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Report of the

WORKSHOP ON USE OF BEST AVAILABLE SCIENCE IN DEVELOPING AND PROMOTING BEST PRACTICES FOR TRAWL FISHING OPERATIONS IN AFRICA

Marrakech, Morocco, 20-25 March 2017

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PREPARATION OF THIS DOCUMENT

This document is the report of the “Regional Workshop on Use of Best Available Science in Developing and Promoting Best Practices for Trawl Fishing Operations in Africa” held in Marrakech, Morocco, from 20 to 25 March 2017. The Workshop was arranged in collaboration with FAO and the international initiative “Finding Common Ground on the Scientific Knowledge Regarding Best Practices in Trawling” (TBP Project). This report summarizes presentations of the Workshop and conclusions from discussions. The document was prepared by Professor Ray Hilborn (School of Aquatic and Fishery Sciences, University of Washington, United States of America) and Dr Petri Suuronen (formerly Fishing Operations and Technology Branch, FIAO). The report benefited from contributions from all workshop participants, especially those provided written materials for Annex 1 which are included with minimal edits. The final editing of the report was done by Dr Pingguo He (School for Marine Science and Technology, University of Massachusetts Dartmouth, United States of America).

ABSTRACT

One of the most contentious issues in management of marine fisheries is the use of mobile bottom-contacting gears, mainly trawls and dredges. There are growing concerns about the overall ecosystem impacts of bottom trawling. Some countries have banned bottom trawling and some major retailers refuse to stock fish caught using bottom trawl gears. However, such decisions are not always based on the best available scientific advice. The initiative “Finding common ground on the scientific knowledge regarding trawling best practices (TBP)” is an international collaboration of leaders in the scientific community to understand how trawling and other forms of towed bottom-contacting gears interact with seabed habitats and their biota. An analysis of the datasets to which the project has had access has revealed an underrepresentation of fisheries from tropical regions. Bottom trawl fishery is important in the region because it provides food and livelihoods for a large number of people.

The TBP project in collaboration with FAO held an expert workshop in 2014 in Bangkok (Thailand) covering South and Southeast Asia and another workshop in 2016 in Cartagena (Colombia) covering the Latin American region. It was considered important to address the data gap and to engage stakeholders in Africa to raise awareness about potential best practices for trawling. Therefore, the TBP project, in collaboration with FAO, conducted a workshop on use of best available science in developing and promoting best practices for trawl fishing operations in Africa in March 2017 in Marrakech, Morocco. Key research institutions, universities, organizations and independent experts involved in data collection and research on assessment and/or management of ecosystem impacts of bottom trawling in Africa were invited to attend the workshop.

The workshop first summarized the progress made in the five phases of the project and then (i) identified availability of data on spatial distribution of trawling activities, source of data as well as gaps in knowledge in the African region; (ii) evaluated availability and applicability of data on habitat, bycatch and ecosystem impacts of bottom trawling in the region; (iii) began to assemble data on trawling intensity in representative ecosystems; and (iv) developed an arrangement for expertise and data sharing, and for continuing to collaborate to develop best practices for trawling to enhance sustainability of marine ecosystem that contribute to food security and livelihoods in African.

The workshop concluded that by using fine-scale analysis we could use total trawling effort data for individual African countries to estimate the total trawl footprint in the region. However, there are considerable variabilities within the region, with Mediterranean area more intensively trawled and the rest of Africa much less trawled. There seem to a considerable amount of data on African trawl fisheries that could potentially be incorporated into a unified database for better understanding trawl impacts in the region, but this has yet to be done.

The workshop served as a very useful first step in building collaboration with a network of global trawl fishing scientists. The collaboration opportunities identified and established should lead to a significant advance in our understanding of how to best manage African trawl fisheries.

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INTRODUCTION

Background

One of the most contentious issues in management of marine fisheries is the use of mobile bottom-contacting gears, such as trawls and dredges. Some 25 percent of world fish catch comes from the use of these gears and catch from trawls is an important element in food security in much of the world. However, there are growing concerns about the overall ecosystem impacts of bottom trawling. Some countries have banned bottom trawling and some major retailers refuse to stock fish caught using bottom trawls, but such decisions are not always based on the best available scientific advice.

Much of the available scientific information on bottom trawling comes from fisheries in temperate waters, whereas decisions on banning trawling in recent years have largely been associated with tropical coastal fisheries where there is a paucity of data. Therefore, there is an urgent need for a global synthesis of the scientific knowledge related to the issue, including tropical and sub-tropical trawl fisheries. The key questions are: (i) how does trawling affect the long-term sustainable yield of aquatic resources from an ecosystem and (ii) how does trawling affect other ecosystem services.

The initiative "Finding common ground on the scientific knowledge regarding best practices in trawling (TBP)" is an international collaboration of leaders in the scientific community to understand how bottom trawls and other forms of towed bottom fishing gears interact with seabed habitats and their biota. The initiative (later called the "project") is led by Professors Ray Hilborn (University of Washington), Mike Kaiser (Bangor University) and Simon Jennings (International Council for the Exploration of the Sea), and is currently funded with contributions, among others, from the Walton and Packard Foundations, fishing industries and FAO (project website: http://trawlingpractices.wordpress.com).

The project brings together global datasets on the spatial distribution of trawl fishing activities and the impact of trawling on marine ecosystems and productivity. The project uses this information to understand the extent and consequence of trawling at a global scale, and on a region-by-region basis for those regions for which we can obtain data. The ultimate goal is to identify a range of suitable "best practices" for trawling, and to determine the consequences of adoption of these practices on biota, sustainable food production, ecosystems and ecosystem services.

Rationale for the workshop

An analysis of the datasets to which the project has had access has revealed an under-representation of fisheries from tropical regions which are important in terms of the amount of bottom trawl fishing that occurs. These trawl fisheries contribute to the alleviation of poverty through the provision of food and livelihoods for many people. The TBP project, in close collaboration with FAO, has already held two expert workshops covering tropical areas, the South and Southeast Asian region in 2014 in Bangkok, Thailand and the Latin American region in 2016 in Cartagena, Colombia.

It was considered important to attempt to address the data gap and to also engage stakeholders and science users in Africa to raise awareness about potential best practice for trawling in the region. Therefore, the TBP project, in collaboration with FAO, conducted a "Workshop on Use of Best Available Science in Developing and Promoting Best Practices for Trawl Fishing Operations in Africa" in March 2017 in Marrakech, Morocco. Key research institutions, universities, organizations and independent experts involved in the data collection and research on the assessment and/or management of ecosystem impacts of bottom trawl fishing in Africa were invited to attend the workshop.

Venue

The workshop was convened on 20-25 March 2017 in Marrakech, Morocco, ensuring adequate participation from the African region. In total, 27 experts from ten African countries (Morocco, Senegal, Guinea, Nigeria, Namibia, South Africa, Mozambique, Kenya, Tanzania and Tunisia) participated in the workshop. Experts from Angola and Mauritania were not able to attend the meeting in person due to travel-related problems but were actively in contact with the project team through emails and other remote means. The Spanish Institute of Oceanography (Instituto Español de Oceanografía, IEO) was specifically invited to join the workshop as its researchers held and subsequently brought significant amount of useful research data and information dealing with the Western African trawl fisheries to the workshop.

Objectives of the workshop

The key objectives of the workshop were:

1) Identification of what data on bottom trawling impacts and trawling activities is available in Africa, and who are involved in generating these data, as well as gaps in knowledge;
2) Evaluation of the availability and applicability of data on habitat, bycatch and ecosystem impacts of bottom trawling in the African region;
3) Collection of data on trawl intensity in representative African ecosystems;
4) Development of a collaborative arrangement for sharing expertise and data; and
5) Development and evaluation of potential best practices for trawling to enhance sustainability of ecosystem that contributes to food security and livelihoods in Africa.

Key activities

The workshop was composed of two parts. Part I was attended by the core project team during the first two and half days, which assessed progresses made in TBP Phases I - V and further planned the conduct of Part II meeting (the last three days). Part II meeting was attended by both the core project team and African experts and was specifically on African trawl fisheries.
In the preparation of the workshop programme, the workshop organizers liaised closely with various regional fisheries projects in Africa and identified relevant experts on the field. All invited experts from Africa were requested to prepare a PowerPoint presentation that would include the following elements from the country or region they represent: (i) description of the bottom trawl fisheries (what type of trawlers, how many and the location of main fishing grounds, etc.) and the management measures in place; (ii) type of data on bottom trawling impacts and trawling activities available and researchers involved in generating these data, and gaps in knowledge; (iii) type of fisheries monitoring measures in place (e.g. VMS, observers, log-books), and (iv) availability and applicability of data on habitat, benthos, bycatch and ecosystem impacts of bottom trawl fishing.

The Workshop included (i) presentations and discussions, (ii) synthesis of the information made available, (iii) formulation of conclusions and recommendations, and (iv) description of relevant follow-up actions.

Summaries of presentations from African experts from various countries around the both coasts of the continent are included in Annex 1. The agenda of the meeting is provided in Annex 2 and the list of participants in Annex 3.

PART I. SUMMARY OF PROGRESSES MADE IN PHASES I-V OF THE PROJECT

Phase I. Trawling footprint

The first phase of the project was to examine distribution and intensity of trawling, by compiling satellite Vessel Monitoring System (VMS) data and tow-by-tow position records from logbooks.
Distributions of trawling effort were traditionally reported for scales of several hundred square kilometres or larger, because similarly coarse scales were used for data collection and recording. Consequently, effort mapped at these scales provided a misleading picture of the small-scale spatial distribution, since frequently trawled areas were aggregated with unfished areas. Latterly, local and regional studies gave a higher resolution view of activity from position data in vessel logbooks, analyses of plotter data, and analyses of overflight data of VMS. The TBP project has been focusing on the analysis of high-resolution data because these provide a more accurate indication of the trawling footprint than data collected at lower resolution.

An increasing number of regional analyses now describe trawling footprints based on VMS or high-resolution tow-by-tow observer and logbook data. In regions where such analyses are available they often suggest that the footprint of trawling can be relatively small in relation to the potential fishing area and that effort is often highly concentrated in a few trawling hot spots. However, systematic comparisons among trawl fisheries in different regions will indicate the extent to which the aggregation of effort is a consistent feature of diverse trawl fisheries and how patterns and footprints of trawling are linked to overall catch and effort in the fisheries.
In the TBP project we have collated and analysed VMS data for shelf seas in North and South America, Africa, Europe and Australasia to compare high-resolution footprints and distribution of trawl and dredge fishing activity on an unprecedented scale. These data have allowed us to assess the effects of resolution on estimates of trawl footprint area and to describe trawling footprints expressed as the swept area ratio (area swept by gear per unit area per unit time). The descriptions of footprint will be linked to descriptions of the seabed habitat (collated in Phase 1) and the sensitivity of the habitats and associated fauna (from Phase 2) to conduct the risk assessment of trawling impacts (Phase 3). We have obtained habitat data from the University of Colorado, which maintains a global database of seabed samples. The collation and analysis of trawling activity data has continued for almost three years, with ongoing refinement of analytical approaches and presentation of analyses. In the main analyses of collated data we focused on regions where our records of the location of activity account for at least 70 percent of total trawling activity. The proportion of activity captured by our collated data was estimated by dividing the catch, landings or effort of vessels for which we have positional data by the catch, landings or effort reported for all trawlers fishing in the region.

We have estimated trawling footprints in three ways in the TBP project: (1) by summing the area of any grid cells in which any trawling activity is recorded in a defined time period (usually one year), even though some of the area within any given grid cell may not have been trawled in that time period, (2) by summing the area trawled within each grid cell in a defined time period, where the area trawled is estimated based on the assumption that trawling in each cell is randomly (Poisson) distributed, and (3) by summing the area trawled within each grid cell in a defined time period, where the area trawled is estimated based on the assumption that trawling in each cell is uniformly distributed.

With approach (1), we found that footprint estimates depend on grid resolution. As grid-cell area is increased from to 1-3 km^2 (the scale at which trawling is usually distributed randomly within cells) to ≥10^4 km^2, the estimated area of the trawl footprint increased substantially (Figure 1). Median increases in trawl footprint were 34 percent, 63 percent, 48 percent and 57 percent in Europe, Africa, Americas and Australasia respectively at depths 0-200 m, and 41 percent, 33 percent, 56 percent and 55 percent at depths 200-1000 m. Thus, analysis at lower resolutions, such as the 0.5° grid cells (about 3 000 km^2) which have previously been used to show trawling distributions, will markedly overestimate trawling footprints, and underestimated untrawled areas. Only by working at high resolutions can we achieve a reasonable description of trawling footprints, as shown in Figure 2. Subsequent TBP analyses based on the grid-cell approach have been conducted using 1 km^2 grid cells, although slightly larger c-squares defined by equal increments of latitude were used in some analyses. These c-squares have less area towards the poles.

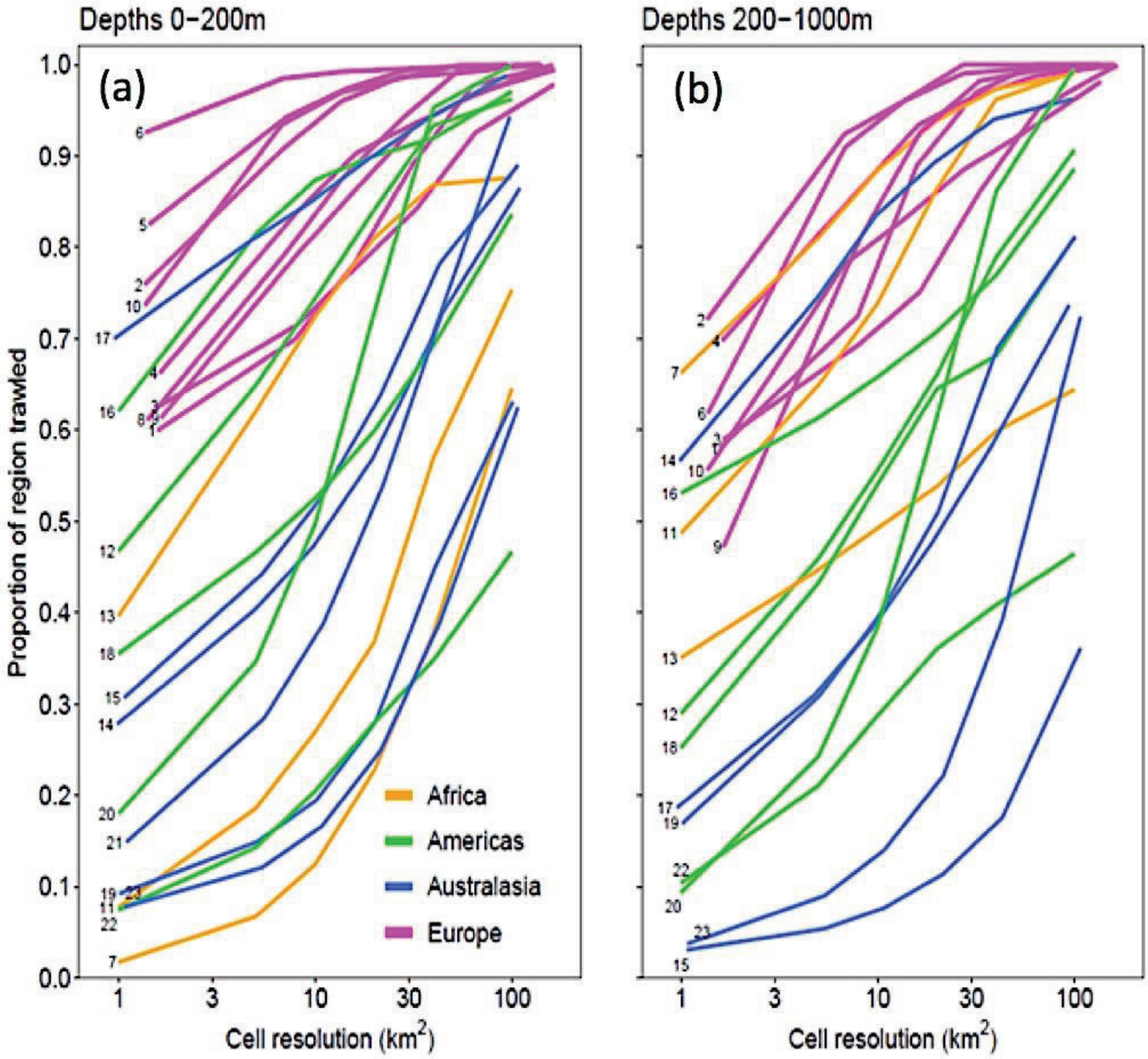


Figure 1. Relationships between the spatial resolution of effort data and the proportion of each region that is estimated to be trawled when applying the cell-based method, for depth ranges of 0-200 m (a) and >200-1000 m (b). The numbers on each line represent different regions. Three regions are not represented on the >200-1000 m panel because these regions are predominantly <200 m deep
Source: Amoroso *et al*., 2018

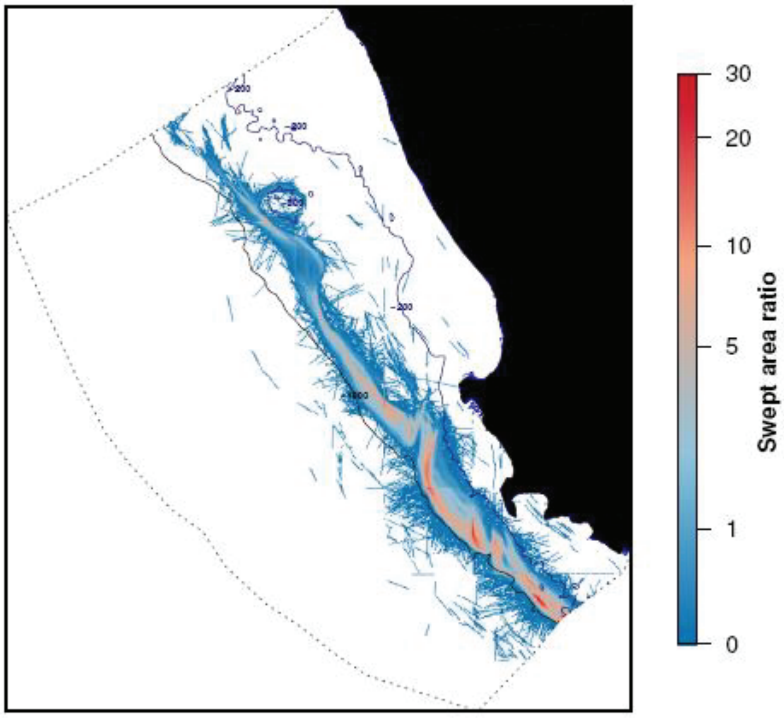


Figure 2. Distribution of bottom fishing activity expressed by swept area ratio (SAR) (see definition below) in the South Benguela Current, South Africa, based on a high-resolution analysis. Swept area ratios are reported in 1 km^2 grid cells. Depth contours indicate 200 m and 1000 m
Source: Amoroso *et al.*, 2018

Even though reductions in the scale of grid cell-based analyses to approximately 1 km^2 will help to characterise trawl footprints more accurately, these footprint estimates will still be larger than those resulting from more detailed analysis of the distribution of individual trawling tracks within cells. This is because it is impossible, or statistically unlikely, that a grid cell will be trawled in its entirety when trawling intensity is low.

Two other alternate approaches for estimating footprint may address this issue. Approach (2) provides a more accurate estimate of annual trawling footprint because the distribution of trawling within cells of close to 1 km^2 has been shown to be random on annual time-scales. Approach (3) is considered more appropriate to estimate footprint over several years because trawling tends to be uniformly distributed within cells on this longer timescale.

To estimate the trawled area within grid cells using approaches (2) and (3), we first calculated the annual swept area ratio (SAR) for each grid cell. SAR can be defined as the total area swept by trawl gear over a defined time-period (usually one year) divided by the total seabed area at a defined spatial scale (in this case the grid cell). The total area swept is calculated as the product of trawling time, towing speed and dimensions of gear components contacting the seabed, summed over the different types of trawl gear operating in the area. The estimated mean annual SAR in each grid cell is then used as the mean of an assumed random (Poisson, approach 2) or uniform (approach 3) distribution of trawling within each cell to determine the proportion of grid cell area that was trawled at least once (contributes to footprint area) or not trawled. Under the uniform assumption, the entire cell is assumed to be trawled when SAR=1, while under Poisson the area untrawled decreases with the SAR but is always positive.

To report frequency of trawling disturbance we have calculated the average interval between trawling events for each of the trawled grid cells. This metric is the inverse of the cell-specific SAR. The distribution of the frequency of trawling over entire regions for which we have data on the distribution of >70 percent of trawling activity shows that more than half the seabed area is trawled at an interval of at least once per year on average in the region with the highest regional SAR (Adriatic Sea), and that over one quarter of the seabed area is trawled with this frequency in five or the other eight European seas (Figure 3). In all Australasian regions, three quarters of the seabed is never trawled or trawled less than once every 10 years, as is the case in the South Benguela Current, East Agulhas Current, North California Current, East Bering Sea, Aleutian Islands and Gulf of Alaska.

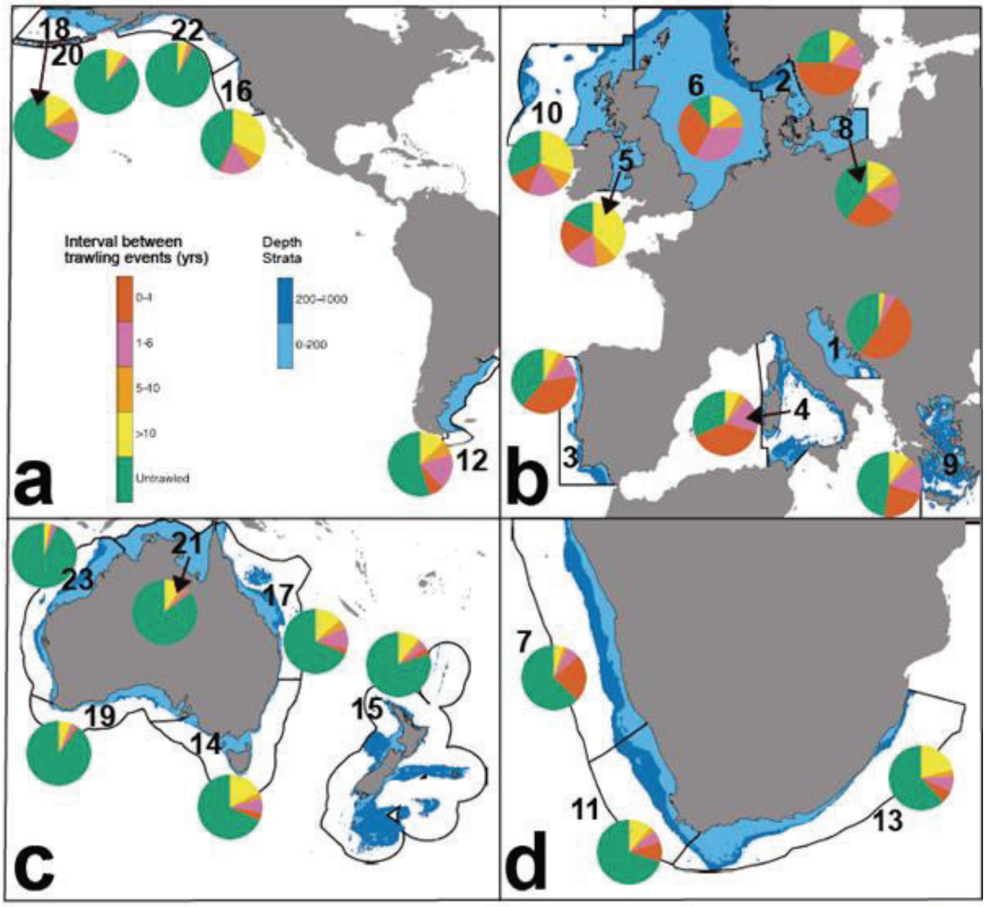


Figure 3. Trawling Best Practice regions where high-resolution trawling effort data for more than 70 percent of the fleets have been processed. The pie diagrams indicate bottom trawling frequency and the proportion of unfished area at depths 0-1000 m for regions in (a) Americas, (b) Europe, (c) Australasia and (d) Africa. Black lines indicate boundaries of study regions, pale blue tones depths 0-200m in the study regions, darker blue tones depths 200 - 1000 m in the study regions, and all deeper areas and areas outside study regions are shown in white. Region codes are: 1, Adriatic Sea; 2, Skagerrak and Kattegat; 3, Iberian Portugese area; 4, Tyrrhenian Sea; 5, Irish Sea; 6, North Sea; 7, North Benguela Current; 8, Western Baltic Sea; 9, Aegean Sea; 10, North-western European Shelf; 11, South Benguela Current; 12, Argentina EEZ; 13, East Agulhas Current; 14, Southeast Australian Shelf; 15, Northeast Australian Shelf; 16, Northern California Current; 17, New Zealand EEZ; 18, East Bering Sea; 19, Southwest Australian Shelf; 20, Aleutian Islands; 21, North Australian Shelf; 22, Gulf of Alaska; and 23, Northwest Australian Shelf

Source: Amoroso *et al.,* 2018.

