm, and with the 44 mm mesh size 17.3 cm was the optimum catch length. For annular sea bream the optimum catch lengths were 10.8 cm and 12.8 cm total length for the 36 mm and 44 mm mesh sizes respectively. Reproduction biology of sampled individuals was also researched and effects of these nets on the stock were investigated.

It was determined that the 36 mm and 44 mm mesh sizes did not damage the red mullet population, but for annular sea bream, the 36 mm mesh size net caught immature individuals.

16.16 Technical specifications of main fishing gears used in the middle Aegean coast of turkey

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Abstract

Although there are various publications on fishing gears and methods used in Turkey, most focus mainly on the operational side of fishing. Information given in these publications usually contains local terms, which vary between geographical areas within Turkey. There is therefore a gap in the literature in that there is no detailed catalogue of the fishing gears used in Turkey. Therefore, there is a need to investigate and prepare technical plans of the fishing gears used in Turkey drawn up according to international standards. The first part of this study was carried out for the Izmir province. This region is one of the most productive fishing areas of the Aegean Sea and more than fifty commercial species are caught using trawls, purse seines, gill and entangling nets, traps, hooks and lines etc.

16.17 Reduced bycatch in the trammel net fishery for prawn (*Melicertus kerathurus*) by using selvedge on lead line in western Turkey

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Abstract

The Prawn species, (*Melicertus kerathurus*), is caught in Turkish waters using trawls, beam trawls and trammel nets. However, Turkish fisheries regulation restricts the use of bottom trawls and beam trawls from May to September when the prawn catches are higher (Anon., 1999). During this period most prawn catches are caught in small-scale fisheries with trammel nets. The boats used are often small with mechanised net hauling systems. The defining feature of this fishery is the low cost of production compared to profits, which are high. Following the introduction of restrictions on the use of beach seining fishing gear (Anon., 1999), beach seining boats have tended to switch to trammel nets for catching prawn. This development has lead to over fishing of prawn species and an increased bycatch. Gökçe (2004) reported 72 species in commercial catches, which included 29 commercial species with the rest classified as discard species. The purple dye murex (*Bolinurus brandaris*), mantis shrimp (*Squila mantis*) and crab (*Goneplax rhomboides*) are often crushed by fishermen, making it easier for them to disentangle from nets. Thus discarded purple dye murexes, mantis shrimps and crabs suffer considerable injuries and usually die, meaning the bycatch make an important contribution to the fishing mortality for these species. The disentangling of this large bycatch also results in extra work for the fishermen, and often gear damage. Entangled purple dye murexes, mantis shrimps and crabs also reduce the effective net area for the target species, and through predation on fish caught in the net reduce the value of the catch. From a commercial standpoint, the prawn trammel net fishery requires a reduction in bycatch levels for the more net efficiency and reduced labour time to improve commercial viability.

Bycatch may be reduced by use of selvedged nets. Selvedged prawn trammel nets were compared with standard prawn nets with regard to reduced bycatch of the purple dye murex, mantis shrimp and crab, while maintaining the catch rates of target species. As a result of this study, using a selvedge on the lead line of prawn trammel nets significantly reduced bycatch species with the catch of target species reduced by no more than 4%. This method also decreased labour time for the fishermen on deck.

16.18 Reducing non-commercial species with sorting grids in Turkish traditional trawl net

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Abstract

In this study, grids with 12 mm and 14 mm bar spacing were tested to reduce the catch of non-commercial species in traditional Turkish trawl designs. These selective devices were installed in the trawl with a 45-degree grid angle in the extension piece of the trawl. Fish passing through the grid were retained into two special retainer codends (lower and upper). The ratio of the non-commercial fish species to commercial species in term of weight was found to be 15% and 21% with the 12 mm and 14 mm bar spacing, respectively. For the lower codend, the non-commercial species to commercial species ratio in the total catch was found to be 2.5%

with the 12 mm bar spacing grid. Using the 14 mm bar spacing, non-commercial species to commercial species ratio in total catch composition was found to be 2.8%. As a result, it was concluded that it difficult to reduce the non-commercial species catch completely in a multi-species fishery using sorting grids due to the different in size and body shape of the fish species caught.

16.19 Reduction in sea cucumber (*Stichopus regalıs, cuvier*, 1817) fisheries of the Marmara Sea

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Abstract

The Sea cucumber fishery has rapidly increased in Marmara Sea because of increased exports to far eastern countries. The main fishing gear used in the sea cucumber fishery is beam trawls, which are also used in the shrimp fishery. Sea cucumber has become the target species for beam trawlers fishing in areas where the sea cucumber population has increased. It was observed that the ratio of bycatch to sea cucumber catch was high. Observations were carried out to determine the bycatch ratio in beam trawls and experiments to reduce the bycatch ratio using an experimental trawl design were carried out. Codend and belly mesh size of traditional and experimental beam trawl nets of 24mm and 32 mm and 44 and 84 mm, respectively were tested. The traditional and experimental beam trawls were hauled every 30 minutes at the same time at 17 stations over a depth range of 40–100 m. Catches were separated on board and the amount of catch for each species and total catch for both nets. The target species catch; bycatch and discards were recorded for every haul. Seventeen species including sea cucumber were caught during the study. The mean length of sea cucumber ranged from 14–16 cm. Although the ratio of catch seemed nearly the same, it was found that the amount caught in the traditional net was nearly twice the amount caught with the experimental net. Catch amounts of *Parapenaeus longirostris* were reduced by nearly 27% in experimental net. It was also calculated that the Sea cucumber stock was 2574 tonnes in an area of 1007 km2. It was concluded that it was important to increase the mesh sizes in shrimp beam trawl fishing for monitoring and sustaining sea cucumber stocks.

16.20 Survival of red mullet (*Mullus barbatus L., 1758*), annular seabream (*Diplodus annularis L., 1758*) and axillary seabream (*Pagellus acarne Risso, 1827*) after escape from trawl codend in the Mediterranean

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Abstract

The purpose of this study was to investigate the survival rates of red mullet (*Mullus barbatus* L., 1758); annular seabream (*Diplodus annularis* L., 1758) and axillary seabream (*Pagellus acarne Risso*, 1827) after escaping from a commercial bottom trawl codend used traditionally in the Bay of İzmir. The experiments were carried out in September 2001 with a traditional bottom trawl with a 40 mm codend, towed for 15 minutes. A codend cover was used to catch escaping fish and then removed from the codend on hauling. After detachment, the cover was moved to an observation site with observations carried out by divers. One control and three experimental hauls were carried out to provide samples for the observation cages. The cod-

line was left untied in the case of the control hauls. Divers observed the cages three times per day over a 6-day period, removing dead fish and feeding the survivors. On average, 93% of the red mullet, and 100% of the annular seabream and auxiliary seabream in the three test cages survived during the observation period.

16.21 Upwelling mechanism associated with Osima Island, Japan

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Abstract

Oceanic islands induce complicated flow fields and cause some important phenomena such as upwelling around the islands. The upwelling and mixing are major processes for the elevated level of primary production around the island. The poster deals with possible upwelling mechanism associated with Osima Island and effects on fishing near to the coastal zone of the continental shelf of Japan and the Kuroshio Current. The objectives of the study were to gain an understanding of the feature of the upwelling associated with an island and describe the local primary productivity. It has focused observational efforts on the Osima Island. Measurements of the ocean phenomenon are important for oceanography, fishery studies, and the monitoring the coastal environmental features.

16.22 Length-weight Relationships of Fishes Captured Around Uzunada (Izmir Bay, Aegean Sea)

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Abstract

Weight–length relationships (WLRs) are presented for 61 fish species captured from Uzunada (Izmir Bay, Aegean Sea). Samples were collected using bottom trawls (mesh sizes 22 and 24 mm stretched codend mesh sizes). The b values in the WLR W=aLb varied between 1.669 and 3.781 and showed a mean value of 3.051 (S.E. = ± 0.037) more than 50% of the values ranged between 2.912 and 3.189.

Keywords: Weight–length relationships; Izmir Bay, Aegean Sea.

16.23 Bottom trawl fish composition around Uzunada (Izmir Bay, Aegean Sea)

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Abstract

The environmental conditions and the structure of the seabed of the Aegean Sea have resulted in the settlement of various species. It is known that approximately 200 macroalgae, 5000 invertebrates and 388 finfish species now inhabit the Aegean Sea (Kocataş and Bilecik, 1992; Bilecenoglu *et al*., 2002). Izmir Bay, one of the biggest bays located in the East Aegean Sea, has been subjected to domestic and industrial sewage for the last 50 years, and because of this

pollution, the species composition has been badly affected, particularly in the inner and middle parts of the bay. This present study is aimed to provide recent information on the structure and composition of the demersal fish fauna caught by trawling in Uzunada, Izmir Bay. This study forms part of the 2004/SUF/004 project, supported by Ege University financially and Faculty of Fisheries.

16.24 The effects of polyamide monofilament and multifilament netting rope on the catching efficiency and species selectivity that used on red mullet gillnets

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Abstract

The catching efficiency of gill nets is affected by netting material, mesh size, hanging ratio and visibility of the nets etc. In this study, comparing the catching efficiency of gillnets two different netting materials, Nylon (PA 6, monofilament) and fibers of the polyamide (PA6.6, multifilament), were used. This study was conducted between September 2003 and May 2004 in Izmir Bay, Turkey. Gillnets were deployed in the same area, with all nets having the same technical properties as mesh sizes, hanging ratio, and depth. A total of 32 species were caught during the study, with 16 commercial species and 16 were non-commercial. The monofilament gillnets caught 15 commercial, and 13 non-commercial species, while the multi-monofilament caught 10 commercial and 13 non-commercial. The monofilament nets had a greater catching efficiency than the multi-monofilament. Despite the result of this study, the commercial fishermen generally do not use monofilament gillnets, because of the high price of the nets, difficulty of repair, and also high discard catches.

Keywords: Gillnet, polyamide, monofilament, multi-monofilament, İzmir Bay, discard.

16.25 Reduction of Bycatch in Shrimp (*Parapenaues longirostris*, Lucas 1846) Beam Trawl Using Separator Panel in Marmara Sea

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Abstract

Traditional and modified beam trawls used for pink shrimp in the Marmara Sea were compared to measure the reduction in bycatch. It was found that the modified gear reduced the bycatch for benthic and demersal organism by approximately 50%. This is important for the conservation of biodiversity in the benthic and demersal ecosystem.

16.26 Small scale fishing gear designs in Homa Lagoon, Izmir Bay

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Abstract

The fishing operational methods have been varying notably for the categories have different of fishing gear type and shape. Therefore, it is impossible to cover in a single work for all the numerous possible variations of the different fishing methods. This study was to put three small scale fishing into consideration in Homa Lagoon. The lagoon has 1852 hectare area and almost 1 m depth and located in northern part of Izmir Bay (Turkey). In the Lagoon, fish capturing mainly have been by catching chamber made from woods and reeds. However, different fishing gears have been used by the lagoon fishermen in order to decrease fish excessive on catching chambers during the harvest period. These gears comprise three styles of fyke nets, six styles of trammel nets and a veranda net. One of these fyke nets has used for crab catching, the others for eel fishing while veranda net is used only for grey mullet catching. The trammel nets have large sizes of catch composition. Aim of the demonstrations was determined all of the small scale fishing gears designs and theirs scheme were showed according to FAO Catalogues.

16.27 Fisheries in Iskenderun Bay

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Abstract

Iskenderun Bay is located at the north-eastern corner of the Eastern-Mediterranean Sea with an area of approximately 2275 km^2, and a width of approximately 35 km. The primary production of the Mediterranean is low. But despite this, Iskenderun Bay is not as oligotrophic as the eastern Mediterranean. It is pointed out that production in Iskenderun Bay is 2 to 4 times higher than that of offshore areas of the eastern Mediterranean. Fishing gears used in Iskenderun bay are divided into lines (longlines), set nets (gill nets and trammel nets), trawls and purse seines. The former two are used mainly in small-scale artisanal fisheries and the latter two are used in large-scale industrial fisheries. There are 50 fish species and 10 invertebrate species considered commercially important in the region. In terms of the catch amount, sardines are the most abundant species, followed by lizardfish, red mullets, shrimp and horse mackerels. One of the main problems related to fisheries in Iskenderun Bay is the decline of stocks. There are several factors causing this, which are Over fishing, Illegal fishing, Pollution, few Statistics, Structure of fishing cooperatives.

16.28 Gillnet selectivity for *Diplodus annularis*, *D. vulgaris*, *Mullus surmuletus*, *Spicara maena flexuosa*, *S. smaris* and *Serranus scriba* in Turkish Coast of middle Aegean Sea

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Abstract

In this study selectivity parameters of annular sea bream (*Diplodus annularis* Linn., 1758), common two-banded sea bream (*Diplodus vulgaris* Geoffroy Saint-Hilaire, 1817), striped red mullet (*Mullus surmuletus* Linn., 1758), blotched picarel (*Spicara maena flexuosa* Rafinesque, 1810), picarel (*Spicara smaris* Linn., 1758) and painted comber (*Serranus scriba* Linn., 1758) at 36, 40, 44, 48, 50 and 56 mm mesh size nets were researched. Study was conducted between December 1998 and November 2000 in the area between Foca (north) and Sigacik Bay (south). In conclusion selectivity parameters of annular sea bream and two banded sea bream at 36–56, striped red mullet, picarel and painted comber at 36-56 and blotched picarel at 36–50 mm mesh sizes were determined.

17 National reports

17.1 Belgium

Institute for Agricultural and Fisheries Research – Unit Animal, Fishery (former Agricultural Research Centre Ghent – Sea Fisheries Department)

J. Depestele, E. Vanderperren, H. Stouten and H. Polet

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) is in its final stage. No effective way was found to reduce cod bycatches in beam trawls.

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. A series of trials with selective designs (lowered headline and BACOMA-codend) have been carried out on RV BELGICA in April and September 2005. The reduction of cod bycatch is low. Further sea trips are planned on a commercial vessel in 2006.

Mesh measurement

The OMEGA project has been finalised. The International Council for the Exploration of the Sea (ICES) has decided to replace the ICES gauge by the OMEGA gauge as the standard gauge for research activities. The mechanical ICES gauge was in use since 1962. Instructions for the use of the new standard gauge are given in the *ICES Cooperative Research Report No. 279* "Protocol for the Use of an Objective Mesh Gauge for Scientific Purposes". The Directorate-General for Fisheries and Maritime Affairs of the European Commission is considering the introduction of an objective mesh gauge for legal purposes. With this aim Commission Regulation (EC) No 129/2003 laying down detailed rules for determining the mesh size and thickness of twine of fishing nets, will be reviewed in line with the conclusions and recommendations presented in the final report of the OMEGA project. The draft of the

new regulation will be presented to the EU Expert Group on Fisheries Inspection later this year.

Reduction of discards in flatfish beam trawls

In a national project "Innovation Centre for Sustainable and Ecological Fisheries" (project n° VIS/02/B/05/DIV), partly financed by the Flemish Community and partly by the European Commission modifications to the flatfish beam trawl are inventoried. The T90-codend and the benthos release panel were selected for trials aboard a commercial vessel. Three commercial sea trips with observers from the Sea Fisheries Department were conducted in August, September and November 2005 in ICES-zones VIIa and VIIf. From August 2005 until now catch comparison data were collected for commercial fish species on board the same commercial vessel. In April 2006 another commercial sea trial is planned with the combination T90-codend and benthos release panel in the Eastern Channel (VIId). One sea trip with observers is scheduled for April – May 2006 to test if the combination of T90-codend and benthos release panel can be combined with big mesh modifications in the back of the beam trawl.

The EU-project "Development of fishing Gears with Reduced Effects on the Environment" (DEGREE) (Contract SSP8-CT-2004-022576) has started in February 2006 and is set up to continue development of the modifications to the beam trawl for a possibly voluntary implementation in the Belgian flatfish beam trawl fleet.

Potential for shifting gears

The national project "Innovation Centre for Sustainable and Ecological Fisheries" (ut supra) is continued and aims at the introduction of more environmental friendly fishing methods. The programme involves making an inventory of fishing methods worldwide including an extensive evaluation of their environmental impact and the exploration of impact mitigating technical modifications in existing gears. Two fishing methods have been selected as more environmentally friendly and less fuel intensive. To ensure their applicability in the Belgian context however, two follow-up projects have been proposed to evaluate their technical feasibility. The first proposal aims at the further development of an electrified beam trawl for shrimp fisheries and the second aims at evaluating the replacement of the beam trawl by otter trawls on the outriggers.

Evaluation of shifting gears

The Belgian fleet is unilaterally structured. Over 90% of the Belgian fleet are beam trawlers. Beam trawl fisheries are known to create high costs and have a significant, well studied and well known impact on commercial and non-commercial fish and invertebrate species. Diversification is desired to ensure the sustainability of the fleet, both economically and ecologically. As stipulated above, the technical possibilities of shifting to gears thought to be more environmentally friendly and to have a higher cost-effectiveness, are investigated.

A proper and more detailed evaluation of the economical impact of adopting new gears is however also needed. In the EU-project DEGREE (ut supra) the economic impact of adopting new fishing gears will be investigated. A doctoral study will complement these results and investigate in depth the economical consequences of shifting gears. A more detailed ecological impact evaluation will be conducted as well by an intensive desk study. Two fishing methods, flatfish beam trawling and trammel netting, are chosen as case study for economical and ecological impact evaluation, as these fishing methods have proven to be technically feasible in the Belgian situation.

New fisheries

A new fisheries for the Belgian fleet, namely with hook-and-line-fishery, will also be tested in a national project called "Project Alternative Fisheries" (project n° VIS/02/B/07/DIVb). The aim of this project is to explore possibilities for new fisheries for the coastal community. Sea trials on a commercial vessel are planned for 2006.

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 2006–2007 – 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).

Reduction of discards in flatfish beam trawls

National project:

- Running: "Innovation Centre Sustainable and Ecological Fisheries" (project n° VIS/02/B/05/DIV)

EU-project:

- Running: "Development of fishing Gears with Reduced Effects on the Environment" (DEGREE) (Contract SSP8-CT-2004-022576)

Both projects aim at the investigation of reducing the environmental impact of the beam trawl (reduction of discards of non-commercial fish and invertebrate species and undersized commercial fish species) and the possible solutions to technical drawbacks for voluntary implementation in the Belgian beam trawl fleet.

Potential for shifting gears

The potential for replacement of the flatfish beam trawl by otter trawl on the outriggers will be investigated by several sea trials on board of a commercial vessel.

Evaluation of shifting gears

Methods for ecological and economical impact evaluation will be under development.

New fisheries

National project:

- Running: "Project Alternative Fisheries" (project n° VIS/02/B/07/DIVb)

First trials on the development of new fisheries will be conducted.

Balancing Impacts of Human Activities in the North Sea

The project "Balancing Impacts of Human Activities in the North Sea" (BALANS) will end in September 2006.

17.2 Canada

Stephen J. Walsh, Canada

CANADIAN ACTIVITIES IN 2005 AND 2006

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

Longlining for Haddock:

A comparative longlining experiment was conducted on the Canadian side of Georges Bank to determine the selectivity and performance of Norbait 700E, an artificial bait produced by Norbait DA of Norway. Although the artificial bait had a slightly lower CPUE for haddock than the traditional bait, it did have a number of positive characteristics. It caught comparable size ranges of haddock, 50–70% less bycatch, hooked in a similar position, and had less waste and smell than the traditional mackerel bait. *Contact: Philip Walsh (Philip.Walsh@mi.mun.ca)*.

Snow Crab Pot Selectivity:

Based on the results of earlier experiments, escape mechanisms were introduced into the 2005 snow crab fishery for commercial trials. Catch data showed that installing three mechanisms around the bottom of the trap resulted in reduced numbers of under-sized crab coming to the surface and being discarded. *Contact: Paul Winger (Paul.Winger@mi.mun.ca).*

Multi-level Trawl for Northern Shrimp:

A multi-level shrimp trawl was designed, flume tank tested, and built for the purpose of investigating vertical size and density distribution around Newfoundland. Based on the results of 3 trips (35 tows), the data indicate strong variability in vertical size distribution and increased densities in the lower codends. The results have lead to the design and testing of a new low profile wide opening trawl design. *Contact: Harold DeLouche (Harold.DeLouche@mi.mun.ca).*

Sea Cucumber Drag Performance:

Underwater observations of a commercial sea cucumber drag were collected to determine drag performance and capture efficiency. Preliminary indications are that the gear is tremendously efficient early in the capture process; but that significant losses of catch may be occurring through mesh selectivity and poor haul-back procedures. *Contact: Paul Winger (Paul.Winger@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.

Survivorship was found to be dependent on tow duration, water temperature, fish length, air exposure duration, and degree of mucus loss. *Contact Scott Grant (Scott.Grant@mi.mun.ca)*.

ACTIVITIES IN 2006

In 2006, research initiatives at CSAR are being directed toward:

- development of new shrimp trawl designs
- live release protocols for American plaice
- the reduction of seabed contact by bottom trawl gears
- longlining experiments through the ice in northern Canada
- commercial trials of alternative trap designs for snow crab
- commercial trials of baited pots for Atlantic cod

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Fisheries & Oceans Canada

ACTIVITIES IN 2005 AND 2006

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

In 2005, a series of comparative fishing experiments were carried out utilizing all three survey bottom trawls currently used for annual resource assessment in Atlantic Canada. This was year 2 of the calibrations. These calibration experiments involved two research vessels towing side by side and examine the selectivity and efficiency of all three bottom trawls. The goal was to derive vessel conversion factors for two vessels and one gear, and a one gear conversion factor for a new survey trawl for Quebec region (also moving from 30 minute tows to 15 minute tows). All 4 Atlantic Fisheries and Oceans Institutes participated. Preliminary analyses concentrated on using logistic modelling and some promised was shown in the used of general linear mixed modelling which considered between haul variation and was more flexible with outliers. Further modelling work is expected in 2006.

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Estimating the effect of shrimp trawling on snow crab mortality.

A study was conducted during spring-summer 2005 to address the hypothesis that the shrimp fishery imposes a substantial mortality on snow crab, which has negatively impacted the exploitable biomass in NAFO Divisions 2J and 3K. The study utilized two experimental approaches. Firstly, remotely operated vehicles were employed (in St. Mary's Bay) to directly observe and record encounters of snow crab with shrimp trawl footgear, and to observe the condition of snow crabs remaining in experimental trawling corridors after encountering a shrimp trawl. Then, secondary trawls were employed in Div. 2J and 3K to collect snow crabs after encountering shrimp trawls, and quantify injuries incurred. The direct observations in St. Mary's Bay trawling corridors showed no evidence of immediate mortality on snow crab due to trawling. Those observations, as well as secondary trawl experiments in Div. 3K, did suggest that encountering trawl footgear was associated with increase in leg loss. However,

those results were not supported by other data on leg loss. Overall, there is no evidence that the shrimp fishery imposes a substantial mortality on snow crab. Indirect mortality on pre-recruits released in the snow crab fishery could represent a more important source of mortality than the shrimp fishery. It is recommended that more data be collected from direct observation of snow crab encounters with trawl footgear, and that the effect of leg loss on snow crab mortality be investigated. Also, the relative effects of the snow crab versus the shrimp fisheries on snow crab mortality and recruitment should be investigated.

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Effect of soak time on cod mortality between longline and gillnets.

A series of parallel fishing sets were conducted in order to examine the mortality associated with soak time in the northern Gulf cod within the sentinel program (www.osl.gc.ca). Soak time varied between 6 and 84 hours. Dead fish were noted as the gear was hauled. Mortality was low for both gears at 6 hours soak time (<5%), however, mortality in gillnets raised to 30% with 12 hours soak time and continued to increase to 65% at 48 hours. Longline mortality never exceeded 10% even at 84 hours soak time. Such mortality in gillnets may lead to higher discarding.

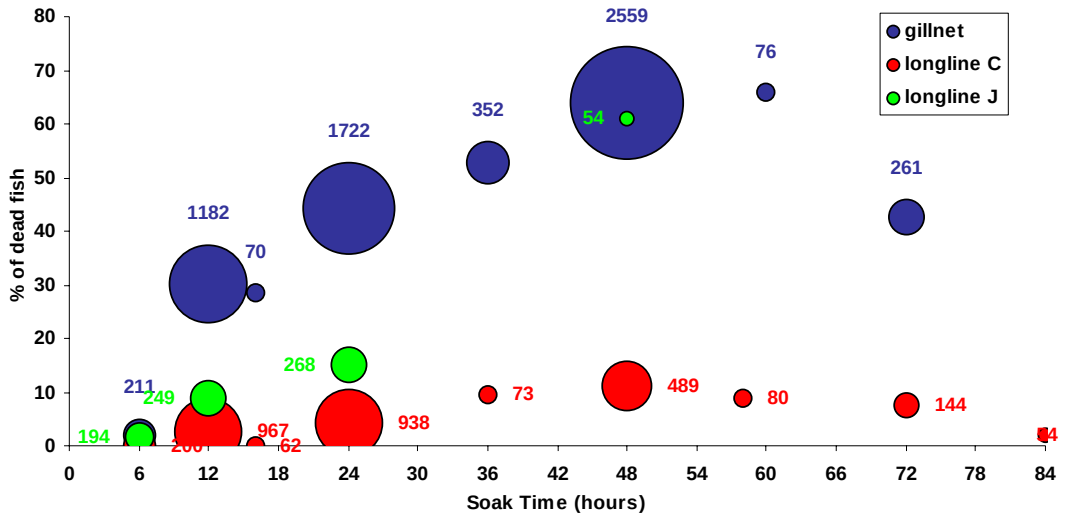

Figure 1: Effect of soak time on cod mortality using gillnet or longline (n = sample size).

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17.3 Faroe Islands

Effect of colours of gillnets.

The effect of different colours of gillnets for monkfish was tested in 2005. The fishing efficiency of the different coloured nets varied much during the experiments and no significant difference was seen. The experiments will continue in 2006 with more colours of gillnets.

Effect of fishery on coral areas

Coral 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 2006 and 2007 and more detailed mapping will be undertaken. This information will be used in the discussion with stakeholders on preserving coral reefs.

Sorting grid in blue-whiting trawl

The fishery for blue-whiting is one of the most important pelagic fisheries in the North East Atlantic. Sometimes there is a bycatch problem in Faroese and Icelandic waters. The by-catches consist mostly of saithe and cod. The fishing industry and the fisheries ministry carried out a project with the aim to reduce this bycatch problem. Different grid types have been tested and the result is a reduction of 95% of the bycatch and 1 – 2% a loss of the target species. The best suitable grid was a "Flexi-grid" which is known from salmon farming industry.

Ground-gear development

Experiments to reduce the impact on the bottom from trawl ground-gear have been carried out in recent years mainly using underwater video observations. This work will continue as cooperation within the EU project 'DEGREE'.

Development of static gear

Development of fish pots for traditional species (cod, haddock and saithe) was initiated in 2005. Existing and new design of pots have been tested using underwater video observation. This work also includes development of long-lasting bait and the use of alternative stimulation to direct fish. This work will continue in coming years.

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17.4 France

Fishing technology unit, IFREMER, FRANCE

Project EU-NECESSITY

Nephrops fisheries bycatches

After the first campaign at sea, carried out in 2004, it was decided with French fishermen and their representatives to test for the next sea trials the combination of a square mesh panel located on the top of the baitings with a flexible selective grid in the extension.

A ½ scale model was built by the Fishing Gear Technology Unit in Lorient then tested in Lorient flume tank. The model was equipped with two small mesh covers, one fitted on top of the baitings above a square mesh panel and the other one behind the *Nephrops* grid. The behaviour of these devices was quite good; the model was presented to the partners at the Nehru's progress meeting hosted in Lorient in March 2005.

Sea tests were then achieved on full size devices (100 mm square mesh panel and EVAFLEX grid with 13 mm bar spacing) onboard the RV "Gwen-Drez" in May 2005. The results will be presented at the next NECESSITY meeting in May 2006.

Ifremer has also launched the work on assessment and simulation of the behaviour of hake and *Nephrops* in front of and inside the fishing gears and selectivity devices that were previously tested. The frame of the work was defined and a working group constituted.

A contract was signed with ENIB, with the objective of modelling the behaviour of *Nephrops* and hakes in interaction with bottom trawls.

The study will (i) formalize the scientific expertise on *Nephrops* and hakes behaviour; (ii) write these behaviours in a specific language (behavioural description language); (iii) and define the typical scenarios of simulation.

Cetacean accidental catches in pelagic trawl fisheries

Tests on escape devices

On the occasion of the workshop hosted in Ifremer flume tank in Boulogne sur Mer (2–4 February 2005), the models of the various excluder devices investigated by the partners, net manufacturers and by French fishermen were shown to the partners involved in the NECESSITY programme, the fishermen and net manufacturers and the fishing authorities.

Tests at sea were carried out from 22 March to 4 April 2005 in the English Channel on Seabass fishery, on a pair of private vessels from La Turballe, the "Rochebonne" and the "Castor".

Ifremer RV Gwen Drez was also on site to carry out acoustic tests and provide technical assistance to Ifremer technologists and CRMM biologist operating onboard the professional vessels.

The main objectives of these trials were to check whether the devices tested enabled catching of seabass in good conditions, whether there were technical or handling problem and if possible, and if we were lucky, to demonstrate that they were able to let dolphin escape.

Three selective devices were tested:

i) A barrier developed by industrialists, consisting of a 300 mm side square mesh tilted panel, fitted in the baitings

ii) A vertical barrier of 300 mm side square meshes placed in the body of the pelagic trawl (in the part constituted by 100 mm side meshes)

iii) A semi-rigid oval grid fitted in the extension of the pelagic trawl

From these trials, the fishermen and technologists agreed on the fact that a vertical barrier is better than a tilted one.

i) A vertical barrier must have reasonable dimensions (4 to 5 m width). 300 mm side square meshes seems fit to both fish and stop dolphins.

ii) The flexible grid is of easy handling. It seems that fishing is good even though clogging phenomenon is observed in case of large Seabass catches. In case of very large catches (several tons), this could be a technical problem. To solve this problem, bar spacing could be increased to 300 mm and the bars could be cylindrical instead of rectangular.

iii) The double overlapping panel over the longitudinal escape trap fits perfectly.

iv) The escape trap must start right at the point the barrier is fitted onto the trawl

v) Only a few dolphins were observed around the boats during the campaign and no dolphin got caught in the trawl, even though twice, common dolphins were observed playing with the floats of the trawl.

The next steps will be:

i) To carry out another campaign on a pair of Seabass trawlers next winter (February 2006) to try to get videos of dolphins escaping and to confirm the good results on fishing with 2 devices : the vertical barrier with 300 mm

side square meshes and the improved flexible grid (300mm bar spacing and cylindrical bars).

ii) to convince the fishermen and authorities to carry out validation tests of the best devices selected (significant number of hauls with observers aboard).

Development and tests of acoustic deterrents

Laboratory experiments to determine the acoustic parameters of existing pingers were done by Ifremer. The results are in concordance with the specifications published by the suppliers.

Ifremer has developed a prototype acoustic deterrent. Non interactive, this device is nevertheless suited for pelagic trawls and can be integrated into some fishing acoustic sensors.

The system has been developed in laboratory by taking into account the biological and acoustical knowledge (hearing parameters) of some dolphin species. A second step was achieved by the French company Ixtrawl to integrate the deterrent system into a fishing sensor (a depth net sensor).

Field assessment were done by IFREMER and CRMM (French Research Center on Sea Mammals) to compare the effectiveness on specific cetacean species through experimentation on common dolphin in south Brittany end August 2005. Four commercial pingers and the Ifremer-IXtrawl prototype underwent 3–5 trials, the distance between source and animals being made as a variable under control. Deterrent effect was obtained in all trials with one commercial pinger and with the Ifremer-Ixtrawl prototype. The behaviour of animals with obvious deterrent reaction was characterised. Video footage was also collected by CRMM during the tests. The prototype was set horizontally for the trials, with tested distance of 100–300 m.

Next bass season Ifremer will conduct sea trials on commercial vessels to test the Ifremer-Ixtrawl prototype in fishing conditions.

Work in Madagascar on energy savings in shrimp trawls.

The Ifremer team has measured the forces and geometry for different speeds on existing shrimp trawls, both single and twin trawls. Trawls were simulated with DynamiT software and optimised trawls were proposed to the fishermen. Complementary tests were carried out in Ifremer Lorient Flume tank to optimize the rigging of the doors. Fishing efficiency of the optimized trawl was confirmed and comparative measures will be carried out in 2006 to assess fuel economy.

Mediterranean trawl selectivity

A workshop was hosted in Sète, in February 2005. It was attended by some thirty scientists of Mediterranean countries, north European and South American countries. The main goal was to harmonize the investigation methods taking into account the great diversity of métiers and the objectives toward resource preservation fixed by both the European Commission and the National Fisheries Committee.

Turtle Excluder Devices (TED)

After preliminary tests in IFREMER's Boulogne sur Mer flume tank, trials on Turtle Excluder Devices (TED) were conducted both in Madagascar and in French Guyana, on shrimp trawls. The devices were optimized in respect of US regulations so that they are most efficient on turtle escape and minimize the losses of shrimps.

Long line fishing in the Bay of Biscay Tuna fishery

Tests were carried out in the Southern Bay of Biscay, on automatic Tuna long line fishing as an alternative to trawling. Different technical and-economic scenarios were studied to determine new potential strategies to catch Tuna.

Impact of the fishing gears on the sea bottom

The studies have been carried out since 2000. In 2005, two campaigns totalling 25 days at sea aimed at assessing the impact of new light sweep lines on the benthic organisms versus the steel ones usually implemented by the fishermen. Tests were then completed to assess the efficiency of such a device in fishing conditions.

Project EU-OMEGA

Ifremer hosted in Lorient the final meeting of the EU project OMEGA. With the aim to develop a new, objective, mesh gauge, the R&D and Demonstration project "Development and testing of an objective mesh gauge", known as the OMEGA project, coordinated by CLO DVZ (Belgium) was started in 2002 within the Fifth Framework Programme of the European Commission. The main objective of the project was to build and test a new, objective mesh gauge, suitable for fisheries inspection, fisheries research and the fishing industry. In support, a protocol was written for using the new mesh gauge for control and scientific purposes. This gauge, recommended by WGFTFB 2005, is now available.

Development of numerical trawl simulation tools

As part of project EU-PREMECS 2, the full dynamics of the trawl doors was integrated in the modelling software. This step represents a major advance which will enable in the future to model accidents such as obstructions.

As part of project EU-NECESSITY the possibility of physical modelling selective devices (mainly selective grids) was added to the software. Year 2005 will be dedicated to finalise the development and test of rigid grid. Comparison with scaled models, for grid, will be carried out in 2006. Other selective devices will also be considered in 2006.

The European project PREMECSII, coordinated by IFREMER, finished in 2005. This project carried out in partnership between IFREMER, MARLAB (UK), CNR/ISMAR (IT), ENIB (FR) and DIFRES (DK) enabled the development of a predictive model of codend selectivity. This model is able de assess the influence on selectivity of various parameters such as mesh size, twine material, twine diameter, and the behaviour and shape of the fish species.

17.5 Germany

Institute for Fishing Technology and Fishery Economics (presentation: Erdmann Dahm)

Federal Research Center for Fisheries, Hamburg

Technical- biological investigations:

1. Selectivity of cod trawls in the Baltic

With effect from 1 January 2006 on the EU Commission has included into its new regulation on technical measures codends made from netting turned 90 degrees (T90) as legal alternative to the existing BACOMA codend. This takes into regard the longterm Polish- German cooperation on this subject.

2005 was used to determine details of the coming regulation. During the course of this development stiff core-sheath netting had gained more and more ground in the fishery and the

regulation had to take regard of that to avoid again the bycatch disaster, which had happened in diamond mesh codends with the earlier changes in mesh size. From previous experiments twine diameter and codend circumference in relation to the joining at the tapered parts of the trawl were thought to be crucial for optimum performance in T90 codends. This was confirmed in a cruise of FRV "Solea" in spring. With an inadequate circumference reduction none of the codends tested showed the same selection performance as the Bacoma codend used as reference. Within the codends tested, however, made from twine diameters of 4, 5 to 6 mm single and 4 mm and 5 mm double no significant differences in selection performance could be detected. Thus, twine diameter seems only to have minor importance on the selective efficiency of T90 codends. With adequate reduction to a 1 to 2 relation the selection is equal or better as with the Bacoma reference codend as experiments in a second cruise in autumn on FRV "Solea" demonstrated again. That does even not change with changes in circumference or twine used in the extension.

The experiments were accompanied by material tests of the netting used in the laboratory of the IFF. A further confirmation of good selection performance was found when using a T90 codend on a small sidetrawler and also in experiments after five months of use on a commercial trawler. Thus, the concern that T90 codends might lose progressively their optimum properties with duration of use cannot be supported from existing evidence.

2. Selectivity of eel in trawls in the Baltic

Experiments with a horizontal sorting grid in an eel trawl were continued. They succeeded in a remarkable reduction of the bycatch. However, this was also accompanied with a loss in catching efficiency of the target species. Ways to improve this again are currently under consideration.