Among regions for which we have obtained data there was a strong positive log-linear relationship between regional SAR and total trawling footprint based on the uniform assumption (Figure 4). This relationship implies that regional SAR estimates, which can be obtained from conventional trawling effort data and some knowledge of gear and vessel characteristics, may be used to predict trawled and untrawled areas of seabed at regional scales. This approach will be used by the project to estimate trawling footprints in regions where high resolution data on the distribution of trawling tracks are not available.

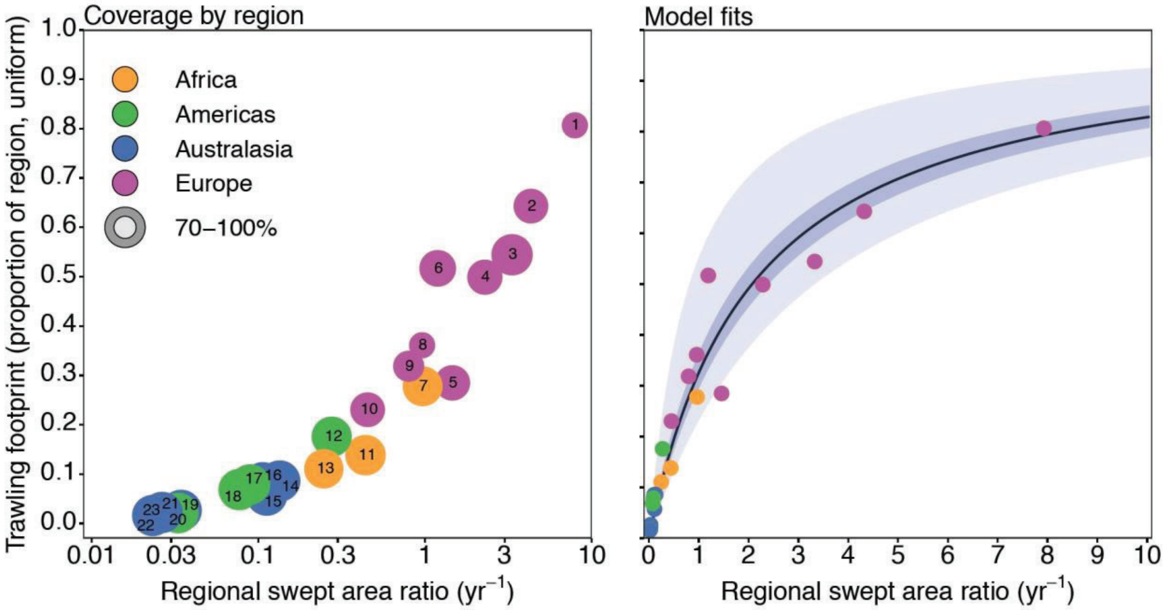


Figure 4. Relationship between the regional swept area ratio (SAR) and the trawling footprint based on the uniform approach. (a) log-linear relationship to display data where symbol sizes indicate the proportion of total fishing activity recorded in each region (all > 70 percent) and numbers in symbols identify regions listed in Table x and (b) fitted relationship between variables, dark blue shading indicates 95 percent confidence intervals for the fits and light blue shading indicates 95 percent prediction intervals
Source: Amoroso *et al.*, 2018.

Phase II. Direct effects of commercial trawling on seabed communities

In order to move towards an ecosystem-based approach to fisheries management, we need to understand secondary effects of fishing on the seabed and consequences for the benthic biota. To achieve this goal, it is necessary to understand spatial distribution of intensity and frequency of fishing disturbance together with an understanding of the amount of benthos is depleted (d) by the single pass of a fishing gear across the seabed and subsequent recovery rate (r) of the benthos to its undisturbed status.

The present study quantified the effects of bottom trawling on abundance, biomass, species richness and diversity of benthic ecosystems using meta-analysis of data derived from published studies of fishing impacts. Estimates of recovery (r) were derived from large-scale comparative studies that account for the impact of fishing at the scale of the fleet. Such studies capture cumulative effects of patchily distributed fishing activity and how this subsequently affects the rate of recovery in benthos. Estimates of depletion (d) by a single pass of a fishing gear were quantified from experimental studies that more precisely measure the removal (mortality) of benthos as a direct result of fishing. Data were extracted from studies that were considered as following acceptable methodologies as in Pullin & Stewart's (2006) systematic review of methodology to ensure scientific rigour and to avoid selection bias when constructing our database. Our study is limited to studies on the continental shelf from which 90 percent of global fish landings are derived. There are very few studies on the impact of fishing on the benthos at depths greater than 200 m.

Methods

This study collated data from published bottom-trawling impact studies that were identified following a systematic review protocol (Hughes *et al.*, 2014) and analysed the extracted data using a meta-analysis. For this project, 'Bottom trawling' encompasses any fishing methods that are towed on the seabed, including otter trawling, beam trawling, scallop dredging and hydraulic dredging. It also includes data from those studies that examined intertidal fisheries that use tools such as spades and rakes. This project does not include passive fishing gears such as gillnets, longlines, pots and creels.

Classification of habitats and gears

The main gear types used in the trawled areas analysis were extracted from source documents, and classified into four gear types: otter trawl (OTB), beam trawl (TBB), towed dredge (TRB) and hydraulic dredge or mechanized dredges (DRM) (Note: FAO gear codes are used). The main habitat types in the trawled areas analysis were also extracted from source documents, and classified into five categories: biogenic habitats, gravel, sand, muddy sand/sandy mud, and mud. Biogenic habitats include mussel beds, seagrass beds and limestone reefs with a cover of sponges and gorgonians. These habitat types were later aggregated further into mud, sand and gravel.

Fishery-wide impacts

To quantify the overall habitat impacts of a fishery in a specific region or location, a measure of "Relative Benthic Status" (RBS) of a habitat, relative to an un-impacted baseline can be calculated using a simple equation (Pitcher *et al.*, 2017):

$$RBS = 1 - F \times D/R$$

where

F is fishing effort (swept area ratio)
D is benthic community depletion rate (removals), following a single pass of the trawl gear
R is the benthic community recovery rate

The formula provides a relative RBS value, scaled between 0 and 1.

A correction must be applied from experimental scale depletion (d) and recovery (r) to grid scale D and R. If a grid cell size is selected so that trawling activity is random, the following adjustment for R values is required (Pitcher *et al.*, 2017):

$$R = rd/[-\ln(1-d)]$$

The method is based on the fact that aggregate properties of seabed habitats respond in predictable ways to trawling impacts. Depletion values were obtained from Sciberras *et al*., (in press). Depletion is expressed as the proportion of organisms killed per trawl pass for each gear. As the penetration depth of a gear varies with habitat type, habitat maps were obtained for the study areas from EDINA digimaps. Sediment descriptions in the dataset were reclassified into three categories (Mud, Sand, Gravel) based on the dominant sediment type, and the sediment type for each 1 km^2 grid cell was extracted from the centre of each cell.

Recovery rates from Hiddink *et al*. (2017) are based on recovery of biomass (as opposed to abundance) and were obtained from a meta-analysis of comparative and experimental studies of fishing gear impacts. The recovery rate for community biomass is slower than for community abundance as the latter is driven more strongly by recruitment. On the other hand, community biomass recovery is linked to the size and age structure of a population through individual growth, and is therefore recommended over the use of abundance when modelling trawling impacts (Hiddink *et al*., 2017). Hiddink *et al*. (2017) found that differences in time to recovery (T) and expected biomass (B/K) were driven primarily by gear type (and hence d) and trawling frequency (F). Therefore, a single recovery rate (r) of 0.82 was used in the present study, which was the median recovery rate for benthic community biomass.

Results and Discussion

No significant effect of habitat on community abundance or biomass was detected in the meta-analysis, suggesting that depletion and recovery rates are influenced more strongly by the type of gear (i.e. penetration depth) rather than the habitat in which the fishing occurs. A strong correlation was observed between penetration depth and depletion of benthic community biomass. It follows that the penetration depth of the different gear types can be used as a proxy for d and the data then used to obtain estimates of depletion for trawl gears for which no direct depletion estimates are available (for example novel or modified gears). Thus, if we can estimate penetration depth, we can make generic predictions about the impact of specific fishing gears, either the whole fishing gear or specific components. In the next phase of our research, we will use published estimates of gear penetration to construct a tool to predict the impact of different gears and their components to enable an assessment of the relative impact of different fishing gears.

Eigaard *et al*. (2015) estimated gear footprints (the area of the gear that comes in contact with the seabed), and the proportion each individual gear component contributes to the overall footprint. His study examined otter trawls, demersal seines, beam trawls and towed dredges, based on technical information gathered in an industry vessel and gear survey conducted across 13 countries covering the European and Black Sea fisheries. A conceptual footprint can be created for a fishing gear that is equal to the sum of the gear component widths. For example, the width of footprint of an otter trawl (single or multiple rigs) is defined as the total spread of the trawl doors during fishing, with clumps/ weights, sweeps/bridles, and the ground gear all contributing to the overall gear impact and seabed penetration depth. Multiplication of gear footprint and component penetration depth can be used to quantify the physical pressure exerted by the gear on the seabed. Gear components that contribute to seabed impact (by fishing gear) are given in Table 1. The mean individual component contributions to the overall footprint size were calculated from Table 5 in Eigaard *et al*. (2015).

Table 1: Fishing gears and their components that contribute to total footprint, with assigned weightings based on the mean widths of each component (Modified from Szostek *et al*., 2017)

Component	Gear	FAO Gear code	Weighting
Whole	Towed dredge	DRB	1
Whole	Rake	MHI	1
Whole	Hand dredge (digging)	DRH	1
Whole	Mechanised dredge	DRM	1
Clump/weight	Multi-rig otter trawl	OTP	0.015
Groundgear	Otter trawl	OTB	0.25
Doors	Otter trawl	OTB	0.02
Sweeps	Otter trawl	OTB	0.73
Groundgear	Beam trawl	TBB	0.94
Shoes	Beam trawl	TBB	0.06

These data can then be integrated into a tool that can be used to examine the relative contribution of different components of a fishing gear to the overall impact, or the benefit derived from removing a particular component of the gear (e.g. moving from demersal to semi-pelagic doors) as illustrated in Figure 5. This information will then enable us to assess the benefit of using technical changes to gear design versus management or behavioural approaches to alter fishing activities to achieve a goal of lower environmental impact on the seabed.

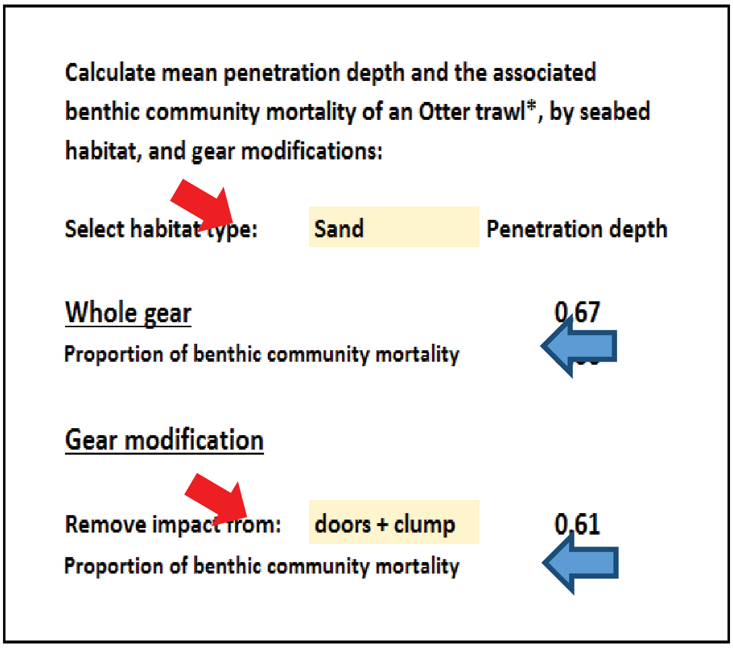


Figure 5. Example of the 'Gear Impacts Tool' for Otter Trawls. Red arrows indicate drop-down menus for user-selectable options. Blue arrows indicate cells that return values from lookup tables of penetration depth and benthic community mortality, based on the selections in the drop-down menus.

Phase III. Risk analysis

Phase III will conduct a risk analysis of the impacts of trawling on sedimentary habitats, for regions and fisheries where adequate data are available from Phases I & II. The analysis will be a spatially explicit landscape-scale assessment of habitat status relative to an untrawled context. Since the last meeting in April 2016 in Cartagena, a worked example of the risk assessment method has been published (Pitcher *et al.*, 2017).

The Phase III risk analysis has critical inputs from Phases I & II, as follows:

Phase I:
1. The spatial maps of trawl effort intensity
2. The spatial maps of sedimentary habitats

Phase II:
3. The impact rates per trawl pass for different sedimentary habitats
4. The recovery rates after trawling for different sedimentary habitats

These data from Phases I and II will be combined in a simple model, based on a simplification of a type used for fisheries stock assessments, to estimate the expected long-term status of each sedimentary habitat type. This will be a relative assessment at the habitat level, essentially aggregating across all fauna that typify each habitat type, to be applied at the widest possible spatial scale. The relative status of habitats (as a proxy for the associated biota) can be mapped or presented in a summarized form, e.g., in cases analysed to date, sedimentary habitat status has typically been >90 percent at landscape scales, compared with status without fishing.

Phase III will include the major synthesis of the trawl footprint and impact on habitats and will allow calculation for each region (where we have data) the amount of proportion of each habitat has been reduced and an estimation of current status as seen in the example below. As Phase III is critically dependent on Phases I and II, further progress relies on the outputs from these pre-requisite phases. To date, most work has been directed at contributing to the collation of necessary data and development of methods. Previous meetings of the Trawl Study Committee have reviewed examples of the risk analysis methods and agreed on methods of presenting the outputs that will avoid confidentiality issues associated with many trawl effort datasets.

The Project will now be able to extend the risk assessment down to the faunal level with funding from CSIRO for an Office of the Chief Executive Post-Doctoral Fellowship (OCE PDF), and recruitment of another TBP post-doc in September 2014. The OCE PDF has extended the risk analysis from sedimentary habitats to benthic invertebrate communities. To date, multiple datasets from benthic invertebrate surveys and environmental predictor variables have been collated, and methods for predicting benthos distribution and conducting status assessment for invertebrate groups have been developed. This extension of the TBP Project will allow estimation of the expected long-term absolute abundance status of benthic invertebrate groups, integrated across sediment types, at landscape scales. This more detailed analysis will be possible only for regional case studies where suitable environmental predictors and benthic invertebrate survey data are available.

Example Faunal Level Status Assessment

This assessment extends the habitat level assessment, to understand the risks of trawling on invertebrate faunal groups. The taxonomic level of the assessment will depend on outputs from Phase II (e.g. a combination of phylum and class levels), and case study regions will depend on high-resolution trawl effort and sediment data from Phase I; both will depend on the availability of benthic invertebrate survey datasets.

Within any given taxonomic class of benthic invertebrates, it is likely that different types of species will have different habitat preferences and different distributions. Thus, different species within a given class may have different levels of exposure to trawl effort even if their depletion and recovery rates are similar. For this reason, statistical methods for grouping species have been developed, based on the similarity of their responses to environmental variables. Once grouped, methods for modelling and predicting the distribution of these groups have been developed using random-forests methodology. The methods enable inclusion of multiple gear types (e.g. sampling of benthic fauna from multiple devices e.g. trawl and sled), and data from multiple datasets that are disparate in space and time. The resulting invertebrate 'group' distribution model can predict either the 'pristine' abundance of the group, by extracting the effect of trawling, or predict the current distribution with trawling exposure.

Following the method of the sedimentary habitat level assessment, the risk status of each benthic invertebrate group is calculated, which represents the estimated equilibrium population status assuming the current level of trawl intensity has been or is applied indefinitely. Given that distributions are available, the faunal group status is an absolute estimate (unlike habitat status estimates, which are relative). Figure 6 highlights the importance of grouping species according to their habitat preference before estimating their risk status. The species distribution models evidently represent two groups of bivalve species, an inshore group (Group 1) and offshore group (Group 2). Given their different distributions they encounter different exposure to trawling (higher inshore). Although, a relatively high status was estimated for both groups, Bivalves group 1 (status ~ 91 percent) has a ~50x higher impact due to trawling (~9 percent impact) than Bivalves group 2 (status > 99 percent; impact < 0.2 percent). The impact maps below represent the distribution of the absolute biomass of each faunal group that is depleted by trawling, clearly showing that Bivalves group 1 encounters more trawling activity (because most trawling activity is also inshore) than Bivalves group 2, and thus has a higher level of risk.

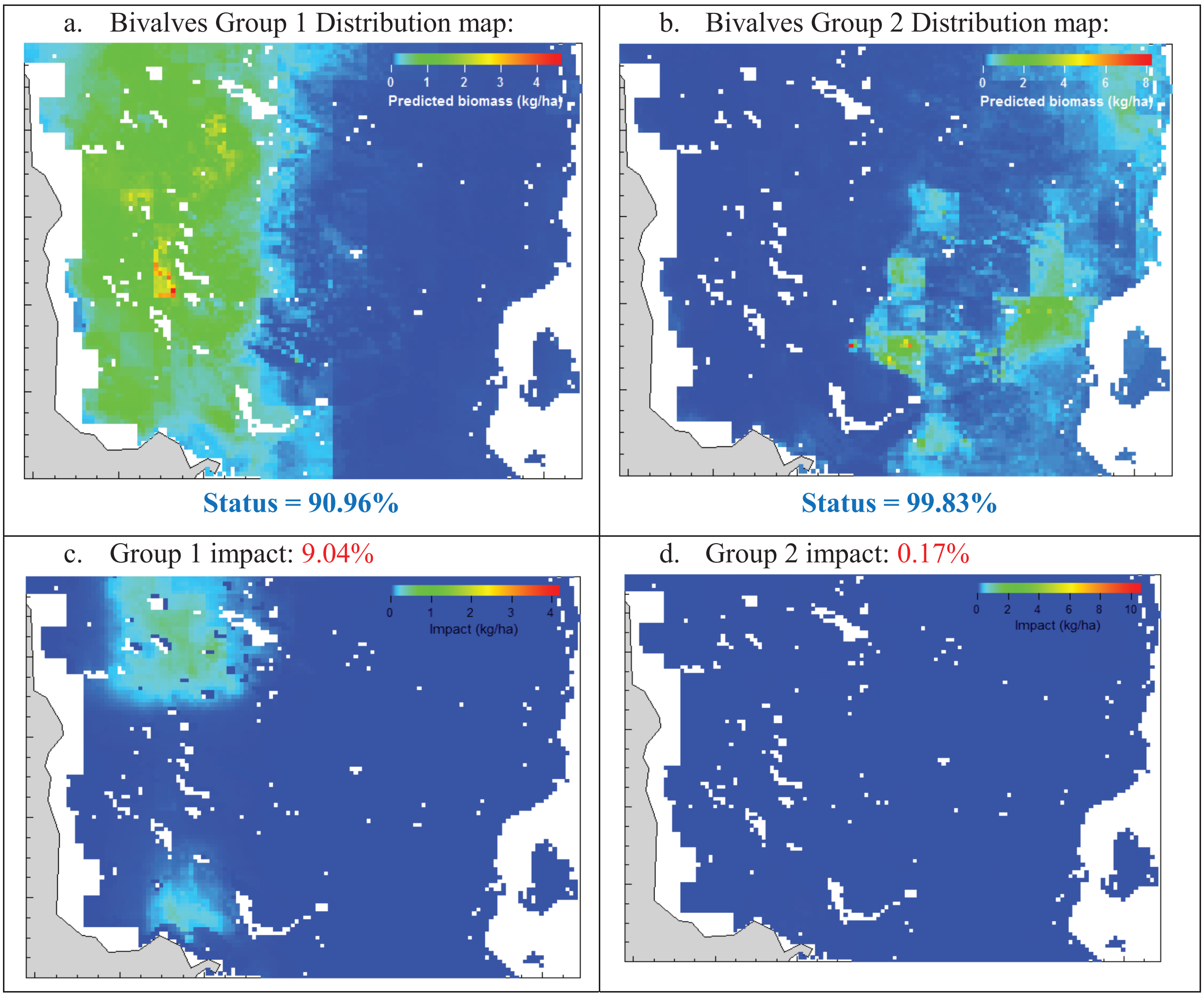


Figure 6: Maps of predicted distributions (a, b) of two species groups of bivalve molluscs, one with an inshore distribution and the other with an offshore distribution, together with maps of their estimated abundance impacted by shrimp trawling (c, d)
Source: CSIRO, 2017.

A comprehensive regional analysis of nine geographical areas for Australia has recently been completed and published (Mazor *et al*., 2017). That paper presents methods for modelling and predicting benthic invertebrate distributions for collated surveys, which will support the extension to the global risk assessment. The Australian analysis predicted and mapped the distributions of taxa groups for the major classes of benthic invertebrates in regions where biological survey data were available. The exposure of these faunal distributions to trawling, and their level of protection in areas closed to trawling, was estimated (Figure 7). In most cases, the proportion of taxa-group abundance that is exposed to trawling is relatively low compared to the percentage of abundance that is protected from trawling by various types of permanent spatial closures. In most regions, but not all, fishery closures typically protect a higher percentage of taxa-group abundance than marine reserves. This exposure–protection assessment has been completed and is currently under review for a peer-review journal.

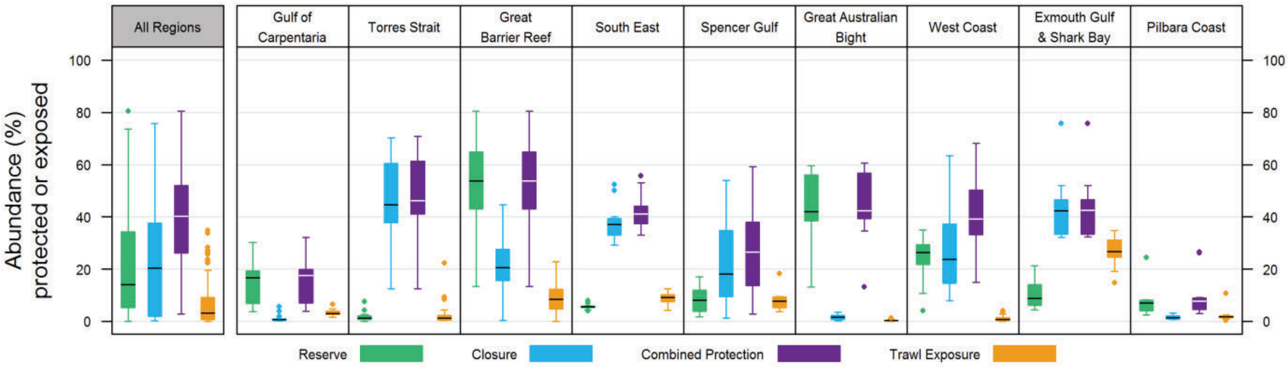


Figure 7. Box plots summarizing protection and trawl exposure of 134 benthos groups, as proportions of their abundance in each Australian region, calculated by mapping their distributions against marine reserves and fishery closure boundaries, and their combination against the multi-year footprint of trawling. Horizontal lines denote the medians and box plot error bars represents the variation of different benthos groups.
Source: Mazor *et al*. (2017).