3. Participation at research on the protection of small cetaceans in big trawls

IFF participated with a cruise of FRV "Walther Herwig III" at the EU-Project "Necessity", coordinator RIVO, where different devices were tested either to chase small cetaceans out of big pelagic trawls or to enable their escape. A tunnel barrier showed least negative effects on target species. Though present in higher numbers in the vicinity of the towed trawl no small cetaceans were caught.

4. A new theoretical model for the optimum exploitation of the Baltic cod stock

This model investigates the effects of a large increase of mesh size compared to other technical means as e.g. temporary or local closures or minimum landing size. It comes to the interesting conclusion that exploiting the stock at a higher age with no effort reduction has much higher benefits both for the fish stock and the fishery as the artificial reduction of the fishing effort by hardly controllable means. Benefits for the discard issue would also be obvious.

Technical investigations:

5. Progress with a cableless video- transmission system

Both versions of the surface towed intelligent powered vehicle (STIPS) with wireless transmission of video and control signals are now, after a refit of components, fully operational and have been successfully used in 5 cruises of FRV "Clupea". A digital video recording system and a signal transmitter allowing for the use of the system on bigger vessels were purchased and will enlarge the applicability.

6. A new mesh measuring device

The IFF was actively involved into laboratory and field tests of a prototype of the new OMEGA mesh gauge, demonstration events for possible users and the final report of the project. Caused by an initiative of the IFF the range of application of the instrument could be augmented to measuring setnets.

7. A new research ship

After participation at the maiden trip of the new FRS "Solea" activities of the IFF are now focusing on the task-related design of a replacement vessel for FRV "Clupea". Different preliminary general arrangement plans were designed in the IFF and by other participating authorities and presented for discussion. The invitation for tenders is expected in near future.

University of Rostock (presentation: M. Paschen)

Department of Mechanical Engineering and Marine Technology, Chair of Ocean Engineering

1. Activities in the field: Fishing technology

The forepart of some types of modern pelagic trawls is commonly made from special ropes. The material which they consist of is a high-strength one. In addition some fishing gear manufacturers use hawsers which are equipped with so-called helical strakes or spirals on their surface. Their argument is to influence fruitfully the hydrodynamic forces acting on theses ropes. To analyse the practical effects experimental investigations as well as numerical simulations were done.

Measurements show that the hydrodynamic loads of new ropes which are equipped with additional spirals differ from those which have not got spirals. The coefficient of the hydrodynamic drag is in every case higher (10 percent and more) when spirals are used (the basis is the significant diameter of the rope; the angle of attack had been varied from zero to 360 degree). The lifting force is comparable between both variants. The transverse force is much higher when spirals are used.

Computer simulations show that spirals have got effects for the net geometry because of the higher drag and the transverse force. If these ropes are correctly placed the application of helical strakes can lead to additional spreading forces of the gear. But, if they are used in a wrong position of the gear the application will be inefficient for the fisherman (see Winkel, Paschen: "Investigations on the Fluid-Structure Interactions of Fishing Nets")

The positive effects mentioned above do apply if the material is new. During use the original structure of the spirals can be damaged. That means the only effect will be an increased drag of the gear.

2. Activities in the field: Observing of fish behaviour

The Chair of ocean engineering is responsible for the development and operation of the technical equipment of the multidisciplinary project "Artificial reef in the Southern Baltic Sea" (water depth 12 metres, 1.5 miles far from the shore). One of the main targets of the project are long-term investigations of the individual behaviour of fish in its natural habitat. One of the topics is to observe the fish behaviour online by means of eight to ten underwater video cameras (see Korduan, Niedzwiedz, Lämmel: "Application of classical methods of survey in modern fishery research"). The introduction of digital photography and more simple methods of evaluation allow performing a three-dimensional survey of objects under water.

3. Selected papers

Mathias Paschen: Prediction of the dynamic behaviour of pelagic trawl doors

DEMaT'05 – Seventh International Workshop on 'Methods for the Development and Evaluation of maritime Technology' 23 – 26 November 2005, Busan, Korea

Abstract

The development of modern designs of fishing gears requires the availability of adequate numerical algorithms for a trustful calculation of all relevant elements of the gear.

Trawl doors have an important influence on the geometry and the kinematic behaviour of pelagic trawls. In this context they are responsible for the distribution of strength in the forepart of the trawl, for the drag and for the manoeuvrability of the whole fishing gear.

Different methods and mathematical models with six degrees of freedom (of the trawl doors) will be presented for the calculation of fixation coordinates of different types of door trawls under defined conditions as well as for the simulation of dynamic motions of pelagic trawl doors.

Selected results will be presented and discussed by the aspect of different trawl parameters and changeable operational conditions.

Mathias Paschen: Seabed-Structure-Interactions of selected Fishing Gear Elements

DEMaT'05 – Seventh International Workshop on 'Methods for the Development and Evaluation of maritime Technology', 23 – 26 November 2005, Busan, Korea

Abstract

Ropes, wires and chains as well as towed under water cables and umbilicals are typical structures respectively elements which are used in bottom trawling, in oceanographic engineering or in other fields of ocean technology.

Generally they are strained by different external loads like hydrodynamic forces and friction.

Whereas the number of those contributions rises and rises since decades which analyse selected subjects of fluid-structure-interactions of smooth cylinders, twisted ropes, wires, cables, etc. scientific investigations dealing with the physical phenomenon of seabed-structure-interactions of these elements are obviously seldom.

But, basic knowledge in this subject could lead to improved technologies characterized by a reduction of both drag and environmental impacts as a consequence of friction and sediment transport initiated by the towed marine elements.

The paper will give an overview of useful experimental methods as well as on fundamental results of model tests in a towing tank and full scale experiments at sea.

Peter Korduan , Gerd Niedzwiedz , Dirk Lämmel:

Application of classical methods of survey in modern fishery research

DEMaT'05 – Seventh International Workshop on 'Methods for the Development and Evaluation of maritime Technology', 23–26 November 2005, Busan, Korea

Abstract

Already in the middle of the 1970s in the development of new trawls in East Germany stereo photogrammetry has been used for contactlessly measuring the shape of fishing gear models

for example in the wind tunnel. In connection with the scientific work on an artificial Baltic Sea reef the idea of a remote controlled size determination of single individuals has been developed with respect to the fish concentrations proven by means of underwater video observation. Financial expenses and the expenditure of technical devices that are necessary today for underwater stereo photogrammetry can not be compared to applications in former times. The introduction and further development of digital photography and more simple methods of evaluation now allow performing a three-dimensional survey of objects under water at much lower costs. Although the theoretical research in the field of the multi-media photography has made big progress, there are still relatively few cases of practical application so far with corresponding considerations of accuracy. The development – and in particular the practical long-term employment of a specially manufactured stereo underwater camera – supply new realizations in this respect. The contribution deals with the characterization of the survey system in the framework of the scientific work spectrum on the artificial reef, reflects on the technical realization and presents first results.

H.-J. Winkel, M. Paschen:

Investigations on the Fluid-Structure Interactions of Fishing Nets

25th International Conference on Offshore Mechanics and Arctic Engineering, 4–9 June 2006, Hamburg, Germany

Abstract

Modern nets consist of meshes made of threads or twines with spirals or helical strakes. Fluid-structure interactions have been investigated in Rostock for a long time applying different theoretical models. Because of great net flexibility there is a need of calculation methods which consider the main physical qualities. This is done by the approximation of wake of threads by results from circular cylinders and influence of circulation, which is known from measurements of transverse force. Results of measurements with two models with and without spirals are given for comparison.

17.6 Iceland

Size selectivity in ground fishery

Three surveys have been carried out in selectivity trials for grids, BACOMA and codends with different mesh sizes or types. Most of the data collected was done with twin trawling. Species in focus was cod and haddock, but all bycatch was measured or counted. Most of the data have been analysed and the report and paper is in product.

Contact Haraldur Arnar Einarsson, haraldur@hafro.is.

Species selectivity in pelagic fishery

Several trials have been contributed with sorting grid similar to the sorting grid in herring trawls, which have been in trial in the IMR-Bergen, and in Faroe Islands. The grid system needs development to fit to the large meshed blue whiting pelagic trawls. The bar distance will be 55 m. Trials will mainly focus at the blue whiting fishery with bycatch of saithe and cod. Some sea trials have been done and filming with ROTV, more developing is needed and is in work.

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

Research into pelagic trawling

In Icelandic waters much effort is exerted by the fleet using large meshed pelagic trawls (Gloria) and possibly 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 some filming with ROTV have been done but still with no clear results. This program is in prior and more work must be done, possibly in cooperation with other nations with similar problems.

Cooperation with the Hampidjan Ltd. 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. Some data is possibly needed but the work in results is in process. Ólafur K. Pálsson, Hjalti Karsson, Haraldur A. Einarsson.

Contact Haraldur Arnar Einarsson, haraldur@hafro.is.

Filming bottom survey trawls.

A survey in 10 days will be carried out in April to film with ROTV two types of research bottom trawls. Different codends will be filmed as well (BACOMA, T90° and more). Measurements' on vertical and horizontal opening in different places will be recorded. New type of trawl will hopefully also be filmed (bottom trawl mate of T90° net only).

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17.7 Ireland

Contact: Dominic Rihan, Irish Sea Fisheries Board, (BIM) rihan@bim.ie

EU Necessity project

The Marine Technical Section of BIM continued its work on selective gear in the *Nephrops* fleet as part of the EU funded NECESSITY project and during 2005 two further trials were completed following on from the work carried out in 2004. The first trial on the Clogherhead vessel "Celtic Venture" tested a modified inclined separator panel similar to the original separator panel tested in previous years in the Irish Sea. The results from this trial gave encouraging separation to a top retainer codend for whiting and haddock of 77% and 69% respectively, which was similar to the results obtained with the original panel design. The second trials tested an experimental trawl design with a reduced top section. This novel design was tested in the important "Smalls" *Nephrops* fishery aboard the Clogherhead vessel Mary Margaret. The trials were a success and along with a reduction of over 50% for whiting and hake, the so-called "coverless trawl" gave increased prawn catches by an average of 13% over the standard trawl design. As a conservation measure this design demonstrates that a substantial percentage of whitefish can be lost while retaining and even increasing *Nephrops* catches.

On the cetacean side of the NECESSITY project, BIM continued to work with Aquatec Subsea Ltd in the UK in developing an interactive acoustic deterrent device to reduce cetacean bycatch in pelagic trawl fisheries. A prototype unit was constructed in February and verification trials to test whether the interactive firing system would respond as designed to

echo-locating dolphins. Trials were successfully completed at the Kolmarden dolphinarium in Sweden with bottlenose dolphins in March 2005. The next phase in the development of the interactive system involved field tests in the Shannon Estuary in Ireland with wild bottlenose dolphins in July. BIM, Galway and Mayo Institute of Technology (GMIT) and the Irish Whale and Dolphin Group (IWDG) conducted this study. This trial aimed to test the response of dolphins to the interactive pingers and also the continuous pingers originally developed by Aquatech Subsea Ltd for BIM. A dramatic and distinctive change in dolphin behaviour was observed in 75% of deployments with both types of active pingers clearing showing a deterrent effect. Further sea trials in early 2006 with common dolphins on the south coast of Ireland gave less encouraging results and have shown differences in behaviour between different cetacean species.

Environmentally-Friendly Fishing Methods

Continuing its promotion of environmentally-friendly fishing methods, BIM conducted a number of gear trials in 2005.

- As a follow up to the DEEPNET report produced in 2004 that highlighted sustainability issues regarding deepwater gillnet fisheries in the NE Atlantic, technical staff from BIM with assistance from Norwegian experts completed an extensive gill net retrieval survey on board the Killybegs vessel "India Rose" during August-September. The vessel surveyed grounds for lost nets both at Rockall and also in areas around the Porcupine Bank covering an area of 172 nautical miles. The findings of the survey highlighted the scale of this problem with 35–40 km of lost and abandoned nets recovered. The state of the nets retrieved was generally poor and would suggest they had been in the water for quite some time, yet they still contained huge catches of mainly crabs and assorted fish species, a phenomenon referred to as "ghost fishing". The conclusion from this survey was that there is a need for the immediate introduction of effective management measures in these fisheries to control the quantities of gear being fished and soak time. As a direct result of the findings of this study the EU introduced a ban on gillnetting in depths over 200m in ICES Areas VI and VII, while NEAFC adopted a similar ban in international waters.
- Catch comparison trials were carried out on two seine net vessels "Harmony" and "Roise Catriona" from the south coast. Square mesh panels in combination with 100mm codend mesh size and turned 90 degree 100mm codends were tested with the aim of promoting the use of more selective gear to land larger, better quality fish and reduce the reliance on high volumes of round fish, while maintaining economic viability through increased prices for a "quality" product. The selective gears tested were intended to meet recognised "sustainability" criteria and practices i.e. less bottom impact and low discarding and go beyond existing regulatory obligations. From these trials initial estimates of discard reductions and corresponding losses of marketable fish achievable with the selective gears have been made along with preliminary work carried out by the Resource Development Section of BIM to develop and on board grading and quality control systems. The ultimate goal of this project will be the formulation of a pilot Environmental Management System (EMS), which it is envisaged will define gear parameters, on board handling and grading practices, as well as quality control both on board vessels and also by the Co-op or processor. Problems with experienced with the T90 codends felt to be related to the joining ratio of the T90 to the standard diamond mesh section of netting. Different joining ratios of 2:1, 3:2 and 4:3 were tried but none of these ratios seemed to work, with the T90 net catching very few fish of any size range. It would appear more work is required with T90 codends with seine net gear in order to establish correct appropriate joining ratios.
- Sea trials were conducted in order to assess the performance of commercially available cetacean deterrents in commercial gillnet and tangle net fisheries in response to recent EU legislation making the use of pingers mandatory in bottom

set gillnet fisheries within the Celtic Sea from the 1 January 2006. The findings of these trials highlighted some serious deficiencies in the reliability of all of the commercially available devices and also difficulties in the practical handling of the deterrents. The findings have been presented to manufacturers and research and development is ongoing with a view to producing a more robust and user-friendly device.

- A joint project between BIM and the Irish South West Fish Producers Organisation (ISWFPO), which aimed to develop a system whereby *Nephrops* caught by trawlers could be maintained in a live condition onboard the vessel and onshore until delivered to continental markets, was also carried out in 2005. Considerable progress was made with extensive work on adapting fishing techniques to maximise the survival rates of live *Nephrops* on board the vessels completed. A shore based holding facility was also set up, which will allow stockpiling marketable quantities of live *Nephrops* and keeping them alive prior to transport to market. The use of selective gears to retain only the larger size *Nephrops* and to reduce the sorting time on board to allow better grading will be carried out in 2006.

Tagging Experiments

During 2005 the Marine Technical Section participated in three separate sets of tagging experiments.

- The first phase in a tagging programme, which aims to collect key information on the horizontal and vertical movements of albacore tuna and contribute to the management of this potentially valuable fishery, was completed in 2005. The work was carried out as part of collaboration between BIM, the Commercial Fisheries Research Group in GMIT and Basque Institute, AZTI. A total of 200 albacore tuna were successfully tagged and released at the end of July from the Duncannon vessel Mellifont chartered specifically for the tagging experiments. As this is the first study of its kind for Atlantic albacore tuna, this first phase concentrated on assessing the feasibility of using electronic archival tags with albacore tuna.
- The BIM bluefin tuna tagging programme continued in 2005 although unfavourable weather conditions meant unfortunately no further satellite tags were deployed. One of the tags deployed in 2004 was recovered by fishermen in the Mediterranean Sea some 246 days from the date of tagging. This is the first tag deployed in Irish waters to be recovered from the Mediterranean Sea. This programme continues to provide important scientific information on the movements of bluefin tuna in the north Atlantic and Mediterranean Sea.
- The Marine Technical Section was once again involved in the Greencastle Codling Closure Project. Established in 2004 by Greencastle fishermen, the Marine Institute and BIM, this project aims to assess the effects on codling numbers of a seasonal closure of nursery grounds off the cost of Donegal through extensive tagging of juvenile codling. The 2005 season of tagging ran from December 2005 to January 2006, later than the previous two tagging seasons. There was a reduction in the amount of cod tagged in 2005 when compared with previous years with a total of 1,595 fish tagged over a 30-day period.

Waste Management

The disposal of waste fishing gear is becoming an increasing problem. At the end of 2005, BIM in conjunction with the Department of Communications, Marine and Natural Resources (DCMNR) and the UK company Petlon Polymers Ltd, who are involved in the extrusion of useful polymers from synthetic materials, have instigated a pilot waste management project in Dunmore East, Co. Waterford. Quantities of discarded monofilament netting have been collected from Irish fishery harbours, cleaned and baled using specialist net baling equipment supplied by Petlon Polymers. The bales of netting have then have been sent to Petlon for

extrusion. Ann economic assessment of the costs involved with this process is being examined on depending on the results it is hoped to extend this scheme.

17.8 Netherlands

B. van Marlen

Further work was done in the EU NECESSITY project. In March-April 2005 a trip was made on RV "Walther Herwig III" with the Institute of fishing technology and economics of Hamburg, Germany. The rope barrier did negatively affect fish catches and was abandoned as a solution to diminish bycatch of cetaceans in pelagic trawls. Stomach analyses were done of by-caught cetaceans to infer a relationship with fish discards, proving this likely. In addition test on the effect of acoustic deterrents were done with trained cetaceans in the marine mammal park of Brugge, Belgium. The work will be continued in 2006.

Extended comparative fishing trials and survival experiments were done on RV "Tridens" on a 12m electrified beam trawl in comparison with a conventional beam trawl. The test showed better catches of sole, lower of plaice and benthos, and improvement in survival of undersized plaice and sole for the pulse trawl. Comparative trials were done on commercial vessels fishing with conventional beam trawls and pulse trawls, but these resulted in lower catch rates for the target species sole and plaice. A considerable reduction in fuel costs was found. The economic performance of the pulse trawl system needs to be improved for it to become a good alternative. This work is currently under evaluation by the ICES WGFTFB.

Further data analyses were done in the RECOVERY project, but did not result in suitable selectivity data for most gear tests. A report was written on the catch comparisons showing the potential of large mesh top panels in V-type beam trawls to release cod and whiting.

New work was started in the EU-project DEGREE in which new gear will be developed with less sea bed contact and impact. The Dutch will concentrate on electrified beam trawls as an alternative to tickler chain beam trawls.

17.9 Norway

The Norwegian college of fishery science, University of Tromsø (NCFS-UiTo), following areas were studied in 2005

i) Fish trawls and size selectivity: More data on selectivity results comparing rigid grids (flexigrid) to flexible mesh panels (exit windows) were achieved during two periods with cruises. Some results are published and more are in press. The results will be further compared to single steel grids and a PE-based twine (Hot Melt) in diamond mesh codends.

ii) Fish survival: A study on the damage and survival of escaping fish from selective fish trawls was carried out in a controlled lab-facility in Kårvika outside Tromsø. The experiments were carried out on cod, more studies will be made later with haddock. The results will be published in the beginning of next year.

iii) Shrimp trawls and species selectivity: A new study revealed the sorting ability of a new version of the Cosmos PA sorting grid using droplet shaped bars. Changing waterflow compared to rounded bars did not make a great effect on selectivity characteristics. The grid has been approved for use in Norwegian waters. The results are published.

iv) Two-body trawl design: A special trawl for selectivity studies and direct comparisons between selectivity systems has been developed at the college. The trawl is also widely used for studies on fish behaviour. Application of the design and results will be published later.

v) Automatic longline hauler: Further studies with this device developed for coastal fisheries, has been carried out. The focus has been adjustments of the construction and documentation of improved quality and outcome on landed fish. A version of the system for autoline vessels has been designed in cooperation with a ship design company and fishermen. The device will be tested in full scale later.

vi) Zooplankton trawls: The College participated in further testing on modified designs of full-scale trawls. The design is based on single-warp design opened with kite-wings to be used with small coastal vessels. The trawl filters a volume of close to 75000m3/trawling/hour with panels built from 500 panels.

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SINTEF Fisheries and Aquaculture

Automated inspection of fishhooks

SINTEF Fisheries and Aquaculture has developed technology for automated inspection of used hooks in mechanized long lining. The technology is based on machine vision, and will replace manual inspection of hooks in this fishery. Good quality on hooks is important to ensure successful fastening of bait and high fishing efficiency. Norwegian long liners can typically haul 30.000–40.000 hooks a day, and this technology is a most welcome relief for the fishermen. The project has been cooperation between SINTEF Fisheries and Aquaculture, The Norwegian Fishery and Aquaculture Research Fund, Best Fishing Gear and Mustad.

Precise control of trawl systems

Karl-Johan Reite has in his PhD with the title "Precise control of trawl systems" looked into how a commercial trawl system may be controlled more precisely than today. The background for this work is the increasing focus towards the environmental challenges especially bottom trawling is facing. It is assumed that improved control would decrease the environmental impact of bottom trawling. It has been developed a model of the six degrees of freedom hydrodynamic forces and moments on a trawl door as a function of the relative speeds and accelerations of the trawl door relative to the surrounding water, also in six degrees of freedom. This is achieved through a combination of model experiments and numerical simulations. To increase the responsiveness of the trawl system, a concept for controlling the hydrodynamic forces on the trawl doors is proposed, and a mathematical model of this is designed. The control concept is optimized using nonlinear optimization with regard to energy efficiency and performance. A control structure that takes industrial considerations is finally proposed, based on model predictive control and nonlinear objectives. It divides the control system into different abstraction layers to provide a modularized system, using conventional feedback controllers to stabilize and control the fastest dynamics of the trawl system and feed forward controllers to minimize the energy consumption on the trawl doors.

Fine meshed trawls

For nets and trawls of high solidity, e.g. intended for harvesting marine zooplankton such as *Calanus finmarchicus* or krill, the filtration performance and towing resistance depend strongly on the design parameters and towing speed. In particular, the Reynolds number dependency may be dramatic for fine-meshed trawls compared to more traditional trawls, and care must be taken when assessing the flow conditions in such trawls, both theoretically and experimentally. Basic aspects of flow through trawls and net samplers have been reviewed and discussed, and a theoretical model for the flow through and the drag on nets and trawls of high solidity has been developed. Simple analytical expressions have been derived for the filtration efficiency and drag on square meshed conical nets as functions of twine diameter, solidity ratio, mesh opening, taper ratio and towing (current) velocity, based on pressure drop

considerations for flow across inclined screens. The model demonstrates e.g. how the filtration efficiency for a square meshed net increases with increasing velocity and decreasing solidity and netting angle to the flow. For a diamond meshed net an increased velocity may cause a further stretching and closure of the meshes and thus increase the solidity ratio, hence the filtration efficiency of a diamond meshed net may decrease or increase with increasing velocity. A simple model for the boundary layer along a non-tapered net section and its contribution to drag and filtration has also been derived; demonstrating the variations with length of net, twine diameter and velocity.

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Institute of Marine Research, Bergen

Development of New Artificial Longline Bait

Today, large amounts of natural longline baits, like squid, mackerel, herring and shrimp, are used in the world's longline fisheries, and natural baits are expensive. Several attempts to make artificial longline baits, with the economic and environmental advantages this would imply, have been conducted during the last 30 years. However, natural longline baits are still superior; they always seem to catch a higher number of fish. Researches at the Institute of Marine Research are involved in a project where the goal is to develop an artificial longline bait based on expanded starch with equal or higher catching efficiency than natural longline baits.

In the reporting period IMR has produced attractants for mixing with a binder provided by a commercial company. Field tests with traps have been conducted using two different attractants. Promising results was obtained with one of the attractant on Norway lobster (*Nephrops norwegicus*). Catch rates for fish are still lower than for natural baits. Forthcoming experiments will focus on testing different attractants by comparative fishing trials and by conducting field trials observing fish attraction towards with at a camera rig.

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Development of an alternative fishing gear for catching lumpfish (Cyclopterus Lumpus)

It has been performed behaviour studies and small scale fishing areas on lumpfish. Based on these results new traps have been produced which will be used in a fishing trail later this year.

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Sorting grid in pelagic trawl for herring

The selectivity work on grid system for medium sized pelagic trawls continued in 2005 with a cruise late October /early November in the Vestfjord area. The problems encountered in 2004 with herring not passing the grid, was simply solved by cutting away all guiding panels in front of the grid. The water flow through the grid did increase, and as a mean the speed of water through the grid was about 0.7 of the normal towing speed. Similar relationship was experienced with the Nordmøre grid system. The grid system gives good release of saithe cod and redfish, with almost nil loss of herring up to catch rates of well above 200 tons per hour. The Directorate of Fisheries is now considering introducing this grid system on a permanent basis, at least during autumn months when the problem of by catch is at its worst.

Observation and gear development in seine net

Gear monitoring equipment developed for trawl was tested on seine net in Northern Norway. Both Scanmar and Simrad gear sensors did reveal that the seine net to low negative weight. Medium sized seine net (2x 210 # in 300mm mesh) with a negative weight of 80 to 150 kg did occasionally "take off" from the bottom up to 5–6 meter, consequently with a dramatic loss of

fish under the ground gear ("skirt"). Both Scanmar and Simrad gave good signals with a distance between vessel and gear of up to 1900 meter. A para vane with cable connection to the head rope of a seine net and video link to the seine vessel has been developed during 2005. The transmission of video is acceptable with the use of five coils of ropes on each side. The equipment gives in situ observations of seine net and fish behaviour towards this gear.

Live fish technology

The fishery for live cod for temporary storage or feeding in pens has been a popular alternative to the conventional delivery of headed and gutted cod. Recently caught live cod has punctured swim bladder, and need a flat bottom for rest during the first 2–3 days of recovery of the swim bladder. A first model of a flat bottom pen capable to carry along onboard the fishing vessel was developed in 2005.

Grid sorting system in tropical shallow water

A grid system similar to the Nordmøre grid has been tested in Mozambique for excluding shark and rays in prawn trawls fishery. The experiments were conducted in cooperation with Instituto de Investigacao de Pescueira, Maputo, and Oceanic Research Institute, Durban.

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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 split beam echo sounder, multibeam sonar, Echoscope and Vemco acoustic positioning system. Among these tools, the Echoscope and the Vemco system proved to give the best recordings of fish movements near the gillnet.

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A new passive fishing gear

A new fishing gear combining the catching principles of trap and baited pot has been designed. The handling performance of the gear during setting and hauling proved to be satisfactory, and underwater observations showed that the gear settled properly on the seabed. The catching efficiency of the new gear has not yet been tested at commercial fishing grounds.

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Mortality of fish crowded and slipped in purse seine fisheries

To document the consequences of crowding and slipping of pelagic fish in purse seine fisheries, the Institute of Marine Research, Bergen, the Norwegian Directorate of Fisheries and the fishing industry did the first field trials for survival experiments of crowded mackerel at the west coast of Norway in August – September 2005. Extreme weather resulted in only two offshore samples being taken, and the maximum monitoring phase was reduced to five hours. No mortality was observed during the first five hours. A new set of experiments is planned to take part in August-September 2006 where the net pens will be held drifting offshore during the monitoring period of five days.

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Sampling of mackerel schools in purse seine fishing

The development towards larger purse seine vessels and the lack of skiff boats in modern purse seine operation has resulted in less use of hand lines for sampling of pelagic registrations before purse seine operations. A project to test if catch by an automatic trolling system could be used to give representative weight-samples of mackerel before pursing

operation started was done in 2005. The correlation was good between samples from the two gears. An experiment to test the same method for herring is planned for 2006.

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Behaviour of red king crab towards a commercial trawl

Bycatch of red king crab in roundfish trawling in the Barents Sea is an increasing problem. To reduce the bycatch a pilot experiment with filming of crab behaviour was conducted in 2005. The results shows that the crab, after entering the trawl, is almost in no contact with the lower panels of the trawl, and has no active escape behaviour. An experiment in 2006 will be done to test riggings of the groundgear to avoid this bycatch.

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Fish trawl development

IMR, Bergen and SINTEF Fisheries and Aquaculture, Hirtshals cooperate with Norwegian trawl gear manufacturers to commercialise a new fish trawl concept equipped with a new type of sheering ground gear. The development also includes the use of flexible "plates" attached between an extra rope and the headline to become an extra or alternative lifting device to traditionally deepwater floats. The sensitivity of rigging the plated ground gear has been documented with prototype angle sensors developed by the Norwegian company Scanmar.

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Trawling techniques for mesopelagic fish and krill

IMR, Bergen has cooperated with research institutes in the Faeroe Island and Iceland to study the feasibility of commercial capture of mesopelagic fish and krill. During a research cruise with RV "Magnus Heinasson" in April 2005 capture behaviour of these species were studied in a pelagic trawl using underwater video camera, acoustic and collecting bags, which retained organisms escaping through belly meshes. Larger meshes did not herd krill whereas herding by belly meshes of small mesopelagic species was low. Prospect for commercial capture of meso-pelagic species and krill in the North-East Atlantic are poor, based on observation in this joint Nordic project.

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Development of a species selective shrimp trawl using behaviour differences between fish and shrimp

An ongoing project at IMR, Bergen aims to use behaviour differences between target shrimp and unwanted fish bycatch to develop an alternative to the Nordmore grid as bycatch excluder in shrimp trawls. Behaviour observations in the aft belly in front of the cod end have shown that shrimp are passively guided along and close to the bottom panel, whereas most fish are capable of swimming at some distance above the bottom panel. Using a frame forming a 10 cm narrow slot above the bottom panel will catch most of the shrimp while most fish passes above the slot. Work continues in the project to learn more about shrimp behaviour in the front belly and about their vertical distribution and migration.

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Size selectivity of shrimp using sorting grids

Jointly with fishers and trawl gear manufacturers IMR, Bergen has tested various designs of sorting grids for size selection in shrimp. The testing has included behaviour observation of shrimp towards the grid device. A grid with 9m bar spacing sloping approximately 20 degrees upwards was found to filter small shrimp with minor blocking of the grid when catch rates was moderate as during the experiments.

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A new environmentally friendly shrimp trawl concept

IMR, Bergen in cooperation with SINTEF Fisheries and Aquaculture, Hirtshals is working on a new shrimp trawl concept aiming to reduce the drag by 25% without reduction in efficiency. Reduced bottom impact and better selective performance than existing shrimp trawls are also major objective of this trawl development project. Self-spreading ground gear, large upper panel meshes and modification of the upper panel design is key elements in the new trawl concept. Mathematical simulation and model testing of new concepts are in progress.

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Technological creeping

An experiment is carried out in 2006, comparing catch rates, species and length composition between demersal trawl with "high" (32 degrees) and "low" (22 degrees) sweep angle. The data has not yet been analyzed.

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A new demersal survey trawl

IMR is presently working on a project with the objective of developing a trawl design that has the potential for taking quantitative catches of fish in survey strata. Two full-scale experiments have been carried out, 2005 and 2006. We experienced during the 2005 trial that it was difficult to adjust the plated ground gear such that the plates along the whole ground gear were oriented vertically. The trawl was re-designed before the 2006 trial. The problem we experienced during the 2005 trial was reduced, when the centre ground gear section was replaced with rockhopper discs. Catch comparisons between the standard survey trawl, Campelen 1800 and the "new" survey trawl showed that the new trawl had higher catch rates for larger cod, but reduced catch rates for small fish such as haddock, possible due to mesh selection in the upper front part of the trawl. In addition to trials onboard Norwegian research vessels, the French research vessel "Thalassa" also tested the trawl in 2006.

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17.10 Spain

Fishing Technology related projects carried out at AZTI Fundación (Technological Institute for Fisheries and Food; www.azti.es) by the Marine and Fishing Gear Technology Research Area.

Fish Aggregating Devices as Instrumented Observatories of Pelagic Ecosystems (FADIO)

EC contract QLRI-CT-2002-02773

The general objective of the project is to develop prototypes of new autonomous instruments (instrumented buoys and electronic tags) to create observatories of pelagic life. The project tries to establish the first steps towards the development of new methods for providing meaningful indices of local abundance in tropical tuna stocks based on data collected by pelagic observatories deployed either singly or in networks. Nine European partners are involved in the project. AZTI is mainly involved in the study of the fishing fleet activity in relation with fishing aggregating devices (FADs), the characterisation of the fishermen experience in relation with FAD colonisation and tuna behaviour, as well as the study of the collective tuna fish behaviour using the technological developments of the project.

The project is under way (2003–2006)

Nephrops and Cetacean Species Selection Information and Technology (NECESSITY)

EC contract 501605

The overall aim of the project is to develop alternative gear modifications and fishing tactics in collaboration with the fishing industry to reduce bycatches in the relevant European *Nephrops* and pelagic fisheries without reducing significantly the catch of target species. AZTI is involved in the part of the project aiming at the minimisation of the cetacean bycatch, focusing in the VHO trawl fishery. After characterisation of the incidental bycatch of cetaceans (seasonality, geographical occurrence), the study has focused in 2005 on the design and test at model scale of dolphin escape devices in the flume tank. In 2006 the escapement devices at full scale will be tested in several fishing trials in the commercial fishery.

The project is under way (2004–2007)

Mechanization and automation of the mackerel hauler/reel in the hand line fishery

The traditional mackerel fishery with hand lines and hook were causing serious risks to the crew due to the large number of hooks moving dangerously on deck during the fishing operation. To improve safety on board an automatic hauler that coils the lines with hooks in a reel has been designed and developed. An assessment of the performance of the first prototype has been done (safety, ergonomics, catch rates) and modifications on the design had been suggested. In the end a new design of line hauler has been developed and introduced successfully in the commercial mackerel fishery in 2005. New automatic functions had been defined for the new line hauler at the end of 2005 in order to reduce the crew number to operate the hauler devices. The technical performance of the improved line hauler is going to be tested in the commercial fishery in 2006.

The project is under way (2005–006)

Development of an electronic log-book for the artisanal tuna fishing fleet.

In the last years, AZTI has developed and provided to the Basque tuna fishing fleet an electronic catch reporting software for on-board utilization. The aims of the project are to help fishermen to better manage the information regarding fishing activities using information from the individual fishing operation, as well as to get detailed information on the activities of the fleet to improve the fisheries catch data base used by AZTI in fisheries monitoring and fish stock assessment. Training on the use of the software and trials of the equipment were performed in the summer tuna fishing season. As a result, several improvements on the software and the data collection were made. New trials are planned for the next summer fishing season. The long term aim of the project is on one hand that the electronic log-book becomes a routinely tool for fishermen, on the other hand to guarantee the collection of complementary information for fisheries monitoring on a routinely basis.

The project is under way (2002–2006)

AZTI Remote Sensing Service.

The application of satellite remote sensing in relation to temperate tuna fisheries has been studied by AZTI since late 1990s. AZTI HRPT Ground Station receives and processes data from NOAA, SEASTAR and FENGYUN satellites to obtain SST images to produce isotherms, chlorophyll '*a*' concentration and altimetric maps. By means of HF transmission and internet facilities, AZTI is sending these oceanographic event maps to the tuna fishermen during the tuna fishing season in order to minimize the time expended to locate the fishing areas where fish aggregate and hence reduce fuel consumption.

The project is under way (routine project)

Application of an Unmanned Aerial Vehicle (UAVs) to fisheries inspection

Fisheries inspection is a time and resources consuming activity. The use of an UAV as a complementary tool could reduce substantially the resources and improve the level of control coverage by fisheries inspectorate services in the coastal area. The main aims of the project are to adapt an UAV model equipped with digital video recording and still photograph equipment for the purpose of inspection, as well as to develop and adapt the inspection protocols considering the use of such a tool. Fisheries inspectorate service is involved in the project to assess the suitability of the UAV and to contribute to the definition of new inspection protocols.

The project is under way (2005–2006)

Development and testing of a semi- automated rod for the tuna fishery with pole and line

The pole and line artisanal tuna fishery with live bait requires a large crew to manually operate the pole to catch tuna fish. The aim of the project is to develop an automated rod prototype which can reduce substantially the man power needed for the fishing operation. A first prototype has been defined, built and tested in the commercial fishery during the summer tuna fishing in 2005. As a result of the fishing trials with the prototype, several technical improvements have been identified and defined in terms of technical specifications to build a second prototype to be tested in the short-medium term.

The project is under way (2005–2006)

Analysis of the acoustic spectrograms of tuna fishing vessels.

Vessel noise seems to be an important factor in the fishing performance of artisanal tuna fishing vessels using trolling as well as pole and line with live bait. The study aims are: to establish a standard procedure for the measurement of noise radiated by vessels using hydro-acoustic equipments; to define the noise pattern of different categories of vessels; to define the noise characteristics that have an influence on fishing performance according to sound and vibration sensitivity of tuna fish.

The project is under way (2005–2006)

Experimental fishing with twin trawl in the monkfish fishery

The twin trawl has been introduced recently in the Basque trawl fishing to test its fishing performance. The project aims at characterising the technical performance of twin trawl as well as its fishing pattern. Moreover, a comparative fishing experiment using the two codends of the twin trawl has been performed in order to test the effect of lateral square mesh panels to reduce the level of discards in the monkfish fishery. The results of the trials show a significant reduction in the proportion of discarded catch when using the square mesh panels.