To date, data have been collated for the global assessment, focusing on several case-study regions for which trawl footprint and benthic invertebrate data are available. Currently, the regions include are Bering Sea, Aleutian Islands, Gulf of Alaska, North Sea, Irish/Celtic Sea, South Africa and Australia. These case study regions spread across four continents (Australia, Europe, America and Africa), with the intention to represent a range of trawl footprints and benthos composition. Collated data include trawl footprints (from Phase I), surveys of benthic invertebrates, and environmental predictors.

Phase IV. Trawling impact on target species through impact on benthic biota

No further activities were reported for this component which has been completed and published (Collie *et al*. 2017).

Phase V: Evaluation of best practices

Phase V has identified a range of management and industry practices that will be used in an evidence-based analysis to propose best practices for minimizing the impact of bottom trawling on benthic habitat. For each option or practice, the impact on benthic biota, sustainable food production and food security, and ecosystem and ecosystem services have been evaluated, along with changes in fuel consumption and other costs, and other impacts on the harvesting sector. Group discussions and external consultations have identified a range of practices and options that are intended to promote sustainable harvesting with trawls (Table 2), including some management practices that are commonly used in the South and Southeast Asia, Latin America, and Africa regions. Each practice has a primary objective, associated habitat benefits, and resource requirements that may or may not perform well depending on the local context. For example, trawling prohibitions in the nearshore and spatial zoning by vessel class are widely used in the geographic regions listed above, particularly when there are multiple scales of fishing operations and when monitoring, control and surveillance capabilities are limited. Similarly, freezing the footprint of trawl fisheries has been implemented as a practical precautionary measure in Alaska, because resources are available to monitor boundary compliance (with onboard observers and VMS) and high catches can be sustained by using the existing grounds.

Table 2. Management and industry practices for minimizing the impact of bottom trawling.

Class of Action	Management Practice	Description
Gear design and operation	Prohibitions by gear type	Trawls are categorically prohibited in national waters.
	Gear and fishing modifications	Specific configurations are required to reduce impact on the seafloor.
Spatial controls	Freeze trawling footprints	Future trawling is limited to previously trawled areas.
	Nearshore restrictions	Trawls cannot be used in fishing zones defined by depth or distance from shore. Also known as 'coastal zoning'.
	Prohibitions by habitat type	Trawls cannot be used in designated areas, especially in sensitive habitat, such as seagrass and corals.
	Broad-scale habitat management	Trawling is prohibited in designated areas (e.g. MPAs), as part of a multi-purpose habitat-conservation program.
	Move-on rules	Trawling effort is voluntarily redirected to another geographic area usually because of high bycatch of prohibited species
Impact quotas	Invertebrate bycatch quotas	The aggregate catch of specific benthic invertebrates is limited (1)
	Habitat-impact quotas	Gear- and habitat-specific "cap-and-trade" system limits trawling effort in sensitive areas (this has been proposed but not implemented) (2, 3)
Effort controls	Reduction of effort	Fleet reductions through buybacks, licensing, and capacity controls that indirectly limit the intensity and distribution of trawling

Notes: 1. Wallace *et al.* (2015), 2. Holland and Schneir (2006a), 3. Holland and Schneir (2006b).

A set of performance metrics has been developed to compare and contrast the efficacy of the different approaches, using an evidence-based analytical framework that links to outcomes from the preceding phases of the project (Table 2). For example, the Phase II penetration tool (Figure 5) and the Phase III risk analysis framework provide a basis for considering possible responses to trawl-gear modifications that are designed to minimize contact with the seafloor and reduce the removal of benthic biota, while Phase IV methodology supports interpretation of the corresponding changes in impact on target species. Similarly, the effect of area closure that often redirects effort to other habitat types can be evaluated based on the knowledge of habitat-specific impact resulted from Phases I and II.

Table 3. Impact metrics being used to evaluate the performance of the different management and industry practices to minimize trawling effects.

Performance Metric	Description
Benthic biota	Biomass, species diversity/richness, species composition, size spectra, and other ecological proxies for indirect impacts on fish populations.
Sustainable food production and food security	Harvest levels and catch composition affecting domestic consumption and export markets.
Ecosystems and ecosystem services	Spatial extent and inclusion of representative habitats, especially those supporting vital ecological functions such as spawning, feeding, and growth to maturity.
Fleet performance	Direct costs affecting operational efficiency, including those related to gear changes or modification, fuel usage, and catch rates.

The TBP Project recognizes that best practices to minimize trawling impacts on the benthos in overfished systems would include efforts to rebuild stocks to MSY (increase target biomass) which would not only reduce effort (and impacts) required to harvest the quota, it would also support a variety of other socio-economic goals including less fuel consumption, less greenhouse gas emission, and higher export revenues. Related to this, a new project has started to investigate the relationship between the state of benthic ecosystem and the yield of bottom trawl fisheries using a conceptual model of population dynamics which assumes that both the exploited fish stock and the benthic biota follow logistic population growth curves (Schaefer 1954). The equilibrium solution of this model describes the effect of bottom trawling on benthic biota (or relative benthic state) with only three parameters: depletion rate d, recovery rate r_b and trawling intensity F, as $B_b/K_b = 1 - F\ d/r_b$ (Pitcher *et al.,* 2017; Phase III). Most of management measures that are being evaluated will affect one or more of these parameters.

Clearly, the definition of best management practices will differ by location and the prevailing circumstances, such that useful guidelines and performance metrics must be flexible and account for a broad range of biological, technical, socio-economic factors, and, more importantly, the local policy drivers for fishery management.

To this end, the committee spent three days at this meeting conferring with trawl fishery experts from Guinea, Kenya, Morocco, Mozambique, Namibia, Nigeria, Senegal, South Africa, Spain, Tanzania, and Tunisia. Our assessment also considers data requirements to implement, evaluate, and enforce various measures, as well as likely interactions with other input controls, output controls, and technical measures already in-place. Overall, we anticipate that the best practice for a particular region will fill gaps or modify the emphasis of current practices, rather than overhaul the existing management system.

Continuing work will include stakeholder consultations on elements of the best-practice analytical framework, a global review of successful and unsuccessful applications of the different management options, and continuing collaborations with Asian, Latin American, and African colleagues.

Conclusions

The TBP study group has completed almost all data collection and analysis for major papers on Phases I-V. The major remaining tasks are to complete manuscripts for their publication.

Planned collaboration and follow-up actions

The major follow-up activities are associated with completion and publication of major findings and outcomes from the different phases. In addition, we are seeking funding to expand the scope of the study to depths beyond 1000 m, and to develop methods to estimate impacts in countries and regions where high-resolution data is not available, particularly in Africa and Asia.

PART II: AFRICAN REGION

Introduction

To gather information on trawl fisheries in Africa region and data on trawling impact, fifteen experts from ten African countries (Morocco, Senegal, Guinea, Nigeria, Namibia, South Africa, Mozambique, Kenya, Tanzania and Tunisia) and Spain (which has active trawling operations in northwest African waters) were invited to the meeting. Experts from Angola and Mauritania were not able to attend the meeting in person due to travel-related problems but actively communicated with the project team through emails and other remote means. Summaries of presentations from these representatives from African countries are included in Annex 1 which were provided by respective countries or named authors. These reports provide very useful information on the status of trawl fisheries in the region, and are valuable resource for the TBP project. Only minor edits were made to these reports. Accuracy and reliability of data and description lie with the respective authors.

Summary of key meeting results

A key result from the fine-scale analysis of the TBP project is that we identified a reliable method to predict overall benthic impacts from data on overall trawl effort. Thus, while VMS or logbook data are currently rare in Africa, we were able to estimate the overall impact of the trawl fisheries on the benthic biota. We were able to assemble overall trawl effort for most of the countries represented at the meeting and will be able to use these data to estimate benthic status.

Each African participant presented a report on the relevant data on trawl fisheries in their country or region. Data included the characteristics of the trawl fleets, their catch and effort distribution. In addition, participants also presented a number of experimental and comparative studies aimed at improving trawl selectivity. In addition, many country representatives also contributed data that are very relevant to the understanding of consequences of alternative best practices. While there are only few areas with complete VMS or observer data that would provide precise locations of all tows, the estimates of total trawl hours and vessel characteristics could provide estimates of total swept area, and overall intensity of trawling per unit area. Data from the limited VMS studies could be used to estimate the concentration of effort and the proportion of area trawled 0, 1, 2 times per year assuming the concentration of trawling is comparable. Few countries have data on seabed and habitat impact of their bottom trawl fisheries. Some countries have sediment composition data, and comparison of biota between trawled and untrawled areas can be used to estimate the overall impact of bottom-contacting trawls on biota.

From the presentations from African countries, some conclusions can be made regarding the trawling best practice:

- Using fine scale analysis from the TBP project we can use total trawl effort data for individual African countries to estimate the trawl footprint.
- When we do so we find that there is considerable variability within Africa, and Mediterranean regions appear to be intensively trawled, while in the rest of Africa the footprint is much smaller.
- There is a considerable body of data on African trawl fisheries that could be incorporated into understanding trawl impacts but these data have not been assembled into a unified data base.
- IUU fishing is not included in current estimates in our report.

OVERALL WORKSHOP CONCLUSIONS

Bottom trawling involves dragging various kinds of fishing gear along the sea floor to capture fish, shrimp and other target species, and provides fish for human consumption and for sustaining livelihoods. At the same time bottom trawling is one of the most controversial fishing methods as the process of dragging gear along the bottom kills or damages some benthic biota, and suspends benthic sediments. Some countries have banned bottom trawls, and many NGOs are calling for much more widespread bans. Most developed countries manage bottom trawl impact by a combination of closing areas of sensitive habitat and in some cases restricting the types of gear that can be used.

The impact of bottom trawling on benthic biota differs greatly by region and biota. A key characteristic of trawl impacts is that some taxa are much more sensitive to trawl net passage than others. In particular, epibenthic species that have a high vertical profile such as sea grasses, corals and sponges are both more sensitive to the passage of trawl gear and have much slower recovery rates, and the impact on these taxa may be underestimated. Such sensitive taxa can be reduced to very low abundance whereas other taxa may be largely unaffected unless trawled several times per year. The major concern about bottom trawl impacts is found around the most sensitive taxa, particularly sponges and corals. These taxa are found in high abundance primarily on hard bottom habitat that is likely rare in most trawled areas.

There are a wide range of management methods that have been used to reduce the impact of bottom trawling on benthic biota, including:

- Banning specific gears (including all trawls, or specific trawl designs)
- Gear modification
- Effort reduction
- Freezing trawl footprint
- Closing areas of known sensitive habitats or biota
- Sensitive species bycatch quotas

Managing bottom trawling involves trade-offs between production of food and jobs from fishing, and protection of biota. Different countries will make different choices on where along this trade-off they wish to be, and thus a best practice should identify the management actions that would achieve the best outcomes at a minimum social and economic costs.

REFERENCES

Amoroso, R.O., Pitcher, C.R., Rijnsdorp, A.D., McConnaughey, R. A., Parma, A.M., Suuronen, P., Eigaard, O.R, *et al.* **2018.** Bottom trawl-fishing footprints on the world's continental shelves. *Proceedings of the National Academy of Sciences (PNAS)* Doi/10.1073/pnas.1802379115

Collie, J., Hiddink, J.G., Kooten, T., Rijnsdorp, A.D., Kaiser, M.J., Jennings, S. & Hilborn, R. 2017. Indirect effects of bottom fishing on the productivity of marine fish. *Fish and Fisheries*, *18*(4), 619-637.

CSIRO (2017). *Example of abundance distributions of benthic invertebrates* (Unpublished map created by T. Mazor, May 2017). Brisbane, Australia.

Eigaard, O.R., Bastardie, F., Breen, M., Dinesen, G.E., Hintzen, N.T., Laffargue, P., Mortensen, L.O., Nielsen, J.R., Nilsson, H.C., O'Neill, F.G. & Polet, H. 2015. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. *ICES Journal of Marine Science*, 73(suppl_1): i27-i43.

Hiddink, J.G., Jennings, S., Sciberras, M., Szostek, C.L., Hughes, K.M., Ellis, N., Rijnsdorp, A.D. *et al.,* 2017. Depletion and recovery of seabed biota following bottom trawling disturbance. *Proceedings of the National Academy of Sciences,* 114(31): 8301-8306.

Holland, D.S. & Schnier, K.E. 2006a. Protecting marine biodiversity: a comparison of individual habitat quotas and marine protected areas. *Canadian Journal of Fisheries and Aquatic Sciences,* 63: 1481-1495.

Holland, D.S. & Schnier, K.E. 2006b. Individual habitat quotas for fisheries. *Journal of Environmental Economics and Management,* 51:72-92.

Hughes, K.M., Kaiser, M.J., Jennings, S., McConnaughey, R.A., Pitcher, R., Hilborn, R., Amoroso, R.O., *et al***.** 2014. Investigating the effects of mobile bottom fishing on benthic biota: a systematic review protocol. *Environmental Evidence*, 3(1): 23.

Mazor, T.K., Pitcher, C.R., Ellis, N., Rochester, W., Jennings, S., Hiddink, J.G., McConnaughey, R.A. *et al.* 2017. Trawl exposure and protection of seabed fauna at large spatial scales. *Diversity and Distributions*, 23(11): 1280-1291.

Pitcher, C.R., Ellis, N., Jennings, S., Hiddink, J.G., Mazor, T., Kaiser, M.J., Kangas, M. *et al.* 2017. Estimating the sustainability of towed fishing-gear impacts on seabed habitats: a simple quantitative status assessment method applicable to data-poor fisheries. *Methods in Ecology and Evolution,* 8(4): 472-480.

Pullin, A.S. & Stewart, G.B. 2006. Guidelines for systematic review in conservation and environmental management. *Conservation Biology*, 20(6): 1647-1656.

Schaefer, M.B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Inter-American Tropical Tuna Commission Bulletin*, 1: 23-56.

Szostek, C.L., Hiddink, J.G., Sciberras, M., Caveen, A., Lart, W., Rodmell, D. & Kaiser, M.J. 2017. Tools to estimate fishing gear penetration depth and benthic habitat impacts of fisheries at a regional scale. *Fisheries & Conservation Report*, No. 68, Bangor University, pp. 87.

Wallace, S., Turris, B., Driscoll, J., Bodtker, K., Mose, B. & Munro, G. 2015. Canada's Pacific groundfish trawl habitat agreement: A global first in an ecosystem approach to bottom trawl impacts. *Marine Policy*, 60: 240-248.

ANNEXES

Annex 1. African Country Presentations

Morocco

In Morocco, trawling is a very important activity in the fisheries sector. Three types of fleet carry out bottom trawling activities: Offshore cephalopod trawlers, also called Cephalopod freezers (243 units [vessels]), deep-sea shrimp fleet (59 units), and demersal coastal fleet (755 units). Different kind of trawls are used according to operating area, target species and fleet. In 2015, trawl catch was around 175 000 tons that was realized mainly by the coastal demersal fleet (55 percent the total) and cephalopod freezer (40 percent of the total). The types of trawl used vary with areas, target species and fleet as summarized below:

Fishery	Trawl type	No. of vessels	Authorized fishing areas
Mediterranean demersal coastal fisheries	• Bottom trawl with bead • Benthic trawl	115	Beyond 1.5 nm between Cap Spartel and Al Hoceima Beyond 2 nm between Al Hoceima and Cap Des Trois Fourches Beyond 3 nm between Cap Des Trois Fourches and Saidia
Atlantic demersal coastal fisheries	• Atomic bottom • Shrimp trawl	640	Beyond 3 nm, except for the area south of Bojador, beyond 10 nm
Shrimp freezing trawling fishery	• Fishing system called twins with two Spanish type trawls	59	Beyond 10 nm
Cephalopods freezing trawling fishery	• Bottom trawl of Spanish type • Bottom trawl of Korean type	243	Between Cap Bojador and Cap Blanc, beyond 10 nm to 12 nm

Information concerning the fishing trips and tows.

	Fleet 1	Fleet 2	Fleet 3
Year	**2015**	**2015**	
Country	**Morocco**	**Morocco**	**Morocco**
Type of Fleet	Deep sea cephalopods	Deep sea shrimps	Atlantic Coastal demersal fisheries
Target Species	Octopus, Sepia, Loligo	Pink Shrimp, other shrimp species	shrimps, cephalopods, hakes, sparidae
Type of vessels	Cephalpods freezer trawlers	Shrimps freezer trawlers	Demersal coastal trawlers
N of vessels	229	41	580
Fishing days per vessel	174	214	230
No. of tows per day	8	5	3
Average distance per tow (km)	10.4	24.6	34.6
Average door spread (m)	100	100	70
Tow speed (km/h)	6.1	5.9	6,3
Average tow duration (h)	1.7	4	6
Swept area all vessel per year (km²)	332 622	107 710	969 172

Trawling activities in Morocco

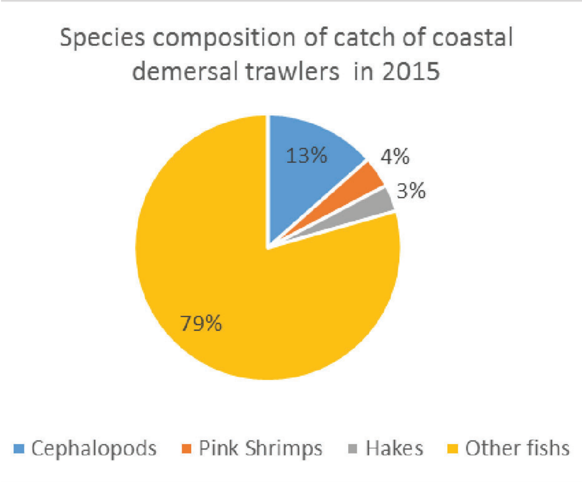
In Morocco, the coastal and deep-sea trawling activities have been tracked by a *Vessel Monitoring Systems* (VMS) since 2012. The VMS have been used for fisheries management to ensure proper fishing practices and prevent illegal fishing. The Cephalopods trawlers frequent the Moroccan southern Atlantic zone from Cap Bojador to Cap Blanc beyond 10 nm, while coastal fishing operates along the Moroccan coast beyond 1.5, 2 and 3 nm according to areas in the Mediterranean side, and beyond 3 nm in Atlantic coast in the fishing ground under 500 m. The shrimp freezer trawlers operate along the Atlantic side beyond 10 nm on the grounds between 100 and 1000 m depth.

Production and bycatch

Demersal Coastal fleet

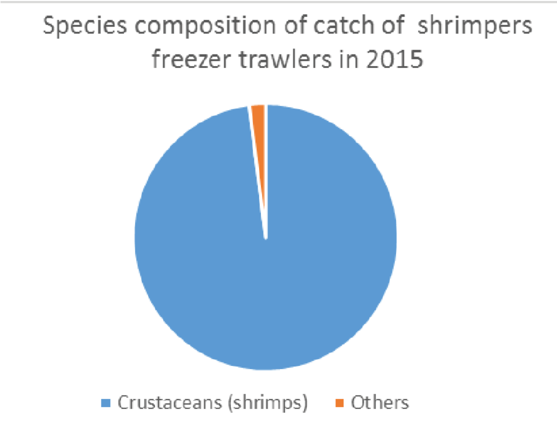
The main species targeted by this fleet are pink shrimp, cephalopod and hake. In 2015, the total catch of this fleet was around 95 400 tons. The mean catch of cephalopod between 2009 and 2015 was about 11 000 tons, pink shrimp about 5000 tons, hake about 3700 tons.

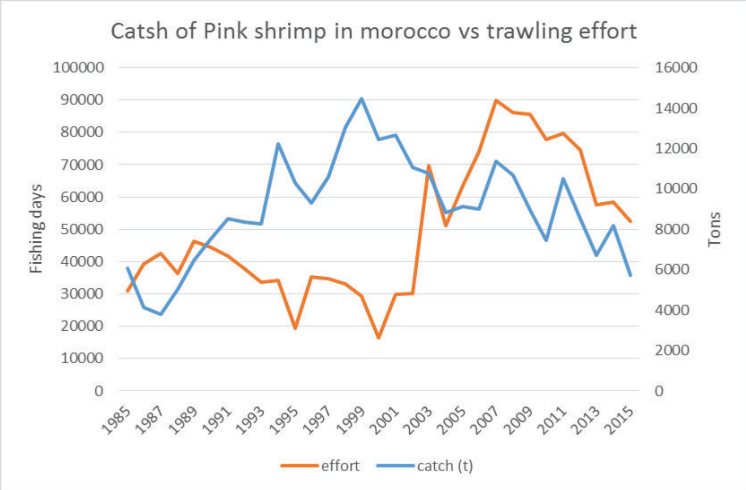
Moreover, a wide range of species was recorded as bycatch in the demersal coastal fleet, representing 79 percent of the total catch in 2015. The bycatch dominated by the sparidae, horse mackerel, flat fish, grundun, etc.



Shrimp freezer trawler fishery

This fleet targets shrimp species, which constitutes 99 percent of the total catch of this trawling activity with an annual mean catch of 4 100 tons from 2009 to 2015. In 2015, the catch of shrimp from this fleet was more than 3 000 tons. The main shrimp species caught was the pink shrimp *Parapenaeus longirostris* (81 percent), followed by *Plesiopenaeus edwardsianus*, *Aristeomorpha foliacea* and *Aristeus antennatus*. These three last species constitued 17 percent of the total catch of crustaceans.

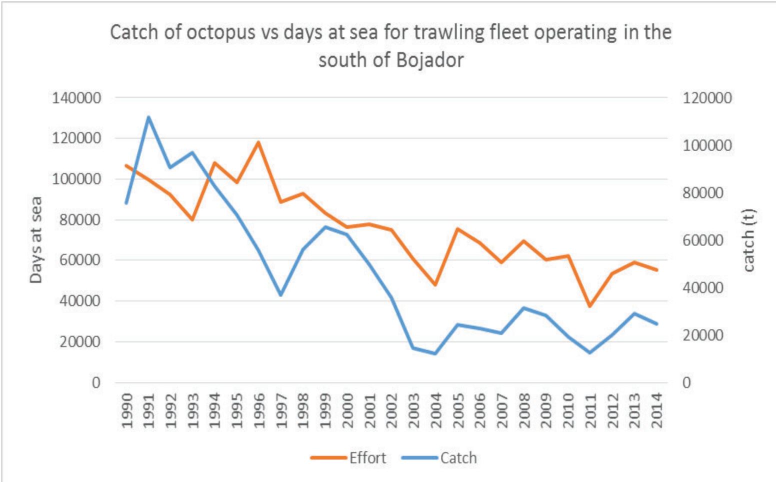




The catch of pink shrimp, targeted by demersal coastal and shrimp freezer fleets, has decreased since 1999. The total fishery effort has also reduced since 2005. During the last five years, the reduction of the effort was mainly due to re-assessment of the stocks which was adopted by Morocco government in the framework of the management plan for the shrimp species.