The project is finished (2004–2005)

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17.11 Sweden

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Swedish Board of Fisheries

Species selective Nephrops trawling

Four experiments were performed during 2005 with the objective to further develop the Nordmore grid used in the Skagerrak/Kattegat *Nephrops* trawl fishery. The work was funded both by the EU-project "NEphrops and CEtacean Species Selection Information and TechnologY" (NECESSITY), and by national funding. The studies involved both catch comparison and formal selectivity experiments on both commercial and research vessels using the twin trawl method. In one of the catch comparison experiments we compared the catch composition between a standard 35 mm grid and a modified grid that had a 15 cm gap along the bottom. The modified grid caught significantly more cod, while there was no difference in *Nephrops* catches. Another catch comparison experiment studied handling properties and catch composition between a trawl with the standard aluminium grid and a trawl with a flexible grid (Flexigrid). Both grids had identical bar distance (35 mm). Results showed that fish catches were similar for the two trawls while the *Nephrops* catches were significantly higher for the standard grid, indicating a higher loss rate for the flexible grid. The third catch comparison experiment tested catch differences between a trawl fitted with the standard grid and 70 mm full square mesh codend, and a trawl fitted with a 90 mm diamond mesh codend and a 3 m long 120 mm square mesh window 3 to 6 m ahead of the codline. These results have not been analysed yet. In the formal selectivity experiment we tested the selectivity of both the 35 mm grid, the 70 mm square mesh codend and for the combination of the two compartments. This dataset has not been analysed yet.

For 2006–2007 we plan to investigate whether the Nordmore grid can be modified so that both *Nephrops* and sole are caught while roundfish is deflected out of the trawl. This will be tested by using horizontal bars in the lower half and normal vertical bars in the upper of the grid, similar to a gear that is used in Faroese coastal waters in the trawl fishery for lemon sole.

Change of the Swedish trawling border and new national technical regulations.

In January 2004, the trawling border was moved out to 3 NM outside the baseline in Kattegat and to 4 NM in Skagerrak in order to reduce fishing mortality on local populations of demersal fish species like cod, pollock and haddock (i.e. both juveniles and adults) and to protect sensitive habitats from trawling. In February 1st 2004, new technical regulations were introduced on these Swedish national waters in Skagerrak and Kattegat (Management Area IIIa).

Compared to the situation before February 2004 these changes means that app. 1900 km^2 bottom area has received an increased protection against trawling. As around 50% of the Swedish annual *Nephrops* landings normally originate from these (now closed) coastal waters, exceptions were made for the fishery with species selective *Nephrops* trawls using grid on 870 km2 (46%) of this area.

The regulations imply mandatory use of 35 mm species selective grid and minimum 8 meter of 70 mm full square mesh codend. This means a nearly complete protection for adult round fish to trawl fisheries in these areas. The protection of juvenile fish is also increased by the banning of fish trawling and by the obligatory use of grid and square mesh codends.

A program to follow up the consequences of these new regulations has been started comprising the effects on bottom fauna, fish community, trawl and creel fishery. The effects

on trawl fishery have been documented mainly through log-book data and show a drastic decrease in fish bycatch in this new *Nephrops* trawls.

The effects on bottom fauna and fish community has yet not been evaluated due to the short time period after the enforcement but will be followed up during coming years.

Mitigation of seal damages

Work is ongoing to find alternative fishing gear and practices that can reduce seal bycatch and seal damages to gear and catch. The seal protection of the fish chamber in salmon traps has been successful. The main ingredients are a rigid frame and double netting which separates the fish and the seal and a mechanism for emptying the rigid gear. This is made by inflating pontoons under the fish camber, lifting it completely out of the water. The trap is called the "pushup" trap and the lifting method is patented. This type of trap is now being modified and tried as replacement for gillnets in the coastal fisheries for whitefish, pikeperch, eel and other Baltic fisheries.

Work is also ongoing with pots and fykes as seal-safe alternatives in the cod gillnet fishery. So far the results are negative and show very low catch efficiency. To address this, a pump for delivering liquid artificial bait has been developed. The output from the pump is proportional to the ambient current speed, to give a constant plume concentration. Trials with this will start in 2006.

To make gillnetting possible in areas with high seal density successful trials have been done with acoustic harassment devices deployed early in the season at strategic points to make a larger archipelago area uncomfortable for the seals to enter. This learning process meant that seals never found and exploited the fishery during the season. Trials have also been made to see if visual search for gear markers was important for the seal. The results indicate that decoy markers may be used as a partial mitigation method for gillnets.

Size selectivity in vendace trawls

Trials to further improve the size selectivity in vendace trawls were continued and finished in the northern Baltic Sea in 2005. The final design was a fringed grid, which successfully excluded juvenile vendace, and small males, from the targeted mature females (only the roe is marketed).

Retrieval of ghost-nets

Ghost-net retrieval exercises were in 2005 performed by two groups of gillnet fishers in the Baltic Sea in cooperation with the Institute of Marine Research. The work was done during the summer closure of the cod fishery and resulted in both cases in about 12 km of retrieved gillnets and a number of other ghost fishing gear like pots and eel fyke nets, and also cod jigs. Such retrieval exercises are planned to be performed routinely in the coming years.

17.12 USA

NORTHEAST

Massachusetts Division of Marine Fisheries – Conservation Engineering Program

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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 and analyzed using the SELECT and REML methods. Modal sizes were determined for pollock *Pollachius virens* and cod *Gadus morhua*. Further research is

proposed to examine selectivity of haddock *Melanogrammus aeglefinus*. A cooperative research program with the Gulf of Maine Research Institute.

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. Field testing is scheduled for 2006.

Cod Potting in a Cod Conservation Zone

Atlantic cod *Gadus morhua* pot designs developed at the Centre for Sustainable Aquatic Resources, Memorial University, Newfoundland successfully caught cod in May/June 2005 and December 2005/January 2006 in Massachusetts Bay. Catch amounts were below commercial quantities and comparison with gillnets indicated selectivity for smaller sizes. Further work is planned to examine seasonal components of cod pots.

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

Two designs of low vertical profile gillnets of 8 meshes deep (MD) of different floatation and hanging ratios will be compared with regular 25 MD cod gillnets, foamcore flounder nets and tie-down flounder nets. The nets with lower vertical profiles have been shown by DMF and UNH to reduce cod catch while maintaining comparable flounder catch. Scheduled for the first half of 2006.

The Design and Preliminary Testing of an Innovative Scallop Dredge

A prototype dredge is being built that uses hydrodynamic shapes to lift scallops off the sea floor and wheels in contact with the bottom. Field testing will begin in 2006 in collaboration with Cliff Goudey of MIT.

Coonamessett Farm

Ronald Smolowitz (cfarm@capecod.net)

Ongoing work continues on modifications to the New Bedford style sea scallop *Placopecten magellanicus* dredge to reduce the take of loggerhead sea turtles and bycatch of non-target flatfish and skates. Modifications include (a) a chain mat that prevents turtles from entering the bag of the dredge and (b) a new concept for construction of the dredge frame to keep turtles from snagging on top or being trapped underneath the dredge.

The chains were found to be 100% effective in keeping turtles out of the dredge bag. (See "Industry Trials of a Modified Sea Scallop Dredge to Minimize the Catch of Sea Turtles" by Bill DuPaul, Dave Rudders and Ronald Smolowitz. VIMS Marine Resource Report No. 2004–11.) In fact, during the tests, no turtles were caught on top of the modified dredge so it is possible that the noise generated by the chains creates a further deterrence to interactions.

If the turtle passes over the top of the front part of the dredge frame, known as the bale, it can get caught in the space between the depressor plate and the cutting bar. Usually, when the dredge is stopped during haul back alongside the vessel the turtle can be seen to swim away unharmed. However, at times the turtle is lifted up aboard the vessel and falls on the deck and becomes injured. On one occasion, it has been reported that the turtle has become injured when trapped between the depressor plate and the cutting bar. If turtles get under the bale frame of the dredge while it is being towed on the bottom, there is the possibility that they can get pinned underneath the bale and then run over by the dredge frame and bag.

Frame alterations can have significant effects on catch and bycatch rates. In previous work, to reduce fish bycatch, we have altered the design of the bale so that it extends forward of the main frame eighteen inches before tapering toward the hauling point (bullring). This allowed us to test sweeps and blocking over the entire dredge width. Blocking is an approach used to prevent fish from entering the dredge from above the cutting bar and below the depressor plate.

We have investigated blocking this space with rope, mesh, steel scallop rings, and 1-inch bar stock but have found these materials do not hold up to the rigors of scallop fishing. Our new design is a significant departure from the standard dredge design in that the cutting bar is moved forward of the depressor plate so that instead of confronting a vertical structure, a sea turtle or large barndoor skate, encounters an upward sloping structure. Our design increases the width of the depressor plate and extends the struts, at twelve inch spacing, between the depressor plate and the forward positioned cutting bar. All the structural bars running from the bale to the dredge have been removed allowing any turtle that gets under the bale to escape before encountering the cutting bar. Thus a sea turtle can not get trapped in this space and is deflected over the dredge.

Two prototypes of the new dredge frame have been constructed. One was tested in the spring of 2005 near Panama City, Florida. Divers place dead turtles and models of turtles in front of a standard dredge frame and the new dredge frame. The new dredge worked as designed. The new dredge was then tested on the mid-Atlantic scallop grounds and found to fish as well as the standard dredge. Testing has indicated some potential design changes and these will be extensively tested on various scallop grounds in 2006 and 2007.

University of New Hampshire

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Two projects to separate haddock from other groundfish species were funded. Flume tank tests have been completed on the initial designs of a rope separator trawl and a raised footrope trawl. Initial sea trial on the rope separator trawl showed promising results. Sea trials on both projects will continue this spring/summer.

A project to compare a Danish style flounder net with other standard and low profile gillnets has initiated with sea trials during this spring/summer.

A new topless shrimp trawl to reduce pelagic species bycatch was initiated with sea trials continuing. Preliminary results indicted around 90% reduction in small herring without loss of shrimp catch. There were some increases in small flounder bycatch with the new net. Another shrimp trawl project to modify the Nordmore grid was also started with flume tank tests complete and the field trials just started.

The project to determine selectivity of codend mesh sizes/shapes has been completed. We tested 6”, 6-1/2”, and 7” 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. Selectivity properties for cod, haddock, yellowtail flounder, American plaice, and witch flounder was determined. Some of the results will be available at the meeting.

University of Rhode Island – Rhode Island Sea Grant

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

RESEARCH

Bycatch Reduction in the Directed Haddock Bottom Trawl Fishery

A study was funded through the 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. 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 began in June 2005 and 3 trips have been conducted to date. The fourth and final trip is scheduled for April 2006. Preliminary data analysis is underway.

Fishery Independent Scup Survey of Eight Selected Hard Bottom Areas in Southern New England Waters

The project is designed to collect scup *Stentotomus chrysops* using unvented fish pots from ten separate hard bottom sites in Southern New England, which are un-sampled by current state and federal finfish trawl surveys. The age distributions of the catch will be statistically compared to each of the other collection sites, to finfish trawl data collected by the National Marine Fisheries Service (NMFS) and the RIDEM – DFW. Analysis for data collected in 2004 is complete and the final report is complete. The 2005 data is currently being analyzed. Sampling in 2006 is expected to begin in May.

OUTREACH

Rhode Island Commercial Fishermen's Association – Dedicated Access Pilot Program

A group of fishermen and managers have been working to describe a sector allocation pilot study to improve the current quota based fisheries management system for summer flounder in Rhode Island. This sector allocation will demonstrate reduced regulatory discards, better reporting, lower operating costs, faster stock recovery rates, safer fishing, and enhanced economic performance for permit holders. A special task force has been authorized to work out the details for that program. We received funding to conduct targeted informational outreach for the task force recommendations by facilitating educational workshops and discussions. Speakers will be brought in from other fisheries to help elaborate on this management approach, as well as faculty and staff from various universities and councils.

Regional Bycatch Assessment Team

The National Marine Fisheries Service established Regional and National Bycatch Assessment Teams (RBATS and NBAT) to develop bycatch reduction implementation plans. URI-RISG is a member of the Northeast (NE) Regional Bycatch Team and played a critical role in the Bycatch Workshop held in June 2004. In 2006, a Northeast Region Workshop was held on creating a guide to Developing a Cooperative Research Project and Proposal. RISG is contributing to that guide by writing chapters and editing, and will aid in educational workshops for distribution of the guide.

Northeast Regional Gear Conservation Engineering Working Group

Since 2004, URI-RISG has been the organizing unit for developing a Gear Conservation Engineering Group. The group was established through funding from the NMFS Saltonstall-Kennedy program and has continued with support from the Northeast Consortium. Educational workshops on gear selectivity and catch comparison have been conducted to date, and in 2006 a workshop will be held on discard mortality. A website was developed: 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, and the newest inclusion is a searchable Research Projects Database consisting of the projects in the northeast.

Capturing the Data

Fishermen's observations will be captured during a series of informal meetings that will be held at various locations in Rhode Island. Invited participants will include commercial and recreational fishermen, environmentalists, state biologists, University experts, NMFS, and Council members. Each meeting will be set up around a theme and questions will be asked of participants to describe things they have encountered over time. The product of these observations will be a set of hypotheses that will be presented to the various funding agencies for consideration.

Northwest

NOAA Fisheries Alaska Fisheries Science Center

Fisheries Behavioral Ecology Program, Newport, Oregon, USA

Bycatch-Related Gear Research

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

Quantitative field measures for fish bycatch discard mortality have been developed based on behaviour impairment of reflex responses (BIMA: Behavior Integrating Mortality Assay). Fish are restrained in a simple holding device and tested for reflex responses such as operculum closure, mouth closure, gag response, body flexure, dorsal fin erection, and vestibular-ocular response. These reflex actions are scored as present or absent and summed to give a behaviour impairment score that is correlated with mortality. This behaviour assay integrates the effects of capture, injury, environmental factors, and fish size to predict mortality. BIMA is ecologically relevant to impairment of complex behaviours such as predator evasion and feeding and may give an indication of the potential effects of predation on discards. Future research will continue to develop reflex behaviour testing methods based in camera cages at depth for fish injured by barotrauma and fish that escape fishing gear. BIMA is a powerful tool for measuring bycatch mortality rates and promises to greatly expand the scope and replication of field fishing experiments.

Laboratory studies of flatfish reactivity and herding behavior: potential implications for trawl capture efficiency

Cliff Ryer (cliff.ryer@noaa.gov)

Laboratory experimentation using a simulated footrope in a flume tank examined the influence of ambient illumination and temperature upon initial behavioural responses of subadult Pacific halibut *Hippoglossus stenolepis* and northern rock sole *Lepidopsetta polyxystra*. (Subadult behavior was assumed to be comparable to that of larger individuals). Unexpectedly, 40% of fish did not react to the approaching footrope; they were not flushed from the sand by the footrope, implying that trawl ground-gear may frequently fail to stimulate any form of flushing response in flatfish. Fish that passively pass beneath the ground-gear may not be adequately accounted for when estimating trawl efficiency/catchability.

Light level had a pervasive influence upon the initial behavioural reaction of flatfish to approaching trawl ground-gear. In the light fish were apt to respond with a 'run' response, swimming away from the gear while staying close to the bottom, i.e. herding. In the dark, 'rising' and 'hopping' upward off the bottom was more common, initiated by a startle response in the absence of visual input. These results suggest that herding ceases in the

night/darkness, with flatfish rising off the bottom in response to ground-gear disturbance, potentially explaining the widely observed increase in flatfish catches from survey trawls in shallow waters at night. However, this ambient illumination effect upon ground-gear function may have its greatest impact on trawl sweeps between the doors and the wings of the net. Rising and hopping off the bottom may make the sweeps less effective at herding fish into the path of the net, decreasing the overall efficiency of the gear. If sweep efficiency decreases dramatically under low ambient light, catch would actually be greater during the day, than at night, the opposite of the pattern frequently seen in survey trawls.

Temperature was also demonstrated to have a small influence flatfish behaviour in this study. The 'hop' response increased in frequency among rock sole at low temperature, particularly in the dark, suggesting a greater likelihood of 'startling' in response to trawl ground-gear disturbance, as opposed to initiation of an ordered behavioural response (herding).

A study underway employs a DIDSON (Dual-frequency IDentification SON) mounted on a benthic sled towed by otter doors and abbreviated (5 m) sections of trawl sweep (3-inch (7.6 cm) cookies). The DIDSON is aimed along the length of one of the sweeps, providing imagery of the seafloor and fish encountered by the sweep as it is dragged along the bottom. In a parallel study, the sled is also being positioned on the sweeps of commercial trawls utilized in summer flatfish fisheries out of Kodiak Alaska. These studies should 'shed light' upon the role of ambient illumination in the herding behaviour of flatfishes, as well as potential diel and depth related changes in the capture efficiency of both survey and commercial trawl gear.

NOAA Fisheries Alaska Fisheries Science Center

Survey Trawl Gear Research, Seattle, Washington, USA

The effect of light intensity on the availability of walleye pollock to the survey gear.

Stan Kotwicki (stan.kotwicki@noaa.gov), Alex De Robertis, Paul Von Szalay

Daytime light intensity profiles collected synchronously with hydroacoustic measurements were used to examine the effect of light intensity on the vertical distribution of walleye pollock and to determine the proportion of fish in the water column vulnerable to the survey bottom trawl. Our results show walleye pollock avoiding the bottom layer when light levels fall below 1E-5 μE*m-2s-1. This implies that a smaller proportion of the walleye pollock biomass are available to the trawl when light levels near the bottom are relatively low, and as such, may result in biased abundance estimates derived either from our bottom trawl survey or our echo-integration survey.

Influential variables on net spread and bottom contact for a survey bottom trawl

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

Multiyear analyses of several factors including procedural, geographical, environmental, and various components of the catch were explored with general additive modelling (GAM) to study their affects on net spread and footrope contact with the bottom for our survey bottom trawl during standard survey conditions. Preliminary results indicate vessel speed, depth, wire-out, sea state, total fish catch, combined catch of shell and starfish, and sediment grain size have significant impact on trawl net width. Analyses of footrope contact data are still in progress.

Correlating acoustic and trawl catch data for walleye pollock (Theragra chalcogramma)

Paul von Szalay (paul.von.szalay@noaa.gov), Dave Somerton, Stan Kotwicki

The vessels used for the eastern Bering Sea demersal trawl survey are equipped with Simrad ES-60 echosounders, which collect continuous backscatter data between trawl stations. We were interested in determining whether these acoustic data could be used to improve the precision of walleye pollock (*Theragra chalcogramma*) trawl index of abundance estimates by incorporating them with the trawl data. We analyzed synchronously collected trawl catch and acoustic backscatter data from over 400 stations to estimate the correlation between acoustic data and trawl catches. The correlation was good with an R2 value of 0.61 on the log-log scale.

18 New business

18.1 Recommendations

18.1.1 Date and venue for 2007 WGFTFB Meeting

WGFTFB proposes to hold a 5-day meeting in 2007 at Croke Park Hotel, Dublin, Ireland. A 5-day meeting was deemed necessary due to the high workload expected. The suggested dates are 23–27 April 2007.

18.1.2 Proposed Terms of Reference for the 2007 WGFTFB Meeting

The **ICES/FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chair: Dominic Rihan*, Ireland) will meet in Dublin, Ireland, from 23–27 April 2007.

Topics:

a) A WGFTFB topic group will be formed to consider the "Application of fish behaviour for species separation in demersal fish trawls"

The topic group will have the following terms of reference:

i) Identify recent behavioural and gear research into the separation of groundfish species in demersal trawl gears;

ii) Identify basic principles, strategies and effectiveness of groundfish species separation techniques such as separator panels, grids and footrope modifications;

Convenors Pingguo He, (USA) and Mike Pol (USA)

b) A WGFTFB topic group of experts will be formed to consider technical issues relating to Mediterranean fisheries.

The group will have the following ToRs:

i) Open dialogue with appropriate Mediterranean management bodies i.e. FAO-GFCM to identify appropriate areas of collaboration

ii) to review, for the non-EU Mediterranean countries, the technical aspects of their fisheries, following the pattern of the report on Turkish fisheries compiled at the 2006 WGFTFB meeting and using, for example, output from the COPEMED project;

iii) and then to extend, for both EU and non-EU Mediterranean fisheries, available technical information on the fishing gears and practices [see for the EU countries: Technical Report SGMED-STECF SEC (2004) 772], in particular:

- to review recent research;
- to identify the main technical problems of the Mediterranean fisheries and the gaps in knowledge needed to solve them;

- to propose, where possible, technical solutions aimed to manage better the fishery resources and to reduce the impact on the marine ecosystem.
- Publish a report on the findings from the above points

Convenors: Antonello Sala (Italy) Jacques Sacchi (France) AN Other (Spain)

c) The Topic Group on Definitions and classifications of fishing gear categories will continue to work by correspondence following an agreed Action Plan timetable and report to the WGFTFB in 2007 to:

- Present a draft FAO/ICES fishing gear classification based on the structure of gear definitions agreed during the 2006 WGFTFB and;
- In consultation with management bodies and by reviewing current initiatives, identify which gear parameters that should be monitored to provide better estimates of commercial CPUE

Convenors: John Willy Valdermarsen (IMR, Bergen) Wilfried Theile (FAO, Italy)

d) Term of Reference on "Incorporation of Fishing Technology Issues/Expertise into Management Advice."

Based on the questionnaire exercise carried out in 2005/06 into developments in fleet dynamics etc, WGFTFB recommends that the topic group continue to carry out this survey on an annual basis.

Dave Reid, FRS, Scotland, Norman Graham, IMR, Bergen, Dominic Rihan, BIM, Ireland

e) FTC recommends a joint WGFTFB/WGFAST one day session on: New and innovative usage of acoustic and optical instruments and computer simulation to monitor and/or estimate fish behaviour, catchability and bottom habitats.

Suggested Chair: Emma Jones, United Kingdom and AN Other (WGFAST)

WGFTFB will report by XX May 2007 to the attention of the Fisheries Technology Committee.

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 3.16, 3.17, 3.18 -i Action Item 5.8, 5.11 –ii Action Item 1.13, 3.18 -iii Action Item 3.2, 3.13, 4.11.3, 4.13, 5.11 –iv Action Item 1.13, 1.14, 1.10 -v Some groundfish species or stocks of these species are in low biomass, or overfished, while others are in healthy conditions. Efficient exploitation of healthy stocks while reducing or eliminating the capture of overfished stocks would provide industry and management means for sustainable utilization and management of the resource. Many members of WGFTFB have been involved in the area of research for many years. The topic group will concentrate on behaviour and species separation in commercial species. A summary of the status of knowledge and future directions in research and application would greatly benefit FTFB members and the fishing industry. The topic group will last for two years. The group will work by correspondence and to meet and discuss, and to report preliminary findings to FTFB at the 2007 WG meting. A report identifying current knowledge, information gaps and recommendations for future work will be presented at the 2008 WGFTFB meeting. WGFTFB is a joint ICES/FAO WG with a wide range of gear technology expertise and terms of reference which include consideration of technical issues related to fisheries around the world. The WGFTFB review of Turkish fisheries has shown that technological advance is becoming a major issue. There are also indications that technological advance is

	accelerating in other Mediterranean countries and that it is often leading to an increase in catching efficiency. A current EU goal is to develop a common fishery management policy for the EU Mediterranean nations. The topic group has in 2006 made a significant progress in modification of the classification of fishing gear categories. As several national and regional management bodies are users of the FAO gear classifications for management and statistical purposes there is an urgent need to complete this work. The action plan as developed will meet this requirement within a year. Fisheries management bodies are often dependant on catch per unit effort for stock assessment purposes and fishery/fleet based advice. Identification and use of gear parameters that affects the fishing efficiency will most likely improve the use of commercial catches for stock assessment purposes. The topic group has the expertise to identify such parameters and will work inter-sessionally with this topic, reviewing existing initiatives e.g. EC data collection regulation and provide a list for consideration during the 2007 WGFTFB meeting. The information collated by the WGFTFB has been well received by ICES assessment and other Expert Groups. It is intended to continue with the collation of this information but further developments are needed. The topic group recommends a number of changes to improve the utility and simplicity of this work. The next questionnaire will be based around the emergent issues identified in this report, and focussed on 2006. Feedback on the content and value of this years reports will be sought from the Assessment working groups and through AMAWGC and will be used to improve the survey in 2007. If possible, the EC should be asked to provide up to date information on recent TCM regulations. These will be included in the survey with a request to detail likely outcomes from these measures. Research that focuses on monitoring and measuring fish behaviour, selectivity and catchability of commercial fishing and survey gears and classification of bottom habitats have benefited from the introduction of new and innovative use of acoustic and optical instrumentation and computer simulation. This joint session presents a forum for discussion of the various uses of these technologies. The session will be limited to instrumentation deployed in the field, either attached to the bottom (stationary) or on fishing and sampling gears, and to computer simulations that show novel ways to analyze field data and model fishing and sampling gears and their use. It is limited to non- conventional use of acoustics, stationary (bottom mounted) and trawl mounted ecshosounders, ADCP instruments, AUVs, ROVs, ROTVs, acoustic cameras, stationary and sampling gear mounted still and video cameras, and transponding acoustic tags.
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
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 Committees or Groups:	This work is of direct relevance to the Working Group on Ecosystem Effects of Fisheries, 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:	

18.1.3 Workshops

WGFTFB Proposal for a Workshop on Nephrops Selection (WKNEPHSEL)

A **Workshop on *Nephrops* Selection** [WKNEPHSEL] (Chair: to be identified) will meet in Copenhagen in February 2007 to:

a) Update information on the selectivity of *Nephrops* gears suitable for use in assessments and stock predictions

b) Collate selectivity data relevant to current *Nephrops* fisheries using regional or geographic grouping, if appropriate;

c) Develop models of retention as a function of length taking account of other significant variables related to gear design, catch and environmental factors, for *Nephrops* and, where possible, by-catch species.

WKNEPHSEL will report by April 2007 to the attention of the Fisheries Technology Committee.

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 3.6, 3.16 Term of Reference a) Members of the ICES-FAO WGFTFB recently provided information and data to an ICES Workshop on *Nephrops* fisheries. It was noted that in many instances there are analytical problems associated with modelling *Nephrops* size selection and much of the information was based on an ICES study group that met in 1996. Since then, considerably more data has been collected from a number of national and international programmes and the technical specifications of legislation pertaining to *Nephrops* trawls and commercial codends has changed considerably. Additionally, recent experiments have shown that on many occasions, the selection profiles of *Nephrops* do not conform to standard selection models e.g. logistic functions. As a consequence of this, data from individual hauls are disregarded from analysis to determine mean selection profiles. It is necessary to develop new analytical methods to parameterise *Nephrops* selection profiles that can be used for management purposes.
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The workshop is likely to attract 10-15 participants.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	ACFM.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to those regional assessment working groups dealing with *Nephrops* stock, Resource Management Committee and Living Resources Committee
LINKAGES TO OTHER ORGANIZATIONS:	The work of this group is closely aligned with similar work in FAO
SECRETARIAT MARGINAL COST SHARE:	ICES: 100%

18.1.4 Study Groups

It is recommended that a **Study Group on the Development of Fish Pots for Commercial Fisheries and Survey Purposes** (SGPOT) is established with the following terms of reference:

The **Study Group on the Development of Fish Pots for Commercial Fisheries and Survey Purposes** [SGPOT] (Chair: Bjarti Thomsen*, Faroe Islands) will be established and will meet in Dublin, Ireland from 20–22 April 2007 to:

a) Review the current use of fish pots and provide a global overview of commercial fisheries and assessment surveys using these gears

b) In order to improve catching efficiency and assessment use of pots, the group will identify fundamental research needs on fish behaviour, in particular:

  i) Development of methodology for describing fish behaviour relevant for the capture and escape process

  ii) Reactions to different stimuli, including bait attraction, in the far and near field;

  iii) Efficiency of pot and trap entrances; and

  iv) Behavioural variation due to biological status and environmental conditions.

c) Make recommendations for improving the mechanical design and construction of pots, with considerations given to ghost fishing, with the specific aim of improving catch efficiency and their utility as survey gear.

SGPOT will report by XXXXX for the attention of the Fisheries Technology Committee and the findings of the SG will be reported in an *ICES Cooperative Research Report.*

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 3.6, 3.16 Fish pots have long been a focus of research and interest as potential alternative gears. These gears display many qualities of a responsible method. Amongst other properties, they are low-energy and low-mortality methods. Generally, it is agreed that further basic research into fish reaction and behaviour is necessary to improve the usefulness of pots and traps as commercial and survey gears, particularly by increasing catch efficiencies. This study group will bring together information and researchers with the aim of illuminating the pot capture process and promoting research in this area and provide a focus for coordination of ongoing research into alternative, eco-friendly fishing methods.
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Study Group is likely to attract 10-15 participants.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to the Working Group on Ecosystem Effects of Fisheries, Living Resorce Committee, Marine Habitat Committee, Resource Management Committee and Living Resources Committee
LINKAGES TO OTHER ORGANIZATIONS:	The work of this group is closely aligned with similar work in FAO
SECRETARIAT MARGINAL COST SHARE:	ICES: 100%

The **Study Group on Catch Comparison Methods and Analysis** [SGCOMP] (Co-Chairs: Andy Revill*, UK and Rene Holst*, Denmark) will be established and will meet in Dublin, Ireland from 20–22 April, 2007 to:

a) Assess the value and analytical issues relating to catch comparison fishing experiments

b) Critically appraise analytical problems associated with selectivity experiments and to what extent these methods are appropriate of for inference about selectivity under commercial conditions.

SGCOMP will report by XXXXX for the attention of the Fisheries Technology Committee and will publish its findings in an ICES Cooperative Research Report.

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 3.17, 3.18 Term of Reference a) Catch comparison (CC) experiments are widely used by the gear technology community for determining the relative differences in catching efficiency between two commercial or survey gears. These types of experiments have certain advantages over traditional selectivity experiments where the estimation of selectivity is determined by sampling the size structure of the fish entering the gear. Data from CC experiments are more readily understood by commercial fishermen and have certain practical advantages and are the only method available for comparing the efficiency between survey gears. Traditionally, analytical methods have been limited to simple (paired) t-tests. These provide limited length based information and are known to be sensitive to violations of the underlying assumptions of normality and in particular variance homogeneity. (Catch-at-length data are count-data and therefore not normally distributed). There have been a number of recent advances in data modelling from these types of experiments including the use of smoothers, GLM mixed models and by aggregating fish over several length classes. While standard protocols exist for determining selection properties of towed fishing gears, none exist for CC experiments where only partial population structures are obtained, for example from experiments comparing two different mesh sizes or devices by catch comparison. It is important to consider what type of information can be obtained from such experiments and there is a need for further development of tools to analyse data from such experiments and to provide standardised experimental and analytical protocols to allow comparisons between experiments. Term of Reference b) Recent investigations have shown that estimates for selection parameters obtained by the paired gear method may be biased. The SELECT method is most commonly used for data analysis but several hauls often fail to converge and estimates from convergent hauls are suspected to be biased. The methods involving both data collection and data analysis need to be reviewed and the possibilities of improvement explored. Species such as *Nephrops* often exhibit selection patterns that do not fit traditional selection models e.g. logistic function; it is therefore difficult to incorporate these data into mean models describing the selection process and are generally discarded. It is necessary to develop new modelling techniques so that these data can be incorporated.

RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Study Group is likely to attract 5-10 participants.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee;, WG on International Bottom Trawl Surveys, , Marine Habitat Committee, Resource Management Committee and Living Resources Committee
LINKAGES TO OTHER ORGANIZATIONS:	The work of this group is closely aligned with similar work in FAO
SECRETARIAT MARGINAL COST SHARE:	ICES: 100%

18.1.5 *Ad Hoc* Discussion Group on calls for Global Bans on bottom trawling

Conveners: Dominic Rihan (Chair WGFTFB) and Wilfried Thiele (FAO representative)

During the 2006 WGFTFB meeting, the WG recognized that collectively it is not directly addressing some of the recent scientific and public perceptions expressing concerns about bottom trawling impact on the seabed and on biodiversity. In the worst case scenario this has led to a ban on bottom trawling in certain areas. In order to address this issue successfully, in the first instance the WG needs to define the problem areas and review the current state of knowledge and actions being taken, as well as examining the scientific basis behind the documentation in the public domain and formulating a response, where appropriate.

The WG recommends that an *ad hoc* discussion group meet at the 2007 meeting to discuss "the rising frequency in the calls for global bans on bottom trawling". The goal is to identify the challenges and obstacles to quantify and then minimize negative effects of bottom trawling on the seabed and on biodiversity while permitting access to the resource. The WG recognizes that it needs input from WGECO, FAO and fishery managers, as well as NGO's and that senior level managers/chairs from these groups should be invited to contribute to discussions.

In preparing for the 2007 WGFTFB meeting, a small group of members should be selected to consider this initiative, and work by correspondence throughout the year, canvassing opinion from a variety of sources. A meeting of this group should be held during the WGFTFB 2007 meeting and a summary of the group findings presented in plenary.

Potential list of Participants:

Dominic Rihan, (Ireland), Chair WGFTFB	Francois Theret (EU Brussels)
Chris Glass (United States)	John Willy Valdermarsen (Norway)
Wilfried Thiele (FAO Rome)	Petri Surronen (Finland)
Francois Gerlotto (France), Chair FTC	Paul Winger (Canada)
Svien Løkkeborg (Norway)	Chair WGECO
Hans Polet (Belgium)	Representative of NGO
	Philip MacMullen (UK)

18.2 Advice requested

See section 4.

18.3 Proposals for 2007ASC – Theme Sessions

Theme Session Proposal 1

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

Theme Session Proposal 2

Science underpinning stock abundance survey practice

Proposed for Helsinki ASC 2007

Co-Chairs: D. Reid (Scotland), one from RMC or FTC

Papers would be invited on;

- Evaluations of current survey procedures and protocols
- Evaluations of proposed changes in survey procedures and protocols
- Accounting for tech creep in survey time series and in assessment process
- Survey continuity and lack of
- New surveys; methods, stocks, gears??
- Use of trawl monitoring equipment old and new
- Fish behaviour and survey trawls efficiency, catchability, species assemblage analysis
- Survey standardization, QA, practice, monitoring, teaching etc.

Dave Reid, FRS, Aberdeen, Scotland

Justification

In a time of increasing unreliability for catch and landings data, stock assessments are increasingly turning to surveys as the primary source of information to provide management advice. New modelling approaches such as SURBA have been developed to make use of these. However, this puts a greater onus on the surveys to provide a Quality Assured provision of data. This theme session is designed to draw together a range of issues surrounding the conduct, analysis and use of surveys. One key issue is that surveys are not carried out in a time warp. Methodologies and equipment evolve with time, and can become obsolete and unavailable. This as true for fishing gears as for sounders and plankton samplers. We need to be able to evaluate and account for these changes, and have statistical methods to make transition possible. In many cases we attempt to keep surveys "consistent" but this is often impossible, as materials or equipment become unavailable. There may also be a need to develop surveys both for changed circumstances, e.g. distributional or species changes and for changed needs; e.g. for surveys that can describe fishery ecosystems not just abundance of one or two species. There is a critical need to understand the behaviour of the fish we survey in relation to the tools with which we survey; e.g. avoidance on acoustic or fishing surveys. Many survey series will have gaps in them due to resource problems etc., so we also need methods for maximising the value of these time series. New surveys are often proposed, particularly in the context of recovery plans, and yet these are often launched with little forethought. An examination of new surveys and the process leading to them would be very useful. Where we have mature multi-nation survey series, there are often problems of QA both within and between national surveys, methods for documenting and controlling these are required.

The proposed theme session covers the remits of three committees; LRC, RMC and FTC. Much of this type of work is already being addressed, in the context of trawl surveys, by SGSTS, and the session will be used to provide a forum for dissemination of their findings. Contribution from other survey approaches and methodologies are also invited.

18.4 ICES Symposia

Fishing Technology in the 21st Century: Integrating Fishing and Ecosystem Conservation Boston, USA, 30 October – 3 November 2006

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?

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Annex 2: WGFTFB Information for other ICES Expert Groups – Questionnaire sent to WGFTB Members

Incorporation of Fishing Technology Issues/Expertise into Management Advice.

Rationale:

Over the past few years, the nature of the advice ICES has been requested to provide by the client commissions e.g. Norway, EU, NAFO etc has changed considerably.

ICES is now asked to provide advice that is more holistic in nature, including information on the influence and effects of human activities on the marine ecosystem.

From the fishing technology perspective this includes information on how fishermen are responding and adapting to changes in regulatory frameworks e.g. the introduction of effort control; technological creep; fleet adaptations to other issues e.g. fuel prices etc.

In response to this WGFTFB initiated a ToR in 2005 to collect data and information that was appropriate for fisheries and ecosystem based advice, co-sponsored by Dominic Rihan (Ireland), Dave Reid (Scotland) and Norman Graham (Norway).

In 2006, the FAO-ICES WGFTFB was formally requested by the Advisory Committee on Fisheries Management (ACFM) to provide such information and to submit this to the appropriate assessment working group.

This type of information is becoming more and more important at both international and national levels. It demonstrates that the community of gear technologists have an important role to play in this and that our expertise is considered to be highly valued.

Please note that this is intended for WGFTFB members from countries that receive their stock/fisheries advice from ICES.

It would be greatly appreciated if you, in collaboration with whoever necessary, fill out the questionnaire and Excel file.

Thank you for your time and effort

Dominic, Dave and Norman

Introduction

This questionnaire is in two parts.

Part 1

1. The first element contains a series of questions relating to recent changes within the fleets in you particular country that you may have observed. It also gives you the opportunity to raise any issues that you think are important but are not currently recognised.