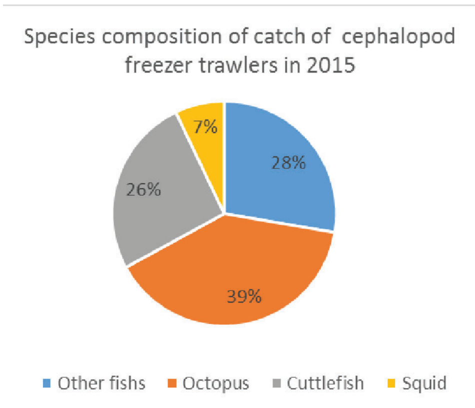
Cephalopod freezer trawler fishery

The fishery mainly targets cephalopods, but also other species (mainly sparidae) which constitute 36 percent of the catches. Octopus (*Octopus vulgaris*) remains the principal cephalopod species caught (50 percent) followed by cuttlefish (40 percent) and squid (*Loligo vulgaris)* (10 percent). During the last seven years, the catch of cephalopods showed an increase with a mean catch of 45 000 tons. In 2015, the total catch was about 70 000 tons.



Octopus is the main targeted species by the fleets using trawls in the south of Morocco (South of Cap Bojador). The fleets composed by Moroccan and Spanish sea-deep trawlers and coastal trawlers. The catch of octopus decreased continually until 2003 and stabilized thereafter, similar to the trend of the total effort. This reason for the decline in catch and fishing effort was due to the departure of European fleets and management measures implemented by Morocco government since 2000.

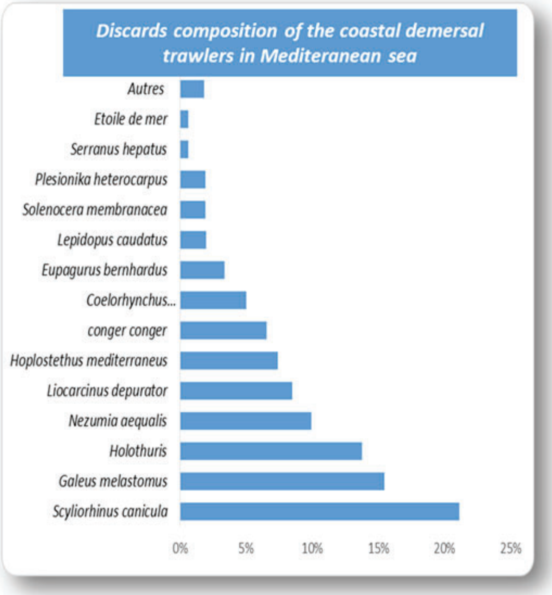
The species others than cephalopods constitute 28 percent (19 300 tons) of the total catch of the *freezer trawler* fleet in 2015. A wide range of non-targeted species was also captured including sparidae and teleosteans.



Discards estimation

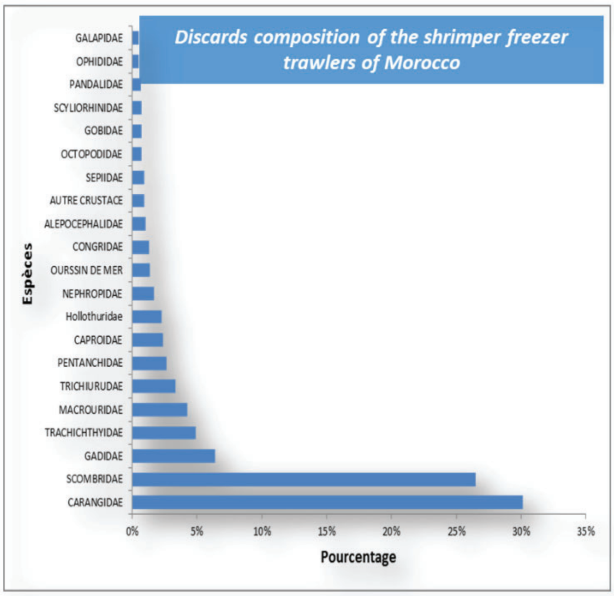
Demersal Coastal fleet

The discards represent a mean of 31 percent of the total catch in the Mediterranean Sea. The elasmobranch is the main species group discarded. In the Atlantic side, data on discards are only partially available and not analysed.



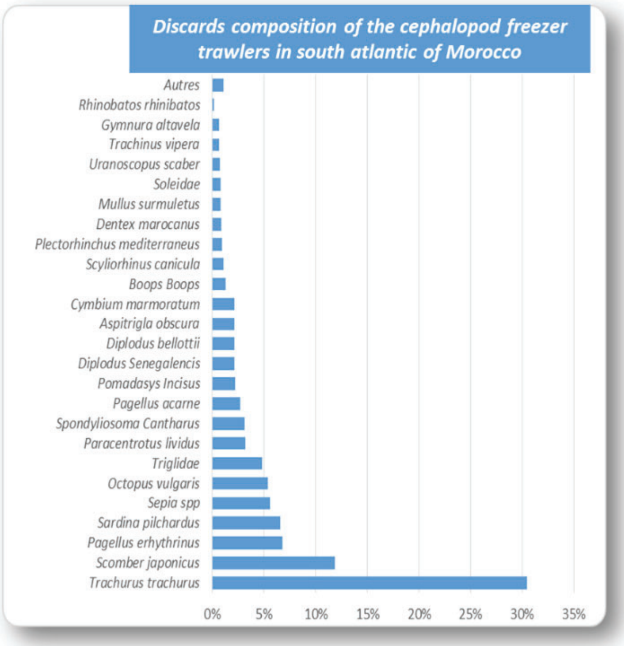
Shrimp freezer trawler fishery

The discards represent a mean of 28 percent of the total catch in this fleet. The discards consist of very low value commercial and non-commercial species, as well as prohibited species. The main part of discards is small pelagic species (Carangidae and Scombridae)



Cephalopods freezer trawler fishery

The discards represent a mean of 34 percent of the total catch realized by this fleet in the south of Morocco. Discarding consists of very low commercial or non-commercial value species, of damaged individuals, of catches exceeding the allowed quota of targeted species, or individuals below minimum allowed size. The small pelagic species represent more than 40 percent of the total weight discarded by this fleet.



Management Measures in Trawl Fishing

Several laws, decrees and legal texts regulate trawl fishing in Morocco. Also, management plans developed by Morocco also incorporate other measures to regulate trawling.

The management regime implemented in the trawl fishing, regulates sea fishing by limiting the mesh size of towed nets (including trawls) and prohibiting the use of double trawl bags.

The national trawl gears are required to comply with the fishing zones and the authorized mesh sizes (according to Circular No. 5060 of 30 October 1992):

- **Mediterranean:**
  - Authorized fishing zone: Beyond 3 miles
  - Allowed meshes: >40 mm

- **Atlantic north of parallel 30°40'N (Agadir):**
  - Authorized fishing zone: Beyond 3 miles
  - Allowed meshes: >50 mm as of 1 July 1993

- **Atlantic south of the parallel 30°40'N (Agadir):**
  - Coastal fishing:
    - Authorized fishing zone: Beyond 3 miles
    - Allowed meshes: >50 mm
  - Deep-sea fishing:
    - Authorized fishing area: Beyond 6 miles
    - Allowed meshes: >60 mm.

There are many other measures applied to fisheries:

<table>
<tr><th>Fisheries</th><th colspan="2">Measures</th></tr>
<tr><td>All</td><td colspan="2">• The activity of all type of freezing trawlers are unauthorized in the Mediterranean sea delimited by the following geographical coordinates (35°47’18’’N-05°55’33’’W) and (35°05’12’’N–02°12’42’’W)
• The trawling activity is authorized as following:
- Beyond 3 nautical miles from Cape Spartel to Aghti Lghazi
- Beyond 1.5 nautical miles between Cap Spartel and Al Hoceima
- Beyond 2 nautical miles between Al Hoceima and Cap des Trois Fourches
- Beyond 3 nautical miles between Cap des Trois Fourches and Saidia</td></tr>
<tr><td>Cephalopod fishery</td><td colspan="2">• Freezing of the fishing capacity for any fleet
• Trawling: Beyond 12 nautical miles during the two months following the autumn biological rest and beyond 10 nautical miles for the rest of the year. Only mesh size more than 70 mm is authorized for the cephalopod freezing trawlers. For the coastal fishery , the mesh size is regulated at a minimum of 60 mm.
• Trawling of the coastal fishery between Tarfaya and Boujdor regulated as follows :
- Beyond 10 miles between Boujdour and the parallel 27° N (South of Laâyoune)
- Beyond 8 miles for the area from parallel 27° N to Tarfaya.</td></tr>
<tr><td>Hake fishery</td><td colspan="2">The trawling activity is authorized as follows:
• Area II a) : Beyond 10 nautical miles calculated from the baselines
• Area II b) : Beyond 12 nautical miles in the period extending from 16 November each year to 16 January of the following year, and Beyond 10 nautical miles from 17 January to 15 November of each year</td></tr>
<tr><td rowspan="2">Shrimp fishery</td><td>For Coastal trawlers</td><td>For freezing trawlers</td></tr>
<tr><td>• Area II b) & c): unauthorized activities of this fleet in the entire area for shrimp species.</td><td>The activity of trawling is authorized as following:
• Fishing zone from Cap Spartel to Aghti Lghazi beyond 10 nautical miles;
• Fishing area from Aghti Lghazi to Cap Barbas beyond the isobath 200 m depth
• Fishing area from Cap Barbas to Cap Blanc beyond the isobath 500 m depth</td></tr>
<tr><td></td><td colspan="2">The trawling activity is unauthorized in the monk seal protected area limited to 12 miles from the coast, between 21°23'00"N and 20°54'40" N</td></tr>
</table>

Spatio-temporal closure for shrimp and hakes fishing	For all vessels (including trawlers), hake fishing is prohibited during the periods of: From 1 to 31 January inclusive: • Between 3 and 23 nautical miles in the fishing zones between the south of Moulay Bousselham and Bouznika • Between 8 and 23 nautical miles and in the maritime zones extending between Cap Sim and Cap Tamghart From the first day to the last day of February: • Between 8 and 23 nautical miles in the fishing zones between Moulay Bousselham and Bouznika and in the fishing zones between Cap Sim and Cap Tamghart From the 1 to 30 September inclusive • Beyond 10 nautical miles in the fishing zones between Cap Tafelney and Cap Sim and in the fishing zones between Oued Messa and Cap Tamghart From the 1 to 31 October inclusive • Beyond 10 nautical miles in the fishing zones between Kenitra and My Bousselham and in the fishing zones between Pointe Sidi Abderrahman and Bouznika

Available data and information on impacts of trawling

In Morocco, the main administrations involved in the data collection dealing with the trawling activities are:

National Institute of Fisheries Research (INRH) which:

- Collects data from scientific sea surveys: for species distribution, biology studies, identifying sensitive areas for fishing closures, recruitment areas, etc.
- Collects data and information on releases
- Facilitates scientists on board commercial fleets: On coastal fleets, deep sea and shrimp vessels

Fisheries Department (DPM) which:

- Centralises the VMS data
- Centralises statistical data (SAMAKNA program)
- Provides information on foreign fleets operating in Morocco
- Delivers fishing licenses
- Provides regulations

National Office of Fisheries (ONP) which:

- Provides statistics on landings of all fleets including trawlers

Several gaps and limitations are identified on the availability of data. It mainly concerns:

- Insufficient data on discards and vulnerable species
- Insufficient observers for all fleets
- Lack of studies on the impact of trawling on seabed and benthic fauna

Surveillance measures set up in Morocco for trawling activities

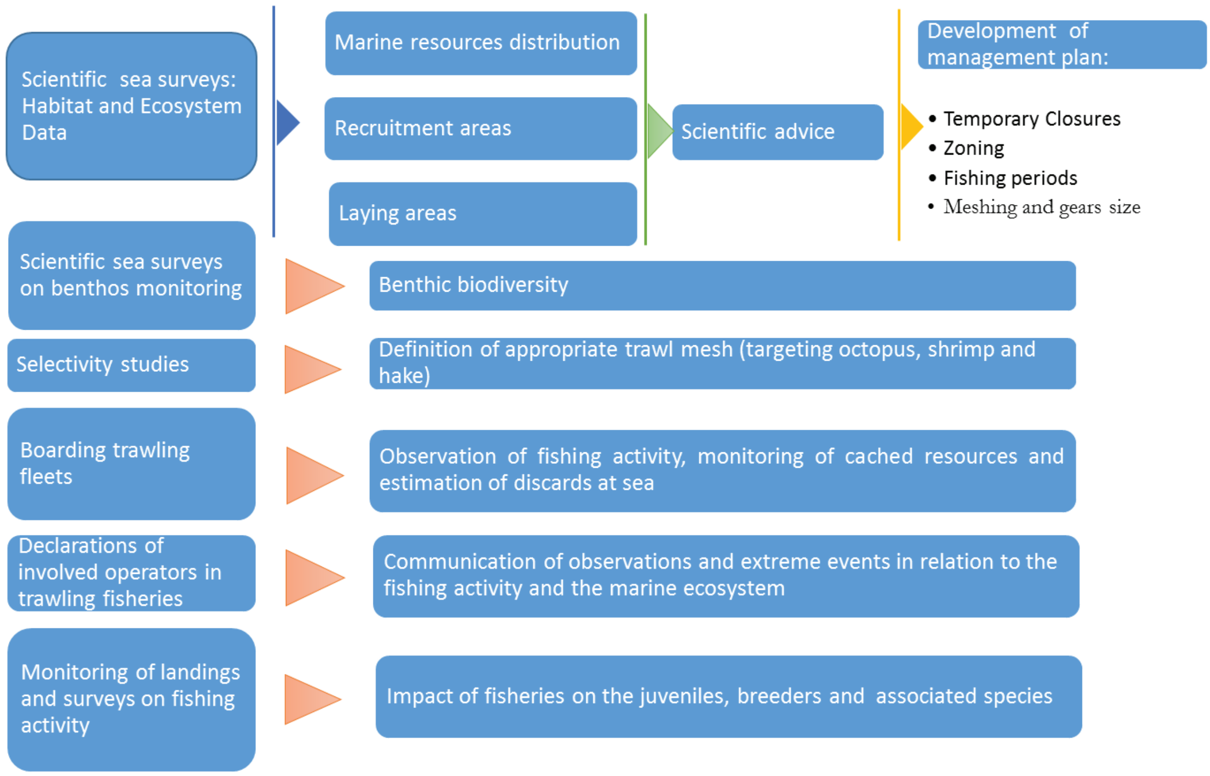
In Morocco, several structures and control procedures on monitoring trawling activities are set up concerning:

- Control of fishing vessels at sea by the Royal Gendarmerie and the Royal Navy
- Vessel Monitoring System (VMS): promulgated by Decree No. 2-09-674 laying down the conditions for the installation and use of a positioning system for ships by a control system
- Logbooks of the deep-sea fishing trawlers

- Weighing and cross-checking with data of declared catch (UNN)
- Ground checks on landings, gear, compliance, etc.
- Regulation of access rights to the fisheries (licenses)
- Specific fishing authorizations for some species (octopus, etc.)

Availability and applicability of data related to habitat, benthos, bycatch and ecosystem effects of bottom trawl fisheries

In Morocco, fishing activities are regulated by several measures and management plans. The basis of the regulation is mainly the scientific knowledge, which is based on scientific surveys and data collection. Also, in term of trawl impact studies, ROV equipment (remotely operated vehicle) was acquired in 2017 by INRH to be used for seabed observations. The following diagram summarises the use of the scientific knowledge for management purposes.



Conclusions

The bottom trawl fisheries have a major role in promoting the fishing sector in Morocco. This activity has realized about 12 percent of the total Moroccan catch in 2015. A wide number of species are targeted (octopus, shrimps, hakes, other cephalopods, etc.) by bottom trawls which take place along the Moroccan coast by different type of fleets. In Morocco, the trawling activity is regulated by several legal texts, decrees and laws, which aim to reduce the impact of fishing and protect the main species targeted. The collection of fisheries statistics is well monitored and associated with an effective control system; however, knowledge on discards and releases remains preliminary. In fact, INRH has developed an onboard system on the commercial fleets for studying discards. In addition, the acquisition of a new equipment ROV (remotely operated vehicle) could improve the ability to conduct seabed studies.

Spain

(Western African trawl fisheries)

THE SPANISH SHRIMPER TRAWL ACTIVITY AND IMPACT IN WEST AFRICA

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1. Description of the Spanish shrimper bottom trawl fishery in West Africa

The Spanish shrimper fleet has been operating in West Africa for more than forty years. Since the integration of Spain to the European Union (EU) in 1985, this activity has been carried out in the framework of Fisheries Partnership Agreements (FPAs) between the EU and the coastal States. After a maximum period of activity in 1990s, when the fleet was active in Morocco, Mauritania, Senegal, Guinea-Bissau, Guinea and Angola, the presence of the fleet in West Africa has been greatly reduced to the current fishing grounds in Mauritania and Guinea-Bissau. The fleet is composed of a number of freezer trawlers based in the Spanish port of Huelva (SW Iberian Peninsula), that currently operate in Mauritania and Guinea-Bissau in fishing trips from one to three months of duration (two months' average). Catches are frozen onboard and landed in fishing ports of the coastal States: the Mauritanian port of Noadhibou, when they operate in Mauritania or the Senegalese port of Dakar, when they operate in Guinea-Bissau (Figure 1). Landings are then transported to the Port of Las Palmas de Gran Canarias (Canary Islands) and from there to the South of the Iberian Peninsula to be sold in Algeciras, Seville or Huelva (ANAMAR, *pers. comm.*).

The main target species of this fleet are deepwater rose shrimp *Parapenaeus longirostris* (Lucas, 1846), southern pink shrimp *Penaeus notialis* Pérez Farfante, 1967 and striped red shrimp *Aristeus varidens* Holthius, 1952. These three species are specifically targeted in three depth ranges from shallow to deep waters, around 14-70 m (*P. notialis*), 150-350 m (*P. longirostris*), and 400-800 m (*A. varidens*). *P. longirostris* and *P. notialis* are caught with outriggers ("tangones") in fishing hauls of around 3 hours and during daylight. *A varidens* are caught at deeper waters, with classic bottom otter trawl ("baka" type) at night hauls of approximately 6-hour duration. One single vessel can carry out all three types of operations during the same day, using outriggers during daylight and changing to the classic bottom otter trawl at night.

Fleet size and technical characteristics

The number of Spanish shrimper vessels operating in West Africa has greatly decreased in the last twenty years, from a maximum of 67 vessels in 2003 to the minimum of 11 vessels in 2013 (Figure 2).

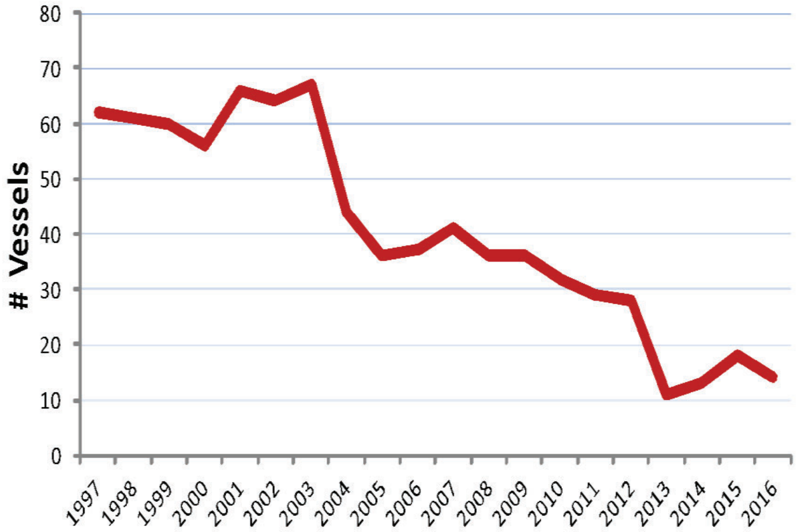


Figure 1. Number of Spanish shrimper vessels operating in West Africa during 1997-2016

During the last 2-year period analysed (2015-2016), the fleet size decreased from 18 to 14 vessels. The number of vessels operating in Mauritania increased from 5 to 8, while in Guinea-Bissau the fleet size decreased from 13 to 6 vessels between 2015 and 2016.

The average technical characteristics of the fleet in the last two years are: 241 GT, 131 GRT, 30 m length and 550 hp. The minimum mesh size authorized in both fishing grounds is 50 mm.

The average door spread is 9 m for outriggers and 20 m for classic bottom otter trawls (ANAMAR, *pers. comm.*). Average towing speed is around 3 knots. An average number of 6 tows (4-5 "short" tows with outriggers during daylight and 1-2 "long" tows with bottom otter trawl at night) can be performed.

Fishing areas

The Spanish shrimp trawlers operate on sandy-muddy bottoms of the Mauritanian and Guinea-Bissau fishing grounds, in those areas delimited in the Protocols of the FPAs between the EU and these coastal States (OJ L 315, 2015 and OJ L 328, 2014, respectively). Figures 3 and 4 show main fishing areas for the Spanish shrimper fleet, in Mauritania and Guinea-Bissau, from VMS information.

2. Management measures

Management of the Spanish shrimper bottom trawlers in Mauritania and Guinea-Bissau are established in the Protocols of the FPAs with the EU, in the Fishing Category 1 "Vessels fishing for crustaceans other than spiny lobster and crab" of the Protocol with Mauritania (OJ L 315, 2015) and in the Fishing Category 2 "Shrimp trawlers" of the Protocol with Guinea-Bissau (OJ L 328, 2014). Main management measures are summarized in Table 1.

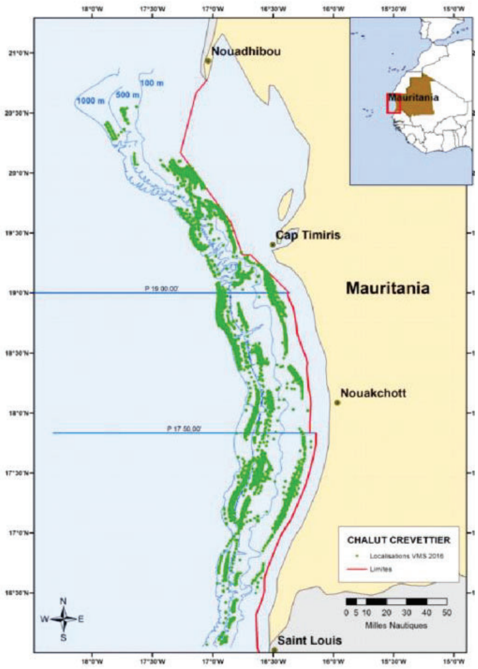


Figure 2. Fishing area of the Spanish shrimper fleet in Mauritania. 2016.
Source: Bouzouma *et al*. 2016.

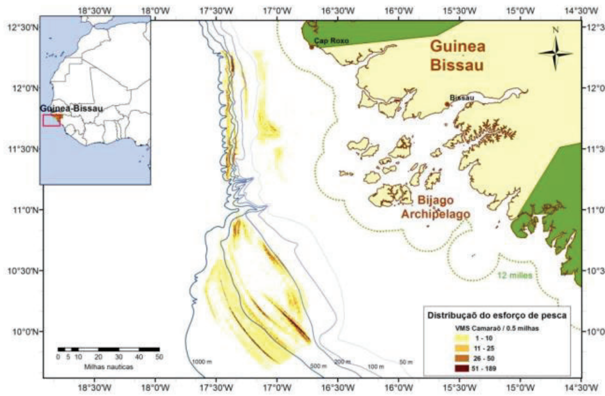


Figure 3. Fishing area of the Spanish shrimper fleet in Guinea-Bissau. 2015.
Source: Sobrino *et al*. 2016.

Table 1. Management measures for the EU shrimper fleet in Mauritania and Guinea-Bissau.

MEASURE	MAURITANIA Fishing Category 1- Protocol 2015	GUINEA BISSAU Fishing Category 2- Protocol 2014
Fishing zone	Established in the Protocol.	Beyond 12 nautical miles from the base line, including the Guinea-Bissau/Senegal joint management area.
Authorized gear	Bottom shrimp trawl, including those fitted with a tickler chain or any other selective device.	Standard otter trawls, outriggers and other selective gears.
	Doubling of the cod-end, wither single or multiple, is prohibited	
Minimum mesh	50 mm	
Minimum sizes	Minimum sizes and weights for fish, cephalopods and crustaceans established by the Mauritanian administration (Appendix VII)	
By-catch limitations	- 15 % fish - 10 % crabs - 8 % cephalopods - 0% spiny lobsters	< 50 % fish + cephalopods of the total catch at the end of a trip.
Others	TAC: 5000 t	Authorized tonnage: 3700 GRT per year

3. Monitoring of the Spanish shrimper bottom trawlers in West Africa

The monitoring of the Spanish shrimper trawlers in West Africa have been carried out by the IEO since 19980s. Different sources of information are considered for monitoring this fishery currently developed in Mauritania and Guinea-Bissau. All of them are finally analysed by the IEO (C.O. Cádiz). These sources are:

- Logbooks - Provided by the Spanish Secretary of Fisheries (Secretaría General de Pesca) under request. They contain information on retained catches by species or group of species and effort by fishing vessels on a daily basis. Available since 2009, with gaps.
- Fishery statistics database provided by the National Association of Freezer Shrimper Ship-owners (Asociación Nacional de Armadores de Buques Congeladores de Pesca de Marisco - ANAMAR) under request. It contains information of retained catches by target species or group of species, and effort by fishing vessels on a monthly basis. Available since 1990 (Mauritania) and 1998 (Guinea-Bissau).
- VMS information (vessel-id, geographical position, date, time, course, speed). Provided by the Spanish Secretary of Fisheries (Secretaría General de Pesca) under request. Information on effort, fishing areas, etc, can be obtained from them. Available since 2000.
- Program of scientific observers onboard Spanish shrimper vessels operating in West Africa. Implemented by the IEO, within the EU-Data Collection Framework, since 2010. This project has been co-funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy (O J L 199, 2008). The observer program has been designed to alternate observations in Mauritania and Guinea-Bissau on an annual basis and to have one scientific observer onboard one fleet vessel in every fishing

trip in a way that scientific observations are carried out every month and different fishing trips are sampled in different fishing vessels. Scientific observers provide data on retained catch by species and discards by fishing trawls; discards composition; length and biological data of random fishing trawls.

4. Effort and landings of the Spanish shrimper bottom trawlers in West Africa

The historical series of landings of the two traditional target species of the Spanish shrimper fleet in West Africa (*P. longirostris* and *P. notialis*) since the early 1980s when first data were recorded, is shown in Figure 5.

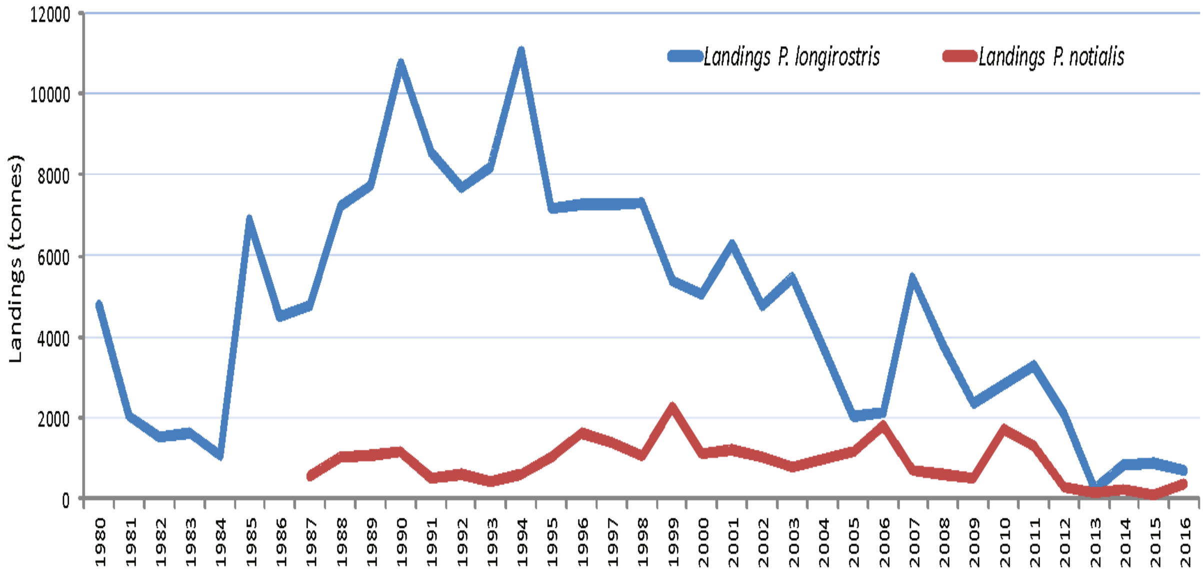
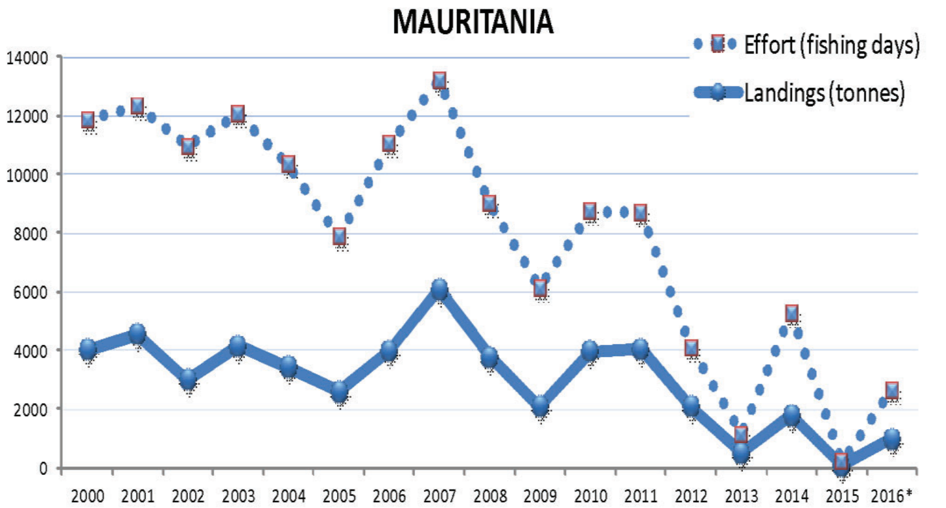


Figure 5. Landings (tonnes) of *Parapenaeus longirostris* and *Penaeus notialis* from the Spanish shrimper fleet operating in West Africa during the period 1980-2016.

Landings of *P. longirostris* has greatly decreased since maximal values in the 1990s when the Spanish fleet was simultaneously operating during certain years in Morocco, Mauritania, Senegal, Guinea, Guinea-Bissau and Angola, to the present when its activity is restricted to Mauritania and Guinea-Bissau (Figure 5). Total effort and landings of the Spanish shrimper fleet in these current fishing grounds show general decreasing trends during the last sixteen years of the fishery (Figure 6). In general, effort shows opposite trends for Mauritania and Guinea-Bissau and landings and effort follow similar trends in each fishing ground. In Mauritania, maximal landings (4 156 tonnes) occurred in 2007, corresponding to a maximum effort of 7 894 fishing days. Minimal values (85 tonnes and 141 fishing days) were recorded in 2015, when the fleet was only operative for one month. In Guinea-Bissau, effort and landings showed increasing trends to a peak in 2009 (1 773 tonnes in 4 782 fishing days), followed by a decreased until the close of the fishery in 2013 and 2014. After the reopening of the fishery, landings have ranged between 700 tonnes and 1 300 tonnes in 1 700-2 600 fishing days.



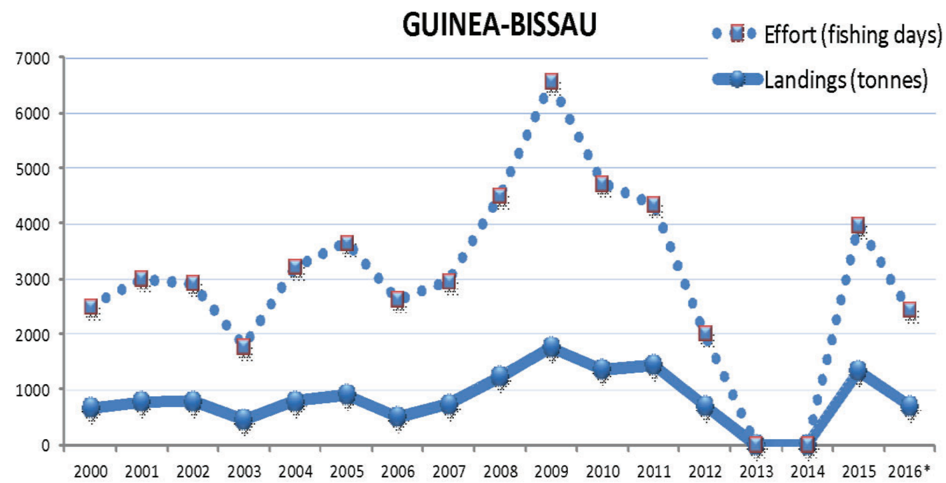


Figure 6. Effort (fishing days) and landings (tonnes) of the Spanish fleet in Mauritania (top) and Guinea-Bissau during the period 2000-2016. *2016: preliminary data.

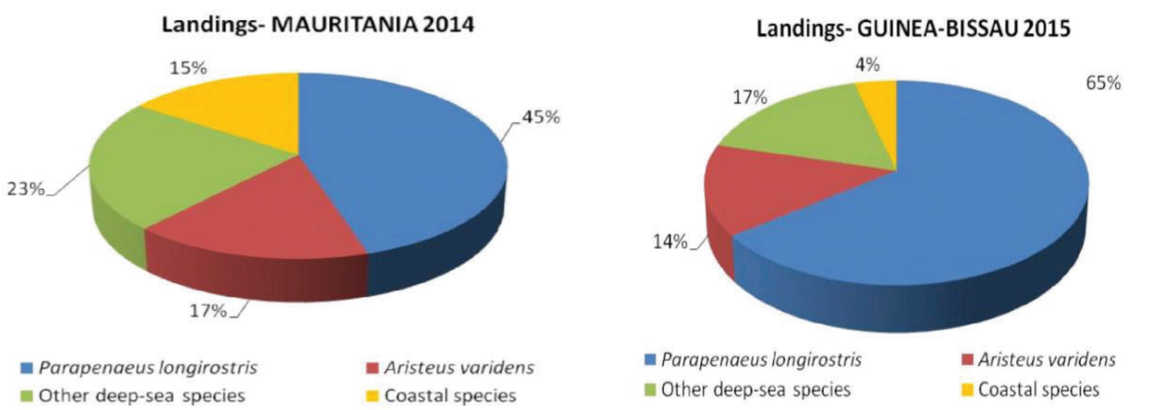


Figure 7. Landing composition of the Spanish shrimper fleet in Mauritania (2014) and Guinea-Bissau (2015).

The landings composition in both fishing grounds in the last complete analysed years (Figure 7) shows that deepwater species constitute up to 85 percent and 96 percent of the landings in Mauritania and Guinea-Bissau, respectively, with deepwater rose shrimp *P. longirostris* being the most abundant species (45 percent in Mauritania and 65 percent in Guinea-Bissau), followed by striped red shrimp *A. varidens* (17 percent in Mauritania and 14 percent in Guinea-Bissau).

5. Bycatch and discards of the Spanish shrimper bottom trawlers in West Africa

The information on bycatch and discards produced by the Spanish shrimper fleet in West Africa was obtained from the observers onboard this fleet in Mauritania and Guinea-Bissau.

Main retained bycatch species are different from one type of haul to another. In the coastal hauls, the target species *P. notialis* accounts for the 71 percent of landings in the case of Mauritania, with bycatch of *octopus vulgaris, Loligo vulgaris* and *Zeus faber,* among others. In Guinea-Bissau, three main species of coastal penaeid shrimps are targeted: *P. notialis* (39 percent), *P. monodon* (7 percent) and *P. kerathurus* (6 percent), with retained bycatch of crab *Sanquerus validus* (28 percent) and fish species such as *Pseudopeneus prayensis* (14 percent) and *Cynoglossus* spp. (14 percent).

Deep water rose shrimp *P. longirostris* is by far the most abundant retained species in those hauls that target it (97 percent-94 percent in Mauritania and Guinea-Bissau), with a small retained bycatch of other crustaceans and fish.

In the deep hauls targeting *A. varidens,* this species account for around 40 percent of the retained catches in both fishing grounds. Some retained bycatch species are *Lophius vaillanti, Chaceon maritae* and *Aristaeopsis edwardsiana,* in different percentages from one area to another.

Discard rates have increased from 64 percent (in 2010) to 73 percent (in 2014) of total catch in Mauritania, with clear variations with depth, as higher discards are produced in the coastal hauls targeting *P. notialis* (García-Isarch *et al*., 2012, 2016). On contrary, a decrease in discards was recorded in Guinea-Bissau from 2011 (69 percent) to 2015 (64 percent) (García-Isarch *et al*., 2013). In this case, no clear bathymetrical trends were observed. There is a potential latitudinal variability in discards, which must be further analysed. Seasonal variations have been recorded in all cases (García–Isarch *et al*., 2012, 2013, 2016).

Diversity of discards

The total number of species recorded in the discards produced by the Spanish shrimper fleet in West Africa ranges between 342 and 354 in Guinea-Bissau and Mauritania, respectively, being fish the most diverse group, followed by crustaceans (García–Isarch *et al*., 2012, 2016). Among the discarded species, benthic species accounted for 105 species in Mauritania and 114 species in Guinea-Bissau.

Changes in biodiversity in relation to the bathymetric strata were analysed. In Mauritania, the total number of species ranged between 162 and 166 for the three bathymetric strata, with the highest value registered in those hauls targeting *P. longirostris*. The number of benthos species was between 47 species (in the deepest hauls targeting *A. varidens*) and 60 species (in hauls targeting *P. longirostris*). Greater variations of discards biodiversity in relation to depth were found in Guinea-Bissau. The lowest number of species (91) was recorded in the shallowest hauls, targeting *P. notialis* and the highest (176) in those hauls targeting *P. longirostris*. In this case, less benthos species (36) were registered in the shallowest hauls, while similar numbers (53-54) were registered in the deep hauls targeting *P. longirostris* or *A. varidens*.

The most abundant discard species in Mauritania were: *Merluccius polli* (7 percent), *Pagellus bellottii* (6 percent), *Helicolenus dactylopterus*, and *Sphoeroides marmoratus* (5 percent each). In Guinea-Bissau, *Chlorophthalmus atlanticus* (15 percent), *Munida rutllanti* (9 percent), *Synagrops microlepis* (6 percent) and *Merluccius polli* (5 percent) were the most abundant species in discards. In terms of abundance, 14-15 percent of discards (Mauritania-Guinea-Bissau) corresponds to benthic species. Discard composition is also available by type of fishing haul (targeting *P. notialis*, *P. longirostris* and *A. varidens*).

6. Main impacts of the Spanish shrimp bottom trawlers in West Africa

Information on the potential impacts by the Spanish shrimp trawlers can be obtained from the data provided by the observers on board.

Potential impacts on vulnerable or protected species have been analysed. There is a number of shark species registered in discards, but in low frequency and abundance, being the most frequent *Deania profundorum* and *D. calcea* (in 17 percent and 13 percent of the tows in Mauritania), and *Scyliorhinus stellaris* (23 percent of tows in Guinea-Bissau).

Although benthic species have not been analysed to species level so far, a preliminary analysis of the fishery impact on those groups that are considered indicators of vulnerable marine ecosystems (sponges and corals) was performed. Sponges have been caught and discarded in less than 15 percent of the tows, in both fishing grounds, and in very small quantities. Among corals, the sea anemones of the family Hormathiidae are the most frequent in discards (32-34 percent of the tows), and the genus Epizoanthus was relatively frequent in Guinea-Bissau (frequency of occurrence of 25 percent).

Conclusions on main impacts of shrimp trawlers in West Africa:

- The fishing effort deployed by this fleet in West Africa has very much decreased over time and it is currently at a very low level, with only 14 vessels operating in Mauritania and Guinea-Bissau.
- This fishery produces high discards rates, with clear bathymetric and temporal variability.
- Benthos species account around 15 percent of the total discard volume; this proportion varying with depth and latitude.
- There is a high diversity in the discards composition, which also changes with depth.
- Benthic species recorded in the discards was 105 Mauritania and 114 Guinea-Bissau.
- There is a low impact on vulnerable/protected species of sharks; some of them are relatively frequent in discards, although in small rates.
- Regarding the impact on indicator benthic species of vulnerable marine ecosystems, certain sponges and coral groups are relatively frequent in discards but in small quantities.
- There is a potential gear impact on the seabed, which has not been studied so far.

References

Bouzouma M., Corten, A., Daniel, P. 2016. Rapport de la Réunion annuelle du Comité Scientifique Conjoint relatif à l'Accord de pêche signé entre la République islamique de Mauritanie et l'Union européenne. Nouakchott, Mauritanie, 05 au 07 septembre 2016. Rapports des Comités Scientifiques Conjoints. Bruxelles, 72 p. + Annexes.

García-Isarch, E., Romero, Z., Duque-Nogal, V., Expósito, P. and J.A. Sebastián. 2016. Información biológica y pesquera obtenida en las campañas de observación científica a bordo de la flota marisquera española en aguas de la ZEE de Mauritania (año 2014). Instituto Español de Oceanografía. Septiembre 2016. 94 pp.

García-Isarch, E., Romero, Z., Sobrino, I., Expósito, P. and de Santos, D. 2013. Información biológica y pesquera obtenida en las campañas de observación científica a bordo de la flota marisquera española en aguas de la ZEE de Guinea-Bissau (año 2011). Instituto Español de Oceanografía. Febrero 2013. 75 pp.

García-Isarch, E., Romero, Z., Sobrino, I., Expósito, P. and Barro, S. 2012. Información biológica y pesquera obtenida en las campañas de observación científica a bordo de la flota marisquera española en aguas de la ZEE de Mauritania (año 2010). Instituto Español de Oceanografía. Mayo 2012. 45 pp.

O J L 199. 2008. Council Regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy. Official Journal of the European Union. 5-3-2008. L 60/1-12.

O J L 328. 2014. Protocol setting out the fishing opportunities and financial contribution provided for in the Fisheries Partnership Agreement between the European Community and the Republic of Guinea-Bissau. Official Journal of the European Union. 13-11-2014. L328/1-32.

O J L 315. 2015. Protocol setting out the fishing opportunities and financial contribution provided for in the Fisheries Partnership Agreement between the European Community and the Islamic Republic of Mauritania for a period of four years. Official Journal of the European Union 1-12-2015. L 315/3-71.

Sobrino I., Nahada V., Rodríguez S. 2016. Relatório da reunião anual do Comité Científico Conjunto sobre o acordo de pesca entre a República da Guiné-Bissau e União Europeia. Cadiz, 71 paginas + 5 Anexos.

SPANISH DEMERSAL TRAWLERS TARGETING BLACK HAKE (FROM MOROCCO TO SENEGAL)

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1. Description of the fishery

The Spanish demersal trawlers are the main fleet targeting black hake on Northwest African fishing grounds (Figure 8). During 2015 and 2016, the fleet was composed of three wet-fish trawlers and four freezer trawlers. The fresh trawlers' activity is more stable and this fleet operates mainly in Mauritania, alternating with other fishing grounds (South of Morocco and Senegal) sporadically. Their fishing trips last around one week, landing in the closest ports, Nouadhibou (Mauritania), Dakhla (South of Morocco) or Dakar (Senegal), from where the catch is transported by truck to the port of Cadiz (SW Iberian Peninsula). The freezer trawlers operate in South of Morocco sporadically, since habitually target cephalopods and other finfish off Guinea-Bissau. Their fishing trips are longer, up to 3-4 weeks, and landings are mostly carried out in Las Palmas port (Canary Islands, Spain). Both fleets' effort is mostly concentrated in bottoms between 400 and 800 m depth, although fresh trawlers also operate sometimes on shallower fishing grounds (<350 m), where they target different species (mainly Sparidae and Zeiidae). Main target species are black hakes, commercialized as *Merluccius* spp., composed by two sympatric species which appear mixed up in the catch, *Merluccius polli* and *M. senegalensis* (Figure 9).

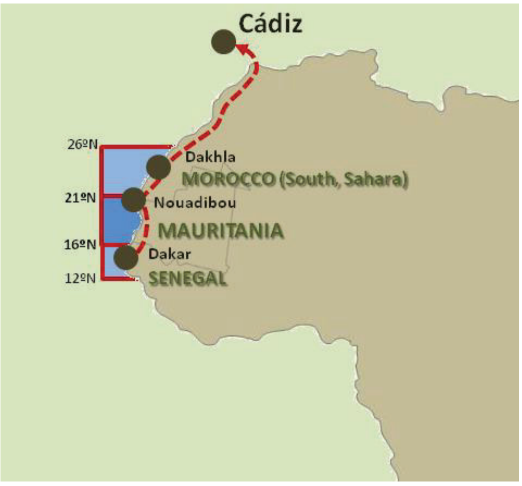

Figure 8. Main fishing grounds (blue) and landing ports in Northwest Africa for the fresh Spanish demersal trawlers. Cadiz (South Spain) is the only fish market for this fleet.

Figure 9. Black hake species targeted by the Spanish demersal trawlers in Northwest Africa: deep water species *Merluccius polli* (top) and shallow water species *Merluccius senegalensis* (bottom)

2. Management measures

These fleets operate under different SFPAs, which establish different conditions and particular management measures on target species, number of vessels, total catch and a particular percentage of bycatch by groups (sharks, cephalopods and crustaceans), as summarized in Table 2.

Table 2. Management measures under different Sustainable Fishery Partnership Agreements (SFPA) with Northwest African countries. F.C.: Fishing category

MEASURE	MOROCCO F.C. 4: Demersal fisheries trawlers	MAURITANIA F.C. 2: Black hake (non freezer) trawlers and bottom long-liners	SENEGAL F.C.: Deep water demersal species
Fishing zone	Established in the Protocol (2013)	Established in the Protocol (2015)	Established in the Protocol (2014)
Authorized gear	Trawlers (5) and longliners	Trawlers and longliners (6 vessels)	Trawlers (2)
Target species	Black hake, scabbardfish, leerfish/bonito	Black hake	Black hake
Minimum mesh	70 mm	70 mm	70 mm
Minimum sizes	-	Black hake > 30 cm (Protocol 2015)	-
By-catch limitations	5% sharks 0% cephalopods 0%crustaceans	5% fish 0% cephalopods 0%crustaceans	15% fish 7% cephalopods 7%crustaceans
Others	Authorized power: 600 GT	TAC: 6000 t	TAC: 2000 t

3. Monitoring

The demersal trawler's activity in the area is monitored by different sources of information: i) vessels spatial and temporal location is registered regularly by satellite (VMS data); ii) effort and catch are recorded both onboard in the logbooks and in the fish market, where the landings and dates are taken from the sales sheets; iii) length frequencies of landings are obtained by routine measurements (four samplings per month) made by samplers, who make length samplings of black hake by commercial categories from fresh trawlers in the Cadiz fish market, and iv) other high quality and complementary information comes from scientific observers onboard these fleets. Commercial catches, bycatch and discards data are collected onboard by haul, with accurate geographic information. Also, individual size and weight as well as biological data are collected on board.

4. Effort and landings

Landings and effort trends of the fresh fleet since 1983 to 2015 (Figure 10) show a progressive decline from the 1990s, which is more evident in the main fishing ground, Mauritania. In 2016, a total of 113 fishing trips has been carried out by the fresh fleet in Mauritania, 22 in South of Morocco (both fleets) and only 3 in Senegal (fresh fleet).