   If at all possible, please try to quantify your statements or state how the information has been derived e.g. common knowledge, personal observations, discussions with industry etc.

a. *Fleet Dynamics*

Have there been any major changes in fleet dynamics over the year in particular fisheries? Specify the fisheries and areas. *For example have there been any significant shifts between fisheries, operating areas, changes in fishing method, including mesh size changes. Can you provide a brief explanation as to why these changes have occurred e.g. changes in regulations, fuel prices etc.*

b. *Technology Creep*

Have there been any significant changes in the fisheries that can be accredited to technological creep? Specify the fisheries and is the effect these changes have had on the fisheries in terms of CPUE quantifiable to any degree?
Include such issues as new gear handling methods/equipment; switch from single to multiple trawling for example; changes in vessel design that could affect effort etc; new fish finding equipment.

c. *Technical Conservation Measures*

Have any new TCM's been introduced into the fisheries? Please specify regulation (national or otherwise) and fishery. Can you briefly describe the rationale for their introduction? *Other important information could include what is the level of uptake if voluntary, has the selectivity of these been determined and if so how does it compare with the earlier estimates, are there any other wider benefits e.g. reduced fuel costs, ecosystem benefits etc.*

d. *Ecosystem Effects*

Are there any fisheries where there are known impacts on non-target species including birds and marine mammals, ghost fishing etc? Are there any mitigation measures in place and how effective have they been?

e. *Development of New Fisheries*

Briefly describe any new fisheries developed? Have these new fisheries removed effort from others, and if so can you provide an estimate of by how much?

f. *Any other comments or remarks?*

2. The second part relates to point c in the list and the tables in the attached Excel file.

These tables are designed to provide information as to whether selectivity data is available for the key stocks and fisheries in different regions, based loosely on the Regional Advisory Council Areas.

They are not designed to be a definitive review of available data but merely to identify gaps in knowledge and also provide an indication of the species composition in different fisheries. Each table in which your country has participation should be completed but rather than including actual estimates all that is required in the species "selectivity data" columns is a **YES** for data is available; **LEAVE BLANK** for no data is available; or **NA** for not applicable if that fish is not caught with the gear type.

If the selectivity data is more than 10 years old, enter either **NO** or alternatively mark with an * indicating the data is old. In the "selectivity device" column please indicate using the codes provided whether estimates of selectivity parameters with the devices listed are available.

Please return both files prior to the WGFTFB meeting by email to Dominic Rihan (rihan@bim.ie) and use a country code identifier in the file name e.g. Norway.xls or Norway.doc. Your information will then be collated during the WGFTFB meeting into a common format.

Annex 3: Information to individual ICES Expert Groups

Annex 3A – FTFB Report to WGNSSK

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the North Sea and Skagerrak.

It should be noted that the information contained in this report does not cover fully all fleets engaged in North Sea fisheries; information was obtained from Denmark, Scotland, England, Belgium, Netherlands, Sweden and Norway.

- Due to increasing fuel prices, 2005/2006 has seen a shift from twin to single trawl by many boats in the Scottish demersal mixed fishery sector – North Sea, IVa, Fladden grounds *Nephrops* and whitefish fisheries. Also some boats shifting to pair seine/trawl in the same sectors. Again for fuel costs and to minimize gear damage. (UK, Scotland. Implication: Change in CPUE)
- Fuel costs and quota availability are also having a significant impact on the fishing strategies of the Norwegian offshore demersal fish trawling fleet. Operators are now targeting aggregated fish to increase CPUE to reduce operating costs (fuel) and are either remaining in port or switching to the shrimp fishery. In addition to targeting high aggregations, vessels are also adjusting practice to maximise revenue obtained from by-products, typically targeting fish with a high roe or liver (oil) content. The move into the shrimp fishery has been greatly reduced in recent years due to the low market value of this species. In many instances, fishermen are using this as an alternative to remaining in port in order to maintain their crews. (Norway. Implication: Change in CPUE).
- In the Swedish *Nephrops* fisheries in the Skagerrak effort has been switched from the trawl fishery to a pot fishery, although no estimates are available of the exact number of vessels involved. (Sweden. Implications: Changes in CPUE).
- There are visible changes in effort in the Danish industry. There has been an increase in haddock landings values by the Danish Seine fleet in the North Sea, although no increase in effort levels. In addition to these small changes in the catch composition the impression from the most recent years is that much effort is being shifted between areas (North Sea and Skagerrak/Kattegat) by the trawl and seine sectors of the Danish fleet without this being visible/changing the overall picture of the total effort allocation on methods and areas. The changes in fleet dynamics are being driven by a variety of underlying mechanism of biological, economical and management related nature with the two major ones being I) the negative stock developments of cod and sand eel with attached regulatory initiatives and II) the ongoing general revision of the Danish management measures towards a system with individual quotas, where building up historical rights (in terms of a catch history) in as many geographical management units as possible is becoming increasingly important for the individual vessels. (Denmark. Implications: Changes in CPUE; Mis-reporting of landings by areas)
- There is evidence of Scottish whitefish boats moving between Areas IVa and VIa to retain haddock and monkfish quotas and create track record in both areas. There is evidence of mis-reporting of haddock and other species caught in VIa and b landed as IVa. (UK, Scotland. Implication: Inaccurate landings data).
- Around a dozen Northern Irish multi-rig vessels participated in the Farne Deeps *Nephrops* fishery in 2005/2006 as fish and *Nephrops* quota restrictions meant it wasn't economically viable to remain in area VIIa. (UK, Northern Ireland. Implications: Changes in CPUE).
- There has been a large expansion in the squid fishery in the Moray Firth area. There has been an increase in effort from smaller <10m vessels, but also a

number of larger vessels have switched from demersal fisheries for haddock and cod to squid fishery to avoid days at sea restrictions. There is evidence of an increase in gear damage by these larger vessels as they strive to work increasingly hard ground areas. Nets are used with high headline, with heavy ground gear, fished hard down on the seabed. These vessels are using small mesh size (40mm codends), which may result in bycatch/discard of young haddock and cod. (UK, Scotland. Implications: Change in CPUE; Discarding; Increased use of Heavy Rockhopper Footropes with increased potential bottom impact).

- The latest days' allocations under EU Regulation No. 51/2006 still provide no incentive for *Nephrops* fishermen to use a mesh size larger than 80 mm. If they use gear in the mesh size range (100–119 mm) then they lose days at sea from 227 to 103 per year. There has therefore been a steady shift into smaller mesh fisheries. The proposed use of the Swedish Grid in 2006 for *Nephrops* fishery, introduced under this regulation to allow extra fishing days, is unlikely to be taken up by the Scottish mixed whitefish/prawn fleet because it requires >70% prawns in the catch which precludes a mixed fishery, and because of perceived problems of handling (grids don't go through powerblocks) and blockage of the grid by mud/debris. A Scottish initiative with industry backing to introduce 95mm codends with 120mm smp for *Nephrops* has been put forward as an alternative gear combination, with a proposed increase in the number of days for this gear combination compared to the 70–99 mm mesh size range. There is still debate as to the correct positioning of the smp, although trials are planned to test different variations. Initial indications, however, from Denmark and Norway indicate the 120smp gives good improvements to selectivity for cod and haddock. (UK, Scotland. Implications: Change in CPUE; Discarding; Uptake of TCM).
- In order to reduce discards of cod in the mixed fishery primarily in the North Sea, a 140 mm window was introduced in the EU effort regulations from 2006. Using the window is granted with 1 day at sea / month. In 2005 the properties of the window was investigated in a catch comparison experiment. There is uptake of this measure in Denmark. (Denmark. Implications: Uptake of TCM with improvements to selectivity).
- In Belgium, with the increased cost of fuel and pressure to use gears that have less bottom impact, beam trawlers are looking at alternative gears, particularly gillnets. The current regulations, however, provide little incentive to switch to such gears such, as the current effort levels contained in the regulation are the same for both gears (~ 140 days). (Belgium. Implications: Management measures counter productive).
- There is evidence from the net makers in Scotland of increased use of "double crown" trouser trawls. These nets have a wider mouth opening, with a twin codend arrangement and are seen by some fishermen as an alternative to twin rigging, given the increase in swept area compared with a standard trawl. (UK, Scotland. Implications: Technology Creep)
- There has been an increasing trend in the past few years for Norwegian fishermen to use thicker rope in the seine net fisheries typically increasing from 32mm to 42mm diameter rope. It is believed that this 'thicker' rope has better fishing power and it has also opened up more areas to exploitation. In addition more Norwegian vessels are now using the triplex hauling system as opposed to the power block for hauling the seine net, as this system is easier to operate and allows for continued fishing in periods of bad weather. (Norway. Implications: Technology Creep; Increased bottom impact; Change in CPUE)
- Many Norwegian seine net operators are choosing to use minimum mesh sizes in excess of the legal Norwegian minimum mesh size of 125mm full square mesh codend, and opting for 145–160 mm in order to a) ensure access to fishing grounds by reducing the retention of fish below minimum catch size and b) to maximise the economic return from individual quotas by targeting larger fish due to high price differential between size categories e.g. 10Nok/kg for 800g fish and 20–22Nok/kg for fish >2.5kg. (Norway. Implications: Change in CPUE; Voluntary uptake of more selective gear)

- The Norwegian offshore trawler fleet has gradually been increasing the size and weight of the trawls used e.g. larger trawls, bigger doors and increased groundgear weight to open up previously inaccessible trawling areas. (Norway. Implications: Technology Creep; Increased bottom impact)
- There haven't been any major shifts between fisheries, beam trawlers still account for more than 93% of the Belgian fleet, however, due to high fuel prices, several vessels of this fleet segment have tested different methods in order to reduce their fuel costs. These include (a) reducing the weight of the beam trawl by decreasing the length of the beam or reducing the weight of the shoes. These adaptations were tested and financed by only a few vessels of the big segment (engine power > 300kW); (b) Installing econometers to monitor fuel consumption. At present, ergonometers are only installed on a few vessels, however in the near future it is to be expected that the use of an econometer will increase, particularly if grant aid becomes available. (c) Limited diversification trials fishing gear to replace beam trawls with other trawl gear. These include 3 small bean trawls (<221Kw) and 1 lager beamer (> 221KW) converting to outrigger trawling, with a further larger beam trawler converting to twin-rigging and a smaller vessel to single-rig trawling. It is to be expected that this kind of (seasonal) replacements will increase in the upcoming years. In addition several fishermen have explored new types of fisheries and/or fishing methods. These changes are only minor, involving 4 vessels, converting from beam trawling to squid, *Nephrops* and one vessel changing to handlining for sea bass. Indications are though, that this trend will continue in Belgium. (Belgium. Implications: Changes in CPUE; Changes to Fleet Structure).
- Two large beam trawlers in the Belgium fleet (~1200Kw) are currently testing two technical modifications for the beam trawl, including T90-codends in combination with a benthos release panel in the belly of the beam trawl. Indications are that the remaining fleet are considering a voluntary uptake of these modifications. (Belgium. Implications: Voluntary uptake of TCM's).
- There is evidence in Belgium that fishermen in the beam trawl sector, who had previously under reported their engine horsepower, have now re-aligned their engine horsepower upwards to increase their fishing entitlements, allocated under national management measures. Similar situations have arisen in a number of other countries. (Belgium. Implication: Changes in CPUE).
- In Belgium, vessel owners have been encouraged to replace smaller beam trawlers with one large vessel but it is debatable whether the fishing operations of these larger vessels, using heavier gear but over a narrower area, has a greater or lesser effect on benthic habitats than a larger number of smaller boats fishing over a wider area. (Belgium. Implication: Effect on bottom impact).
- The development of electrified beam trawling for flatfish species has been tested in the Netherlands. The main driver is to lessen impact on benthic communities and diminishing discarding of target species sole and plaice, but recently also to decrease fuel consumption. Attempts are currently made to lift the European ban and while there are definite benefits in terms of fuel consumption and less bottom impact on the use of electricity, concerns have been raised about the possible ecosystem effects of using the electric beam trawl system. (See FTFB expert group report). (Netherlands. Implications: Changes in CPUE; Ecosystem effects).
- Currently Dutch skippers in the beam trawl fleet reacting to high fuel prices are reportedly towing slower and changing gear components, including using larger mesh sizes in forward parts of the trawl and thinner twines in codends. (Netherlands. Implications: Changes in CPUE; Improved selectivity of gear).
- Another development seen in the Dutch beam trawl fleet is the installation of automatic winch controls (Marelec™-system), thus avoiding gear fasteners leading to smaller losses in fishing time, and possibly working on new grounds. (Netherlands. Implications: Technology Creep; Bottom Impact)
- Twin/multiple trawl rigs have increased in use in Denmark increasing the catch efficiency for demersal species (e.g. *Nephrops* and plaice) significantly and probably to such a level that the changes in CPUE cannot be derived analytically

from official catch and effort data. DIFRES is presently working on this subject but results are not yet available on the actual increase in effort. (Denmark. Implications: Changes in CPUE; Technology Creep).

- Approximately 4 UK vessels have switched from twin-rig to quad-rigs in an area in IVb mainly in the *Nephrops* fishery. The change in CPUE has not been quantified but evidence suggests an increased catches of small lemon sole. (UK, England. Implication: Change IN CPUE; Technology Creep)
- Their gross earnings. The Irish beam trawl fleet, the larger twin-riggers and the 30m+ whitefish trawlers have been hardest hit. Owners have become increasingly fuel conscious, steaming to and from fishing grounds at reduced speed and shutting down all engines while at port. There is also evidence of fishermen begin to experiment with gear designs to improve fuel efficiency. (UK, Ireland. Implication: Change in CPUE)
- There has been increased effort in the *Nephrops* fisheries in Area VIa. Several of the larger 24m+ demersal trawlers have switched to trawling for *Nephrops* after the spring whitefish fishery in the south-east finished in early April. These vessels have targeted monkfish previously but due to increased enforcement and the days at sea restrictions for mesh size over 100mm in Area VIa, several of the vessels have switched to *Nephrops* fisheries. These vessels have concentrated on the Stanton Bank. (Ireland. Implication: Change in CPUE)
- There is concern about moves by certain Galician based companies to acquire "double licences", enabling the large freezer trawlers working in NAFO waters to switch their fishing effort to Areas VI and VII and international waters, initially fishing against Spanish blue whiting quotas. The first of these vessels (77m trawler) set sail from Vigo in March. According to the Spanish Ministry these vessels are being allowed access to the blue whiting quota, which has traditionally used for "quota swaps" with other countries for monkfish, hake and megrim quota primarily for the large Grand Sol fleet, but sources in Spain have indicated the real reason is to provide a window-of-opportunity to gain eventual access to Areas VI, VII and VIII for the NAFO fleet. The consequences for the Irish industry if this is allowed to happen are potentially catastrophic and there is also a lot of concern amongst the Grand Sol fleet as well. (Ireland, Spain. Implications: Changes in CPUE)
- There has been increased use of duplex "trouser" trawls with two codends. These nets have increased opening with a wide bosom section and increase ground coverage. This type of trawl is used mainly by *Nephrops* vessels and there are reports of at least one vessel twin-rigging with two Duplex nets. At least one seine net vessel has fished with a Duplex seine net, mainly to improve fish quality. (Ireland. Implication: Technology Creep)
- Due to increasing fuel costs, several Irish twin-rig vessels are now using nets for monkfish constructed in 200mm top and bottom wings and belly sheets with 160mm codends. These nets are low drag and easy to tow and due to the fact that this fishery is almost 100% monkfish, no marketable catch is lost with the large mesh codends. (Ireland. Implications: Improved selectivity/targeted fishery)
- In 2005, Ireland did not manage to fully catch the hake caught, due to a decline in the number of gillnet vessels and as a result several 24m demersal vessels are planning to pair trawl for hake using Spanish style VHO trawls to target hake. This is seen as a viable fishery, particularly given the gillnet ban currently in force in Areas VI and VII has meant a huge reduction in effort in the area and good signs of hake in all areas. (Ireland. Implications: Changes in CPUE; Targeted fishing with selective gear).
- The latest days' allocations under EU Regulation No. 51/2006 still provide no incentive for *Nephrops* fishermen to use a mesh size larger than 80mm. If they use gear in the mesh size range (100-119mm) then they lose days at sea from 227 to 103 per year. There has therefore been a steady shift into smaller mesh fisheries. The proposed use of the Swedish Grid in 2006 for *Nephrops* fishery, introduced under this regulation to allow extra fishing days, is unlikely to be taken up by the Irish *Nephrops* fleet in Area VIa or VIIa because it requires

>70% prawns in the catch which precludes a mixed fishery, and because of perceived problems of handling (grids don't go through powerblocks) and blockage of the grid by mud/debris. (Ireland. Implications: Change in CPUE; Discarding; Uptake of TCM).

- Under Regulation 51/2006 the use of gillnets has been banned outside 200m depth. This was largely as a result of the DEEPNET report, which raised concerns about the deepwater tangle net fisheries for monkfish and deepwater shark involving up to 50 Anglo Spanish vessels. This ban has also affected vessels targeting hake and caused a shift in effort to other areas but greatly reduced the effort in Area VI and VII. This ban is not considered permanent and the EU has indicated that are willing to open the fisheries again if a property management framework for these fisheries can be agreed. (All countries. Implications: Changes in CPUE)

Annex 3B — FTFB Report to WGNSDS

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Northern Shelf Assessment Area including the Irish Sea.

It should be noted that the information contained in this report does not cover fully all fleets engaged in Northern Shelf fisheries; information was obtained from Ireland, Belgium, UK and France.

- There is evidence of Scottish whitefish boats moving between Areas IVa and VIa to retain haddock and monkfish quotas and create track record in both areas. There is evidence of mis-reporting of haddock and other species caught in VIa & b landed as IVa. (UK, Scotland. Implication: Inaccurate landings data).
- In Belgium, with the increased cost of fuel and pressure to use gears that have less bottom impact, beam trawlers are looking at alternative gears, particularly gillnets. The current regulations, however, provide little incentive to switch to such gears such, as the current effort levels contained in the regulation are the same for both gears (~ 140 days). (Belgium. Implications: Management measures counter productive).
- There haven't been any major shifts between fisheries, beam trawlers still account for more than 93% of the Belgian fleet, however, due to high fuel prices, several vessels of this fleet segment have tested different methods in order to reduce their fuel costs. These include (a) reducing the weight of the beam trawl by decreasing the length of the beam or reducing the weight of the shoes. These adaptations were tested and financed by only a few vessels of the big segment (engine power > 300kW); (b) Installing econometers to monitor fuel consumption. At present, ergonometers are only installed on a few vessels, however in the near future it is to be expected that the use of an econometer will increase, particularly if grant aid becomes available; (c) Limited diversification trials fishing gear to replace beam trawls with other trawl gear. These include 3 small bean trawls (<221Kw) and 1 lager beamer (> 221KW) converting to outrigger trawling, with a further larger beam trawler converting to twin-rigging and a smaller vessel to single-rig trawling. It is to be expected that this kind of (seasonal) replacements will increase in the upcoming years. In addition several fishermen have explored new types of fisheries and/or fishing methods. These changes are only minor, involving 4 vessels, converting from beam trawling to squid, *Nephrops* and one vessel changing to handlining for sea bass. Indications are though, that this trend will continue in Belgium. (Belgium. Implications: Changes in CPUE; Changes to Fleet Structure).
- Two large beam trawlers in the Belgium fleet (~1200Kw) are currently testing two technical modifications for the beam trawl, including T90-codends in combination with a benthos release panel in the belly of the beam trawl.

Indications are that the remaining fleet are considering a voluntary uptake of these modifications. (Belgium. Implications: Voluntary uptake of TCM's).

- There is evidence in Belgium that fishermen in the beam trawl sector, who had previously under reported their engine horsepower, have now re-aligned their engine horsepower upwards to increase their fishing entitlements, allocated under national management measures. Similar situations have arisen in a number of other countries. (Belgium. Implication: Changes in CPUE).
- In Belgium, vessel owners have been encouraged to replace smaller beam trawlers with one large vessel but it is debatable whether the fishing operations of these larger vessels, using heavier gear but over a narrower area, has a greater or lesser effect on benthic habitats than a larger number of smaller boats fishing over a wider area. (Belgium. Implication: Effect on bottom impact).
- In 2005 Ireland introduced a decommissioning scheme aimed at removing around 6,000 GT/18,000 kW from the Irish fleet. This follows from the two Whitefish Renewal Schemes, which introduced around 32 new vessels into the Irish fleet. The decommissioning scheme is targeted at demersal and scallop vessels over 18m. The scheme is split into three rounds, with around 8 vessels already scrapped as part of the first phase and a total of 44 vessels in all due to be scrapped by the end of 2006. (Ireland. Implications: Changes in CPUE; changes in Fleet Structure).
- There is increasing concern in the industry in the rising cost of fuel, with many vessel owners seriously considering leaving the industry. Several twin-rig vessels targeting monkfish have reverted to single-rigging. Fuel costs across nearly all sectors are now running at 35–50% of their gross earnings. The Irish beam trawl fleet, the larger twin-riggers and the 30m+ whitefish trawlers have been hardest hit. Owners have become increasingly fuel conscious, steaming to and from fishing grounds at reduced speed and shutting down all engines while at port. There is also evidence of fishermen begin to experiment with gear designs to improve fuel efficiency. (UK, Ireland. Implication: Change in CPUE)

Annex 3C — FTFB Report to WGSSDS/WGHMM

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Southern Shelf Assessment Area including the Celtic Sea and hake, monkfish and megrim stocks.

It should be noted that the information contained in this report does not cover fully all fleets engaged in Southern Shelf fisheries; information was obtained from Ireland, Belgium, UK and France.

- There is evidence of Scottish whitefish boats moving between Areas IVa and VIa to retain haddock and monkfish quotas and create track record in both areas. There is evidence of mis-reporting of haddock and other species caught in VIa & b landed as IVa. (UK, Scotland. Implication: Inaccurate landings data).
- In Belgium, with the increased cost of fuel and pressure to use gears that have less bottom impact, beam trawlers are looking at alternative gears, particularly gillnets. The current regulations, however, provide little incentive to switch to such gears such, as the current effort levels contained in the regulation are the same for both gears (~ 140 days). (Belgium. Implications: Management measures counter productive).
- There haven't been any major shifts between fisheries, beam trawlers still account for more than 93% of the Belgian fleet, however, due to high fuel prices, several vessels of this fleet segment have tested different methods in order to reduce their fuel costs. These include (a) reducing the weight of the beam trawl by decreasing the length of the beam or reducing the weight of the shoes. These

adaptations were tested and financed by only a few vessels of the big segment (engine power > 300kW); (b) Installing econometers to monitor fuel consumption. At present, ergonometers are only installed on a few vessels, however in the near future it is to be expected that the use of an econometer will increase, particularly if grant aid becomes available. (c) Limited diversification trials fishing gear to replace beam trawls with other trawl gear. These include 3 small bean trawls (<221Kw) and 1 lager beamer (> 221KW) converting to outrigger trawling, with a further larger beam trawler converting to twin-rigging and a smaller vessel to single-rig trawling. It is to be expected that this kind of (seasonal) replacements will increase in the upcoming years. In addition several fishermen have explored new types of fisheries and/or fishing methods. These changes are only minor, involving 4 vessels, converting from beam trawling to squid, *Nephrops* and one vessel changing to handlining for sea bass. Indications are though, that this trend will continue in Belgium. (Belgium. Implications: Changes in CPUE; Changes to Fleet Structure).

- Two large beam trawlers in the Belgium fleet (~1200Kw) are currently testing two technical modifications for the beam trawl, including T90-codends in combination with a benthos release panel in the belly of the beam trawl. Indications are that the remaining fleet are considering a voluntary uptake of these modifications. (Belgium. Implications: Voluntary uptake of TCM's).
- There is evidence in Belgium that fishermen in the beam trawl sector, who had previously under reported their engine horsepower, have now re-aligned their engine horsepower upwards to increase their fishing entitlements, allocated under national management measures. Similar situations have arisen in a number of other countries. (Belgium. Implication: Changes in CPUE).
- In Belgium, vessel owners have been encouraged to replace smaller beam trawlers with one large vessel but it is debatable whether the fishing operations of these larger vessels, using heavier gear but over a narrower area, has a greater or lesser effect on benthic habitats than a larger number of smaller boats fishing over a wider area. (Belgium. Implication: Effect on bottom impact).
- In 2005 Ireland introduced a decommissioning scheme aimed at removing around 6,000 GT/18,000 kW from the Irish fleet. This follows from the two Whitefish Renewal Schemes, which introduced around 32 new vessels into the Irish fleet. The decommissioning scheme is targeted at demersal and scallop vessels over 18m. The scheme is split into three rounds, with around 8 vessels already scrapped as part of the first phase and a total of 44 vessels in all due to be scrapped by the end of 2006. (Ireland. Implications: Changes in CPUE; changes in Fleet Structure).
- There is increasing concern in the industry in the rising cost of fuel, with many vessel owners seriously considering leaving the industry. Several twin-rig vessels targeting monkfish have reverted to single-rigging. Fuel costs across nearly all sectors are now running at 35–50% of their gross earnings. The Irish beam trawl fleet, the larger twin-riggers and the 30 m+ whitefish trawlers have been hardest hit. Owners have become increasingly fuel conscious, steaming to and from fishing grounds at reduced speed and shutting down all engines while at port. There is also evidence of fishermen begin to experiment with gear designs to improve fuel efficiency. (UK, Ireland. Implication: Change in CPUE)
- There has been increased effort in the *Nephrops* fisheries in Area VII. Several of the larger 24m+ dual RSW/demersal trawlers switched to trawling for *Nephrops* after the mackerel fishery finished in early March. These vessels have concentrated on the Porcupine and Labadie Bank fisheries. Due to increased enforcement in the monkfish fishery, several of the 20–24m twin-rig vessels have also switched to *Nephrops* fisheries. Again much of this effort has been in the Porcupine and Labadie fisheries.
- There is concern about moves by certain Galician based companies to acquire "double licences", enabling the large freezer trawlers working in NAFO waters to switch their fishing effort to Areas VI and VII and international waters, initially fishing against Spanish blue whiting quotas. The first of these vessels (77m

trawler) set sail from Vigo in March. According to the Spanish Ministry these vessels are being allowed access to the blue whiting quota, which has traditionally used for "quota swaps" with other countries for monkfish, hake and megrim quota primarily for the large Grand Sol fleet, but sources in Spain have indicated the real reason is to provide a window-of-opportunity to gain eventual access to Areas VI, VII and VIII for the NAFO fleet. The consequences for the Irish industry if this is allowed to happen are potentially catastrophic and there is also a lot of concern amongst the Grand Sol fleet as well. (Ireland, Spain. Implications: Changes in CPUE)

- There has been increased use of duplex "trouser" trawls with two codends. These nets have increased opening with a wide bosom section and increase ground coverage. This type of trawl is used mainly by *Nephrops* vessels and there are reports of at least one vessel twin-rigging with two Duplex nets. At least one seine net vessel has fished with a Duplex seine net, mainly to improve fish quality. (Ireland. Implication: Technology Creep)
- Due to increasing fuel costs, several Irish twin-rig vessels are now using nets for monkfish constructed in 200mm top and bottom wings and belly sheets with 160mm codends. These nets are low drag and easy to tow and due to the fact that this fishery is almost 100% monkfish, no marketable catch is lost with the large mesh codends. (Ireland. Implications: Improved selectivity/targeted fishery)
- In 2005, Ireland did not manage to fully catch the hake caught, due to a decline in the number of gillnet vessels and as a result several 24m demersal vessels are planning to pair trawl for hake using Spanish style VHO trawls to target hake. This is seen as a viable fishery, particularly given the gillnet ban currently in force in Areas VI and VII has meant a huge reduction in effort in the area and good signs of hake in all areas. (Ireland. Implications: Changes in CPUE; Targeted fishing with selective gear).
- The latest days' allocations under EU Regulation No. 51/2006 still provide no incentive for *Nephrops* fishermen to use a mesh size larger than 80mm. If they use gear in the mesh size range (100–119 mm) then they lose days at sea from 227 to 103 per year. There has therefore been a steady shift into smaller mesh fisheries. The proposed use of the Swedish Grid in 2006 for *Nephrops* fishery, introduced under this regulation to allow extra fishing days, is unlikely to be taken up by the Irish *Nephrops* fleet in Area VIa or VIIa because it requires >70% prawns in the catch which precludes a mixed fishery, and because of perceived problems of handling (grids don't go through powerblocks) and blockage of the grid by mud/debris. (Ireland. Implications: Change in CPUE; Discarding; Uptake of TCM).
- Under Regulation 51/2006 the use of gillnets has been banned outside 200m depth. This was largely as a result of the DEEPNET report, which raised concerns about the deepwater tangle net fisheries for monkfish and deepwater shark involving up to 50 Anglo Spanish vessels. This ban has also affected vessels targeting hake and caused a shift in effort to other areas but greatly reduced the effort in Area VI and VII. This ban is not considered permanent and the EU has indicated that are willing to open the fisheries again if a property management framework for these fisheries can be agreed. (All countries. Implications: Changes in CPUE)
- There is evidence of decreased catches of juvenile hake in the French *Nephrops* fishery in the Bay of Biscay, since the introduction of regulations under the Hake Recovery Plan making the use of square mesh panels mandatory. (France. Implications: Improved selectivity)

Annex 3D — FTFB Report to WGBFAS

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates;

identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Baltic.

It should be noted that the information contained in this report does not cover fully all fleets engaged in Baltic; information was obtained from Sweden and Denmark.

- New regulations have been introduced into the cod fishery in Area IVd. The MPA in central Bornholm Basin, which is the main spawning area, has increased in size considerably in 2005, to ca 4 500 km^2. BACOMA window in cod trawls to improve selectivity for cod in the regulation since 2002, when MLS also was increased from 35 to 38 cm and in 2006 T90 meshes in the codend and extension has been introduced as an alternative to BACOMA. According to on board sampling by Swedish observers, most of the trawlers experience a lower discard rate with BACOMA windows than in previous years. No definite figures are available yet and indications would suggest similar results with the T90 codend/extension. Fishermen in Sweden appear satisfied with the BACOMA window. (Sweden. Implication: Improved selectivity)
- Longlining for cod has increased in Sweden in recent years, although a still account for only 10% of the total catches. The main driver for this shift in method is the better price for longline caught cod and it is expected to increase over time. (Sweden. Implications: Changes in CPUE; Improved selectivity)
- The cod gillnet fishery in the Baltic is restricted with regard to total fleet length per vessel (12 km for vessels <12 m and 24 km for vessels >12 m) and a maximum soak time (48 h). This imposes no restrictions, however, on the Swedish fishery because average total fleet length used is only ca 6 km, with no vessel using >12 km. Normal soak-time is around 13 – 18h. Thus these regulations are out of line with current practice. (Sweden. Implications: Ineffective management measures)
- Similarly the salmon drift-net fishery in the Baltic (due to be phased out in 2008) is restricted to 600 nets per vessel, with a maximum net length of 35 m (headline). For salmon long-lines the number of hooks is restricted to 2000 hooks per vessel. For both gears these amounts are the maximum possible to handle so again these regulations have no impact in reducing overall effort. (Sweden. Implications: Ineffective Management measures)
- Retrieval experiments by the Institute of Marine Research in Sweden and special efforts by gillnet fishers to remove ghost-nets have resulted in ca 30–40 km of netting per year removed from the Baltic Sea in recent years. However, the small losses, ca 0.1% of the gears used, in the Swedish (the same for the Danish) gillnet fishery for cod, still means about 165 km of new nets are lost every year. The mortality caused by them is estimated to be in the order of 200–300 tonnes of cod, insignificant compared to e.g. discard rates in the trawl fishery, but still a considerable source of unaccounted fish mortality. (Sweden/Denmark. Implications: Ecosystem effect/Unaccounted fish mortality)
- There are visible changes in effort in the Danish industry. There is a marked – although economically not important – increase in catch values of plaice and flounder in the Eastern Baltic from both trawlers and gill-netters. In addition to these small changes in the catch composition the impression from the most recent years is that much effort is being shifted between areas without this being visible/changing the overall picture of the total effort allocation on methods and areas. The changes in fleet dynamics described above are driven by a variety of underlying mechanism of biological, economical and management related nature with the two major ones being I) the negative stock developments of cod and sand eel with attached regulatory initiatives and II) the ongoing general revision of the Danish management measures towards a system with individual quotas, where building up historical rights (in terms of a catch history) in as many geographical management units as possible is becoming increasingly important for the individual vessels. (Denmark. Implications: Changes in CPUE).

- The German pair pelagic trawl fleet, which consists of vessels < 26 metres and 300hp have begun to use low drag /easily manoeuvred trawls for herring in the Baltic in 2005. These trawls have headline openings of 20–40 metres are superior to traditional designs used by this fleet. One pair of vessels of 26.5m landed 3,000 tonnes of herring in the Baltic in 2005. These vessels have also begun to tow with two warps each side, which gives greater flexibility than a single warp system traditionally used, with more scope for fine-tuning the gear and the trawls position relative to fish shoals. (Germany. Implications: Technology creep; Changes in CPUE).

Annex 3E — FTFB Report to AFWG

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Arctic Fisheries areas.

It should be noted that the information contained in this report does not cover fully all fleets engaged in fisheries; information was obtained from Norway, primarily.

- In recent years there has been a shift from both longline and gillnet fisheries in North Western and Northern Norway, particularly of vessels in the 16–28 m size category. The move from the gillnet fishery has been prompted by the fact that with a seine net, it is possible to move to alternative grounds more quickly and due to the discarding legislation there is more pressure to retrieve gear once it deployed even in bad weather. The reduction in longline fisheries has been primarily caused by the cost of bait. The price of mackerel has increased considerably in the last few years. Despite the availability of automatic and semi-automatic baiting machines, the majority of smaller operators still rely on land based hand baiting. As this effectively ties vessels to a particular area, as they have to return to the baiting station frequently, it limits there operating strategy. Data is available from selling agents, which quantifies the extent of these changes; this will be explored in due course. (Norway. Implications: Changes in Fleet Structure and CPUE).

- Fuel costs and quota availability are having a significant impact on the fishing strategies of the Norwegian offshore demersal fish trawling fleet. Operators are now targeting aggregated fish to increase CPUE to reduce operating costs (fuel) and are choosing to remain in port. In addition to targeting high aggregations, vessels are also adjusting practices to maximise revenue obtained from by-products, typically targeting fish with a high roe or liver (oil) content. The move into the shrimp fishery has been greatly reduced in recent years due to the low market value of this species. In many instances, fishermen are using this as an alternative to remaining in port in order to maintain their crews, as crew wages can be offset against shrimp catches. (Norway. Implications: Changes in CPUE).

- There has been an increasing trend in the past few years for Norwegian fishermen to use thicker rope in the seine net fisheries typically increasing from 32mm to 42mm diameter rope. It is believed that this ‘thicker’ rope has better fishing power and it has also opened up more areas to exploitation. In addition more Norwegian vessels are now using the triplex hauling system as opposed to the power block for hauling the seine net, as this system is easier to operate and allows for continued fishing in periods of bad weather. (Norway. Implications: Technology Creep; Increased bottom impact; Change in CPUE).

- The Norwegian offshore trawler fleet has gradually been increasing the size and weight of the trawls used e.g. larger trawls, bigger doors and increased groundgear

weight to open up previously inaccessible trawling areas. (Norway. Implications: Technology Creep; Increased bottom impact)

- Many Norwegian seine net operators are choosing to use minimum mesh sizes in excess of the legal Norwegian minimum mesh size of 125mm full square mesh codend, and opting for 145–160 mm in order to a) ensure access to fishing grounds by reducing the retention of fish below minimum catch size and b) to maximise the economic return from individual quotas by targeting larger fish due to high price differential between size categories e.g. 10Nok/kg for 800g fish and 20–22Nok/kg for fish >2.5kg. (Norway. Implications: Change in CPUE; Voluntary uptake of more selective gear).

- Several Icelandic pelagic vessels have experimented with redfish trawls constructed with hexagonal mesh in their fore part. Hexagonal mesh, like T90, opens the mouth of the trawl and increases water flow. (Ireland. Implications: Technology creep; Less meshing)

Annex 3F — FTFB report to WGHMSA

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects in pelagic fisheries for mackerel, horse mackerel, sardine and anchovy.

It should be noted that the information contained in this report does not cover fully all fleets engaged in fisheries; information was obtained from Ireland, Norway, Scotland and France.