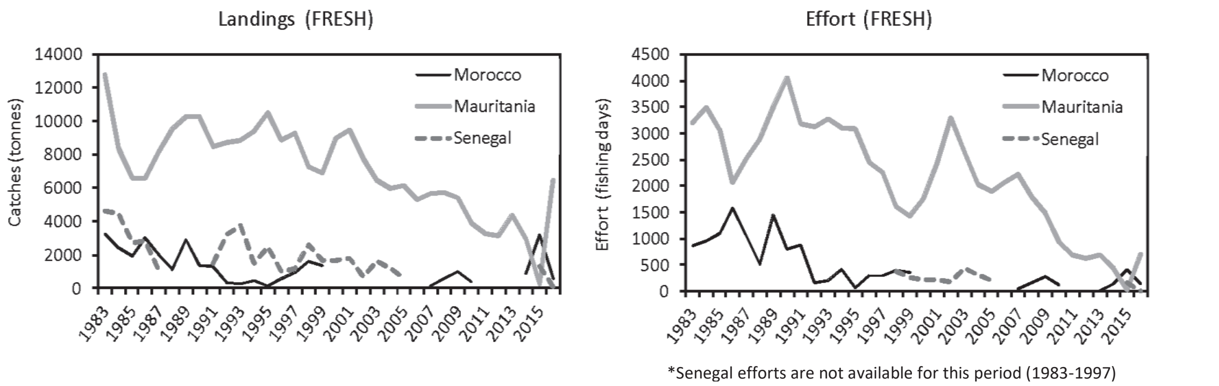

Figure 10. Landings (left) and effort (right) of the Spanish fresh demersal trawlers targeting black hake in Northwest Africa

5. Bycatch and discards

Figure 2. Landing (left) and effort (right) of fresh fleet from 1983 to 2015.

The EU established a Community framework for collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy (2016/1251/EC). This programme supports the presence of scientific observers onboard the UE fleets to carry out routine sampling. Since 2003, a scientific observer has been onboard the fresh fleet in Mauritania at irregular intervals, collecting data on the total catch, both commercial and discards. In 2016, commercial catch, bycatch and discards have been analysed in the fresh fleet during seven onboard fishing trips.

When analysing the retained catches, we observed significant differences in species composition by depth strata. In the deeper strata (>350 m), 96 percent of catches were *Merluccius* spp., with a clear dominance of *M. polli* (91 percent). The rest of the commercial catch was composed by shortspine African angler *Lophius vaillanti* (3 percent) and a mixture of elasmobranchs (1 percent). In the shallower strata (<350 m) black hake catch is only represented scarcely by *M. senegalensis* (3 percent). *Dentex spp*, *Zenopsis conchifer*, *Zeus faber* and *Trachurus* spp. composed 82 percent of the commercial catch (Figure 11).

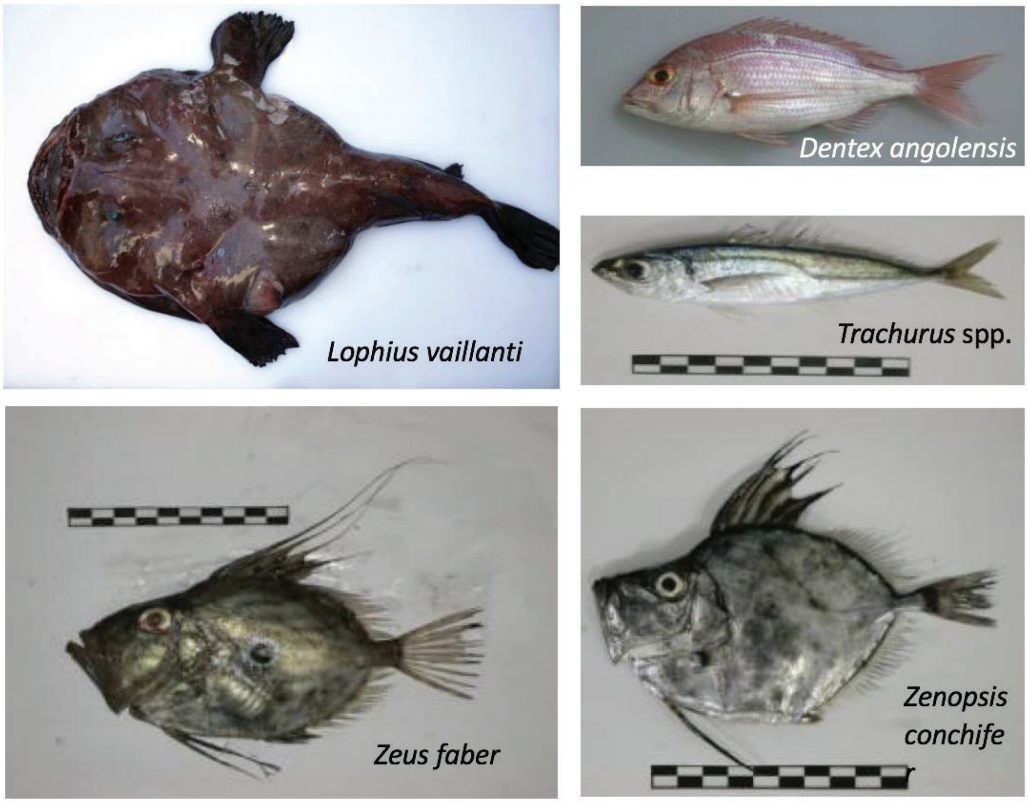

Figure 11. Main bycatch species of the Spanish demersal trawlers targeting black hake in Mauritania.

Discards were around 33-51 percent (mean 43.6 percent) of the total catch. The variability of discards volume between hauls and trips is noticeable and greatly dependent on the fishing strategy (latitude, depth and months) among other reasons.

Discard composition is also highly dependent on the depth strata. The presence of black hakes in discards was important along the whole depth range, although each species occurrence was variable at different depths. In shallower waters (<350 m) the abundance of black hakes rose to 31 percent of discards in weight, being *M. senegalensis* the most abundant species (19 percent). In the deeper strata (>350 m), the black hake abundance slightly decrease to 25 percent of the total discards, being *M. polli* significantly dominant (21 percent). Considering the total discards, black hake contribution was of 34 percent (21 percent *M. polli* and 13 percent *M. senegalensis*). Other remarkable species contributing to the discards in weight were *Trachyrincus scabrus* (9 percent), *Pontinus* spp. (9 percent) and *Hoplostethus cadenati* (6 percent) (Figure 12).

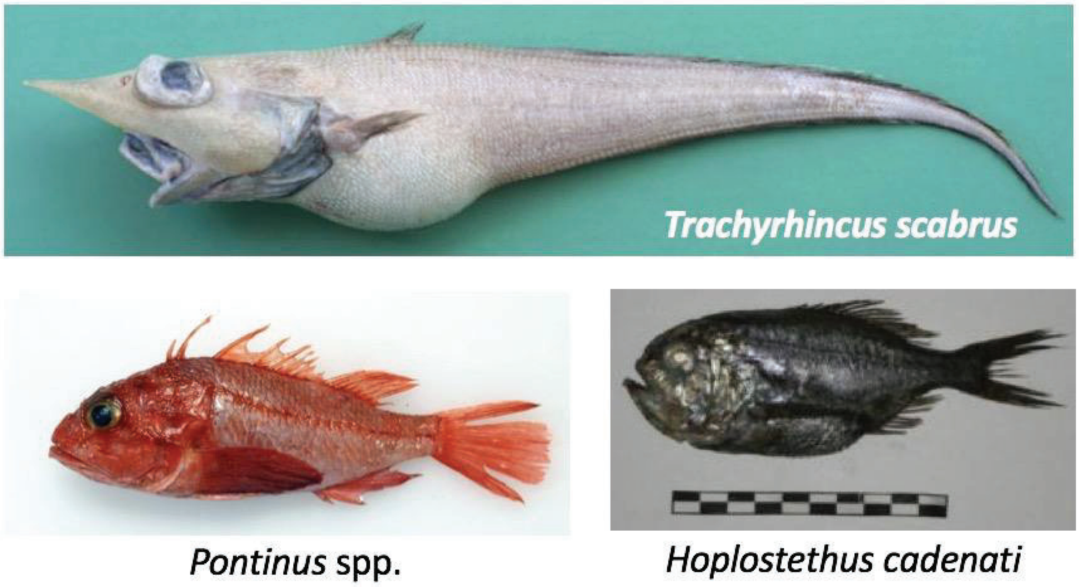

Figure 12. Main discarded species of the Spanish demersal trawlers targeting black hake in Mauritania

6. Main impacts

Demersal trawling has a direct impact on some vulnerable or endangered species, as well as condrichthyans or demersal invertebrates. Condrichthyans are long lived species with low fecundity, and consequently highly influenced by fishery mortality. A mixture of elasmobranches represented a 6 percent of the total discard and a 2.6 percent of the total catch in weight.

Invertebrates are affected mostly by habitat damage since trawl gears erode the sea floor and may cause a serious impact on benthic communities. Invertebrates corresponded to 7 percent of the total discard in weight (3.1 percent of total catch). The most represented groups were cephalopods (3.4 percent) and crustaceans (2.5 percent).

Apparently, discard composition has been changing progressively from first observations on board in the area, carried out in 2003. Consequently, discard evolution over the years and species replacement deserves to be thoroughly studied and related to oceanographic variables and climate proxies.

SPANISH FINFISH-CEPHALOPODS BOTTOM TRAWLERS IN GUINEA BISSAU

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Eva Hernández, José F. González, Eva García-Isarch & Catalina Perales-Raya.

The Spanish industrial freezer trawler fleet targeting cephalopods and fish operates in Guinea-Bissau waters. This metier arises from the fleet targeting cephalopods that operated mainly in the fishing grounds of Morocco, Mauritania, Senegal and Guinea in the 1990s. This fleet used to operate in Guinea-Bissau waters as an alternative fishing ground when closures were imposed in the main fishing areas. This fleet, that used to have more than 50 vessels in NW Africa in the past, is currently composed of only 11 trawlers that are currently fishing under the Fishery Partnership Agreement (FPA) between the EU and Guinea-Bissau. The technical characteristics of the fleet are summarized in Table 3.

Table 3. Fleet characteristics

	Vessel GT	Overall length (m)	Power (HP)
Mean	277	39	932
Maximum	390	49	1260
Minimum	158	32	622

The target species of this fishery are black hake (*Merluccius spp*), horse mackerel (*Trachurus spp*), octopus (*Octopus vulgaris*) and cuttlefish (*Sepia spp*). Thus, the fishing operations are distributed mainly in three depth strata: shallow stratum (<100 m), intermediate stratum (100 m – 200 m) and deep stratum (350 m – 550 m).

The gear type used is the "Spanish trawl" type, with a mesh size of 80 mm. Trawl spread is on average 175 m while the vertical opening varies between 1.5 and 2.5 m with an average towing speed of 3.5 knots.

The duration of the fishing trip usually varies between two and four weeks, after which the vessel land in the port of Dakar, where catches are transferred to cargo vessels. The vessels usually perform around four tows per day, with an average duration of 4.57 hours per tow (minimum 1.30 and maximum of 8.40 hours). This variability is mostly related to the differences between the bathymetric strata of the different target species.

The trend of the fishing effort in the area made by this fleet since 2000 is shown in Figure 13. There was no fishing agreement during the years 2013 and 2014, and thus no fishing activities. The effort in 2015 was 1 591 fishing days.

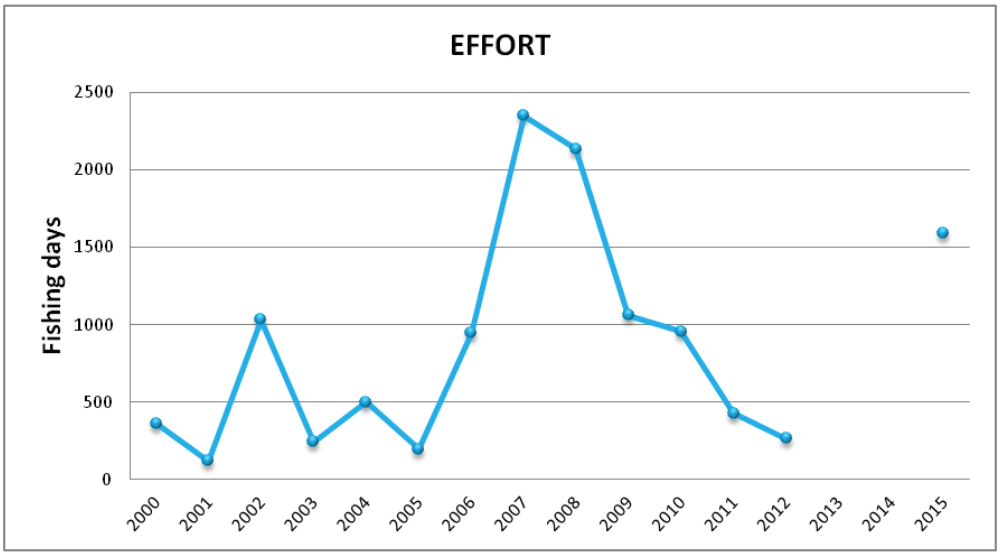

Figure 13. Fishing effort of Spanish finfish-cephalopods bottom trawlers in Guinea-Bissau fishing ground (Source: Sobrino *et al.* ,2016).

The spatial distribution of the fishing effort reflects the three reported bathymetric strata, although it seems to be concentrated from the central zone to the north of the fishing ground (Figure 14).

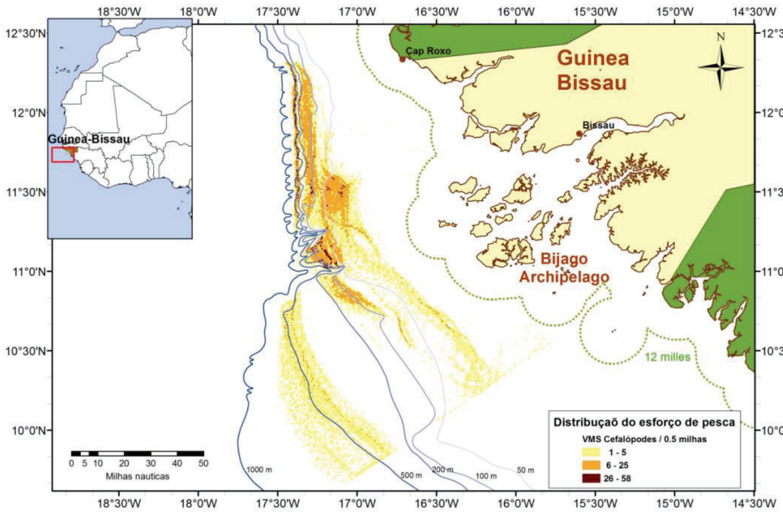

Figure 14. Spatial distribution of the fishing effort in Guinea-Bissau fishing ground based on VMS data (Source: Sobrino *et al.*, 2016).

The evolution of the fleet landings, which initially targeted cephalopods, is indicative of the adaptation to the new fishing opportunities. Figure 15 shows the significant increase of the group "Others" in landings of 2015, thus becoming a mixed metier targeting cephalopods and finfish.

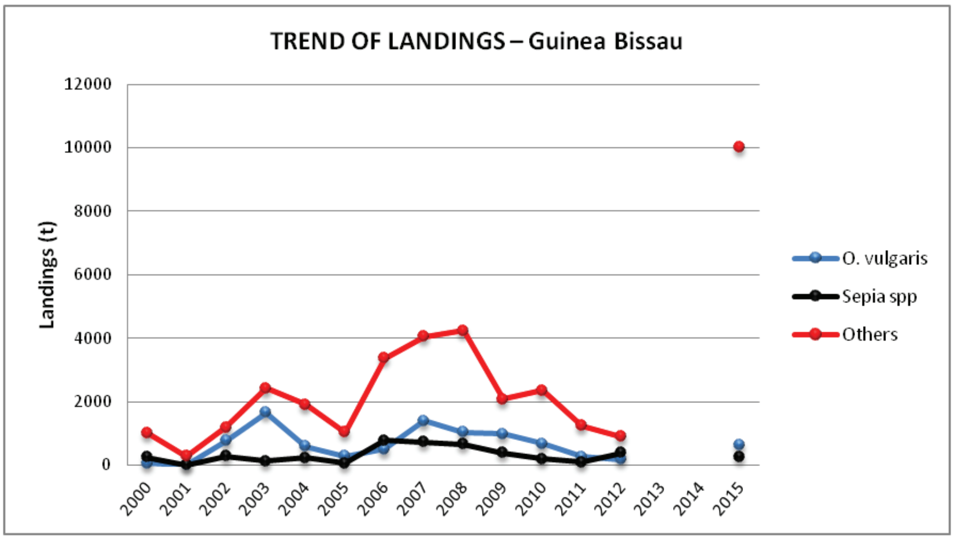

Figure 15. Trend of landings of Spanish finfish-cephalopods bottom trawlers in Guinea-Bissau (Source: Sobrino *et al.*, 2016).

In this sense, landings in 2015 showed a proportional distribution among target species in which the black hake dominated (41 percent). Octopus and cuttlefish accounted for only 5 percent and 2 percent of the total respectively (Figure 16). The figure also shows that 26 percent of the reported landings corresponds to a variety of other species (bycatch).

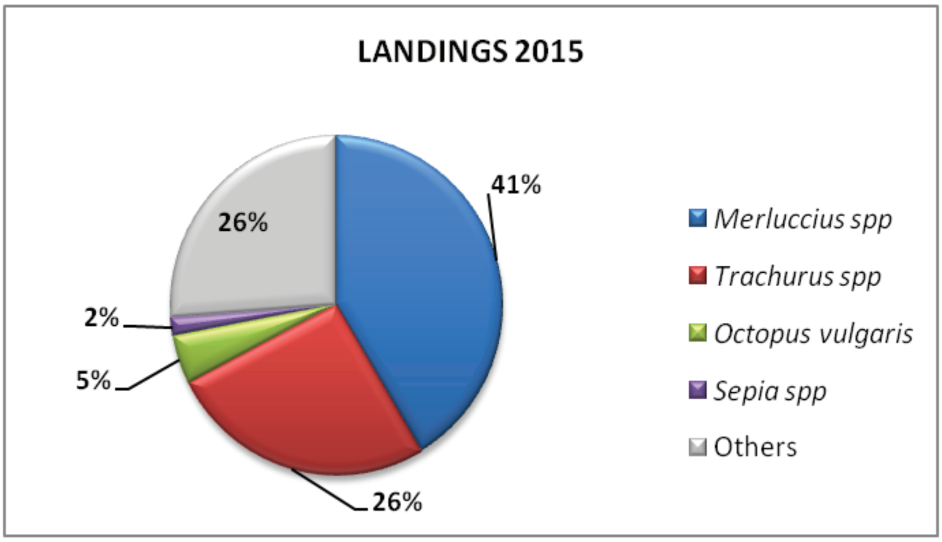

Figure 16. Proportional distribution of landings of the target species.

An onboard observer program was implemented in mid-2015 in order, among other objectives, to analyse the faunal composition and the proportional distribution of bycatch and discards. This program is still in the initial phase and only 4 fishing trips have been sampled so far. This, together with the species richness of this fraction of the catch and the wide range of fishing depth, is probably responsible for the high variability of the bycatch composition observed between the different fishing trips. Therefore, preliminary results are presented noting that these catches are mainly made up of finfish species (Figure 17).

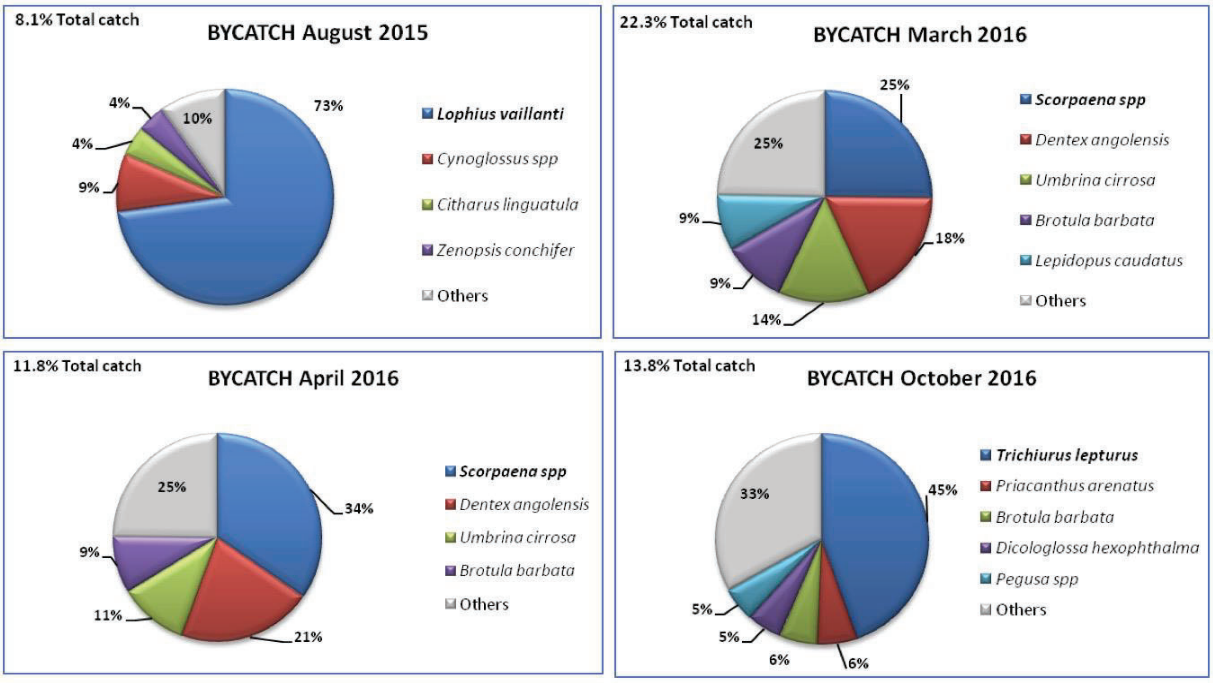

Figure 17. Preliminary results of bycatch analysis based on on-board observer programme data.

The data on discards obtained in these observations is currently being analysed. Much more effort is still needed in the taxonomic identification of some groups as well as a greater number of sets sampled for a reliable estimate. Although the number of sampled fishing trips is quite small, the group of finfish seems to dominate in both volume and species richness.

The management measures adopted in the agreement between the EU and Guinea-Bissau for Fishing Category 1 (freezer trawlers for finfish and cephalopods) have a period of validity from 2014 to 2017. This regulation is applicable in waters until 12 miles from the coast line and includes the joint management zone between Guinea-Bissau and Senegal, which extends northwards to 286° azimuth. The authorized annual tonnage for this metier is 3500 GRT, allowing the use of standard trawl mesh and other selective gears. In addition, the percentage of crustacean bycatch per fishing trip should be less than 9 percent.

The monitoring of this fishery is mainly based on information from logbooks and VMS data provided by the General Secretariat of Fisheries of the Spanish Government. This information is reviewed and crosschecked by the IEO, which also compile data from its Information and Sampling Network. In addition, since 2015 the fleet is collaborating to develop campaigns with scientific observers on board commercial vessels. This onboard monitoring is part of the EU Program in accordance with the Council regulation establishing an EU framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy (2008/949 / EC).

References

Sobrino I., Nahada V., Rodríguez S., 2016. Relatório da reunião anual do Comité Científico Conjunto sobre o acordo de pesca entre a República da Guiné-Bissau e União Europeia. Cadiz, 71 paginas + 5 Anexos.

Senegal

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Fisheries plays a very important socio-economic role in Senegal. It covers about 70 percent of the protein intake of the population. The fisheries sector in Senegal has many challenges caused by factors such as overcapacity and use of prohibited gears. The fisheries resources are declining, so is the profitability from fishing. The trawl fisheries play an important role in the Senegal fisheries.

The coastal trawler fleet consists of 21 small-sized trawlers (<50 GT) targeting finfish and cephalopods. Their share of the coastal catch is about 93 percent (ca 14 170 tons) and the average total number of fishing days per year is 4 355. There are 8 trawlers targeting shrimp; their share of the total catch is about 7 percent (ca 1 067 tons) and the average total number of fishing days per year is 1 022. The discards are small in these fisheries.

The deepwater bottom trawl fishing fleet consists of 18 freezer shrimp trawlers (>50 GT) and of 3 hake trawlers. The shrimp trawlers target deepwater shrimp such as *Parapenaeus longirostris,* with total annual landings of about 3 000 tons. The total average number of fishing days is about 2600 per year. The hake trawlers land about 720 tons annually with a total of 117 fishing days.

In the deepwater shrimp trawl fishery, bycatch and discards are considerable: up to 75 percent of total catch. Therefore, various bycatch reduction devices, including modified Nordmøre grid, were tested in 2015 under commercial conditions in trawl fishery for deepwater prawn. Three different grid spacings were tested (24 mm, 28 mm and 30 mm) to find out the optimal space in terms of maximum bycatch reduction and minimum shrimp loss.

The sea trials indicated that the Nordmøre grid with 30 mm bar spacing effectively released large-sized bycatch species of great interest, including rays and sharks. The shrimp loss varied between 3 percent and 20 percent with an average loss of 8 percent. The problem of poor selectivity remains for small fish species and juvenile fish. Furthermore, in some fishing grounds, benthic crustaceans (*Munidae*), when abundant, could mask the bars of the Nordmøre grid, preventing shrimps from passing through the grid. This problem will have to be solved in further studies. The bycatch to shrimp ratio was around 2.2 to 1, which is lower than the world average for similar fisheries (5 to 1). In the further work the contact of trawl to the bottom should be tested to find a point where the catches of small crustaceans and small flat fish are reduced without affecting the yield of the shrimp. The possibility of using a top-less trawl that would facilitate the escape of some groundfish should also be tested.

There are many management measures in place in the Senegal fisheries. Fisheries monitoring is conducted with the help of VMS system and observers on board.

Guinea

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Bottom trawl fisheries are very important in Guinea. Demersal trawlers authorized to fish between 1995 and 2013 dominated with 88 to 99 percent of the total trawl fleet and 58 to 87 percent of the total catch of the total trawl fleet. Three types of bottom trawl fisheries existed until 2015: demersal fish fishery, cephalopod fishery and shrimp fishery.

Demersal fish trawlers operate mainly in the northwestern area of the continental shelf. The main targeted species belong to the families of Sciaenidae, Ariidae, Sparidae, Lutjanidae, Cynoglossidae, Serranidae and Mugilidae. These species are caught by all demersal trawlers and artisanal fishery canoes. Catches are composed of fish, cephalopods, shrimps and other species. The number of demersal fish trawlers authorized to fish during the period 1995-2013 ranged from 25 to 83 vessels and their total catches varied from 7 149 to 33 287 tonnes. There was a general trend of the total catch increase over the period 1995-2013.

Cephalopod trawlers also operate mainly in the northwestern area of the continental shelf. The main target species are cuttlefish and octopus. These species are caught exclusively by demersal trawlers. Catches include cuttlefish, octopus, fish, shrimp and other species. The number of cephalopod trawlers authorized to fish between 1995 and 2013 ranged from 17 to 58 vessels and their total catch ranged from 5 648 to 15 759 t. There is a general trend of small total catch decline over the period 1995-2013.

Shrimp trawlers operate on the continental shelf and the continental slope. The main target species are *Penaeus notialis*, *Parapenaeopsis atlantica* and *Parapenaeus longirostris*. These species are caught exclusively by demersal shrimp trawlers. Catches consist of shrimp, fish, cephalopods and other species. The number of shrimp trawlers authorized to fish from 1995 to 2013 ranged from 2 to 57 vessels and their total catches varied from 205 to 9 817 t. The general trend of the total catches decreased slightly over the period 1995-2013.

The total catches of all demersal trawlers authorized to fish between 1995 and 2013 ranged from 17 103 to 52 156 t. During the same period, bycatches varied from 7 028 to 17 716 t. The general trend of the total catches and bycatches increased over the period 1995-2013.

Management measures for demersal trawl fisheries are indicated in the annual management plan for all fisheries. The management method is the control of the means of production or the limitation of the fishing effort. Management measures include traditional measures related to fishing areas, seasonal closures, bycatch, discards, mesh size of trawl and species. They also include other measures such as those related to fishing vessel, trans-shipment and landing of catches, landing obligation, declaration of catch and/or fishery products, etc. It should be noted that fishing gear related measures have included the prohibition of using the scraper chains on footropes since 2015. This measure mitigates the impact of trawls when they are in contact with the seabed.

Available data on impacts of bottom trawling are catches, fishing effort and trawling coordinates. These data are available at the Boussoura National Centre for Fisheries Sciences and are collected by observers. The main gaps are: lack of size frequency data for key species, lack of sampling data from discards, lack of habitat data, and lack of benthos data.

The types of monitoring measures include inspections of vessels at the port of Conakry, the program of observers, logbooks, sea and air surveillance, satellite vessel monitoring system, monitoring of trans-shipments and landings.

Nigeria

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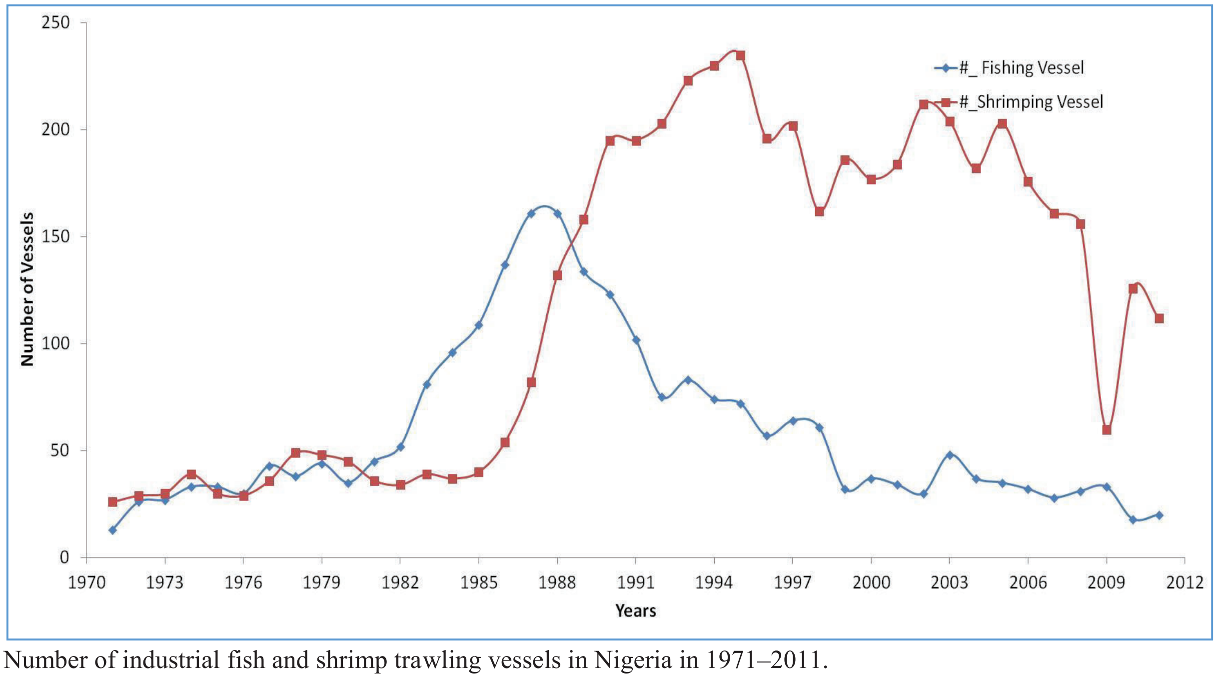
Nigeria is a coastal state on the shore of the Gulf of Guinea. It has an area of 923 768 sq km. Coastline length is 853 km and continental shelf area is about 37 934 sq km. Shelf width is 27 km – 80 km (from west to east). In 1978 Nigeria established a 200 nautical miles Exclusive Economic Zone (EEZ) contiguous with a 30-nmTerritorial Sea (210 900 sq km).

Trawl fisheries in Nigeria is operated by the industrial sector that operates medium size fishing trawlers with an average length (LOA) of 25 m and Gross Tonnage of >150 tonnes. This sector has two categories based on the types of license: shrimp trawling and fish trawling. The type of license is based on the type of target species and codend mesh size of the trawl net. Shrimp vessels have a 44 mm whereas fishing trawlers have a 76 mm minimum codend mesh size. All shrimp and majority of fish trawlers conduct otter bottom trawling while a few of the fishing vessels sometimes also use midwater trawling.

Shrimp trawlers target the Penaeid shrimps (*Parapenaeus longirostris, Penaeus notialis, Paranenaeopsis atalantica, Penaeus monodon*) and they also catch various demersal finfish as bycatch. The fish trawlers target finfish such as croakers (*Pseudotolithus* spp.), soles (*Cynoglossus* spp.), groupers (*Epinephelus* spp.), snappers (*Lutjanus* spp.), Bigeyes (*Brachydeuterus* spp.), threadfins (*Polydactylus* spp.), barracudas (*Sphyraena* spp.), jacks (*Caranx* spp.), horse mackerels (*Trachurus* spp.), and cutlass fishes (*Trichiurus* spp.). Sometimes they also catch tunas and tuna-like fishes.

Figure 18. Industrial Fish / Shrimp Trawler (Nigeria)
Source: Akanbi Bamikole Williams, Fisheries Resources Department, Nigeria

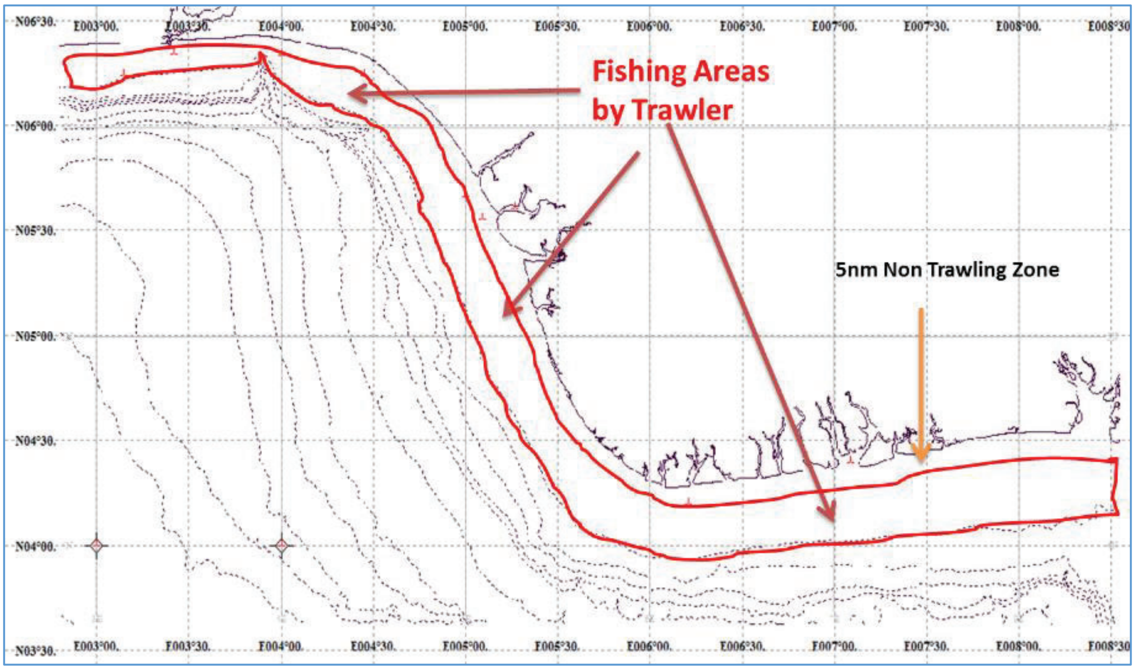
At the inception of the commercial fishing in Nigeria, there were more fish trawlers than shrimp trawlers but as the industry developed, the trend changed and there are now far more shrimp trawling vessels. The highest number of shrimp vessels (235 vessels) was recorded in 1995. There has been a gradual decrease in the total number of vessels due to incidences of militancy and sea piracy coupled with economic meltdown. As of 2014, a total of 133 trawling vessels were registered: 121 shrimp trawlers, 10 fish trawlers, and 2 distant-water trawlers.



Number of industrial fish and shrimp trawling vessels in Nigeria in 1971–2011.
Source: Fisheries Resources Department, Marine Biology Section, Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria

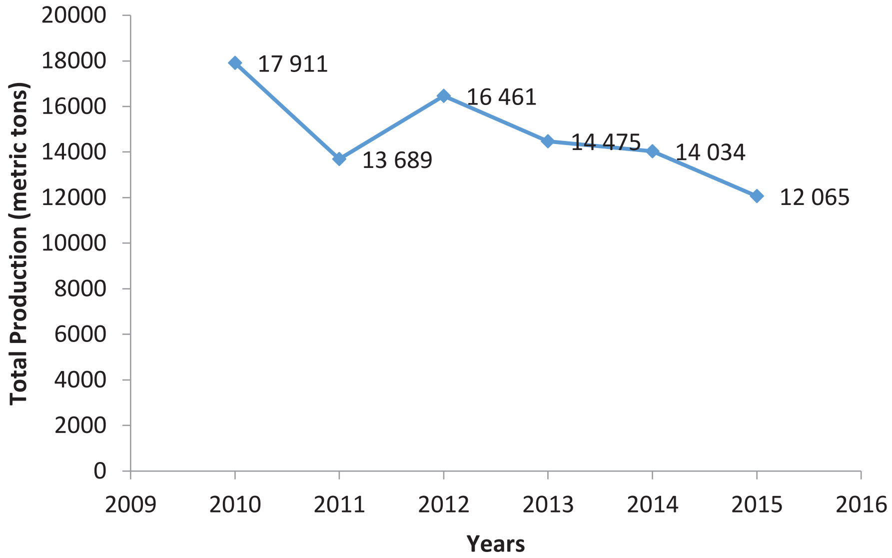
Almost the entire continental shelf of Nigeria is trawlable except for areas where there are canyons and marine installations particularly for the oil industry. There is a 5 nm non-trawling zone (from shoreline) established by law. However, much of the fishing activities takes place in the Nigeria Delta area. All areas are fertile fishing grounds but higher catches are usually recorded at areas close to river mouths. Thus the following areas are regarded as better fishing grounds: Bonny Anchorage, Brass, Escravos, Pennington, Middleton, Fish Town, Dodo, Benin Rivers, Calabar, Forcados, Opobo, Qua-Ibo.

Most of the vessels fish only in the inshore areas (less than 50 m depth) and very few venture beyond 50 m depth, as their main target species are in this zone.



Areas of active trawling in Nigerian waters.

Total landings recorded from all vessels in 2010-2015 is shown in the figure below. Highest landings were recorded in 2010. Since then the landings have decreased due to many factors including increase in fuel cost, militancy and sea piracy, and devaluation of national currency (Naira).



Total production from all vessels (fish and shrimp trawlers).

Summary of target catch and bycatch in shrimp and fish vessels (metric tonnes).

		Year	2010	2011	2012	2013	2014	2015
Shrimp Vessels	Target Species	Shrimp	4 643.274	3 922.344	4 614.778	4 054.904	4 835.857	4 523.342
	Bycatch	Finfish	9 043.785	7 575.423	7 773.104	6 519.604	7 183.637	6 895.185
		*Others	538.642	346.12	287.911	324.254	323.909	335.893
	Total		14 225.7	11 843.89	12 675.79	10 898.76	12 343.4	11 754.42
Fish Vessels	Target Species	Finfish	3 673.265	1 843.635	3 745.107	3 432.886	1 652.983	286.466
	Bycatch	Shrimp	0	0	9.247	26.521	18.249	6.441
		**Others	11.914	1.72	30.671	116.789	19.655	17.322
	Total		3 685.179	1 845.355	3 785.025	3 576.196	1 690.887	310.229

**Others = Lobsters, crabs, cuttlefishes (squids), Octopus and cucumbers*

Data from 2010-2011 suggests that the fishery is heavily dependent on two shrimp species: *Penaeus monodon* (46 percent), and *Penaeus notialis (*37 percent). Less important species include *Parapenaeopsis atlantica* (12 percent), *Melicertus kerathurus* and *Parapenaeus longirostris* (both just over 2 percent).

In Nigeria, the quantity of fisheries discards is relatively low as there is enough market for almost all products from the sea. In the past, most of the small sized fish were discarded but now there is a big market. There are no data on discards but comparing research data with those of the commercial fishing, the following are some of the species that are generally discarded: crustaceans (some crabs, mantid shrimps, other shrimps), and small size cephalopods, echinoderms and jelly fishes. Estimated discard quantity range from about 2 to 10 percent of total catch. There have been no scientific studies on the potential benthic impact of bottom trawling.

The type of management measures in Nigeria are mainly input controls and technical measures as contained in the following national regulations:

- Sea Fishery Act No 71 of 1992 & the related regulations
- Inshore Fishing Licensing Regulation
- Offshore (Distant Water & EEZ) Licensing Regulation

These measures include:

- A non-trawling zone of 0 – 5 nm from the coastline
- A trawl codend mesh size restriction of 44 mm for shrimping
- A vessel size restriction for inshore shrimping operation (23-25 m overall length and 130 Gross Registered Tonnage)
- The obligation to use Turtle Excluder Devices (TEDs) and other Bycatch Reduction Devices (BRDs).

The fisheries monitoring systems in place include:

- Shore-based observers that inspect catches, nets and others
- Submission of log books from captains
- Vessel monitoring system (VMS) is yet to take off - fully operational by the end of 2017. All vessels are to install transponders on their vessel on or before 31 May 2017
- Regular patrol by Nigerian Navy for illegal fishing and sometimes check for TEDs compliance

Angola

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The coastline length of Angola is about 1 650 km. Continental shelf area is about 51 000 square kilometres. Total marine landings in 2012 was 277 000 tonnes. The landings have increased from the 1990s but during last few years there has been no increase. Small pelagic fish are most important (about 50 percent) target species. Industrial and semi-industrial sectors land about 57 percent of the total marine catch – the rest comes from the artisanal fishery.

Industrial demersal trawling fleet target shrimp, deepsea red crab, lobster and various demersal fish species. There are about 25 licensed shrimp trawlers (shrimp mainly exported) and about 40 active finfish trawlers. Shrimp trawling is conducted near coast and exclusively uses bottom-contact fishing gear. Total demersal trawl landings in 2015 were about 90 000 tons. There is also a deepsea trawling fleet (not clear how many boats). Foreign fleets also operate in Angolan waters.

Stocks are mainly overexploited (except sardinella). The management measures include fishing effort controls, catch/landing limits (quotas), area restrictions (zoning), mesh size regulations and bycatch limits. Fishery monitoring system includes onboard observers and Vessel Monitoring System (VMS) which is recently introduced. In 2017, six vessels have been deployed to collect information on bycatch. There have been no studies on potential benthic impact of bottom trawling.

Namibia

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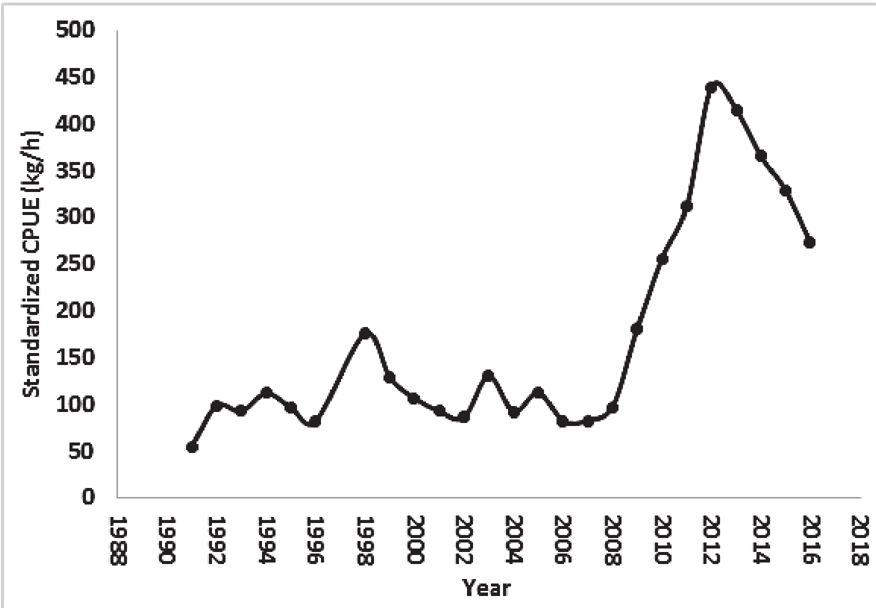
There are two main trawl fisheries in Namibia, those targeting hake (*Merluccius capensis* and *Merluccius paradoxus*) and those targeting monkfish (*Lophius vomerinius*). A third fishery targeting orange roughy (*Hoplostethus atlanticus*) has been on moratorium since 2008.

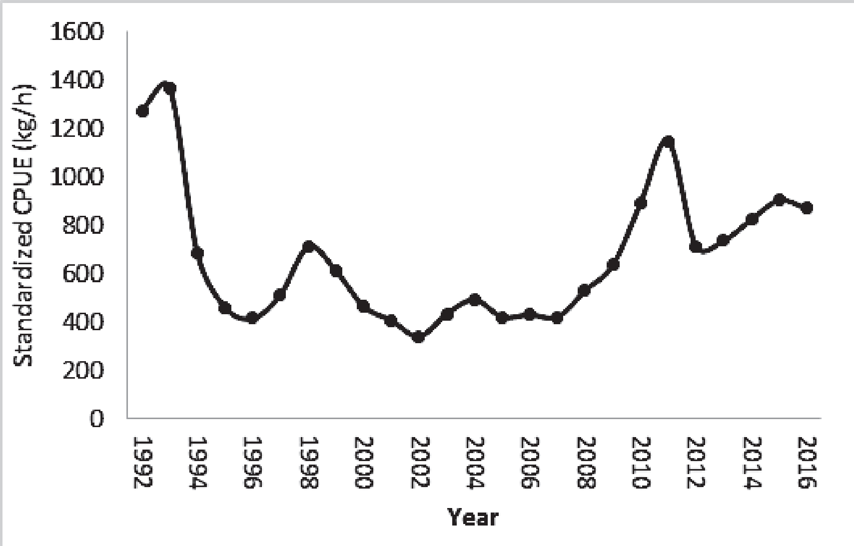
Monkfish fleet

The monk vessels fish mainly between 18°S and 28°S with little fishing south of 28°. In 2016, a total of 16 monkfish vessels were active on the fishing grounds operating for a total of 2 438 days. The vessels employ otter trawls and technical measures regarding fishing are regulated (see Technical Measures below). Catches are obtained mainly at depths of 320m-440m with a decreasing depth factor with increasing latitude. An average of *three* fishing tows are conducted per day lasting on average five hours per tow. The main fishing grounds in the past were on the south (<24°S) shallow (<350m) grounds however in recent years more effort is invested in the north shallow fishing regions. Standardized catch rates between 1991 and 2007 remained stable at around 100kg/h, however between 2008 and 2012, catch rates increased to 439 kg/h but have since declined to 272 kg/h in 2016.



Hake fleet

The most economically important species in Namibia are the hakes. The hake trawl fishery consists of two fleets, a wet-fish fleet and a freezer fleet. Freezer trawlers have processing facilities on board while wet-fish trawlers land their catches for further processing on shore. The TAC for the hake industry is apportioned between freezer and wet-fish vessels that currently limits freezer vessels to 30 percent of the TAC. This policy aims to increase onshore processing and thereby increase employment in the hake wet-fish sector. Both fleets cover the entire coast, while the most effort from both fleets are in the South Deep (>350m; <24°S). The number of vessels licensed to harvest hake fluctuates year to year; during the past few years it varied from 78 to 121 vessels. Hake vessels can spend an average total number of 15 000 days at sea with trawling dynamics similar to those of the monk trawls. Wet-fish vessels generally undertake shorter fishing trips, on average eight days per trip whilst freezer vessels stay on average 58 days. The figure below shows the standardized catch rates for hake.