- Legal action against factories in NE Scotland and Shetland has resulted in significant reduction in quota for most pelagic boats. Action is apparently based on overlandings in 2005, and so different for each vessel. Estimates for some vessels of up to 80% of 2006 mackerel quota lost. Details are still unclear, but this has led to a drastic reduction in effort and, presumably, in illegal landings. The mackerel fishery in Ia finished early in 2005 – October, rather than November. Reduced effort and an early finish to the season in 2006 Q1 has also been seen. No details of potential impact on the summer herring fishery are available, although illegal landings are likely to be greatly reduced. There are expected heavy reductions in effort in the Q3/Q4 mackerel fishery by the Scottish fleet as a result of the rigorous enforcement regime. (UK, Scotland. Implications: Reduced CPUE; Improved Landing Data).
- Similar Investigations into overfishing by the Irish RSW fleet based primarily in the port of Killybegs are ongoing. No prosecutions have been made as yet but there has been increased control and enforcement resulting in reduced landings by this fleet. Following investigations in fish factories in Scotland, illegal landings made by Irish vessels were discovered, resulting in the Irish mackerel quota being reduced by 7,000 tonnes. The fishery in 2005/2006 was closed in early February to protect the remaining quota. The Q3/Q4 fishery is expected to see reduced effort levels, as the quota will be exhausted quickly. There are reports of several of these vessels up for sale largely due to the high levels of enforcement. (Ireland. Implications: Reduced CPUE; Improved Landing Data).
- New national regulations introduced in early 2006 in Ireland have increased effort in the polyvalent mackerel fleet. This fleet is split into vessels < 65ft and> 65ft. In 2005, this fleet consisted of 11 vessels > 65ft and 7 vessels < 65ft with a total allocated quota of 7,000 tonnes. Additional 6–8 vessels participated in this fishery in 2006, closing the fishery in mid-February. There is increasing pressure on this quota and there are rumours that a further 4 vessels are being built purposely to fish against this quota. There are reports of widespread overfishing by certain vessels in this sector. (Ireland. Implications: Changes in CPUE; Mis-reporting).

- There is increasing concern in the pelagic sectors of all countries in the rising cost of fuel, with many vessel owners seriously considering leaving the industry. Fuel costs across all pelagic fleets are now running in excess of 50% of their gross earnings. Owners have become increasingly fuel conscious, steaming to and from fishing grounds at reduced speed and shutting down all engines while at port. The pelagic vessels are also now much more targeted in their approach, spending less time searching for fish. (All countries. Implications: Changes in CPUE).
- Almost all of the Irish pelagic vessels are now using brailers constructed in T90º mesh. It is reported that T90 mesh improves water flow through the trawl and reduces meshing, which can be a particularly problem in blue whiting fisheries. (Ireland. Implications: Technology creep; Less meshing)
- Several pelagic vessels have experimented with trawls constructed with hexagonal mesh in their fore part. Hexagonal mesh, like T90, opens the mouth of the trawl and increases water flow. (Ireland. Implications: Technology creep; Less meshing)
- Dutch pelagic freezer trawlers are using satellite fish maps, which provide information on plankton distribution for targeting horse mackerel. (Netherlands. Implications: Technology creep)
- FRS, Aberdeen University, SFF and the Sea Mammal Research Unit are documenting interactions between Orca and Scottish pelagic vessels in the mackerel fishery. Initial indications are that this is a major and benign interaction. (UK, Scotland. Implications: Marine Mammal interaction)
- There are increased reports of seals becoming a problem in pelagic fisheries off the west coast of Ireland. Pelagic fishermen report observing seals as far as 70–80 miles offshore and the bycatch of seals in these fisheries has grown alarmingly. This is a real problem for the fishermen as large seals cause serious damage to fish pumping equipment if not detected in time. Due to their large size they also cause net damage. Fishermen have asked net makers to design escape openings for pelagic trawls to release seals. (UK, Scotland. Implications: Marine Mammal interaction; Unaccounted Fish Mortality; Technical Conservation Measures).
- Two Irish 16m vessels fished successfully off the South-west of England for sardine during February-March 2006. (Ireland. Implications: New fisheries).
- The closure of the Anchovy fishery in the Bay of Biscay since July 2005 has resulted in major shifts in the French pelagic fleet into the Albacore tuna fishery (summer and autumn 2005) and the bass fishery (from November to March 2006. Closing of Anchovy fishery on 1 July 2005. (France. Implications: Displacement of effort)

Annex 3G — FTFB Report to HAWG/WGNPBW

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects in pelagic fisheries for mackerel, horse mackerel, sardine and anchovy.

It should be noted that the information contained in this report does not cover fully all fleets engaged in pelagic fisheries; information was obtained from Ireland, Norway, Scotland, Faroes, Germany and Sweden.

- A number of Norwegian pelagic vessels targeting coastal herring are using species selective grids to exclude bycatch of cod and saithe in order to gain access to the fishing grounds due to discard and quota restrictions. (Norway. Implications: Improved selectivity)
- The Irish Blue Whiting quota was caught by early March, following several large landings by the freezer vessel “Atlantic Dawn”. The RSW vessels were restricted to only 2–3 landings per boat and these vessels will now be tied up until

September/October. This fleet now effectively fishes for only three months of the year and there are fears that many of the experienced crewmen on these vessels will retire or go to work in other industries. It is expected in a few years that these vessels will be crewed almost entirely by East European crew. (Ireland. Implications: Changes in CPUE)

- There is concern about moves by certain Galician based companies to acquire "double licences", enabling the large freezer trawlers working in NAFO waters to switch their fishing effort to Areas VI and VII and international waters, initially fishing against Spanish blue whiting quotas. The first of these vessels (77m trawler) set sail from Vigo in March. According to the Spanish Ministry these vessels are being allowed access to the blue whiting quota, which has traditionally used for "quota swaps" with other countries for monkfish, hake and megrim quota primarily for the large Grand Sol fleet, but sources in Spain have indicated the real reason is to provide a window-of-opportunity to gain eventual access to Areas VI, VII and VIII for the NAFO fleet. The consequences for the Irish industry if this is allowed to happen are potentially catastrophic and there is also a lot of concern amongst the Grand Sol fleet as well. (Spain. Implications: Changes in CPUE; Changes in Fleet Profile).
- Almost all of the Irish pelagic vessels are now using brailers constructed in T90º mesh. It is reported that T90 mesh improves water flow through the trawl and reduces meshing, which can be a particularly problem in blue whiting fisheries. (Ireland. Implications: Technology creep; Less meshing)
- Several pelagic vessels have experimented with trawls constructed with hexagonal mesh in their fore part. Hexagonal mesh, like T90, opens the mouth of the trawl and increases water flow. (Ireland. Implications: Technology creep; Less meshing)
- Swedish trawlers fishing for herring and sprat fishery (mainly industrial) in Area IVd are using midwater trawls equipped with T90 meshes in the codend, not to improve selectivity (not investigated) but to improve water-flow through the trawl and thereby increase catches. The T90 effect ceases rather quickly so the codend has to be exchanged after at most two weeks of fishing. The costs for that are obviously more than compensated by the higher CPUE. (Sweden. Implications: Technology creep)
- Faroese trawlers targeting blue whiting are using a flexible grid on the grounds east of Iceland. These grids appear much easier to handle on board compared to rigid grids tested in these fisheries previously, and show the same selectivity characteristics as the rigid grids. These grids are used to sort species such as cod and saithe from bleu whiting. (Faroe Islands. Implications; Bycatch reduction)
- The German pair pelagic trawl fleet, which consists of vessels < 26 metres and 300hp have begun to use low drag /easily manoeuvred trawls for herring in the Baltic in 2005. These trawls have headline openings of 20–40 metres are superior to traditional designs used by this fleet. One pair of vessels of 26.5m landed 3,000 tonnes of herring in the Baltic in 2005. These vessels have also begun to tow with two warps each side, which gives greater flexibility than a single warp system traditionally used, with more scope for fine-tuning the gear and the trawls position relative to fish shoals. (Germany. Implications: Technology creep; Changes in CPUE).
- A bycatch of pilot whales has been reported in the pelagic pair trawl fishery for herring in Skagerrak (ICES IIIa). No mitigation measures have been introduced. (Sweden. Implications: Marine Mammal Interaction).

Annex 3H — FTFB Report for WGDEEP

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates;

identification of recent technological advances (creep); ecosystem effects; and the development of new deepwater fisheries.

It should be noted that the information contained in this report does not cover fully all fleets engaged in deepwater fisheries; information was obtained from UK, Ireland and France.

- There is evidence of increased use of Olex bathymetric plotting equipment by most vessels engaged in deepwater fisheries. This system, which, allows fishermen to overlay 3-dimensional bathymetric information on their fishing charts allows them to open new areas in deepwater. Several Irish skippers have used this system successfully to target orange roughy over seamounts, although this has been restricted in recent years through EU Regulation 2270/2004. (Ireland/UK. Implication: Ecosystem effect)
- Under Regulation 51/2006 the use of gillnets has been banned outside 200m depth. This was largely as a result of the DEEPNET report, which raised concerns about the deepwater tangle net fisheries for monkfish and deepwater shark involving up to 50 Anglo Spanish vessels. This ban has also affected vessels targeting hake and caused a shift in effort to other areas but greatly reduced the effort in Area VI and VII on deepwater species, particularly deepwater shark. This ban is not considered permanent and the EU has indicated that are willing to open the fisheries again if a property management framework for these fisheries can be agreed. Despite the introduction of this ban on gillnetting outside 200m, Irish fishermen, particularly in the south-west are still catching large quantities of lost or dumped gillnets on a regular basis. Many of the nets recovered are of a mesh size of 90mm or less, which is well below the minimum mesh size required in Area VII of 120mm. Much of the recovered gear consists only of sheet netting that has been stripped from the headline and footrope of the net. (Ireland. Implications: Changes in CPUE)
- Due to increasing fuel prices, 2005/2006 has seen several of the new 44m French deepwater trawlers have converted from twin-rig to single rig for deepwater species. (France. Implication: Change in CPUE)

Annex 3 I — FTFB Report for WGECO

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour; technological advances (creep); ecosystem effects; and the development of new fisheries that may have an impact on the ecosystem.

It should be noted that the information contained in this report does not cover fully all fleets engaged in deepwater fisheries; information was obtained from UK, Ireland, Netherlands and France.

- There is evidence of increased use of Olex bathymetric plotting equipment by most vessels engaged in deepwater fisheries. This system, which, allows fishermen to overlay 3-dimensional bathymetric information on their fishing charts allows them to open new areas in deepwater. Several Irish skippers have used this system successfully to target orange roughy over seamounts, although this has been restricted in recent years through EU Regulation 2270/2004. (Ireland/UK. Implication: Ecosystem effect)
- There has been an increasing trend in the past few years for Norwegian fishermen to use thicker rope in the seine net fisheries typically increasing from 32mm to 42mm diameter rope. It is believed that this ‘thicker’ rope has better fishing power and it has also opened up more areas to exploitation. In addition more Norwegian vessels are now using the triplex hauling system as opposed to the power block for hauling the seine net, as this system is easier to operate and allows for continued fishing in periods of bad weather. (Norway. Implications: Technology Creep; Increased bottom impact; Change in CPUE)

- The Norwegian offshore trawler fleet has gradually been increasing the size and weight of the trawls used e.g. larger trawls, bigger doors and increased groundgear weight to open up previously inaccessible trawling areas. (Norway. Implications: Technology Creep; Increased bottom impact)
- In Belgium, vessel owners have been encouraged to replace smaller beam trawlers with one large vessel but it is debatable whether the fishing operations of these larger vessels, using heavier gear but over a narrower area, has a greater or lesser effect on benthic habitats than a larger number of smaller boats fishing over a wider area. (Belgium. Implication: Effect on bottom impact).
- Under Regulation 51/2006 the use of gillnets has been banned outside 200m depth. This was largely as a result of the DEEPNET report, which raised concerns about the deepwater tangle net fisheries for monkfish and deepwater shark involving up to 50 Anglo Spanish vessels. This ban has also affected vessels targeting hake and caused a shift in effort to other areas but greatly reduced the effort in Area VI and VII on deepwater species, particularly deepwater shark. This ban is not considered permanent and the EU has indicated that are willing to open the fisheries again if a property management framework for these fisheries can be agreed. Despite the introduction of this ban on gillnetting outside 200m, Irish fishermen, particularly in the south-west are still catching large quantities of lost or dumped gillnets on a regular basis. Many of the nets recovered are of a mesh size of 90mm or less, which is well below the minimum mesh size required in Area VII of 120mm. Much of the recovered gear consists only of sheet netting that has been stripped from the headline and footrope of the net. (Ireland. Implications: Changes in CPUE)
- Retrieval experiments by the Institute of Marine Research in Sweden and special efforts by gillnet fishers to remove ghost-nets have resulted in ca 30–40 km of netting per year removed from the Baltic Sea in recent years. However, the small losses, ca 0.1% of the gears used, in the Swedish (the same for the Danish) gillnet fishery for cod, still means about 165 km of new nets are lost every year. The mortality caused by them is estimated to be in the order of 200–300 tonnes of cod, insignificant compared to e.g. discard rates in the trawl fishery, but still a considerable source of unaccounted fish mortality. (Sweden/Denmark. Implications: Ecosystem effect/Unaccounted fish mortality)
- The development of electrified beam trawling for flatfish species has been tested in the Netherlands. The main driver is to lessen impact on benthic communities and diminishing discarding of target species sole and plaice, but recently also to decrease fuel consumption. Attempts are currently made to lift the European ban and while there are definite benefits in terms of fuel consumption and less bottom impact on the use of electricity, concerns have been raised about the possible ecosystem effects of using the electric beam trawl system. (See FTFB expert group report). (Netherlands. Implications: Changes in CPUE; Ecosystem effects).
- Another development seen in the Dutch beam trawl fleet is the installation of automatic winch controls (Marelec™-system), thus avoiding gear fasteners leading to smaller losses in fishing time, and possibly working on new grounds. (Netherlands. Implications: Technology Creep; Bottom Impact)

Annex 3J — FTFB Report to WGMME

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may have an impact on marine mammal stocks and also interactions of fisheries with marine mammals.

It should be noted that the information contained in this report does not cover fully all fleets engaged in deepwater fisheries; information was obtained from UK, Ireland, Denmark, Sweden and France.

- EU regulation 812/2004 that makes the use of acoustic deterrent devices mandatory in a number of areas from the 1st January 2006 has caused huge difficulties to fishermen. Several studies carried out in Ireland, UK, France and Denmark have highlighted serious practical deployment problems with the commercially available devices. These trials have also shown none of the models available are reliable, while safety issues relating to their use have also been highlighted. The Commission has convened a meeting in April to discuss possible short and longer-term solutions to the problems being experienced with these regulations. (Ireland, UK, Denmark and France. Implication: Counter productive management measure)
- There are increased reports of seals becoming a problem in pelagic fisheries off the west coast of Ireland. Pelagic fishermen report observing seals as far as 70–80 miles offshore and the bycatch of seals in these fisheries has grown alarmingly. This is a real problem for the fishermen as large seals cause serious damage to fish pumping equipment if not detected in time. Due to their large size they also cause net damage. Fishermen have asked net makers to design escape openings for pelagic trawls to release seals. (UK, Scotland. Implications: Marine Mammal interaction; Unaccounted Fish Mortality; Technical Conservation Measures).
- The bycatch of cetaceans in the Albacore tuna fishery in 2005 was reported to be very low. This is felt largely due to the fact that fishermen are now dropping their nets to 10–20fm by stropping off the floats mounted on the wings and headline of the trawl. Fishermen report they have seen a reduction in bycatch since they started fishing at deeper depths as opposed to keeping the headline of the trawl on the surface, as was previous practice. (Ireland & France. Implications: Reduced bycatch)
- In 2001 an investigation was done on bycatches of seals, harbour porpoises and birds in the Swedish fishery. Bycatches of cormorants were estimated to be ca 7 500 in the Swedish fisheries (some of them in freshwater fisheries but the main part in coastal gillnet fisheries). This has not prevented the population increasing by 40% from 1999 to 2005, now causing severe problems to e.g. the eel fyke-net fishery. The number of grey seals and harbour seals caught was ca 460 for each, ringed seals ca 50. At the west coast ca 115 harbour porpoises were drowned in fishing gears. Also the populations of all seal species have continued to increase and have an increased impact on fisheries. (Sweden. Implications: Unaccounted fish mortality)
- A bycatch of pilot whales has been reported in the pelagic pair trawl fishery for herring in Skagerrak (ICES IIIa). No mitigation measures have been introduced. (Sweden. Implications: Marine Mammal Interaction).
- FRS, Aberdeen University, SFF and the Sea Mammal Research Unit are documenting interactions between Orca and Scottish pelagic vessels in the mackerel fishery. Initial indications are that this is a major and benign interaction. (UK, Scotland. Implications: Marine Mammal interaction)

Annex 4: Summary of a Qualitative Review of Fish Capture Methods as Responsible Techniques, by the ICES WGFTFB Topic Group on Alternative Fishing Gears

The topic group conducted a qualitative assessment of different gears types with the aim of identifying "responsible fishing methods", with respect to a number of "ideal gear properties" (see section ### and Table 1 for definitions). A range of capture methods were considered, including: beam trawling, bottom trawling, Danish/Scottish Seining, diving, dredging, drift nets, gillnets, jigging, long-lines, pelagic trawling, pole & line, purse seining, pots, trammel nets and traps.

The "ideal gear properties" were considered by the topic group to be definitive of three key areas of impact, with respect to "Responsible fishing", and were grouped accordingly: Controllability of Catch, Environmental Sustainability and Operational Functionality (see Table 1). Each capture method was scored with respect to each "ideal property" and then a simple index (index = mean score) was defined, with respect to each of the key impact areas (Table 2). To visualise the relationship between the three impact areas, for different capture methods, the indices were plotted in Figures 1 – 3.

Please note, none of the indices described in this report account for the relative catch efficiency (i.e. catch per unit effort) of the different capture methods. This omission is deliberate and was necessary for the following reasons. The catch efficiency of a particular capture method is fishery specific; i.e. it is highly dependent on the target species, location of the fishery, prevailing environment conditions, etc. Furthermore, it was generally accepted that most commercial fisheries will have evolved to use the most efficient capture method available to them. Therefore, most "alternatives" are likely to be less efficient than the current capture method. So, it was not practical, nor particularly informative, to assign an efficiency score in this qualitative overview.

In general, it was the opinion of the Topic Group members that no single capture method could be described as "an ideal gear". Different fisheries and management strategies will of course prioritise each of the "ideal gear properties" differently and will therefore have different requirements of a responsible fishing method. But when considering each of the properties equally, three capture methods were prominent as potentially responsible techniques:

- Diving – This technique was considered to be the most environmentally sustainable method, with the greatest control of the catch. However, its application in a commercial fishery is very restricted. It is a highly specialised technique that is limited by working depth (<50m using air), which would make it almost impossible to apply to most commercial fisheries.
- Pole & line – This technique also scored highly for environmental sustainability and catch control. Moreover, along with jigging, it was thought to have the greatest operational functionality: having low investment costs, usable in most habitats and relatively user safe. However as a practical capture method, it is generally limited to larger, and mostly predatory, fish species.
- Pots – This technique was also considered to have a minimal impact upon the environment; apart from the potential for ghost fishing, which can be mitigated for with inbuilt bio-degradability of pots and gear recovery schemes. The moderate score for catch controllability was primarily due to the poor size selectivity of current gears, which again could be improved with minor design changes. However, in terms of application as an alternative gear pots score highly. They can be used relatively safely in most habitats, with only moderate investment in terms of gear costs and training.

Finally, the scores given here are the consensus opinion of the members of the ICES WGFTFB Topic Group on Alternative Fishing Gears. As such the results of this exercise should not be considered as definitive, but this approach has been a useful tool in considering what properties may be important with respect to the ideal responsible fishing method. Moreover this approach, with a wider and more thorough application with respect to input "opinions", could prove to be a useful management tool when considering the introduction of "alternative" capture methods to commercial fisheries.

Table 1: Summary of "Ideal Gear Properties", with the most suitable capture methods identified for each property.

PROPERTY	DEFINITION / RATIONAL FOR "IDEAL GEAR"	SUITABLE CAPTURE METHODS
Catch Controllability		
Quality of Catch	Minimal physical impact on catch, with a minimal delay recovering catch → maximising catch quality	diving, pole & line, pots and traps, jigging and Danish seine
Species Selectivity	Catching only target species → minimising bycatch	diving, pole & line & purse seine
Size Selectivity	Ability to catch a specific size range of target species, → to the exclusion of smaller/larger individuals	drift nets, gill nets and diving
Environmental Impact		
Habitat Impact	Minimal habitat impact on the environment in which it is used, including the potential for "ghost-fishing".	diving, pole & line, jigging, purse seine and pelagic trawls
Energy Cost	Minimal use of fuel during fishing operations / trips → reduced "carbon footprint".	drift nets, gillnets, diving, pole & line, long-lines, jigging, pots, traps and trammel nets
Non-commercial Bycatch	Minimal catch of non-target species, in particular endangered non-commercial species.	diving, pole & line and pots
Catch Welfare	Minimal physical impact and psychological stress on catch → minimising discard mortality	diving, pots and traps
Operational Functionality		
Safety	Minimal risk of injury/fatality to fishers using gear	traps, gillnets, trammel nets and pots
Durability	Longevity of gear, including maintenance requirements and costs	traps, pots, jigging, pole & line and pelagic trawl
Gear Costs	Minimal initial investment cost → allowing quick shift in gears as fishery management requires	jigging, pole & line, Danish seining and gillnets
Ease of use	Minimal training requirements → allowing quick shift in gears as fishery management requires	jigging, pole & line, gillnets, traps, pots and trammel nets
Applicability	Usable in all aquatic habitats, without seasonal or environmental limitations	jigging, pole & line, gillnets, traps, pots and trammel nets

Table 2: Summary of "Ideal Gear Property" Mean Scores and Indices for different Capture Methods.

	Catch Controllability				**Environmental Sustainablity**					**Operational Functionality**					
	Catch Quality	Species selective	Size selective	*index*	Habitat Impact	Energy cost per kg fish	Non commercial Bycatch	Welfare	*index*	Safety	Durability	Gear cost	Ease of use	Applic - ability	*index*
Beam trawl	0.3	1.0	0.0	*0.4*	0.0	0.0	1.7	0.0	*0.4*	0.7	1.0	0.0	0.0	0.0	*0.3*
Bottom trawl	0.0	0.0	1.0	*0.3*	0.0	0.0	1.7	0.0	*0.4*	0.7	1.3	0.0	0.0	0.0	*0.4*
Danish seine	1.7	1.0	1.0	*1.2*	1.0	1.0	1.7	1.0	*1.2*	1.7	1.0	2.0	0.0	0.0	*0.9*
Diving	2.0	2.0	2.0	*2.0*	2.0	2.0	2.0	2.0	*2.0*	0.0	1.7	1.0	0.0	0.5	*0.6*
Dredge	0.7	0.3	0.0	*0.3*	0.0	0.0	1.7	0.0	*0.4*	0.7	1.0	1.0	0.0	0.0	*0.5*
Drift-net	0.0	0.3	2.0	*0.8*	1.3	2.0	0.0	0.0	*0.8*	1.0	1.0	1.0	1.0	1.0	*1.0*
Gillnet	0.0	1.0	2.0	*1.0*	1.3	2.0	0.0	0.0	*0.8*	2.0	0.0	2.0	2.0	2.0	*1.6*
Jigging	1.7	2.0	1.0	*1.6*	2.0	2.0	0.7	0.0	*1.2*	1.3	2.0	2.0	2.0	2.0	*1.9*
Longline	0.7	1.0	1.0	*0.9*	1.3	2.0	0.3	0.0	*0.9*	1.0	1.0	1.0	1.0	2.0	*1.2*
Pelagic trawl	0.0	1.0	0.0	*0.3*	2.0	1.7	1.7	0.0	*1.3*	0.7	2.0	0.0	0.0	0.0	*0.5*
Pole and line	2.0	2.0	1.3	*1.8*	2.0	2.0	2.0	1.0	*1.8*	1.0	2.0	2.0	2.0	2.0	*1.8*
Pot	2.0	1.0	0.7	*1.2*	1.3	2.0	2.0	2.0	*1.8*	1.7	2.0	1.0	2.0	2.0	*1.7*
Purse seine	1.0	2.0	0.7	*1.2*	2.0	1.3	1.3	1.0	*1.4*	1.0	0.0	0.0	1.0	1.5	*0.7*
Trammel net	1.0	0.0	0.0	*0.3*	1.3	2.0	0.0	0.0	*0.8*	2.0	0.0	1.0	2.0	2.0	*1.4*
Trap	2.0	1.0	0.7	*1.2*	1.7	2.0	0.3	2.0	*1.5*	2.0	2.0	1.0	2.0	1.0	*1.6*

0 least reponsible
1 moderately responsible
2 most responsible

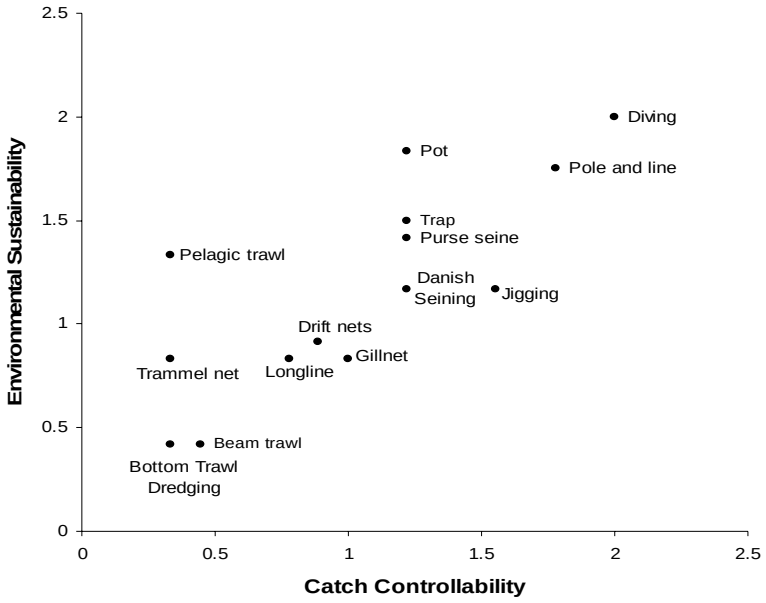

Figure 1: The relationship between Indices of "Environmental Impact" and "Catch Controllability" for different fish capture methods.

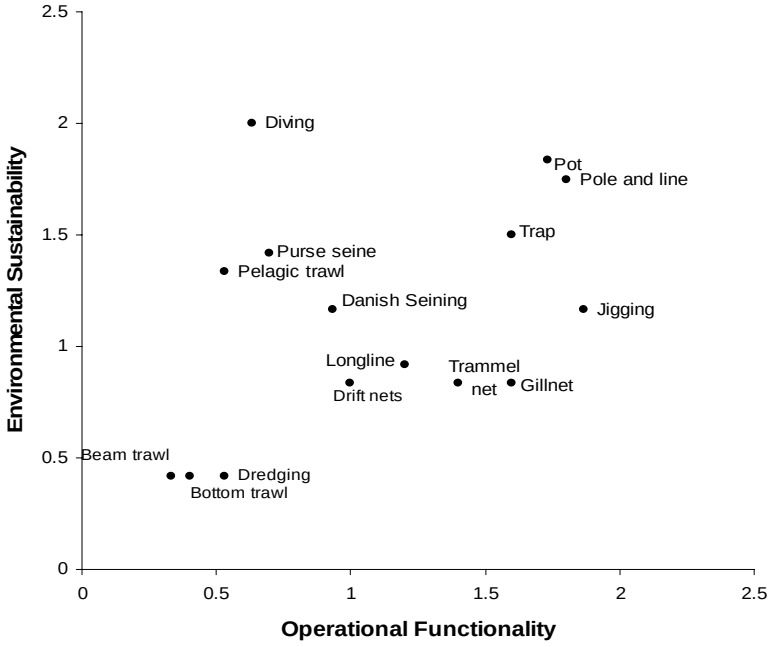

Figure 2: The relationship between Indices of "Environmental Impact" and "Operational Functionality" for different fish capture methods.

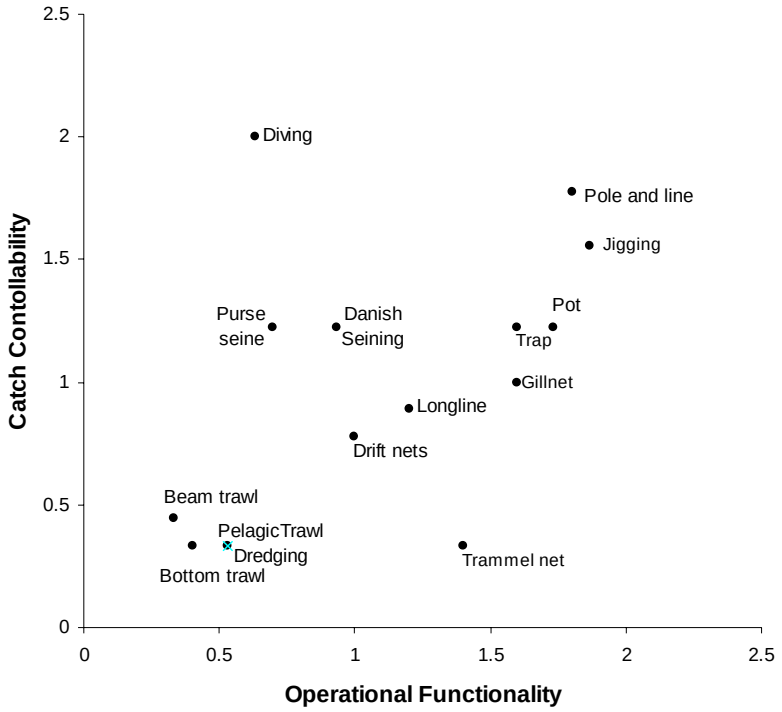

Figure 3: The relationship between Indices of "Environmental Impact" and "Catch Quality & Selectivity" for different fish capture methods.

Annex 5: Report of Topic Group on technological issues affecting Turkish fisheries

An *ad hoc* topic group will be formed to identify and review fishing technology matters affecting the fisheries of Turkey. This group should consider issues such as recent developments in fishing technology that may affect fishing mortality, an appraisal of current fishing gear and vessel legislation and identify possible sources of unaccounted mortality.

Organization

The Group met during the annual meeting of the Working Group on Fishing Technology and Fish Behaviour on 4th and 5th April 2006 in Izmir, Turkey. A total of 27 Turkish gear technologists (Appendix 1) participated under the Chairmanship of Dr Ozbilgin, Ege University and with Dr Ferro as Rapporteur.

Prior to the meeting, data were compiled summarizing the structure of the main Turkish fleets by fishing method and landings. A start was also made on gathering information on recent research in the gear technology field in approximately twenty research institutes and Universities throughout the country. A reference document containing this information will be produced by Ege University, Izmir.

During the meeting the main work of the Topic Group was to consider each main gear category represented in Turkish fisheries. The key technical issues and problems were summarized. These were associated with technical measures related to gear design, technological creep, ecosystem effects, gear conflicts and unaccounted mortality. Until the reference document detailing current research is complete, it will not be possible to consider potential solutions to these problems fully nor to identify what prior research may be needed.

National Fisheries Data

Turkey is one of the biggest fish producers in the Mediterranean. According to the State Institute of Statistics (Anon, 2005), total marine and inland water production including aquaculture was 587,715 tonnes in 2003. Approximately 14% of this amount comes from aquaculture. The amount of capture fisheries has levelled off at approximately half a million tonnes since early 1990s. Of the total amount 70% is marine fish, 8% is other marine products and the final 8% are inland water products. About 70% of the marine fish production is anchovy, followed by blue fish (5%), horse mackerel (4%), sardine, scad, grey mullet, whiting and hake. When the distribution of other sea products are examined cockle has the highest catch of 42%, followed by mussel (17%), prawn and shrimps (13%), sea snail, common jelly fish and great scallop.

The numbers of registered vessels by operating type in 2003 were 404 trawlers, 409 purse seiners, 492 trawler — purse seiners, 134 carrier vessels and 17,103 others (18,542 total). Approximately 16,000 of these boats are smaller than 10 m, 2,000 are between 10 and 20 m, and 500 are bigger than 20 m.

Although the volume of landings has not changed much in the last 15 years, the number of vessels has doubled. Moreover, the size and the engine power of the new vessels have also increased.

Research on Fishing Technology

There is much gear research in Turkey. However, this is usually at local level. Only a small percentage of it is internationally published. Most of the gear research in Turkey has not taken into account social and economic concerns. Additionally communication between the researchers, administrators and the industry is far below the desired level. Regulations are

usually not based on research data and the opinions of the commercial fisheries sector may not be taken into account sufficiently.

More selectivity studies need to be conducted on commercial fishing vessels, on commercial grounds and targeting a range of species compositions and these studies should also include social and economic data. The results of such selectivity studies could be disseminated more widely to the fisheries sector and managers.

Regulation of the Fisheries

Investigation and management of fisheries have gained more attention in recent years as Turkey is aiming to join the European Union, which requires compliance with the Common Fisheries Policy.

There are some suspicions regarding the reliability of statistics. It is known that misreporting to avoid taxation is common. Additionally, data may not be collected on a regular basis in small harbours where artisanal fishers sell their catch directly to consumers. There is a need to define the present socio-economic structure of the fishing community and to monitor and control the number of active vessels. The number of active vessels, their area of fishing and catches need to be monitored in order to study fishing effort trends for all gear types. There is some use of illegal gear types, which needs to be taken into account in the calculation of fishing effort. Closed area and season violations would be reduced by use of VMS.

There is a need to improve the quality of the control, inspection and law enforcement relating to the design and operation of fishing gear.

Information on fleets by gear category

Turkish fisheries, as defined by gear type according to the current FAO classification, are evaluated in the following sections. The main topics, which are addressed, are on going and possible further research, including selectivity, current problems (discarding and bycatch issues, technological creep, environmental effects of gears, fishery conflicts) as well as legislation (Anon, 2004) and potential technical solutions.

Where reference is made to sea areas, it should be understood to refer only to the Turkish waters within those areas.

1. Surrounding Nets

1.1. Purse seine

There are 409 purse seiners, 492 trawler-purse seiners and 134 carrier vessels in Turkey.

There is no information on size selectivity. Systems exist in some fisheries to release some juveniles and jellyfish by use of areas of larger mesh netting but their effectiveness has not been studied.

Discarding is a problem, but its level has not been studied. Significant numbers of immature fish are caught in some fisheries (e.g. blue fish). Marine mammal interactions can cause operational problems in fishing with light in the Aegean and Mediterranean. There is occasional sea turtle bycatch in the Aegean and Mediterranean fisheries. In both of these cases it is unclear whether the level of injuries and mortalities is significant. In the Aegean and Mediterranean, operations are conducted with the help of lamp boats. The light can attract not only the target species but also juveniles, marine mammals and also non-target species.

New electronic bridge and deck equipment are in use. Vessel size and engine power are growing, particularly in tuna fisheries. The number of vessels registered in the Black Sea and fishing in the Aegean and Mediterranean are increasing every year. With the establishment of

tuna rearing farms, the fleet has focused more towards live tuna capture. Fishing is conducted with fleets of up to 20 vessels operating together to increase capture efficiency. With the new gears and more powerful engines, a fleet can operate in waters, which have relatively stronger currents.

There are several problems related to ecosystem effects. The leadline in Turkish purse seiners is usually in contact with the bottom in areas where trawling may be banned. This potentially causes harm to the bottom, but has not been studied. The effect of light on fish behaviour and catch composition in sardine fisheries is a concern and only briefly studied. Ghost fishing is known to occur occasionally when nets cannot be retrieved, particularly in rocky areas of the Aegean Sea.

There are closed areas mainly in inshore waters, a closed season (1st May – 31st August) and a depth limitation (it is not allowed to fish in waters shallower than 10 fathoms). In the Sea of Marmara, gears are not allowed to fish deeper than 90 fathoms although it is difficult to enforce. Each vessel can use only one lamp boat and total light power cannot exceed 8,000 W. Lamp boats cannot be used in waters shallower than 30 m. In terms of weight, a maximum of 15% of anchovy and horse mackerel and 5% of other fishes are allowed to be smaller than minimum landing sizes at the stage of landing.

Misreporting is common to avoid taxation. Discarding due to low market values is also known.

2. Seine Nets

2.1. Beach Seines

Beach seining is forbidden in general in Turkey. In inland waters, gear may be allowed by obtaining special permission from the Ministry of Agriculture and Rural Affairs (MARA).

2.2. Boat Seines

Boat seines are not allowed in general. However, in Edremit Bay (Aegean coast) only a few boats continue fishing with temporary permission, and in some locations of the Sea of Marmara some vessels fish for rose shrimp using this type of gear, locally called ‘Manyat’.

3. Trawl Nets

3.1. Bottom trawls

3.1.1. Beam Trawls

Beam trawls are forbidden in the Aegean and the Mediterranean. They are commonly used in the shrimp and sea cucumber fisheries in the Sea of Marmara and in the Rapa whelk fisheries in the Black Sea.

Studies on the selectivity of gears used in the Sea of Marmara are being published. Size selectivity, bycatch, discard and damage to the habitat are major concerns, both in the Sea of Marmara and in the Black Sea.

There are beam and mesh size limitations, seasonal and area closures. Whelk fishing is allowed only during the daytime.

Discards and unrecorded landings are common.

Species and size selectivity need to be studied in more detail. Grid applications might have a big potential in reducing both fish and benthos bycatch. A lot of work has been done in Europe on benthic release, which may be applicable in Turkish fisheries.

3.1.2. Bottom Otter Trawls

There are 404 trawlers and 492 trawler-purse seiners in Turkey. A significant number of these vessels operate demersal otter trawls. There have been many studies on the selectivity of presently used commercial trawl codends and modifications such as narrow codends, square mesh codends, square mesh panels as well as grid applications. Effects of material type, protective netting and double codends are also studied. Recently there are also some laboratory experiments investigating the swimming performance of fish to improve the understanding of behaviour in the fish capture process.

The main problem related to selectivity is the multispecies nature of the fishery. Both size and species selectivities are rather poor. However, discarding is much less than expected due to illegal landing of the specimens below minimum landing size (MLS).

Technological creep is clearly seen in the development of electronics and vessel design. However, gear designs are surprisingly traditional with small mouth opening and headline height. Almost the entire gear is made of the same small mesh netting as the codend. With the better boats, better weather forecasting and electronic equipment, more and more vessels are coming from the Black Sea to work in the international waters of the Aegean and Mediterranean Seas. Recently there have been contracts for fishing rights in the EEZ of the Georgia and Ukraine.

Few studies on discarding exist. The overall picture and seasonal variation in discards are unknown. Survival of a few species (red mullet, annular seabream and axillary sea bream) after escaping from trawl codend has been studied and found to be quite high in September. However, there is a need to extend such studies to gather information on several other species and the seasonal variation of post-escape survival. Trawlers are often blamed by small scale fishermen for destroying their gill and trammel nets. Illegal trawling very near shore and damage to seagrass beds are common.

There are seasonal and area closures for trawling in Turkey. There is a minimum codend mesh size regulation (40 mm in the Black sea and 44 mm in the Aegean and Mediterranean Seas). Square mesh codends are intended to be compulsory from 1st September 2006 although only limited information has so far been given to the fishing sector, which may cause problems in the implementation of the new legislation. Other characteristics of codend design have been shown to affect selectivity significantly. There may be a need to ensure all significant factors are controlled if the legislation is to be fully effective.

Presently available data on fish behaviour from the laboratory experiments need to be supported by underwater observations at sea and this needs to be used as basic information to design gears with improved size and species selectivity.

3.1.3. Bottom pair trawl

This type of gear is forbidden in Turkey.

3.2. Midwater trawl

3.2.2. Midwater pair trawl

Midwater pair trawling is used in small pelagic fisheries in the Black Sea. There are some preliminary studies on bycatch, selectivity and catch composition of this relatively recent fishery. The design of these gears may not be optimal, reducing their efficiency. There are concerns about bottom contact in relation to potential environmental effects and increase in bycatch. There are seasonal and area closures for mid-water pair trawling.

3.3. Twin trawls

This type of gear is not used in Turkey but gives the potential for unregulated increases in fishing effort in some fisheries.

4. Dredges

Both boat dredges and hand dredges are in use for bivalve capture in Turkey. There have been few studies on the gears used in this fishery.

5. Lift Nets

Only shore-operated lift nets are in use in Turkey. There are problems with licensing and conflicts with other small scale fishers and aquaculture where the sitting of lift nets (and also fish farms) can disrupt the natural migration of fish and their encounter with gill or trammel nets.

6. Falling Gear

Cast nets are in use along the Black Sea coast and in rivers on a very small scale. These fishers are usually not registered.

7. Gillnets and Entangling Nets

There are more than 16,000 registered fishing boats smaller than 10 m in Turkey. Most of these boats operate these gears both in marine and fresh waters. Gears are usually designed to target a species, and are distinguished by the name of the species. There are a great variety of such gears. The result of a recent study indicates that in Izmir province alone, there are almost twenty different types of gill or trammels nets named by reference to a species. Moreover, there are gears targeting more than one species and operated in several different ways. The classification system in the present FAO catalogue is not sufficient to describe all the gears used in this category. For example, combined gill nets and trammel nets are used as encircling gears for a variety of species. Boats use different types of gears in different seasons and there are no detailed data on the total number of gears in use.

There are many studies on size selectivity of these gears. Bycatch and discards are big concerns with some gear types such as prawn trammel nets. There are few recent studies on bycatch reduction. Marine mammal interactions are also a big concern. Dolphins and seals often damage the gears, causing financial loss to fishermen. Acoustic repellents may be a solution to protect the gears from damage but these systems are not yet fully developed.

More and more boats are getting equipped with hydraulic net-haulers with which they can operate more gears in a given time. The use of GPS and echosounders is also getting more common in these boats. Continuous deployment tends to increase fishing effort.

There has not been much study on the ecosystem effect of these gears. In fact even the total numbers of gears used in these fisheries are still unknown. Ghost fishing may be a big problem but there is very limited study on this issue. There are few legal limitations concerning these gears. They include mesh size, for example for turbot gill nets, and seasonal closure, for example for sole.

Shared use of fishing ground by trawlers, purse seiners and fish farms is usually a problem in these fisheries. Buoys indicating the positions of the gears are usually not visible.

8. Traps

Pots, fyke nets and aerial traps are in use in Turkey. There are few studies on trap design, efficiency, catch composition and selectivity. There are some recent studies on designing rapa whelk pots as an alternative fishing gear to beam trawling. There are several types of fyke nets targeting different species such as eel, octopus and some bait fish. These gears are usually deployed at sea constantly and therefore cause conflicts with other small scale fishers. They are used both in inland waters and at sea. There are concerns about the selectivities of both traps and fyke nets. Aerial traps are mostly used in lagoons for catching grey mullet.

9. Hooks and Lines

Various handlines and hooks are used both for commercial and recreational purposes. There are usually conflicts between these two groups of fishers as most of the fish caught by recreational fishers are marketed.

Both pelagic and demersal longlines are used commercially in Turkey. The numbers of these gears are unknown. There are possible ghost fishing problems due to loss of lines on rough ground.

10. Grappling and Wounding

Spears are commonly used by many professional and recreational fishers. There are several species banned in spear fishing.

11. Harvesting Machines

Thirty-nine vessels equipped with hydraulic dredges for fishing striped Venus clam (*Chamelea gallina* L., 1758) were recorded in Turkey in 2004. There is technological creep and overfishing in some areas.

20. Miscellaneous

Poisons and explosives are used illegally in Turkey.

References

Anonymous. 2004. The commercial fish catching regulations in seas and inland waters in 2004–2006 fishing period (in Turkish). Republic of Turkey, Ministry of Agriculture and Rural Affairs, General Directorate of Conservation and Inspection, Circular no. 36/1, Ankara.

Anonymous. 2005. Fisheries Statistics 2003. State Institute of Statistics, Prime Ministry, Republic of Turkey, Ankara.

Annex 6: Preliminary text for FAO-ICES Gear Classification

DRAFT Report on proposed FAO-ICES Classification and Description of Fishing Gears

Note that this is a Draft and as such should not be used to replace the existing 1971 Classification

FAO Fishing Gear Classification

GEAR CATEGORIES	STANDARD ABBREVIATIONS	FIIT (2000)	ISSCFG
SURROUNDING NETS		01.0.0	01.0.0
Purse seines	PS	01.1.0	01.1.0
One boat operated purse seines	PS1	01.1.1	01.1.1
Two boats operated purse seines	PS2	01.1.2	01.1.2
Surrounding net without purse line -	LA	01.2.0	01.2.0
SEINE NETS		02.0.0	02.0.0
Beach seines	SB	02.1.0	02.1.0
B oat seines	SV	02.2.0	02.2.0
TRAWL NETS		03.0.0	03.0.0
Bottom trawls		03.1.0	03.1.0
Beam trawls	TBB	03.1.1	03.1.1
Single Bottom otter trawl	OTB	03.1.2	03.1.2
Double bottom otter trawls	OTD		
Multiple bottom otter trawls	OTT		
Bottom pair trawls	PTB	03.1.3	03.1.3
Midwater trawls		03.2.0	03.2.0
Single boat midwater trawl	OTM	03.2.1	03.2.1
Midwater pairtrawl	PTM	03.2.2	03.2.2
DREDGES		04.0.0	04.0.0
Boat dredges	ORB	04.1.0	04.1.0
Towed dredge			
Mechanized dredges			
Hand dredges	DRH	04.2.0	04.2.0
LIFT NETS		05.0.0	05.0.0
Portable hand lift nets	LNP	05.1.0	05.1.0
Boat-operated lift nets	LNB	05.2.0	05.2.0
Stationary lift nets	LNS	05.3.0	05.3.0
FALLING GEARS		06.0.0	06.0.0
Cast nets	FCN	06.1.0	06.1.0
Cover pot/Lantern net	FG	06.9.0	06.9.0
GILLNETS AND ENTANGLING NETS		07.0.0	07.0.0
Set Gillnets	GNS	07.1.0	07.1.0
Driftnets	GND	07.2.0	07.2.0
Encircling gillnets	GNC	07.3.0	07.3.0
Fixed gillnets (on stakes)	GNIF	07.4.0	07.4.0
Trammel nets	GTR	07.5.0	07.5.0
Combined gillnets-trammel nets	GTN	07.6.0	07.6.0

GEAR CATEGORIES	STANDARD ABBREVIATIONS	FIIT (2000)	ISSCFG
TRAPS		08.0.0	08.0.0
Stationary uncovered pound nets	FPN	08.1.0	08.1.0
Pots	FPO	08.2.0	08.2.0
Fyke nets	FYK	08.3.0	08.3.0
Stow Nets	FSN	08.4.0	08.4.0
Barriers, fences, weirs, etc	FWR	08.5.0	08.5.0
Aerial traps	FAR	08.06.0	08.6.0
HOOKS AND LINES			09.0.0
Hand line	LHP	09.00	09.1.0
Mechanized line			
Vertical set lines	LHM	09.1.0	09.2..0
Set longlines	LLS	09.2.0	09.3.0
Drifting longlines	LLD	09.4.0	09.4.0
Trolling lines	LTL	09.6.0	09.6.0
OTHER GEARS		10.0.0	10.0.0
Wrenching gear		10.1.0	10.1.0
Clamps		10.2.0	10.2.0
Rakes		10.3.0	10.3.0
Tongs		10.4.0	10.4.0
Spears		10.5.0	10.5.0
Harpoons		10.6.0	10.6.0
Electric fishing			
		13.0.0	
		13.1.0	
		13.2.0	
Towed fyke net			
Push nets			
Scoop nets			
Drive in nets			
Pumps			
Diving			
	MIS		
NOT CODED	NK		

1. Surrounding nets

Surrounding nets consist of netting framed by lines; a floatline on top and sinker line at the bottom. They catch the fish by surrounding them both from the sides and from underneath, thus preventing the target preys from escaping into deep waters by diving downwards. Apart from a few exceptions, they are surface nets in which the float line is supported by numerous floats.

1.1. PURSE SEINES

A purse seine is made of a long wall of netting framed with a lead line of equal or longer length than the float line. Characteristic is the purse rings hanging from the lower edge of the gear. The purse seine is set around a detected school of fish. The net is closed by hauling the purse line running through the rings. The purse seines, which may be very large, are operated by one or two boats. Most usual is a purse seine operated by a single boat, with or without an auxiliary skiff. The handling of the gear may be mechanised, e.g. by a hydraulic power block or a net drum.

1.2. LAMPARA NETS

The lampara net is designed with the central bunt in the form of a spoon and two lateral wings. The fish is captured when the two wings are hauled up at the same time. The gear can only be used to catch fish close to the surface.

1.3. RING NETS

A ring net is an intermediate hybrid form of a purse seine and a lampara net. It normally has a groundrope shorter than the headline, a bunt in the middle and provided with rings through which a purse can be pulled and thus close the net from below.

2. Seine Nets

A seine net is composed of a bunt (bag or lose netting) and long wings often lengthened with long towing ropes or warps. Seines are usually set from a boat to surround a certain area and can be hauled either from the shore (beach seines) or from the boat itself (e.g., Danish or Scottish seines).

2.1. BEACH SEINES

Beach seines comprise the seine nets operated from land, which are generally used near the shore in shallow waters. The bottom and surface act as natural barriers, which prevent the fish from escaping from the area enclosed by the net. A distinction is made between beach seines with a bag and beach seines without a bag; the latter do have, however, a central part with smaller meshes and more slack, which retains the fish caught.

2.2. BOAT SEINES

The boat seine consists of two long wings, a body and a bag. Another important component for the capture efficiency of boat seines is the long ropes extending from the wings, which are used to encircle a large area. Fish inside the ropes are frightened into the forward moving path of the seine net where they are subsequently overtaken by the net and captured. The seine is commonly used on the bottom and the codend mesh size is used to regulate size selectivity.

3. Trawl Nets

Trawl nets are towed gears consisting of a cone-shaped body, closed by codend.

They can be towed through the water by one or two boats on the bottom or in midwater (pelagic). The horizontal opening of the gear while towing is maintained by beams, otter boards or by two vessels. Floats and weights and/or hydrodynamic devices provide for the vertical opening. Two or more parallel trawls might be rigged between two otter boards. The mesh size in the codend or special designed devices are used to regulate the size and species to be captured.

3.1. BOTTOM TRAWLS

A bottom trawl is a trawl designed and rigged to catch species living on or near the bottom.

3.1.1 BEAM TRAWLS

A beam trawl is a bottom trawl in which the horizontal opening of the net is provided by a beam

- made of wood or metal.
- which may be up to 12–16 m long.

Beam trawls are used mainly for flatfish and shrimp fishing. One beam trawl can be towed from the stern or alternatively two beam trawls from outriggers. Close bottom contact is necessary for successful operation.

3.1.2 BOTTOM OTTER TRAWLS

is (means) a single bottom trawl in which the horizontal opening is provided with two otter boards.

consists of a cone-shaped body, normally made from two or four panels, ending aft in codend and with lateral wings extending forward from the opening. Bottom trawls usually have an extended top panel (square) to prevent fish form escaping upwards over the top of the net. The horizontal opening is obtained by two otter boards. A boat can be rigged to tow a single or two parallel trawls from the stern or from each of two outriggers. The trawl is designed and rigged to have bottom contact during fishing, and is, depending on the bottom substrate equipped with different kinds of ground gear with the purpose of keeping bottom contact, protecting the trawl from damage and facilitating movement across the bottom. Selective devices and codend mesh size are commonly used methods to reduce capture of non-target species and sizes.

3.1.3 BOTTOM PAIR TRAWLS

A bottom pair trawl consist of a cone-shaped body, normally made of two panels, ending aft in a codend and with lateral wings extending forward from the opening. It is towed simultaneously by two boats, the distance between them ensuring the horizontal opening of the net. Varying length of sweeps in bottom contact in front of the trawl may effect the catching width of such gears.

3.2. MIDWATER TRAWLS

A midwater trawl consists of a cone-shaped body, normally made of four panels, ending aft in a codend and with lateral wings extending forward from the opening. It is usually much larger than a bottom trawl and designed and rigged to fish in midwater, including in the surface water. The trawl front parts are sometimes made with very large meshes or ropes, which herd the targeted fish inwards so they can be overtaken by smaller meshes in the aft trawl sections. The fishing depth is usually controlled by means of a net sounder (netsonde) or depth recorder. They may be towed by one or two boats.

3.2.1 MIDWATER OTTER TRAWLS

A midwater otter trawl is towed by a single boat. The horizontal opening is maintained by otter boards. Mid-water otter boards are normally designed with higher hydrodynamic efficiency and with a larger surface area than bottom otter boards. Mid-water trawls may also be rigged with four otter boards.

3.2.2 MIDWATER PAIR TRAWLS

A midwater pair trawl is towed simultaneously by two boats, thus ensuring the horizontal opening of the net. It has similar characteristics as midwater trawls used with otter boards. This gear is easy to operate in surface waters. Midwater pair trawls might be rigged with two towing warps form each vessel or alternatively with one towing warp from each vessel and a bridle arrangement.

4. Dredges

These are gears consisting of a mouth frame attached to a holding bag constructed of metal rings or meshes. They are gears dragged along the bottom, usually to catch molluscs such as mussels, oysters, scallops, clams, etc.

4.1. BOAT DREDGES

These dredges are towed forward by a boat and are of varying weight and sizes. Some dredges are mechanised for transporting the catch by pumps or conveyor belts to the deck for sorting.

4.2. HAND DREDGES

These are small, light dredges, operated by hand in shallow waters, from the shore or from a boat.

5. Lift Nets

Lift nets consist of a horizontal netting panel or a bag shaped like a parallelepiped, pyramid or cone with the opening facing upwards. The prey is attracted and brought over the net by light or bait. They are caught when the net is lifted or hauled out of the water, by hand or mechanically, from the shore or from a boat.

5.1. PORTABLE HAND LIFT NETS

Small lift nets operated by hand, often supported by ringed frames.

5.2. BOAT-OPERATED LIFT NETS

These gears comprise the bag nets (‘basnig’) and the blanket nets, operated from one or more boats.

5.3. SHORE OR SHALLOW WATER-OPERATED LIFT NETS

These lift nets, which can be relatively large, are usually operated from stationary installations situated along the shore, where the lifting system is sometimes mechanized.

6. Falling gear

These are gears that are clapped down on the prey to be captured. Wooden cover pots and cast nets made of netting are typical gears belonging to this group.

6.1. CAST NETS

The cast net is a circular net with weights attached to the perimeter. The catching principle is that the net is thrown flat upon the water surface and catch the fish by falling and closing in on them. It is used from the shore or from a boat. Their use is usually restricted to shallow waters.

6.2. COVER POTS/LANTERN NETS

A cover pot is commonly of a wicker construction like a beehive with an opening at the top whereas the lantern net is cover pots made of wooden frames covered by netting. The gear is clapped over the prey and any catch, often a single individual, is taken out though the opening on top. These gears are, generally hand-operated by wading fishers in very shallow waters.

7. Gillnets and entangling nets

Gillnets and entangling nets are strings of single, double or triple netting walls kept more or less vertical by floats on the upper line and mostly by weights on the ground-line. The means of capture is that the fish are gilled, entangled or enmeshed in the netting. Several types of nets may be combined in one gear (for example, trammel net combined with gillnet). These nets can be used either alone or, as is more usual, in large numbers placed in line ('fleets' of nets). According to their design, ballasting and buoyancy, these nets may be used to fish in surface layers, in mid water or at the bottom.

7.1. SET GILLNETS

A set gillnet consists of a single netting wall kept more or less vertical by a floatline and a weighted groundline. The net is set on the bottom, or at a certain distance above it and kept stationary by anchors or weights on both ends. The dominant method of capture is by gilling. The size distribution of the catch is very much dependant on the mesh size used in the gillnet.

7.2. DRIFTNETS

Driftnets means any net operated on the sea surface or at certain distance below it by floating devices , consist of a string of gillnets and are used in the open sea to catch fish and other marine organisms near the surface. They may drift independently, accompanied by a vessel, but generally they are fastened to a boat that drifts with them. The predominant method of capture is by gilling and driftnets are highly size selective.

7.3. ENCIRCLING GILLNETS

This gear is generally used in shallow water with the floatline on the surface. After the fish have been encircled by the net, noise or other means are used to force them to gill or entangle themselves in the netting surrounding them.

7.4. FIXED GILLNETS (ON STAKES)

These are gillnets stretched between two stakes and are therefore used in coastal waters where there are significant tidal differences. The fish are collected at low tide.

7.5. TRAMMEL NETS

A trammel net consists of three layers of netting with a slack small mesh inner netting between two layers of large mesh netting. The fish entangle themselves in a pocket of small mesh webbing between the two layers and large meshed walls.

7.6. COMBINED GILLNETS-TRAMMEL NETS

This bottom-set gear is made with a gillnet, the lower part of which is replaced by a trammel net. It may catch bottom fish in the lower trammel net part, together with semidemersal or pelagic fish in the upper gillnet part.

8. Traps

These are a group of gear in which the fish enters voluntarily, but is hampered from coming out. Usually in these traps there is one or more chambers which will be closed when the prey enters or which have a retarding device like a gorge or a funnel. Smaller types are completely closed except for the entrance.

8.1 STATIONARY UNCOVERED POUND NETS

Stationary uncovered pound nets are usually large nets, anchored or fixed on stakes, usually open at the surface and provided with various types of fish herding and retaining devices. They are mostly divided into chambers closed at the bottom by netting. In Japan this group is usually referred to as ‘set-nets’ (not to be confused with the fixed gillnets referred to above)

8.2 POTS

A pot is designed in the form of cages or baskets made from various materials (wood, wicker, metal rods, wire netting, plastic etc.) They might have one or more openings or entrances. They are usually set on the bottom, mostly with bait, singly or in strings connected to a line (longline system)

8.3 FYKE NETS

A fyke net consists of cylindrical or cone-shaped netting bags mounted on rings or other rigid structures it has wings or leaders, which guide the fish towards the entrance of the bags. The fyke nets, fixed on the bottom by anchors, ballast or stakes, may be used separately or in groups.

8.5 BARRIERS, FENCES, WEIRS, CORRALS, ETC.

This is a group of gears made of various materials (stakes, branches, reeds, netting, etc.), and they are usually constructed for use in tidal waters. They generally have a narrow slit leading to an enclosed catching chamber.

8.6. AERIAL TRAPS

Jumping fish (e.g., mullets) and gliding fish (flying fish) can be caught on the surface in boxes, rafts, boats and nets (“veranda nets”). Sometimes the fish are frightened to get them to jump out of the water.

9. Hooks and lines

Hooks and lines are gear where the fish is attracted by a natural or artificial bait (lures) placed on a hook fixed to the end of a line or snood, on which they get caught. Hooks or metallic points (jigs) are also used to catch fish by ripping them when they pass in its range of movement.

Hook-and-line units may be used singly or in large numbers.

9.1 POLE AND LINES

A pole and line consists of a hooked line attached to a pole. The line is generally of the same length as the pole. Pole and lines may be mechanized, e.g., for tuna catching, with the pole movement being entirely automatic.

9.2. VERTICAL LINES

A vertical line consists of a vertical line to which there are attached a sinker and at least one hook. The lines might be operated manually or mechanically, using powered reels or drums. They are generally used on medium size vessels, but they may also be used on relatively small boats

9.3 SET LONGLINES

A set longline consists of a main line and snoods with baited hooks at regular intervals. The gear is set on the bottom or near the bottom (semipelagic). Its length can range from few hundred meters in coastal fisheries to more than 50 km in large scale mechanised fisheries. The baiting of hooks may be manual or by a machine.

9.4 DRIFTING LONGLINES

A drifting longline consists of a mainline kept near the surface or at a certain depth by means of regularly spaced floats and relatively long snoods with baited hooks. Drifting longlines may be of considerable length. Some drifting longlines are set vertically, each line hanging from a float at the surface. They are usually worked in groups of several lines operated by a single boat.

9.6 TROLLING LINES

A trolling line consists of a line with natural or artificial baited hooks and trailed near the surface or at a certain depth by a vessel. Several lines are usually towed at the same time, by using outriggers. Handling of trolling lines, including removal of fish from the hooks might be mechanised.

10. Grappling and wounding gears

As in hunting, man has extended the range of his arm by using long-handled implements, which can be pushed, thrown or shot. The prey is taken by grappling, squeezing, piercing, transfixing or wounding. Barbs prevent efforts to escape. Clamps, tongs and raking devices are types within this group but so also are spears, harpoons, arrows and other missiles.

11. Stow nets

This is a stationary gear made from netting, usually in the form of a cone or pyramid. These nets are fixed by means of anchors or stakes, placed according to the direction and strength of the current. The mouths are usually held open by a frame, which may or may not be supported by a boat. This gear can be used in rivers, estuaries or areas with strong currents. The fish or other organisms entering, more or less voluntarily, are caught by filtering.

12. Stupefying Devices

The manner of capture of this group is to prevent fish from escaping by stupefying or stunning them. This can be achieved in various ways.

12.1 CHEMICALS

12.2 EXPLOSIVES

12.3 ELECTRICAL FISHING

13. Miscellaneous

13.1 PUMPS

Pumps are usually used to catch fish attracted by light; they should not be confused with the pumps used to transfer fish already caught. This method is limited to a small number of species.

13.2 DRIVE IN NETS

Fish can be caught by driving them into a fishing gear of any type. Most of them are caught also without driving, but in small quantities. There are some stationary gear constructions, which catch only when the fish are driven into them, among other methods, by swimming or diving fishers or by frightening lines.

13.3 SCOOP BASKET/NETS

These are small hand operated devices formed like bagnets used to scoop fish and other prey out of the water. Originally they were made of wood like flat baskets but are now more or less deep bags made of netting materials. A typical feature of this gear is that it is held open by a frame around the opening of the bag.

13.4 PUSH NETS

These are similar in construction to scoop nets, but are used in a different manner. The device has a straight edge so that they can be pushed along the bottom in shallow water. The prey, which often may be shrimp, is collected by pushing or thrusting the net, and caught when it is raised form the water.

13.5 DIVING

Annex 7: Working Documents

Technical and operational overview of fishing vessels dredging striped Venus (*Chamelea gallina* L., 1758) in Turkey

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ABSTRACT

Technical and operational features of fishing vessels dredging striped Venus (*Chamelea gallina* L., 1758) in Turkey were investigated conducting surveys in 2004 and 2006.

Thirty-nine vessels equipped with hydraulic dredges for fishing striped Venus were recorded in Turkey in 2006. The fleet consisted of vessels with size range of 12 to 28 m and employing 4 to 9 crew depending on size of vessels. It was also found that there isn't any regulation about the sieves in fishing circular.

In the paper we have analyzed findings of the survey, compared Turkish and Italian style hydraulic dredged vessels and presented recommendations for sustainable clam fisheries in Turkish waters.

Keywords: Chamelea gallina, striped Venus, bivalve fishing, hydraulic dredge, Black Sea.

INTRODUCTION

Chamelea gallina (L., 1758) is a well-known clam species wide-spread all over the coasts of Mediterranean and the Black Sea (Fischer *et al*., 1987). According to the data given 19700 tones of *C. gallina* had been fished in Turkey whose had the second place at world-wide production after Italy where 41784 tones had been fished in 2003 (FAO, 2005). Although *C. gallina* lives all over the seas of Turkey, all this production had been done just from the Black Sea coasts. Due to its non-consumption within the country, it wholly exports to EU countries as frozen or canned.

The fishery for *C. gallina* started with towed rake in the northern part of the Marmara Sea in 1986. The first experimental dredging with a boat equipped with hydraulic dredge was carried out at the same region in August 1986 (Bilecik, 1986). Deval *et al*. (1992) reported just two commercial hydraulic dredge boats from all over the coasts of Turkey.

Although the technical properties of hydraulic dredges (Froglia, 1989), selectivity and the effect of the gear to the bottom structure (Palma *et al*., 2003; Rambaldi *et al*., 2001) and benthic macrofauna after modifications (Gaspar *et al*., 2003) has been extensively studied by some authors from Mediterranean countries, a few investigations have been conducted on this species in our country in spite of its high economic value. The studies are just about the general characteristics of the Marmara region populations (Alpbaz and Önen, 1989; Deval and Oray, 1992; Oray *et al*., 1992).

In this study technical and operational features of fishing vessels dredging *C. gallina* in Turkey were investigated.

MATERIAL AND METHODS

Data on technical specifications of 14 boats were collected from boat owners and by the field surveys at the fishing ports of Kastamonu (Cide and Çatalzeytin) and Sakarya (Karasu) where vessels based in between July 2004 and March 2006. Also data about the numbers of vessels,

their lengths and engine powers were taken from the local fisheries directorates. The boats grouped and handled according to the fishing ports.

RESULTS

The number of hydraulic dredge boats operated in *C. gallina* fishing in the Blacksea coasts was 39. The distributions of those boats according to the fishing ports were given in Figure 1.

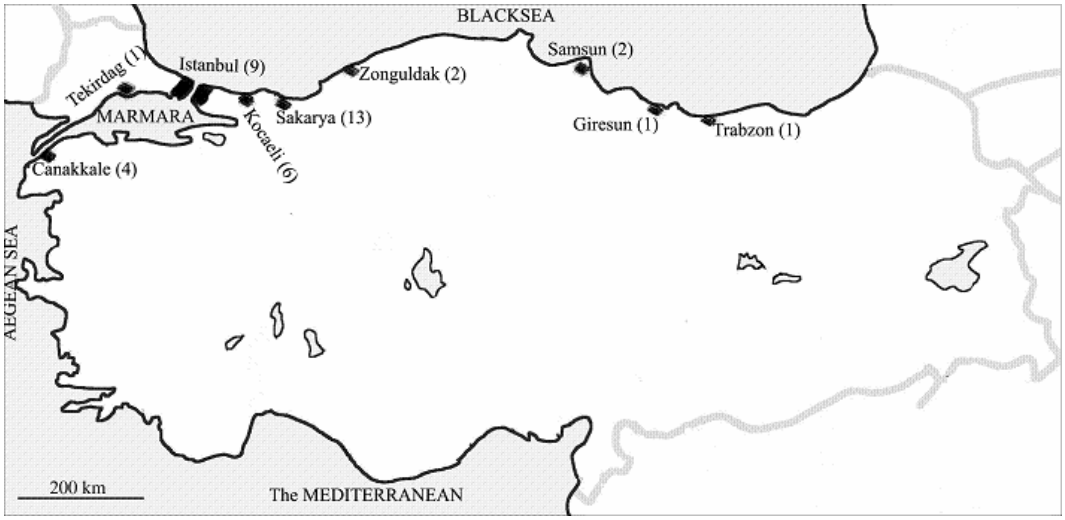

Figure 1: The distributions of the boats according to the harbours.

The boats involved in hydraulic dredging were made of sheet iron or wooden and 12 to 28 m in length. They were 10 to 100 gross tons, and powered by 82 to 540 HP engines. Boats were consisting of 105–170 HP second engines for the injection of water under pressure to the dredge. The number of the crews employing on the boats were depending to the size of boats and ranges from 4 to 9. The presence of radar and eco-sounder on hydraulic dredge boats make possible to determine the location and depth of the suitable area for operations.

The dredges were consisting of iron grids and their length varies between 1 and 3 m. The mouth length and the height of the dredges were between 2 and 3.5 m and 35 and 45 cm, respectively. The distance between the bars of iron grid ranges from 5.5 to 8.5 mm. The structural arrangement of dredge was given from Froglia (1989) in Figure 2a. All the boats were using spiral sieve (Figure 2b) to sift the yield except those imported from Italy. The imported boats were using shaky sieve (Figure 2c). The distance between bars of iron grids of the spiral sieve were ranging from 7 to 9 mm.

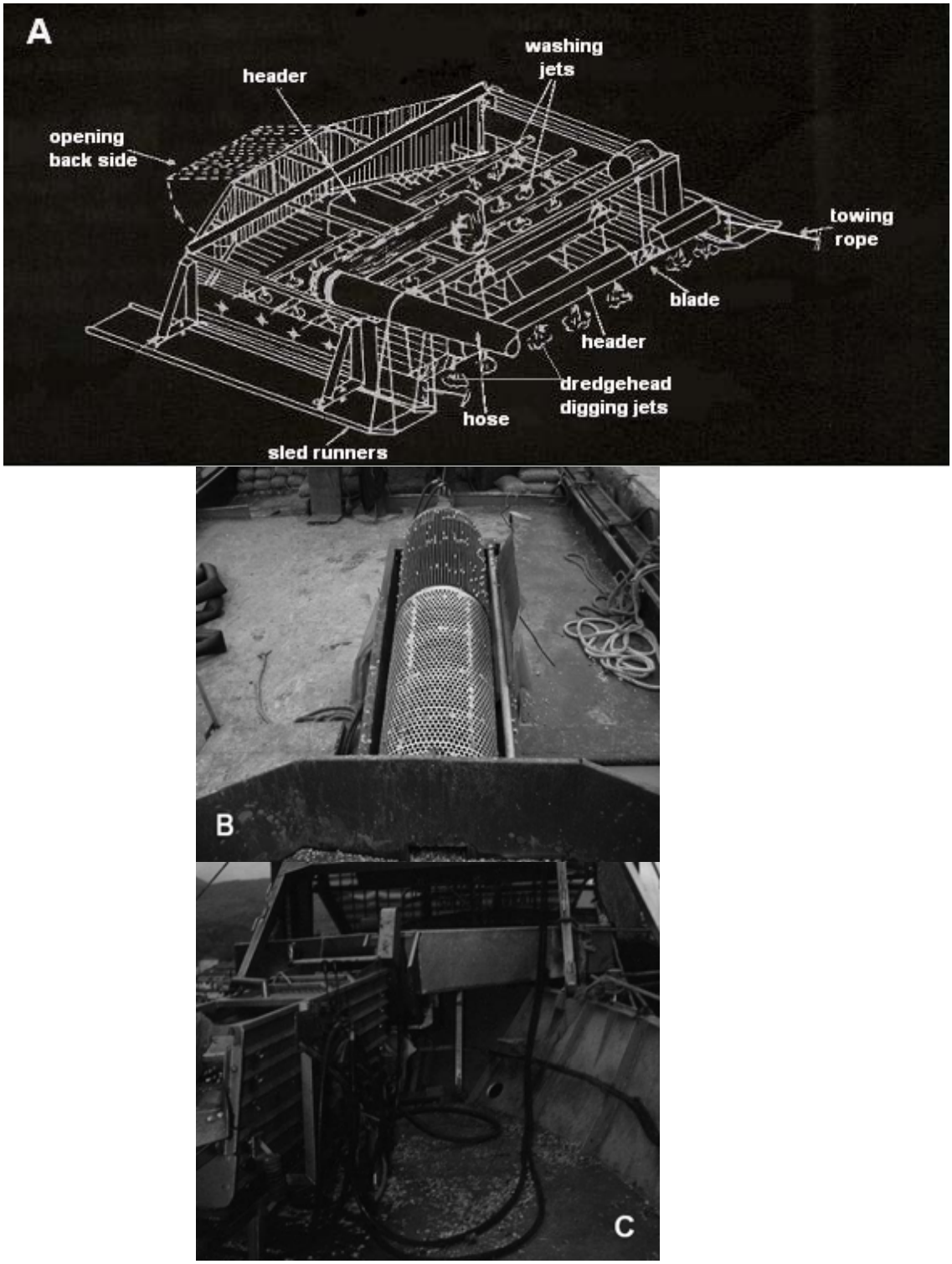

Figure 2: (A) Details of dredge structure (from Froglia, 1989); (B) spiral sieve; (C) shaky sieve.

The settlements of the dredges on Turkish boats were different from those imported from Italy (Figure 3).

Figure 3: The settlement of the dredges at Turkish boats (behind) (A) and Italian boats (ahead) (B).

The fishing season starts at 1st September and lasts at 30th April. Boats could work for 100–120 days in a fishing season because of the sea conditions. Although there isn't any limitation, *C. gallina* fishing is usually done during day time. The average towing is 5–6 in an hour.

The towing system of Turkish boats was different from those imported from Italy. According to Froglia (1989) when the Italian boats reaches a suitable fishing ground the stern anchor is cast, and 250–300 m of steel cable is paid out as the boat moves forward. The dredge is then

lowered, and water under pressure is injected through a hose that connects the dredge to a centrifugal water pump on board. Each tow lasts 10–15 minutes at a towing speed of 0.6–1.0 knots. If the skipper judges the ground commercially profitable the anchor is not hauled and the next tow is made on a course divergent by a few degrees from the preceding one; thus at the end of the fishing operations at a given locality, the dredger has covered one or more circular sectors (Figure 4).

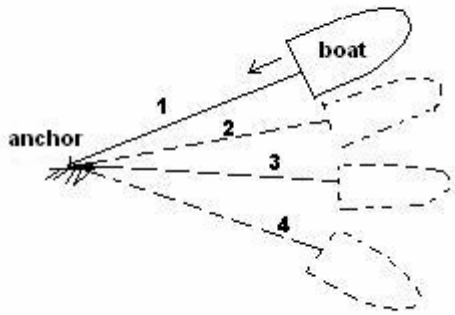

Figure 4: The fishing operation system of the boats imported from Italy (from Froglia, 1989).

The hydraulic dredge and the automatic sieves were at the behind of Turkish boats. Furthermore there was a second diesel engine to pump the water under pressure to the dredge on the boats. The Italian boats were using a centrifugal water pump that connected to the main engine. In Turkish style when the boat reaches a suitable fishing ground dredge is lowered and the second engine is run. Water under pressure (3–4 bars) is injected by this second engine with a hose to the dredge. The boat goes forward and the tows the dredge. Each tow lasts 6–10 min at a towing speed of 2–2.5 knots. At the end of the tow, the dredge is hauled up and the whole catch dumped into a collecting box. If the yield is commercially profitable then the next tow is made on the opposite direction of the first. During a tow, the previous catch is sieved by spiral sieve and packed in nylon sacks.

DISCUSSION

The towing techniques of hydraulic dredge boats have been described in the Sea of Marmara (Bilecik, 1986; Deval *et. all.*, 1992). These studies focused on the positive effect of the sieving for non-target and under commercial size species.

The hydraulic dredges were preferred by fishermen instead of towed rake not only the requirement of less manpower but also more and quality yield. From the beginning of 2000 all the towed rakes have been transferred to hydraulic dredges in Turkey.

It was decided that the difference at the towing system is made Turkish boats more practical and fast. They could fish three or four times more than Italian ones in a fishing day.

According to the data of the official units (Samsun, Giresun, Sakarya, Kocaeli, İstanbul, Çanakkale and Tekirdağ) of Minister of Agriculture there were 39 hydraulic dredge boats in Turkey in 2006. Belonging to the fishing ports of Sakarya, Kocaeli and İstanbul of 28 of these boats showed us that the clam fishery was concentrated at the southern west of the Blacksea. Due to the drastic reduction of stocks at the eastern parts of Kefken Island the area closed for *C. gallina* fishery for 2 years from 2004 to 2006 (Anonymous, 2004).

Measures of the dredge dimensions of all the boats were fit with the law, regulating fishing, and related fishing seasons of 2004–2006 (Anonymous, 2004). Even though there is distance

between the bars of iron grid, the dredges are non-selective gears. The base selecting is on the deck of the boats with sieves. The absence of a topic about the sieves in the fishing circulars is caused under-size fishing in Turkey.

Sometimes nonexistence of limited fishing licence, annual and daily quotas keep the fisheries of *C. gallina* to difficult positions. For a sustainable production it is important to standardize the sieves, freezing the fishing licence of *C. gallina*, putting quotas and sharing out the fishing grounds between the boats.

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Relationship between critical and maximum sustainable swimming speeds

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ABSTRACT

The Maximum Sustainable Swimming Speed (U_{ms}) of fish is an important parameter in our understanding of fish behaviour, as it defines the boundary between aerobic and anaerobic swimming capacity. However, it is difficult to measure U_{ms}, as it requires a considerable number of swimming trials, over a range of speeds, to produce valid and usable dataset. Also the experimental animals should be rested at least 24 hours between each trial. Clearly it takes a considerable amount of time to complete these experiments during which all the factors influencing swimming performance, other than speed, need to be kept constant.

Critical Swimming Speed (U_{crit}) experiments, on the other hand, are relatively easier way of measuring swimming performance, requiring fewer swimming trials to obtain a valid result.

In this preliminary study U_{crit} was measured for three commercially important species; *Mullus barbatus* (red mullet), *Pagrus pagrus* (red porgy) and cultured *Sparus aurata* (sea bream) from the Mediterranean. In addition, prolonged swimming speed and sustainable swimming speed data were collected for the same fishes and U_{ms} values were estimated using the inverse-linear relationship. The mean proportional difference between U_{ms} and U_{crit} for red mullet, red porgy and cultured sea bream were 73.7, 77.6, and 69.7 respectively. These data suggest that U_{crit} measurements may be used to provide estimates for U_{ms}. However, physiological mechanisms involved in these two types of swimming tests need to be better understood.

Keywords: Mullus barbatus, Sparus aurata, Pagrus pagrus, swimming endurance, critical swimming speed, U_{crit}, maximum sustainable swimming speed, U_{ms}.

INTRODUCTION

Swimming performance is one of the crucial factors determining the survival of most fish species within the aquatic environment (Plaut, 2001). It is assumed that the swimming speed limits and endurance are directly related to escape from predators, food capture, reproduction, avoid dangerous conditions and therefore subjected to a strong selection pressure that enhance evolutionary fitness (Videler, 1993; Plaut, 2001; Videler and Wardle, 1991). Furthermore, swimming endurance of fish in relation to swimming speed is important in avoidance of towed nets and may assist in the design of fishing gear (Beamish, 1966; Breen *et al.,* 2004).

The swimming performance of fish can be classified into three major categories: sustained, prolonged and burst (Beamish, 1978). Sustained swimming performance can be maintained for long periods (longer than 200 min), and that are fuelled aerobically, therefore, without resulting in muscular fatigue (Beamish, 1978). Prolonged swimming can be maintained between 15 sec and 200 min, require some anaerobic energy, thus, ends in fatigue of the fish (Beamish, 1978). Burst swimming speeds are the speeds at which fish can swim for less than 15 s, where energy is made available largely through anaerobic processes (Beamish, 1978).

The boundary between sustained and prolonged swimming speeds is defined as the 'maximum sustainable swimming speed' (U_{ms}) (Peake, 2004). It represents an important threshold in the behavioural physiology of fish, marking the upper limit of aerobic swimming (Breen *et al.,* 2004). Previous studies have estimated U_{ms} as the maximum speed at which a fish can swim for 200 min (He and Wardle, 1988). For measuring U_{ms}, swimming endurance needs to be measured over a range of different speeds.

Critical swimming speed (U_{crit}) is a special category of prolonged swimming first introduced by Brett in 1964 (Peake, 2004). Ever since Brett's work, the most common way to measure swimming performance of fishes has been by the procedure of U_{crit} (Hammer, 1995). To estimate U_{crit} fish are stimulated to swim at a pre-determined velocity for a set time interval. The swimming speed is then increased in steps by fixed increments for a prescribed duration until the fish can no longer swim at the set velocity.

Information on the Maximum Sustainable Swimming Speed (U_{ms}) of fishes has significant value in our understanding of how fish reacts to towed fishing gears. However, it is rather difficult to measure U_{ms} as it requires repeated swimming trials to obtain a useable dataset. During these exercises swimming endurance needs to be measured at different speeds and experimental animals should be rested at least 24 hours between the exercises. Clearly it takes a considerable amount of time to complete these experiments during which all the factors influencing swimming performance, other than speed, need to be kept constant.

U_{crit} experiments, on the other hand, are relatively easier way of measuring swimming performance. By using this methodology results can be obtained with fewer swimming trials, which reduce the stress on the experimental animals and will mean greater controllability over experimental conditions.

In this study U_{crit} and U_{ms} of three commercially important Mediterranean species *Mullus barbatus* (red mullet), *Pagrus pagrus* (red porgy) and cultured *Sparus aurata* (sea bream) were measured to understand the relationship between U_{crit} and U_{ms}, and the potential for U_{crit} to be used to estimate U_{ms} is discussed.

MATERIAL AND METHODS

Experiments were carried out between January 2004 and May 2005 at Urla Fish Behaviour Laboratory of Ege University Fisheries Faculty.

Experimental animals

Red mullet and red porgy were colleted on board the RV "Egesüf" (27 m in length, 500 HP engine), by using a conventional bottom trawl in Izmir Bay. A towing duration of five minutes was used for red mullet, to prevent skin injuries and scale loses, while 45 minutes was used for red porgy. Fish were the transported to aquaculture unit of the Fisheries Faculty in Urla-Iskele. Cultured sea bream were transported from Akva-Tek fish farm in Aliaga, Izmir. Experimental animals were adapted for four weeks. During adaptation and after each swimming experiment red mullet and red porgy were fed with fresh sardine and anchovy, while cultured sea bream were fed with pelleted food (Bioaqua 3 mm diameter, crude protein % 45, crude fat % 12, crude ash % 12, crude fibre % 2, N.F.E % 13, total phosphorus % 1.5). Experimental fish were transferred to the stocking area of the current channel two days before the start of each experiment and the feeding was ceased the day before the first trial.

Experimental device

Experiments were carried out in an open flume tank (Fig 1). The channel was constructed from two oblong pools: a larger 6.8 x 2.4 m pool inside which a second smaller (5.9 x 1.2 m) pool was assembled. The channel between the inner wall of the larger pool and the outer wall of the small pool was used to circulate a regulated current of water. The width and depth of the channel were 0.45 and 0.6 m, respectively. Water depth during the experiments was maintained at 0.4 m. The water flow was created in the channel by means of a rotating wheel fitted with six paddles. This system was powered by a 2.2 HP electric motor, and the current speed was adjusted by means of a speed controller (SIEMENS, SINAMICS G110, UK), which controlled the power supply to the electric motor.

The inner pool which had the same water quality as the channel was used as an adaptation and stocking area for the experimental animals. Fish in this area were kept in 40 l buckets which allowed water changeover by means of narrow vertical cuts on the sides and aeration in them.

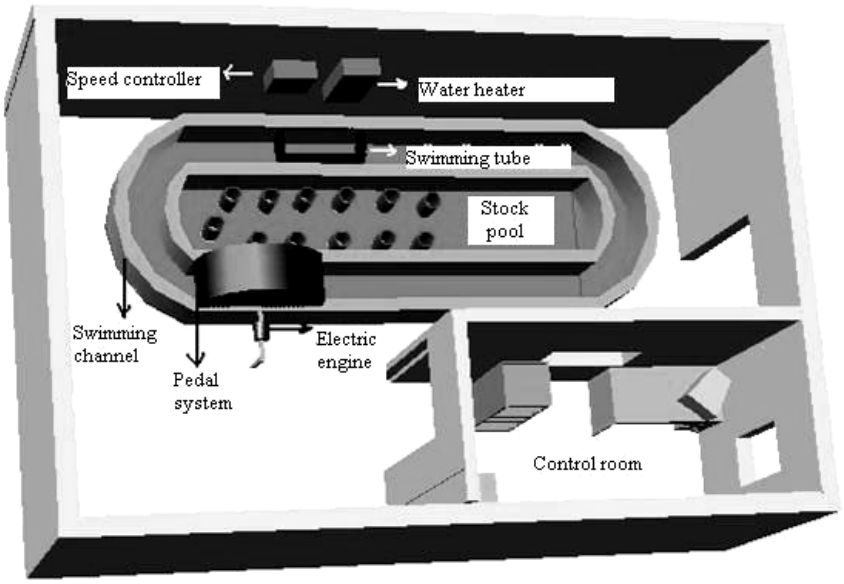

Figure 1: Schematic diagram of the flume tank system (approximately scale: 1/50).

To provide a uniform flow during the swimming experiments, the fish were contained in a 0.4 m diameter and 1 m long PVC pipe – or "swimming tube" – mounted in the channel on the opposite side to the paddle wheel, where water turbulence was assumed to be lowest, The pipe was fixed 10 cm from the bottom and 2.5 cm from the side walls of the channel, using two metal legs; so the depth of water in the swimming tube was 30 cm. A 29 cm access hole along the length of the pipe was used for taking the fish in and out of the swimming tube. The front and rear ends of the pipe were covered with 6 mm bar length thin PA netting, to keep the fish in the swimming tube. To provide contrast between the fish and background, the bottom of the pipe was covered with white light reflecting material.

The relationship between input power and water flow velocity was calibrated using a flow-meter (DUMAS-NEYPRIL 2117 AA). Thus the required power setting for each speed was predetermined, which ensured the fish were not disturbed by the presence of a flow-meter in the swimming tube during the experiments.

Experimental protocol

U_{crit} tests

Fish were placed in the swimming tube in groups of 10–17 individuals, depending on size. Then, the water flow velocity was raised in increments of 0.1 ms^{-1} at 10 min time intervals, until the fish became fatigued. When a fish stopped swimming and fell back onto the netting at the rear of the tube, it was gently stimulated by means of a wooden stick. If the fish could not be stimulated to swim again, it was regarded as 'fatigued'. Then fatigue time (min) and fish total length (mm) were recorded. U_{crit} was calculated by using the formula:

$$\mathbf{U_{crit} = U_i + \left[\frac{T_i}{T_{ii}} \times U_{ii}\right]}$$

Where U_i was the highest speed that the fish was able to maintain for the prescribe period (ms^{-1}); U_{ii}, velocity increment (0.1 ms^{-1}); T_i, time (min) fish swam at the 'fatigue' velocity; T_{ii}, is

the time interval (10 min) (Brett, 1964; as cited in Beamish, 1978). After the experiments fish were taken into buckets in the stocking area and fed.

U_{ms} tests

The day after the U_{crit} experiments, experiments were conducted on the same groups of fish to measure their endurance at fixed target speeds. The initial target swimming speed was 0.4 ms^{-1}. These experiments continued for each group, with the target speed increasing by an increment of 0.1 ms^{-1}, until all the fish in that respective group had endurance times of less than 10 min. At the beginning of each experiment, the flow speed was set to 0.1 ms^{-1} and fish were allowed to adapt for 5 min. Then, it was gradually increased to in the target speed over a period of two minutes. When the target speed was reached, a stopwatch was started to measure the endurance time. Each experiment lasted for a maximum of 200 minutes (He and Wardle, 1988). When a fish stopped swimming and fallen to the netting on the rear end of the tube within the 200 minutes, it was gently stimulated by means of a wooden stick. If a fish maintained its position on the netting despite the stimulation, endurance time was recorded, its total length (mm) measured, and the fish transferred into a bucket, in the stocking area. At the end of each experiment, fish were fed and rested for a minimum of 24 hours (He and Wardle, 1988).

In this study, the relationship between swimming speed and endurance time was modelled using the inverse-linear model (Breen *et al.*, 2004).

$$\frac{1}{t} = mU + c$$

Where, t is endurance time (min), U is the swimming speed (ms^{-1} or body length per second (BLs^{-1})) and m and c are the linear coefficient and intercept, respectively. As swimming speed decreases, endurance time in this relationship tends to an asymptote (to infinity) at a speed that corresponds to the Maximum Sustainable Swimming Speed (U_{ms}). Thus, this model can be used to provide a parameter-based estimate of U_{ms}, where $1/\infty \Rightarrow 0$ (Breen *et al.*, 2004):

$$U_{ms} = \frac{-c}{m}$$

Not all swimming endurance data were used in the analysis. Firstly, endurance times of 200 min were excluded as the experiments were terminated before the fish fatigued. These are generally referred to as censored data. Secondly, data were also excluded when fish showed a lower performance than the calculated U_{ms} (Winger *et al*, 2000; Breen *et al.,* 2004).

RESULTS

Red mullet

U_{crit} was calculated to be 6.81 BLs^{-1} for red mullet at 15 ^{o}C of water temperature. The relationship between the inverse endurance time (1/min) and relative swimming speed (BLs^{-1}) for red mullet (n: 17; mean TL: 11.32 cm) is shown in Figure 2. Regression analysis showed this was a significant relationship ($P<0.05$) which was described as follows:

$$\frac{1}{t} = 0.124 \times U_{ms} - 0.622$$

From this, U_{ms} was calculated to be 5.02 BLs^{-1}. Figure 3 shows censored and uncensored endurance data at different water velocities with the fitted inverse-linear model.

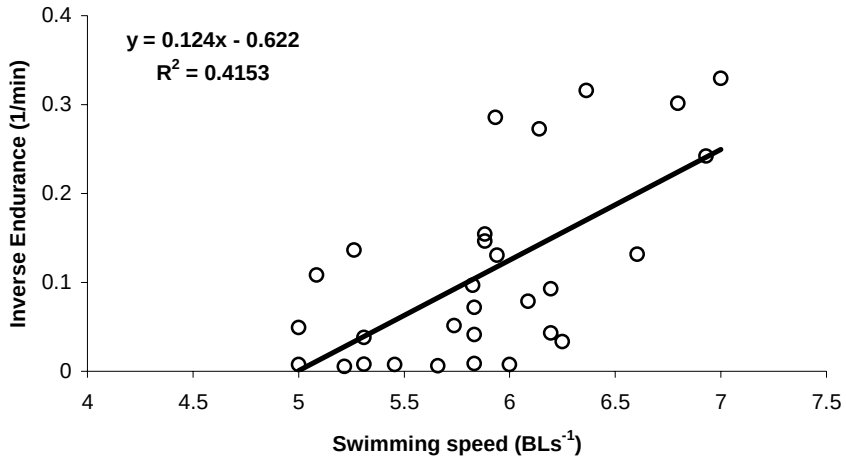

Figure 2: Inverse of endurance times (1/min), relative swimming speed (BLs^{-1}) data points, linear regression line and equation describing data points of red mullet (n: 17; mean TL: 11.32 cm) at 15 ^{o}C.

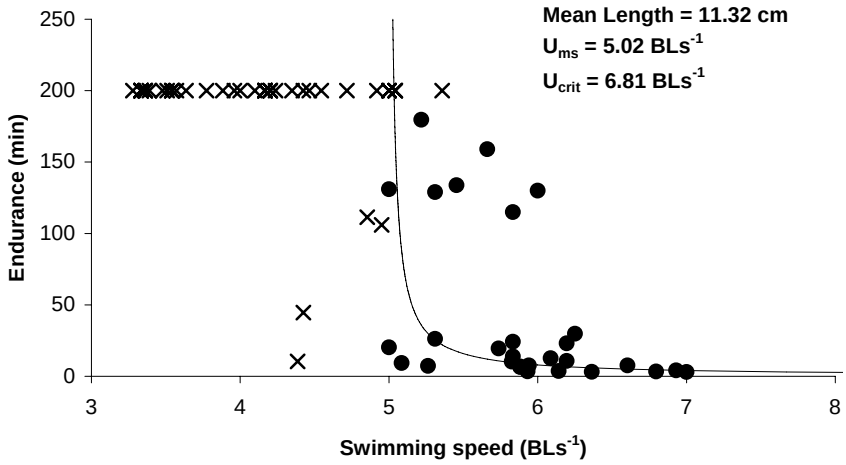

Figure 3: Red mullet. The relationship between endurance (min) and swimming speed (BLs^{-1}). Measured values of endurance are shown as closed circles (●); censored data as cross (X); fitted inverse-linear model as a line.

Red porgy

U_{crit} was calculated to be 4.92 BLs^{-1} for red porgy at 18 ^{o}C. The relationship between the inverse endurance time (1/min) and relative swimming speed (BLs^{-1}) for red porgy (n: 15; mean TL: 16.23 cm) is shown in Figure 4. Regression analysis showed this was a significant relationship ($P<0.05$) which was described as follows:

$$\frac{1}{t} = 0.074 \times U_{ms} - 0.283$$

From this, U_{ms} was calculated to be 3.82 BLs^{-1}. Figure 5 shows the censored and uncensored endurance data at different water velocities with the fitted inverse-linear model.

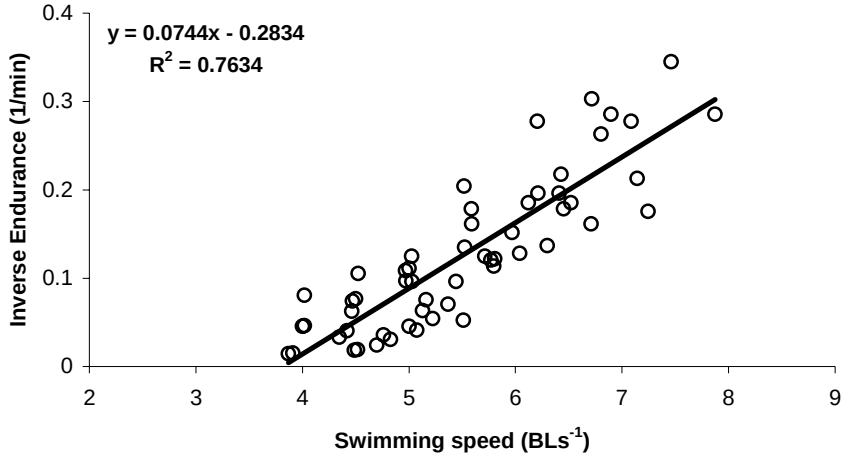

Figure 4: Inverse of endurance times (1/min), relative swimming speed (BLs−1) data points, linear regression line and equation describing data points of red porgy (n: 15; mean TL: 16.23 cm) at 18 °C.

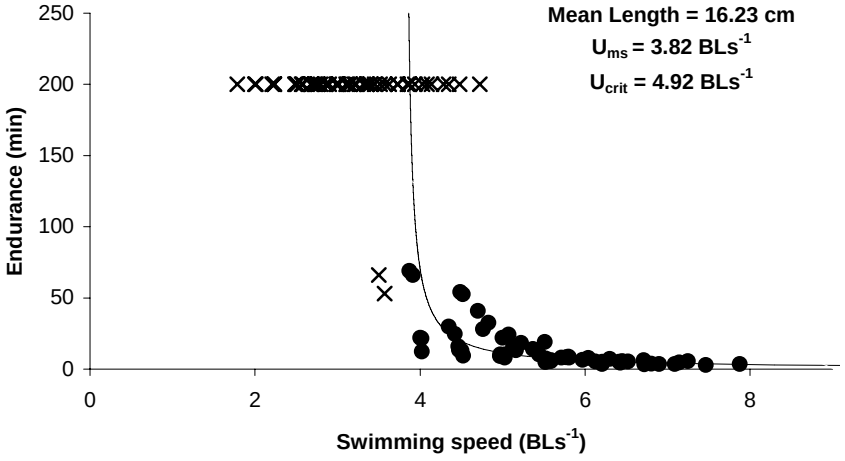

Figure 5: Red porgy. The relationship between endurance (min) and swimming speed (BLs^{-1}). Measured values of endurance are shown as closed circles (●); censored data as cross (X); fitted inverse-linear model as a line.

Cultured sea bream

U_{crit} was calculated to be 5.74 BLs^{-1} for cultured sea bream at 26 °C of water temperature. The relationship between the inverse endurance time (1/min) and relative swimming speed (BLs^{-1}) for cultured sea bream (n: 10; mean TL: 15.78 cm) is shown in Figure 6. Regression analysis showed this was a significant relationship ($P<0.05$) which was described as follows:

$$\frac{1}{t} = 0.040 \times U_{ms} - 0.160$$

From this, U_{ms} was calculated to be 4.00 BLs^{-1} by using this equation. Figure 7 shows the censored and uncensored endurance data at different water velocities with the fitted inverse-linear model.

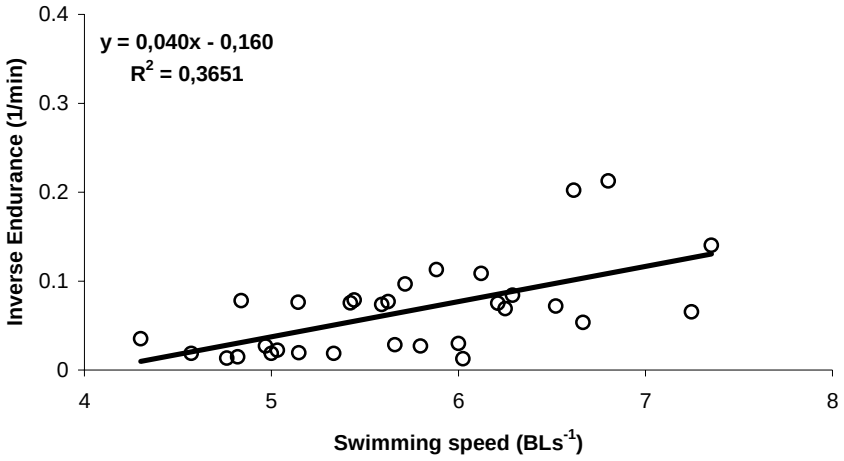

Figure 6: Inverse of endurance times (1/min), relative swimming speed (BLs^{-1}) data points, linear regression line and equation describing data points of cultured sea bream (n: 10; mean TL: 15.78 cm) which swam at 26 ^{o}C.

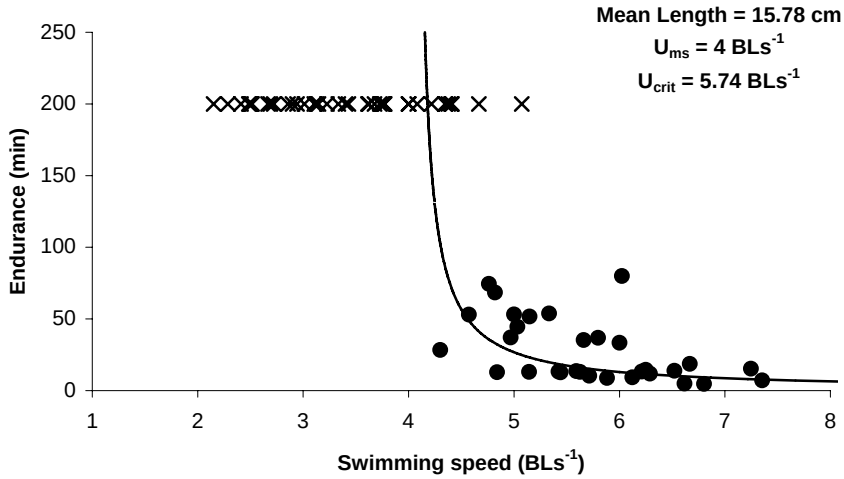

Figure 7: Sea bream. The relationship between endurance (min) and swimming speed (BLs^{-1}). Measured values of endurance are shown as closed circles (●); censored data as cross (X); fitted inverse-linear model as a line.

Relationship between U_{crit} and U_{ms}

U_{crit} values of red mullet, red porgy and cultured sea bream were determined the day before the U_{ms} experiments. Both U_{crit} and all the U_{ms} experiments were conducted by using the same fishes at the same water temperature (within ± 0.5 °C). It was found that U_{ms} was 73.7%, 77.6% and 69.7% of the mean U_{crit} for red mullet, red porgy and cultured sea bream, respectively (Table 1).

Table 1: Maximum sustainable swimming speeds (U_{ms}), mean critical swimming speeds (U_{crit}) and U_{ms}–U_{crit} percentage of red mullet, red porgy and cultured sea bream.

	TEMPERATURE (^{o}C)	N	TOTAL LENGTH (CM)	U_{MS} (BL.S^{-1})	U_{CRIT} (BL S^{-1})	U_{MS}-U_{CRIT} PERCENTAGE (%)
Red mullet	15	17	11,32±0,17 (10,0 –12,2)	5.02	6.81±0.184	73.7
Red porgy	18	15	16,23±0,73 (12,7 –22,4)	3.82	4.92±0.107	77.6
Cultured sea bream	26	10	15,78±0,50 (13,6 –18,6)	4.00	5.74±0.120	69.7

DISCUSSION

This study presents estimates of U_{ms} for red mullet, red porgy and sea bream for the first time. The Maximum Sustainable Swimming Speed (U_{ms}) of fish is an important parameter in our understanding of fish behaviour, as it defines the boundary between aerobic and anaerobic swimming capacity. However, it is difficult to measure U_{ms}, as it requires a considerable number of swimming trials, over a range of speeds, to produce valid and usable dataset. In addition, these experiments may result in injuries and even mortalities among the experimental subjects, as was observed in this study and Breen *et al*. (2004).

Conversely, U_{crit} is comparatively easier to measure and many authors have used it as an ecologically relevant parameter (Plaut, 2001). However, since U_{crit} is in the range of prolonged swimming speed (Plaut, 2001), its direct relevance to some applications (eg. fish behaviour during fishing operations) is limited.

The relationship between U_{crit} and U_{ms} is not well understood. However, in Hammer (1995) there is a brief review of aerobic and anaerobic power delivery in relation to U_{crit}, which suggests that anaerobic muscle use is only detectable at higher swimming speeds greater than 80% U_{crit}. This compares well with the correlations between U_{ms} and U_{crit} described in this study, and suggests that it may be possible to find a consistent relationship between U_{ms} and U_{crit}, even between species and at different temperatures. It is well known that both U_{ms} and U_{crit} tend to increase with temperature (Videler, 1993; Hammer, 1995). Therefore, the relationship is not expected to show great variations at different temperatures.

In the present study, it was not possible to individually identify the experimental animals and therefore investigate the individual variation in the endurance data. However, as the same animals were used in both the U_{ms} and U_{crit} experiments, the estimates of U_{ms} as a mean percentage of U_{crit} are still informative, at this preliminary stage.

The relationships between U_{ms} and U_{crit} described in this study were obtained empirically from the results of the swimming performance tests. Detailed investigation of the red and white muscle activities during different stages of U_{crit} in these species would further our understanding of this relationship. When the mechanism behind this relationship is well understood, it might be possible to have a shortcut in rather long way of reaching U_{ms} information.

Acknowledgements

We would like to thank to the Scientific and Technological Research Council of Turkey (TUBITAK) for funding the project No. 102Y126 and to Dr. Mike Breen for commenting on and editing earlier version of the text.

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Maximum Swimming Speed Predictions for *Mullus barbatus* and *Diplodus annularis*

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Abstract

Maximum swimming speeds of red mullet (*Mullus barbatus*) and annular sea bream (*Diplodus annularis*) were estimated from muscle twitch experiments at Ege University, Fisheries Faculty, Urla –Iskele Fish Behaviour Laboratory in August and September 2005.

It was estimated that an average size of 16.9 cm red mullet had a maximum speed of 3.14 m/s or 18.6 bl/s at 26 ºC. At 20 ºC maximum speed was estimated as 16.7 bl/s for an average size of 11.5 cm annular sea bream. It was also observed that the maximum swimming speed decreased with decreasing temperature.

Keywords: Red mullet, Annular sea bream, Maximum speed, Muscle contraction, Temperature.

Introduction

The speed of a steadily swimming fish is the product of stride length and tail beat frequency. Wardle (1975) suggested that to perform a tail beat, fish had to contract the myotomes on each side of the body consecutively; therefore, minimum time required to complete one tail beat could not be shorter than double the minimum contraction time of the swimming muscles on one side of the body. Wardle (1975) measured the contraction time of the muscle blocks dissected from freshly killed fish by stimulating them with a single electric pulse (20V, 1ms) in a temperature-controlled saline solution. He also recorded the movements of fast swimming fish on a modified closed circuit television system by either racing or startling them. The predictions he made after the muscle contraction experiments were similar to the observed tail beat frequency of the species he managed to record in fast swimming speeds. Wardle (1975) concluded that the muscle contraction time of a fish was a limit to the maximum attainable tail beat frequency and thus the maximum swimming speed.

Information on swimming performance of fishes in the Mediterranean is rather limited in the literature. This study aims to predict the maximum swimming speed of red mullet and annular sea bream by using the information on minimum muscle contraction time.

Material and Methods

Stride Length Measurements

Video recordings of steadily swimming fish in the current channel were used. Time spent for three tail beats at fixed water velocity were measured and time to complete one tail beat was calculated for each observation. Ten observations were analyzed and their average value was computed. Distance covered in one tail beat was calculated, and its rate to the total length of the fish was found as stride length.

Experimental animals

Experiments were conducted with 12 red mullet (mean length 16.9 ± 0.63 cm) and 11 annular sea bream (mean length 11.5 ± 0.28 cm). The fish were captured during demersal trawling

operations in Izmir Bay. All the fish were rested at least two days prior to the experiments which were conducted in Ege University, Fisheries Faculty, Urla -Iskele Fish Behaviour Laboratory in August and September 2005.

Instrument

An instrument was designed to measure the muscle contraction speed (Plate 1). It had fife main components.

- Electric stimulator
- Power unit
- Recording unit
- Temperature control unit
- Recording box

Plate 1. Instrument used for measuring muscle contraction speed.

Method

The fish were measured, killed, and a block representing anterior dorsal white lateral muscles was removed from location just behind the dorsal part of the gills.

The muscle sample was placed on two needle electrodes of a metal plate of a force transducer. A single pulse ~20mA electric stimulus was applied to the muscle block for 1 ms via the two needles. The electric pulse stimulated a single muscle contraction known as a twitch. The time from start of the stimulus electric pulse to the peak (maximum force) of the contraction was calculated by software. Contractions were stimulated in a solution (5% dextrose lactate) in the recording box. Temperature of the muscle block was changed by heating or cooling this solution.

Plate 2. Fish muscle sample placed on needle electrodes of the measuring box.

For red mullet ten measurements with 5 s time intervals for each fish were conducted at 26 ºC. For annular sea bream temperature was reduced from 20 to 10 ºC and one measurement was taken for every 0.3 ºC intervals.

Results

Red mullet

Mean muscle contraction time of 12 red mullet was 15.8 ms (se. 0.59) at temperature of 26ºC. Tail beat frequency was 1000/(15.8*2)=32 Hz. Stride length was estimated as 0.58 body length. A 16.9 cm red mullet can reach maximum speed of 3.14 m/s or 18.6 bl/s at a muscle temperature of 26ºC. While the absolute maximum speed (as m/s) tends to increase with the increasing fish size, the relative maximum speed (as bl/s) tends to decrease.

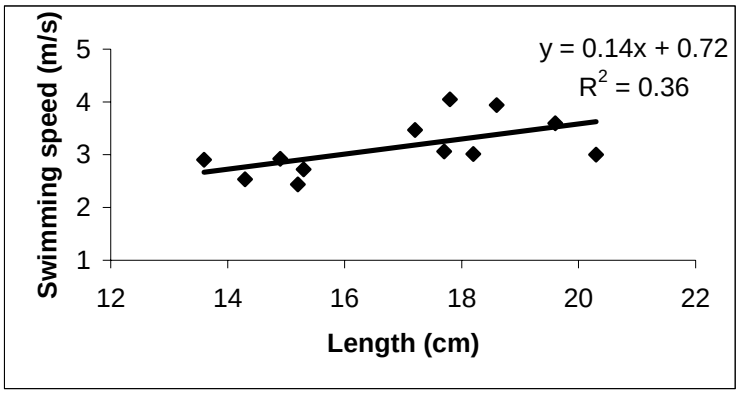

Figure 1: Length burst speed relationship of red mullet at 26 ºC.

Table 1: Maximum swimming speed estimations of 12 red mullet at 26 ºC.

LENGTH (CM)	MEAN CONTRACTION TIME (MS)	TAIL BEAT FREQUENCY (HZ)	MAXIMUM SWIMMING SPEED (M/S)	MAXIMUM SWIMMING SPEED (BL/S)
20.3	19.62 ± 0.16	25.5	3.00	14.8
14.3	16.38 ± 0.27	30.5	2.53	17.7
13.6	13.59 ± 0.13	36.8	2.90	21.3
15.2	18.10 ± 0.10	27.6	2.44	16.0
17.2	14.39 ± 0.09	34.8	3.47	20.2
18.2	17.53 ± 0.06	28.5	3.01	16.5
17.7	16.77 ± 0.07	29.8	3.06	17.3
18.6	13.70 ± 0.09	36.5	3.94	21.2
19.6	15.82 ± 0.64	31.6	3.59	18.3
17.8	12.75 ± 0.23	39.2	4.05	22.7
15.3	16.29 ± 0.07	30.7	2.72	17.8
14.9	14.81 ± 0.08	33.8	2.92	19.6

Annular sea bream

Muscle contraction time decreases logarithmically with increasing temperature between 10 and 20 ºC. Relationship between temperature and contraction time is usually well described with logarithmic regression lines for the individual fish data (Figure 2). However, the combined data from eleven fish give relatively scattered fit (Figure 3). This indicates the variation in their maximum swimming performance. Muscle contraction times, calculated from the logarithmic regression equation of the combined data, for 10, 15, and 20 ºC were found as 22.1, 19.9, and 18.3 ms, respectively. Estimated tail beat frequencies from these values are 22.6 Hz for 10 ºC, 25.1 for 15 ºC, and 27.3 Hz for 20 ºC.

Stride length was estimated as 0.61 body length. For an average size of 11.5 cm annular sea bream, speed at 10 ºC was calculated as 1.58 m/s or 13.8 bl/s, at 15 ºC as 1.76 m/s or 15.3 bl/s, and at 20 ºC as 1.92 m/s or 16.7 bl/s.

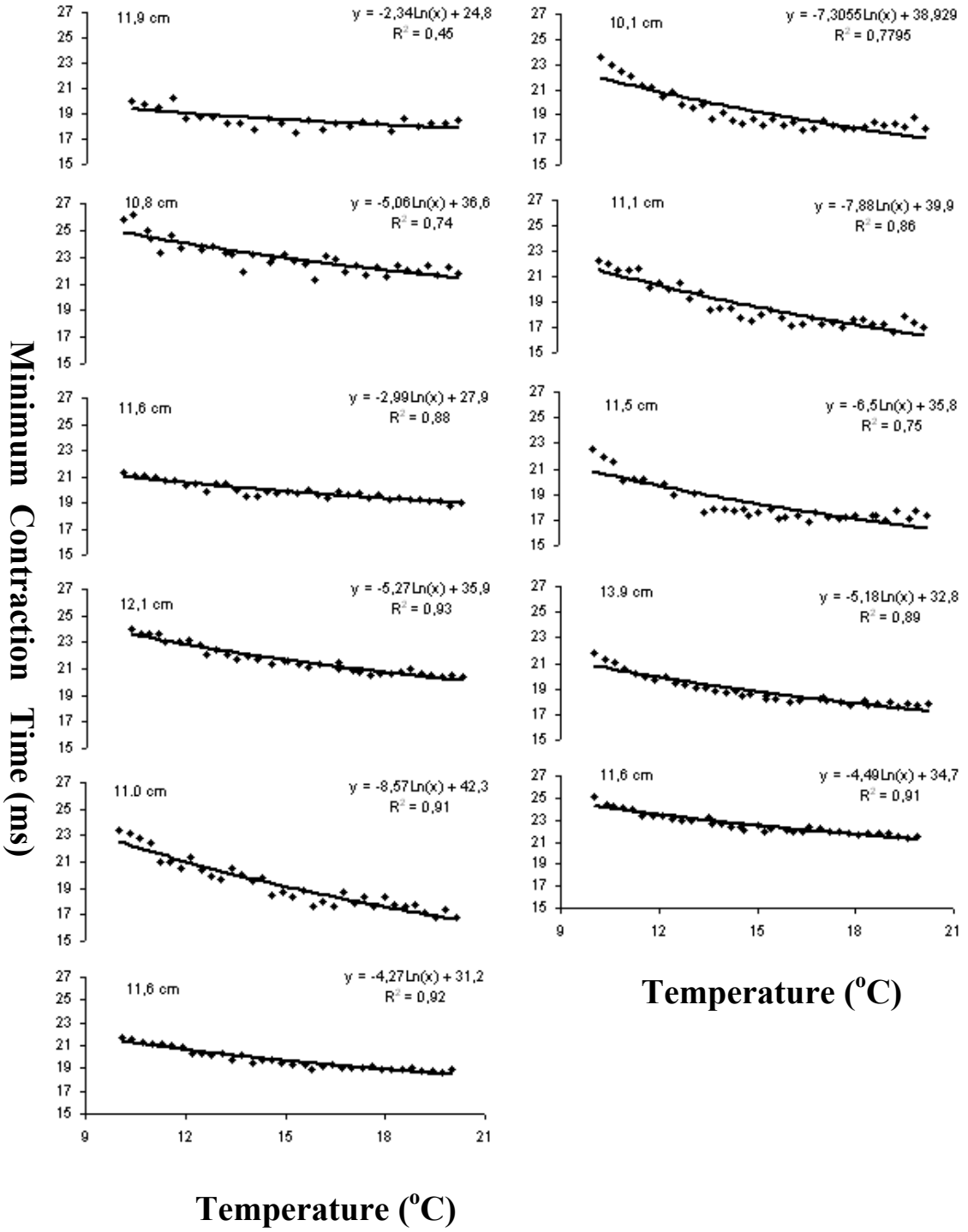

Figure 2: Annular sea bream. Individual fish data and logarithmic regression lines.

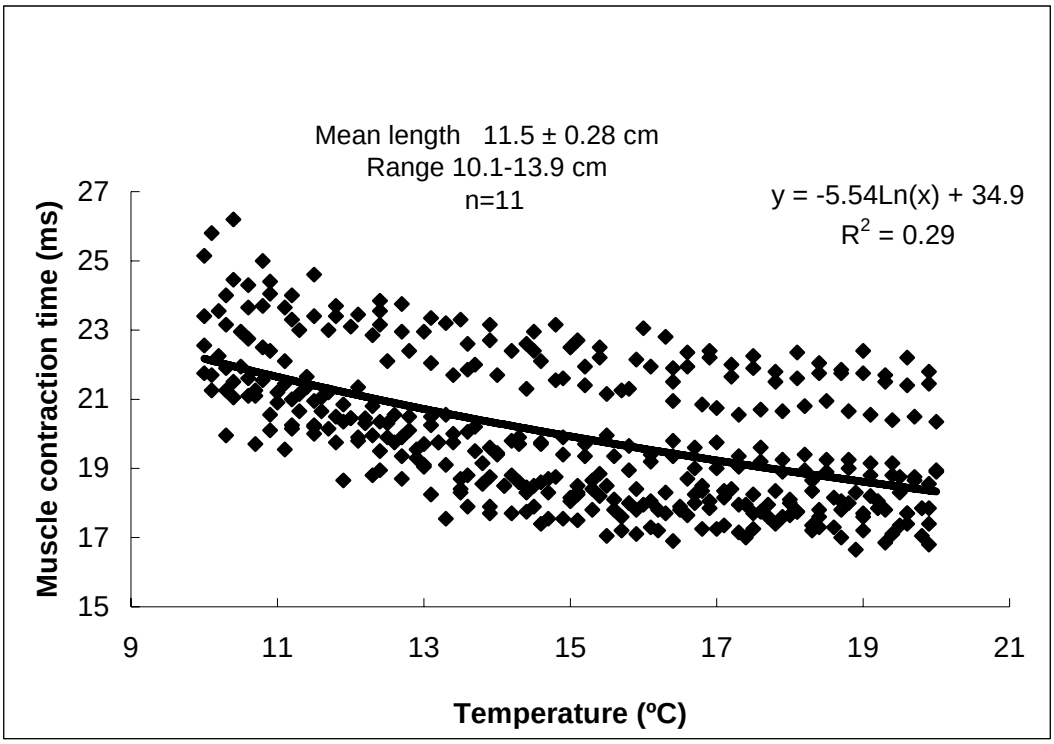

Figure 3: Annular sea bream. Combined fish data and logarithmic regression line.

Discussion and Conclusion

Although the fastest burst swimming are of very short endurance (Wardle, 1980), they are of great survival value to the fish during their escape from a codend (He, 1993). These are the first data to estimate the maximum swimming speed for red mullet and annular sea bream. Therefore, direct comparison of the results with any other study is not possible. However, as reported by Wardle (1975; 1980), Arimoto *et al.*, (1991) and Ozbilgin and Wardle (2002), a tendency of increase in muscle contraction time with increased fish size is observed in the present study for red mullet.

Maximum swimming performances of annular sea bream is temperature dependent. It is significantly lower at water temperature of 10 ºC than it is at 20ºC for all of the experimental animals.

Muscle contraction time decreases logarithmically with the increasing temperature. In other words, the effect of a one degree temperature change on muscle contraction time decreases with increasing temperature.

Acknowledgements

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Comparison of the swimming performance of farmed and wild gilthead sea bream, *Sparus aurata*.

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Abstract

Farmed gilthead sea bream, *Sparus aurata*, frequently escape from the sea cages and interact with wild populations. The impact of these interactions on the wild populations will depend, in part, on differences in their performances. This study compared the swimming performance of the wild and farmed fish in a current channel.

It was found that the absolute U_{crit} increases with increasing size while the relative U_{crit} decreases. Even at the same length there can be noticeable performance differences between the individuals. The wild sea bream have significantly higher ($P<0.05$) CSS performance (0.86 ± ms^{-1}) than the farmed fish (0.79 ± 0.01 ms^{-1}).

Keywords: Gilthead sea bream, Critical swimming speed (U_{crit}), Wild, and Farmed

Introduction

Farmed gilthead sea bream, *Sparus aurata*, frequently escape from the sea cages and interact with wild populations. The impact of these interactions on the wild populations will depend, in part, on differences in their performances. Sustained (endurance), prolonged (critical swimming speed, U_{crit}) and burst swimming ability are commonly used measures of performance in fish (Hammer, 1995), and have been used in numerous studies to compare the fitness of introduced and wild fish of various species. The aim of this study is to test swimming performance of farmed and wild gilthead sea bream using incremental velocity tests to find their critical swimming speed (U_{crit}).

Materials and Methods

Experiments were carried out in the current channel of the fish behaviour laboratory at Urla Research Station of the Ege University, Fisheries Faculty, in Izmir, Turkey, in May 2005. Experimental farmed fish (18.0 to 20.5 cm, n=13) were transferred from Akva-Tek Fish Farm in Izmir and wild fish (18.2 to 20.6 cm, n=36) were caught by demersal trawl in Izmir Bay. Experiments were conducted at 17 °C of water temperature.

U_{crit} tests

Critical swimming speed (U_{crit}) was calculated according to formula given by Brett (1964):

$$U_{crit} = U_i + (T_i/T_{ii} \times U_{ii})$$

Where U_i is the highest speed that the fish is able to maintain for the prescribe period (cms^{-1}); U_{ii}, velocity increment (10 cms^{-1}); T_i, time (min) fish swam at the 'fatigue' velocity; T_{ii}, is the time interval (10 min).

Statistical analysis

Significance tests of the normal distribution of the total lengths of two groups were done by using one-sample Kolmogorov Smirnov's, and homogeneity tests were done by using Levene's statistical analysis. The significance test of total lengths was compared by independent sample t-test. After total lengths of two groups showed statistical similarity

(P>0.05), significance of the normal distribution and homogeneity of their CSSs were tested. To compare the CSSs of wild and farmed fish, independent sample t-test was used.

Results

It can be seen in the figures that the absolute CSS increase with increasing size while the relative CSS decrease. Even at the same length there can be noticeable performance differences between the individuals. Both the figures clearly show that the wild sea bream have significantly higher CSS performance than the farmed fish (P<0.05).

Table 1: Absolute (m s^{-1}) and relative (B.L. s^{-1}) U_{crit} of wild and farmed sea bream. The significance test was used independent sample t-test and 'N. S.' is not significance and 'S.' is significance.

CLASSES (W-F)	*N*	MEAN±SE TOTAL LENGTHS (CM)	MEAN±SE TOTAL WEIGHTS (G)	MEAN±SE U_{CRIT} (M S^{-1})	MEAN±SE U_{CRIT} (B.L. S^{-1})
Wild	36	19.1 ± 0.1	99.3 ± 1.6	0.86 ± 0.01	4.52 ± 0.05
Farmed	13	18.9 ± 0.2	95.9 ± 4.3	0.79 ± 0.01	4.21 ± 0.05
Statistics		N. S.	N.S.	S.	S.

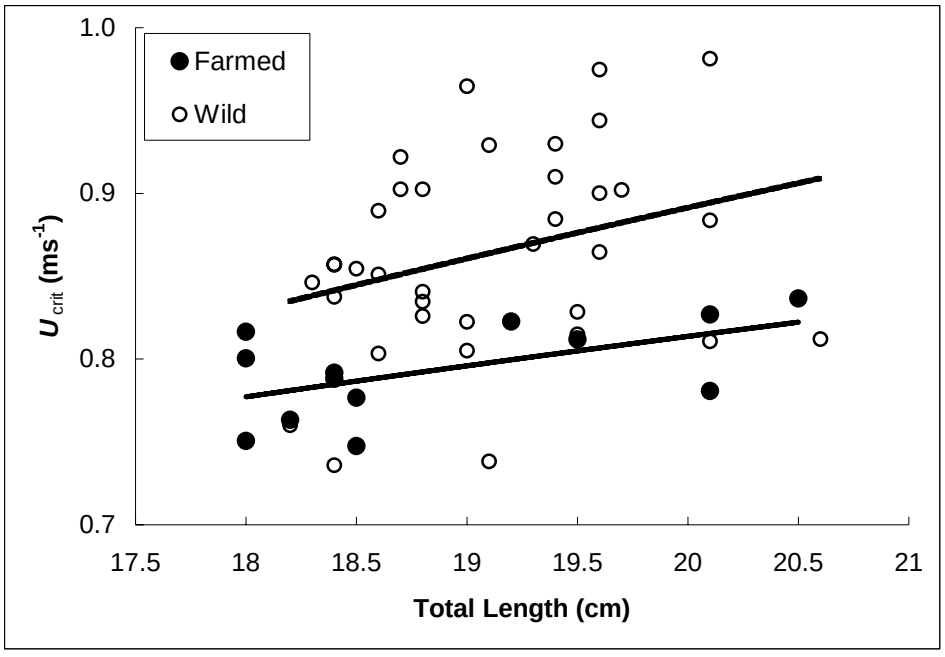

Figure 1: Absolute U_{crit} (ms^{-1}) of wild and farmed sea bream at a water temperature of 17 ºC.

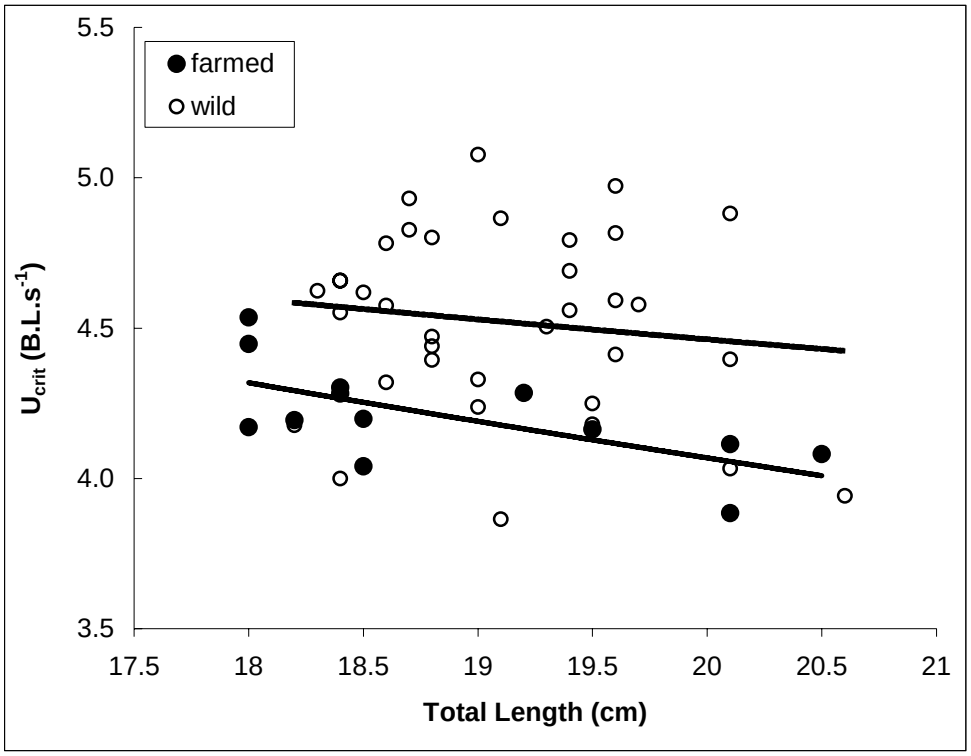

Figure 2: Relative U_{crit} (B.L.s^{-1}) of wild and farmed sea bream at water temperature of 17 ºC.

Discussion

Table 2: Comparison of the swimming performances of wild and farmed fish.

FISH	SWIMMING PERFORMANCE (U_{CRIT} OR ENDURANCE)	DIFFERENCES (BETWEEN WILD AND FARMED FISH)	STUDY AUTHORS
Coho salmon (*Oncorhynchus kisutch*)	U_{crit}	Wild > farmed	Brauner *et al*., 1994
Atlantic salmon *Salmo salar*)	U_{crit}	Wild > farmed	McDonald *et al.,* 1998
Brook trout (*Salvelinus fontinalis*)	Endurance	Wild > farmed	Vincent, 1960
Atlantic salmon (*Salmo salar*)	U_{crit}	Wild ≈ farmed	Peake *et al.,* 1997
Atlantic salmon (*Salmo salar*)	Endurance	Wild ≈ farmed	Thorstad *et al.,* 1997
Atlantic salmon (*Salmo salar*)	U_{crit}	Wild ≈ farmed	Dunmall and Schreer, 2003
Gilthead sea bream (*Sparus aurata*)	U_{crit}	Wild > farmed	In this study

It is well reported that cultured fish have a higher fat content (Vincent, 1960; Thorstad *et al*., 1997) and may be less conditioned to swimming than their wild counterparts (Thorstad *et al.,* 1997). Wild fish, by contrast, must swim to survive, and therefore may have the increased cardiac growth that has been associated with exercise training in teleost fish (Davison, 1989).

Genetic differences between cultured and wild gilthead sea bream may also cause different swimming performance as introduced salmon are selectively bred for characteristics desirable to fish farming operations, such as increased growth and delayed maturity (Fleming and Einum, 1997), and not for performance related traits such as predator avoidance and food acquisition.

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Swimming performance and deformity separation of juveniles of sea bass (*Dicentrarchus labrax* L.) by using current channels

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Abstract

To separate the abnormal sea bass juveniles, *Dicentrarchus labrax,* from the normal specimens, differences in their swimming performances were investigated. Firstly, Critical Swimming Speed (U_{crit}) tests were applied with 5 cms^{-1} increments and 5 min period, and then endurance tests were performed at a fixed water velocity of 50 cms^{-1}. Results of experiments were compared in 3 length classes of 6.1–7.0, 7.1–8.0 and 8.1–9.0 cm. Absolute U_{crit} (cms^{-1}) and relative U_{crit} ($B.L.s^{-1}$) values normal fish were significantly higher than those of the fish with lordosis ($P<0.05$).

Both normal fish and those with lordosis showed increased endurance with increasing length during the exercise in the fixed water velocity of 50 cms^{-1}. At the end of 40 min exercise in this velocity, percentages of the normal fish maintained swimming in all three length classes were higher than those of deformities. Potential use of differences between the swimming performances of normal fish and deformities in hatcheries to sort the deformities is discussed. Results might have potential to be used in commercial hatcheries.

Keywords: deformity separation, sea bass, swimming performance, lordosis.

Introduction

Skeletal anomalies have an important role in aquaculture, as they decrease the quality of the produced fish by affecting their external morphology, growth and survival (Andrades *et al.,* 1996; Koumoundouros *et al.,* 1997a). Rate of discarded sea bass with skeletal abnormalities in Turkish hatcheries have been as high as 25% depending on the year of the production. Malformations are economically important, as they require manual sorting (Koumoundourous *et al.*, 1997b), and they lower the performances of hatchery-reared fish. Furthermore, they have a negative effect on the final step of commercialisation because hatchery-reared fish have a different shape from the wild-caught ones (Loy *et al.,* 1998), and are therefore ruled out by the consumers (Koumoundourous *et al*., 1997b).

Presently skeletal abnormalities are manually sorted on a frozen glass table illuminated from underneath after application of anaesthesia. There is a great need to develop more efficient techniques for separating the abnormalities from the normal fish in the aquaculture industry.

In the present study, we used swimming performance of sea bass juveniles to separate the skeletal deformities from normal fish in a flow channel under laboratory conditions.

Materials and methods

Experiments were conducted at the current channel of the fish behaviour laboratory of Ege University, Fisheries Faculty, in Urla, Izmir, Turkey, in July 2005, at 25 °C of water temperature.

Experimental animals

Approximately 1000 deformities of sea bass juveniles were randomly taken during the sorting process in a hatchery, and about 500 normal fish were added to them. A total of randomly

taken 918 juveniles were used in two experiments. Among these, 426 individuals were used in the U_{crit} tests and 492 individuals were used in swimming endurance tests.

Experimental device

Swimming was performed in a 0.4 m diameter and 1 m long PVC pipe mounted in the current channel. To provide a uniform flow, the pipe was fixed on two metal legs by means of which 10 cm distance from the bottom and 2.5 cm distance from the side walls of the channel were provided. To release the fish into the pipe, top part of it was cut in 29 cm width and removed. By this way a water depth of 30 cm was obtained between the bottom of the pipe and water surface. To maintain the fish in the pipe, its front and rear ends were rigged with 6 mm bar length thin PA material netting. To provide contrast between the fish and background, bottom of the pipe was covered with white light reflecting material.

U_{crit} protocol

At the start of U_{crit} experiments, fish were taken into the tube, current speed was set to 5 cms^{-1} and the stopwatch was started. Then, every 5 minutes the speed was increased 5 cms^{-1}, until the last fish in each trial was exhausted and fall back on to the netting at the rear and the swimming tube. Once a fish was exhausted and fallen on to the rear netting, time was recorded, total length was measured to the nearest mm, fish was weighed to the nearest 0.1 g, and its deformity was visually identified on a small glass table illuminated from underneath. Each fish was used only once. Each trial of experiment lasted for about 1.5 hours. Four trials were conducted in a day.

Calculation of U_{crit}

Critical swimming speed (U_{crit}) was calculated according to formula given by Brett (1964):

$$U_{crit} = U_i + (T_i/T_{ii} \times U_{ii})$$

Where U_i is the highest speed that the fish is able to maintain for the prescribe period (cms^{-1}); U_{ii}, velocity increment (5 cms^{-1}); T_i, time (min) fish swam at the 'fatigue' velocity; T_{ii}, is the time interval (5 min).

Swimming endurance tests

Endurance tests were conducted in three trials. Once randomly taken fish were transferred into the swimming pipe, they were allowed to adapt for 5 min. Then, current speed was gradually increased to 50 cm s^{-1} in two minutes. After that speed was reached, the stopwatch was started and all the exhausted fish in each 5 minutes period were collected in separate buckets. After 40 minutes, the experiment was terminated and unexhausted fish were taken into another bucket. Then, total lengths of the fish in each bucket were measured and their deformity was identified.

Results

For statistical comparisons of the U_{crit} and endurance of normal and deformed fish, they were grouped into three size classes (6.1–7.0, 7.1–8.0 and 8.1–9.0 cm). In U_{crit} tests, 202 normal and 224 abnormal fish were used. Lordosis was identified in 219 and scoliosis was identified in 5 specimens.

In all the three groups, U_{crit} increases with increasing length. Although there is a considerable amount of overlap, for a given length, mean U_{crit} values of the normal fish are usually higher than those of the deformities. Amongst the deformities, fish with lordosis show a better swimming performance than the fish with scoliosis.

Statistical comparison between the U_{crit} values of different groups within each length class, showed that normal fish have significantly higher U_{crit} values than the fish with lordosis ($P<0.05$).

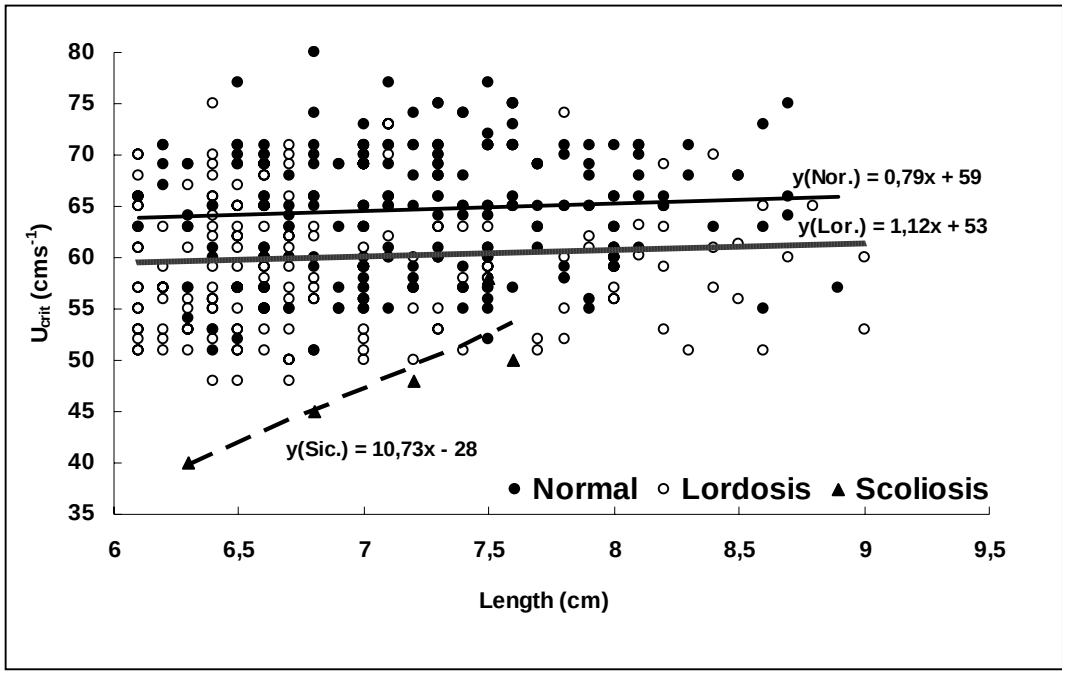

Figure 1: U_{crit} of normal and two types of skeletal deformities in sea bass juveniles.

Table 1: Absolute (cm s^{-1}) and relative (B.L. s^{-1}) U_{crit} of normal sea bass juveniles and deformities with lordosis.

Length Classes (cm)	Deformity Groups	*N*	Mean±Se Total Lengths (cm)	Mean±Se U_{crit} (cm s^{-1})	Mean±Se U_{crit} (B.L. s^{-1})	Mean±Se Total Weights (g)
6.1–7.0	Normal	83	6.6±0.029	63.7±0.73	9.5±0.12	3.0±0.03
	Lordosis	146	6.5±0.022	59.6±0.56	9.1±0.22	
7.1–8.0	Normal	99	7.5±0.026	65.2±0.54	8.6±0.17	4.4±0.05
	Lordosis	53	7.5±0.043	61.0±0.93	8.1±0.14	
8.1–9.0	Normal	20	8.3±0.058	66.4±1.19	7.9±0.15	6.2±0.12
	Lordosis	20	8.4±0.061	60.5±1.72	7.4±0.22	

At the end of 40 min, percentages of the normal fish maintained swimming in all three length classes were higher than those of abnormal fish. While 40, 76 and 94% of the normal fish maintained swimming after 40 min, only 1, 17 and 48% of the abnormal specimens for the respective length classes of 6.1–7.0, 7.1–8.0, and 8.1–9.0 cm continued swimming.

Table 2: Failure periods (min) and percentages (%) of the normal fish and those with lordosis used in swimming endurance tests at 50 cm/s water velocity.

Length Classes	Deformity Groups	Total *N* (Indv.)	Failure periods (min) and percentages (%)								
			0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40+
6.1–7.0 cm	Normal	60	-	-	8.3	23.3	8.3	5	6.7	8.3	40.1
	Lordosis	143	15.4	16.8	36.4	18.9	9.1	0.7	0.7	0.7	1.3
7.1–8.0 cm	Normal	76	-	-	9.2	2.6	5.3	1.3	2.6	2.6	76.4
	Lordosis	71	9.9	16.9	9.9	16.9	9.9	7	7	5.6	16.9
8.1–9.0 cm	Normal	17	-	-	-	-	-	5.9	-	-	94.1
	Lordosis	25	-	8	16	8	4	8	8	-	48.0

Discussion and conclusions

Results of this study show that there are significant differences between the swimming performances of normal fish and fish with skeletal deformities. The normal sea bass juveniles are significantly better swimmers than the abnormal specimens with lordosis and scoliosis. This difference may have potential to be used in fish hatcheries to sort the skeletal deformities from the normal fish.

Separation of the deformities from the normal fish in hatcheries might be possible for sea bass juveniles up to a certain degree. Unfortunately the results of the present experiment do not provide an endurance time at a certain water velocity at which 100% of the deformities could be sorted as a result of fatigue. This is very much expected as performance of even the normal fish show great variation between the individuals (Hammer, 1995; Koumoundouros *et al.,* 2002; Ozbilgin, 2005), and reduction in swimming ability due to deformity is likely to be influenced by the level of deformity which was not investigated in detail in the present study.

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Effects of body length and water temperature on the critical swimming speeds (css) of red mullet and annular sea bream

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ABSTRACT

Critical swimming speeds (U_{crit}) of *Mullus barbatus* L.1758 (red mullet) and *Diplodus annularis* L.1758 (annular sea bream), which are common commercial catch components in the Aegean Sea demersal trawl fisheries, were measured to investigate the effects of water temperature and fish length.

It was found that increasing water temperature and fish length increased the absolute CSS (m/s). Results were discussed in a way to improve our understanding of fish behaviour in relation to trawl operation.

Keywords: Mullus barbatus, Diplodus annularis, CSS, temperature, length.

Introduction

Swimming performance is one of the crucial factors determining the survival of most fish species within the aquatic environment (Plaut, 2001). Moreover, it is assumed that the swimming speed limits and endurance are directly related to escape from predators, food capture, reproduction, avoid dangerous conditions and therefore subjected to a strong selection pressure that enhance evolutionary fitness (Plaut, 2001; Videler, 1993; Videler and Wardle, 1991). Furthermore, swimming endurance of fish in relation to swimming speed is important in avoidance of towed nets and may assist in the design of fishing gear (Beamish, 1966).

Material and Methods

Red mullet and annular sea bream were colleted on board the RV "Egesuf" (27 m in length, 500 HP engine), by using a conventional bottom trawl in Izmir Bay. Experiments were carried out in Ege University, Fisheries Faculty, Fish Behaviour Laboratory from January 2004 to May 2005 (Figure 1). Trawl caught fish were transported to the aquaculture unit in Urla – Iskele. During three to four weeks acclimation fish were fed with fresh sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*). After acclimation, fish were transferred to stocking area of the current channel and fasted 24 h prior to swimming experiments. A total of 160 fish were tested.

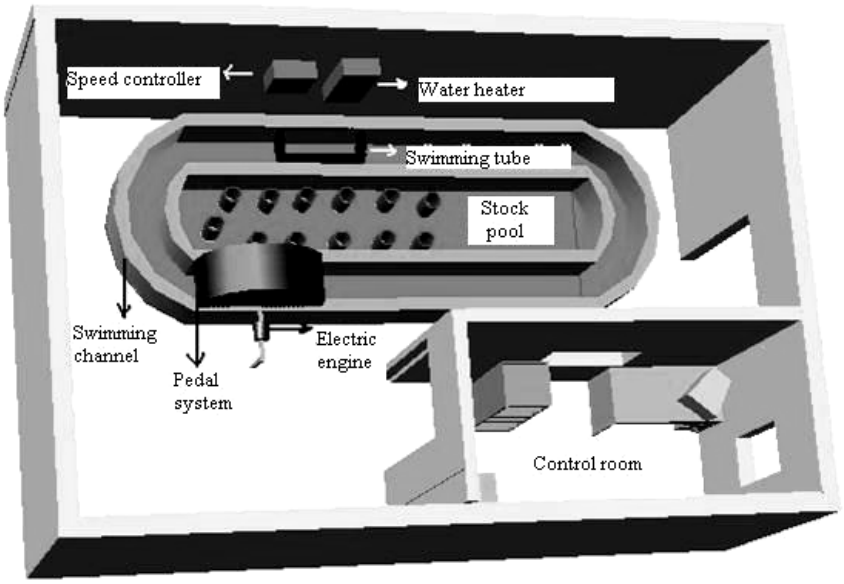

Figure 1: Illustration of the current channel system where the experiments were carried out.

CSS tests

The protocol of the U_{crit} test is carried out by placing the fish in a current channel to swim against a particular water velocity for a set time interval. Fishes usually tend to hold their position against the current due to opto-motor response (Plaut, 2001). Water velocity, thus the swimming speed, is then raised in steps at a particular increment (0.1 ms^{-1}) for a prescribed duration (10 min) until the fish fails to swim or could no longer maintain their position in the swimming tube. At this stage critical swimming speed is calculated as:

$U_{crit} = U_i + (T_i/T_{ii} \times U_{ii})$

Where U_i is the highest speed that the fish is able to maintain for the prescribe period (ms^{-1}); U_{ii}, velocity increment (ms^{-1}); T_i, time (min) fish swam at the 'fatigue' velocity; T_{ii}, is the time interval (min) (Brett, 1964).

Statistical Analyses:

In the statistical analysis independent sample student-t test for comparison of the differences between two groups, ANOVA for comparison of the differences between more than two groups, regression analysis for determining the relationships between CSS and total lengths for each species were conducted by using SPSS (9.0).

Results

A total of 37 red mullet (10.9 – 16.7 cm) at 13 – 25°C and 123 annular sea bream (9.0 – 16.2 cm) at 13 – 17 – 25°C were tested respectively. It was found that increasing water temperature and fish length increased the absolute CSS (ms^{-1}). Water temperature (°C), number of the tested fish, mean of the total length of the samples (cm), absolute (ms^{-1}) and relative (TLs^{-1}) critical swimming speed are presented in Table 1.

Table 1: Water temperature (°C), number of the tested fish, mean of the total length of the samples (cm), absolute (ms^{-1}) critical swimming speeds. Length values are shown as mean ± standard error (minimum length – maximum length).

SPECIES	TEMPERATURE (°C)	N	TOTAL LENGTH (CM)	CSS (M/S)
Red mullet	13	20	13.57±0.33 (10.9–16.5)	0.63±0.013
Red mullet	25	17	13.42±0.43 (11.4–16.7)	0.94±0.021
Annular sea bream	13	23	11.09±0.30 (9.7–16.2)	0.59±0.010
Annular sea bream	17	88	11.79±0.14 (9.2–16.0)	0.68±0.007
Annular sea bream	25	12	12.04±0.52 (9.0–15.5)	0.85±0.020

Absolute CSS data points of red mullet which swam at 13 and 25°C water temperature, linear regression lines describing data points are shown in Figure 2. There is no statistical differences found between mean total length of the fish belong these two groups (P>0.05). Mean absolute CSS of the fish swum at 25°C water temperature is found significantly higher than that of the fish swum at 13°C water temperature (P=0.000). The linear relationships between absolute critical swimming speed (ms^{-1}) and total length of red mullet at 13 and 25°C are as follows:

At 13°C CSS = 0.014 TL + 0.4415

At 25°C CSS = 0.0321 TL + 0.5131

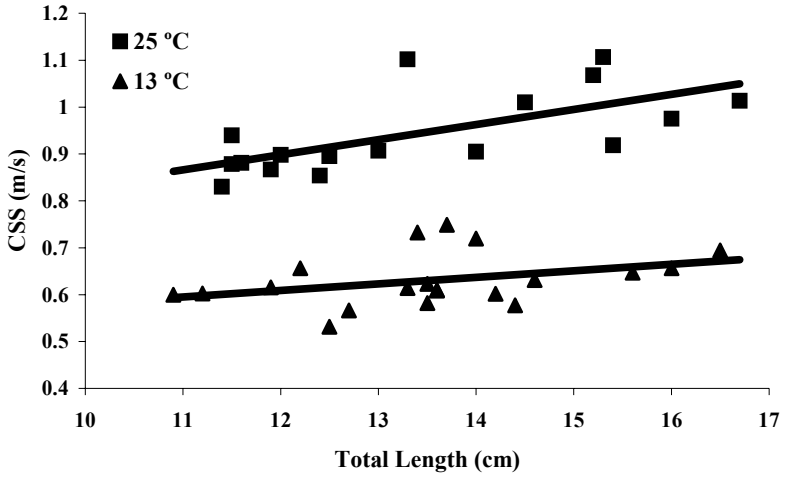

Figure 2: Total length (cm) and absolute critical swimming speed (ms^{-1}) of red mullet at 13 and 25 °C.

Figure 3 shows the absolute CSS data points of annular sea bream which swam at 13, 17 and 25°C water temperature, and linear regression lines describing data points. There are no statistical differences found between mean total length of the fish belong these groups (P>0.05). However, it was found that temperature had a statistically significant effect on CSS (P<0.05). Absolute CSS was measured as 0.59, 0.68 and 0.85 at 13, 17 and 25°C respectively. These values show that the CSS increases 15.3% when the water temperature increases from 13 °C to 17°C and increases 25% when the water temperature increases from 13°C to 25°C. The linear relationships between absolute critical swimming speed (ms^{-1}) and total length of annular sea bream at 13, 17 and 25°C are as follows:

At 13°C CSS = 0.0231 TL + 0.3149

At 17°C CSS = 0.0289 TL + 0.3459

At 25°C CSS = 0.0173 TL + 0.6317

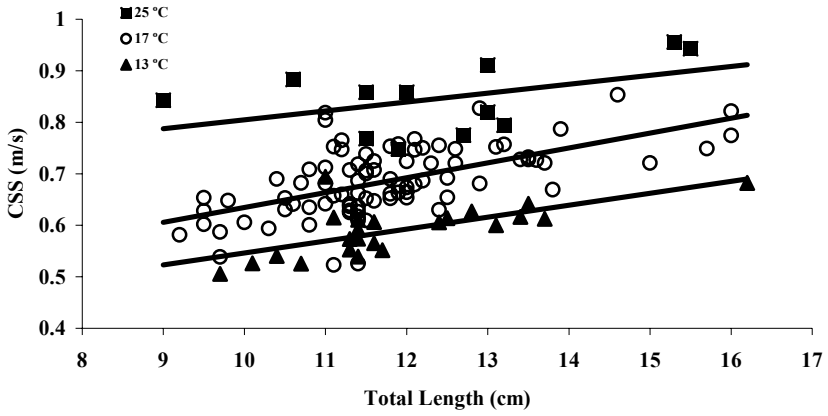

Figure 3: Total length (cm) and absolute critical swimming speed (ms^{-1}) of annular sea bream at 13, 17 and 25°C.

Mean CSS for red mullet and annular sea bream, as calculated from the linear regression equations, increased 16.7% when the length increased from 10 to 15 cm and increased 33.4% when the length increased from 10 to 20 cm at 13°C, as can be seen in Table 2.

Table 2: Effect of 5 (from 10 to 15) and 10 (from 10 to 20) cm body length increase on CSS as percentage (%).

	% DIFFERENCE IN CSS FROM 10 TO 15CM	% DIFFERENCE IN CSS FROM 10 TO 20CM
Annular sea bream	21.3	42.6
Red mullet	12.1	24.1

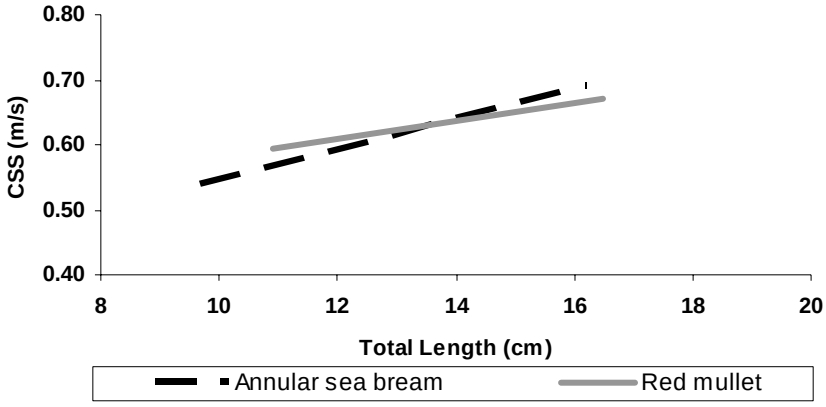

Figure 4: Linear regression lines which show the relationships between absolute CSS and length at 13°C.

Discussion

It is well known that fish swimming speed increases with increasing body length (Beamish, 1978; Hammer, 1995). Similar relationship was found in the present study. At 13°C, a body length increase from 10 to 20 cm was estimated to cause an average of 33.4% increase in absolute mean CSS.

Duthie (1982) reported a mean increase of 36% in the CSS values for *Platichthys flesus* from water temperature of 5 to 15°C. In the present study temperature increase from 13 to 25°C, increased the mean CSS values 49% for red mullet, and 44% for annular sea bream.

CSS experiments, as used in the present study, are easy to conduct and can provide valuable information on the effects of many variables such as water temperature and body length on swimming performance. A comprehensive investigation of relationship between CSS, maximum sustainable and burst speeds is considered to provide valuable information. Once such relationship is well understood, CSS experiments which are easy to conduct can help to improve our understanding of fish behaviour in relation to fishing operations.

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