Catch rates for the hake fishery have been relatively stable since 1996 increasing from 2008 onward.

Technical measures and monitoring

The management of the trawl fishery consists of a combination of exploitation rights, TACs, individual quotas (IQs), quota fees, bycatch fees, a number of technical measures, and a comprehensive MCS (Including VMS), logbook and observer system. Various technical measures are in place, first and foremost with the aim of protecting the hake resource and the environment. For instance, a bottom trawl may not have a codend mesh size under 110 mm, while area and time closures are used primarily to protect spawning grounds. All vessels have been banned from fishing within the 200 m depth line since the early 1990s in order to protect both the small pelagic stocks and juvenile hake. More recently this has been extended south of 25°. Since 2006 wet-fish vessels have been banned from fishing within the 300m isobath, and freezer vessels within 350 m, to protect juvenile hake. Since 2006, fishing for hake is not allowed during the month of October, once again to protect juvenile hake which are perceived to move offshore, and so become mixed with the adult fish at that time.

Bycatch

Information on bycatch in both trawl fisheries is poor or not published. Historically there have been estimates of bycatch in trawls based on research surveys, but data on commercial fisheries seems lacking. Namibia has a comprehensive observer programme (100 percent coverage) – dumping is not permitted and all bycatch must be retained. Some “trash” fish species are discarded with offal. The trawl fishery has a bycatch of around 30 species, most of which are retained (by law), although a few are informally permitted to be discarded with offal (e.g. rattails). The most significant bycatch species in the hake fishery are monkfish and kingklip and to a lesser extent snoek, dories, gurnards, horse mackerel, squid, and skates and rays. Vessels fishing deeper than 450 m also have a small bycatch of deepwater demersal species that include deepwater dories, orange roughy, black shark and cardinals.

Impacts of bottom trawling

Trawl impacts on benthos and substrate are sparse. Physical impacts are based on global research – there is an on-going research initiative by the Benguela Current Commission to determine physical impacts of trawl gear on substrate flora and fauna. The main impacts of trawl gear use on the habitat are therefore not adequately identified. Trawl gear is lost periodically when fouling underwater obstructions, although obstructions are therefore carefully plotted by skippers and so gear loss is not common. Although there is no clear management strategy on habitat protection, the ban on fishing inside the 200 m depth contour (300 m in the south), as well as a ban on using beam trawls, can be considered a partial strategy. With regard to information the main habitat types have been described (BCC).

South Africa

AN OVERVIEW OF THE DEMERSAL TRAWL FISHERIES

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The fisheries

Two demersal trawl fisheries currently operate in South African waters, both of which have inshore and offshore components that are to some extent managed independently. The first of these, the KwaZulu-Natal prawn trawl fishery, is a small fishery operating in a small area (2 200 km^2) on the KZN Bight. Effort in the fishery has declined appreciably in recent years, with only two vessels operating during 2016, and consequently will not be discussed further in this report (further information can be found in Everett, 2014). The second is the hake trawl fishery, currently the most valuable fishery in South Africa, which directly employs more than 7 000 people (Lallemand *et al.,* 2016). The fishery has been certified by the Marine Stewardship Council since 2004, which has yielded appreciable economic benefits to the fishery as well as being a driver of research and management aimed at minimising the ecosystem impacts of the fishery. A notable development has been the "freezing" of the trawl footprint, first implemented by the fishery as a voluntary measure in 2008, and then formally implemented as a regulatory measure in permit conditions in 2015 (Figure 19).

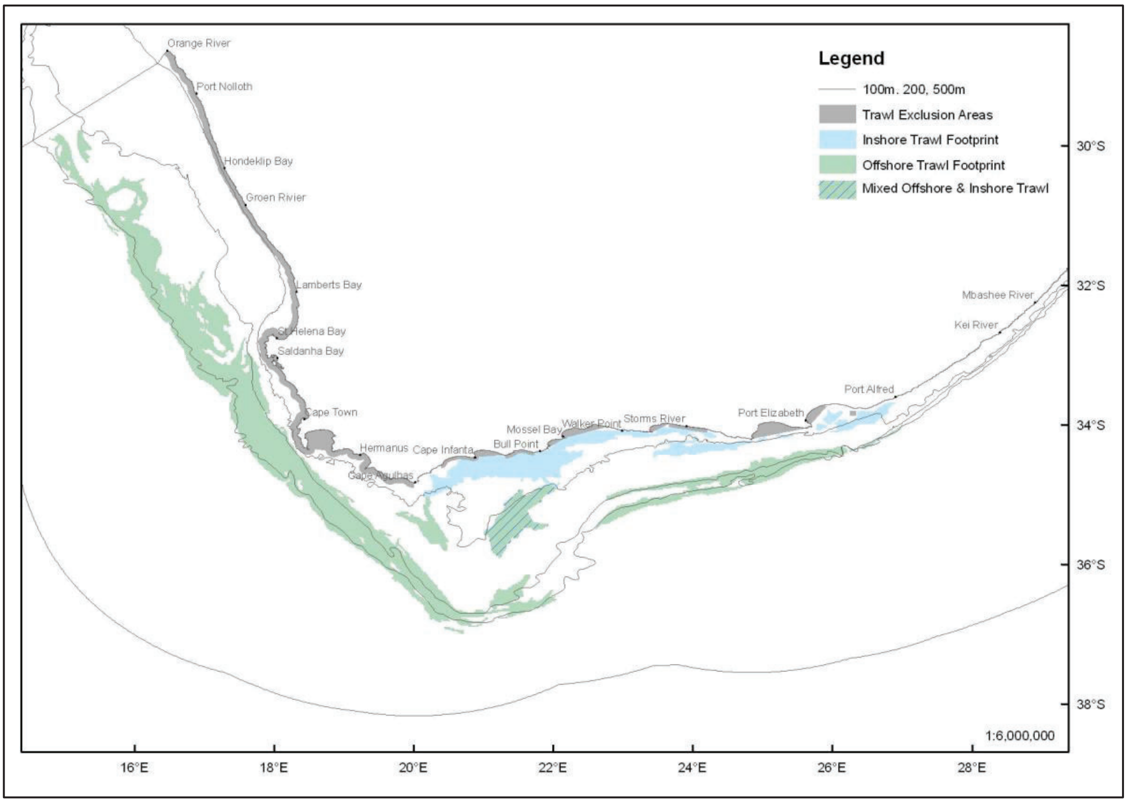

Figure 19. The South African hake trawl "footprint" (no demersal trawling outside of the areas indicated with green/blue shading) and trawl exclusion areas (no demersal trawling in the areas indicated with grey shading). Mapped by Wilkinson and Japp (2008), and figure taken from Sink *et al*. (2012).

Both inshore and deepsea sectors use otter trawl gear. Vessels in the inshore trawl sector are "wet-fish" vessels, with minimal processing on board and the fish are stored on ice until landing. The deepsea trawl sector comprises both wet-fish and freezer vessels, the latter having factories on board that are capable of variable degrees of processing and freezing of fish products. Details of the fishery are provided in Table 4.

Table 4: Details of the South African hake trawl fishery

	INSHORE	DEEPSEA
Number of vessels in 2015	15	Wet-fish: 32 Freezer: 28
Number of drags in 2015	9 608	38 450
Vessel length	14–35 m	Wet-fish: 23–61 m Freezer: 30–90 m
Vessel engine(s)	Restricted to ≤ 900 hp	Wet-fish: 1 799–2 991 hp Freezer: 1 000–4 500 hp
Vessel tonnage	50–200 t	Wet-fish: 95–1 100 t Freezer: 500–2 500 t
Mean door spread	60 m	170 m
Mean trawling speed	2.8 knots	3.5 knots
Mean days at sea per trip	5.31	Wet-fish: 5.13 Freezer: 19.14
Mean tows per day	3.71	Wet-fish: 3.22 Freezer: 3.09
Mean tow duration (hrs)	3.23	Wet-fish: 2.83 Freezer: 3.25
Mean fishing depth	100 m	Wet-fish: 265 m Freezer: 386 m
Minimum mesh size	75 mm (sole-directed fishing) 90 mm (hake-directed fishing)	110 mm
Bobbins, rollers, discs	< 375 mm, < 200 kg	< 750 mm, < 200 kg
Beam trawls and twin trawls	Prohibited	Beam trawls prohibited, twin trawling permitted but rare
Codend liners	Prohibited	Prohibited
Bird-scaring (tori) lines	Mandatory	Mandatory

The number of vessels active in the deepsea trawl sector since 1983 has fluctuated between 50 and 82 per annum (Figure 19). The peak in the number of active vessels (and number of tows completed) in 2003 to 2005 reflects the increases in the hake TAC arising from the recovery of the resource after the over-exploitation of the 1960s and 1970s. The subsequent decline to about 50 vessels in 2011 resulted from decreases in the hake TAC in response to several years of below average recruitment. The number of vessels in the inshore trawl sector has declined steadily over time (Figure 19), largely due to the high costs of replacing vessels coupled with uncertainty in future long term fishing rights allocations. The number of tows conducted by the inshore trawl sector each year remained relatively stable at about 20 000 tows per annum up until about 2005, following which effort declined to less than 10 000 tows in 2015 (Figure 19), primarily due to the reduced number of active vessels.

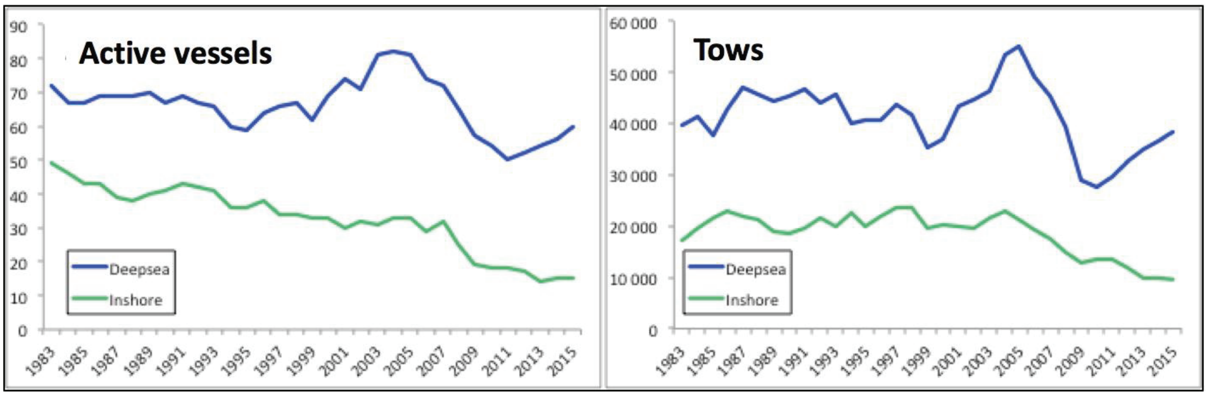

Figure 19. Time series of the numbers of active vessels and tows completed per annum by the two sectors of the SA hake trawl fishery 1983 – 2015.

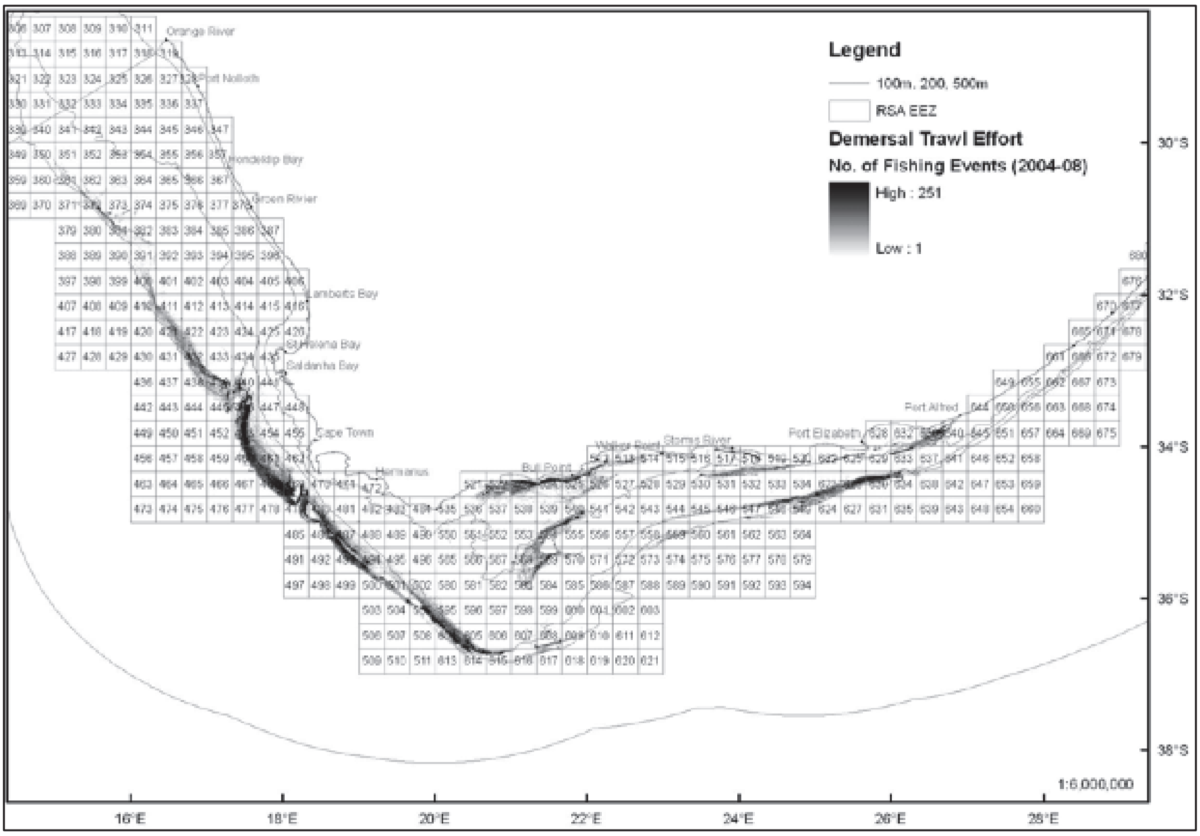

Figure 20. The distribution of the SA hake trawl fishery effort as determined by the number of tow start positions recorded on a 1 by 1 nm resolution for the years 2004 to 2008. Data obtained from DAFF commercial logbook records. Figure taken from Sink *et al*. (2012).

Trawl effort by the deepsea sector is typically concentrated along the shelf edge (Figure 20), whereas the inshore trawl fishery generally operates in the inshore areas of the Agulhas Bank on the South Coast. An area in the middle of the Agulhas Bank ("the Blues") is fished relatively frequently by both sectors (see Figure 19). Work on quantifying the spatial distribution and intensity of SA trawling effort was conducted during the Trawling Best Practice ("TBP") workshop run in Cape Town, South Africa in May 2015. The data used were records of individual tows (start and end coordinates) conducted during the period 2008-2013 with accompanying average gear width information. These data enabled calculation of the area swept by each tow, the swept area ratio (proportion of the area swept within each cell relative to the total area of the cell) as well as the total area that is trawled 0, 0-1, 1-2 and more than 2 times per annum (Figure 21). The analyses conducted during the workshop demonstrated the benefits of data being available at the finest spatial resolution possible (Figure 22).

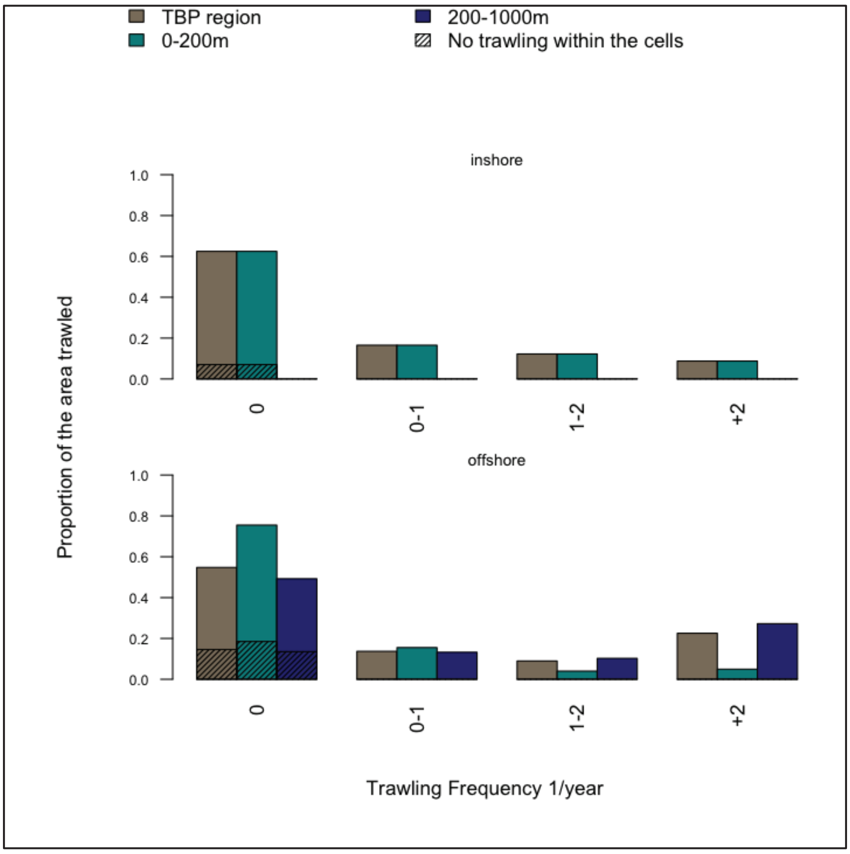

Figure 21. Distribution of trawling coverage within the inshore and offshore (deepsea) components of the trawl footprint for the footprint as a whole ("TBP region", brown bars), for the area between 0 and 200 m depth within the footprint (green bars) and the area between 200 m and 1 000 m depth within the footprint (blue bars). The 0 category aggregates the area of the cells for which no effort was recorded (dashed area) plus the fraction of the area untrawled for those cells where the mean swept area ratio was lower than 1 (calculated assuming an uniform distribution; open area). Figure provided by Ricardo Amaroso (University of Washington).

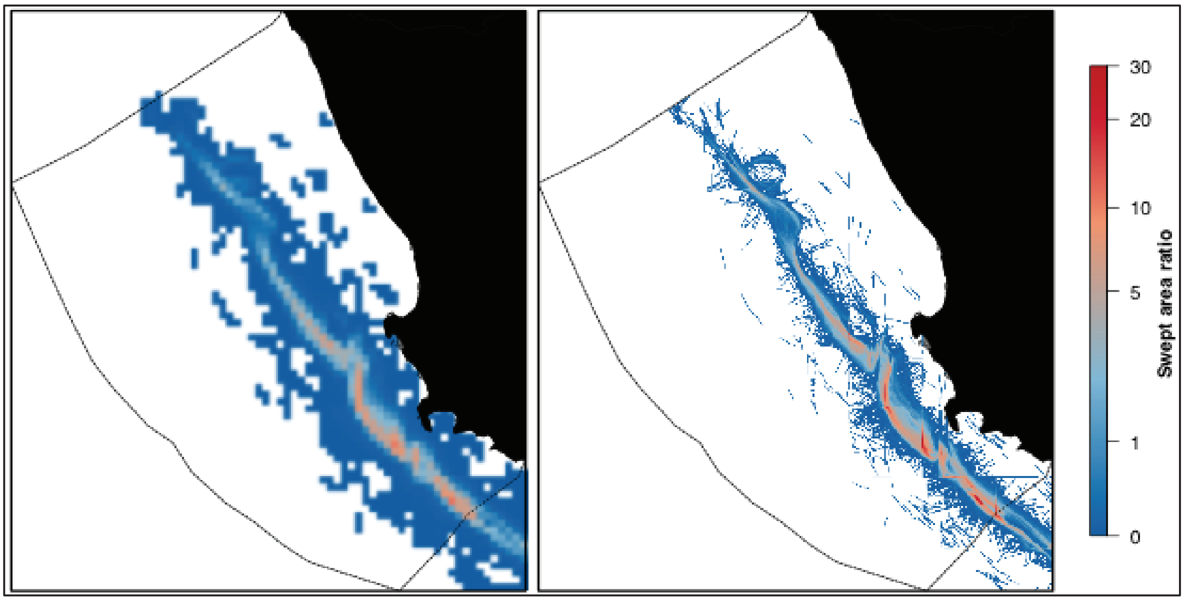

Figure 22: Comparison of low (10 km^2, left panel) and high (1 km^2, right panel) resolution gridding of the SA hake trawl fishery swept area ratio on the South African West Coast. Figure provided by Ricardo Amaroso (University of Washington).

Total landings by the deepsea trawl sector have fluctated between 155 000 t and 220 000 t per annum since 1983 (Figure 23) with the landings being dominated by the two hake species, although appreciable amounts of horse mackerel (*Trachurus capensis*) and to a lesser extent monkfish (*Lophius vomerinus*) and kingklip (*Genypterus capensis*) are also landed as bycatch. All three of the latter species are regulated with a Precautionary Upper Catch Limit (PUCL). Note that in this report, "bycatch" is considered to encompass catches of all non-target species (i.e. anything other than the two species of hake and Agulhas sole), and therefore includes both retained bycatch (often referred to as "joint product") as well as all discards.

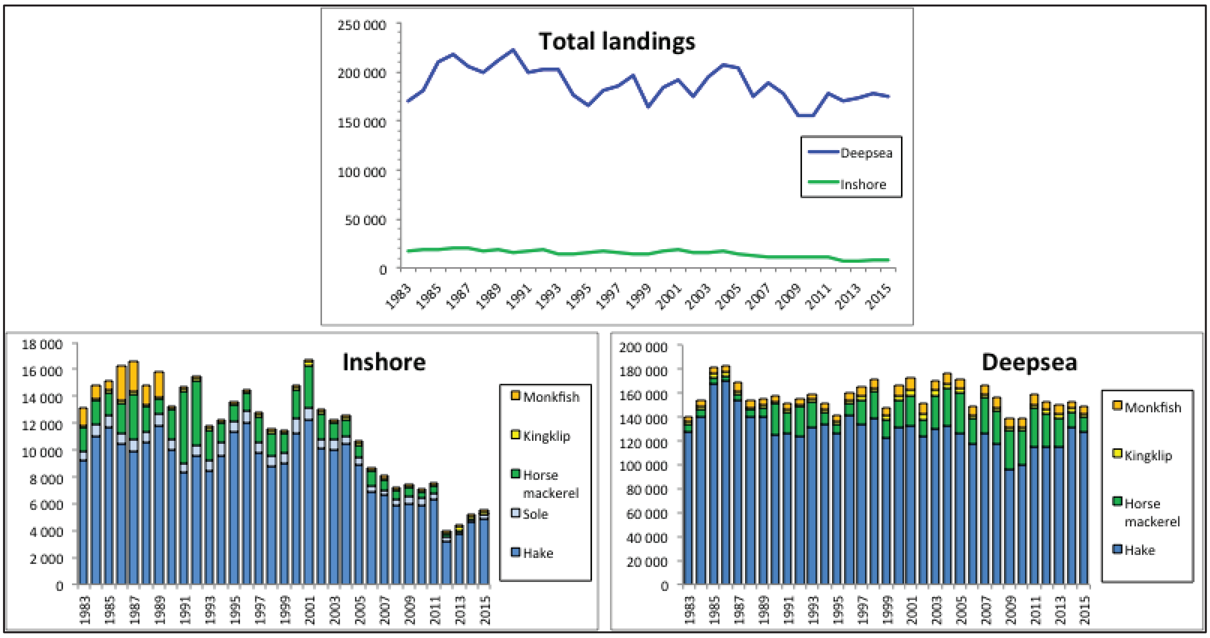

Figure 23: Landings by the SA hake trawl fishery 1983–2015. The upper panel illustrates a time series of total landings (tons) by the two hake trawl sectors, while the lower panels illustrate a time series of landings (tons) of key species for each sector.

Total landings by the inshore trawl sector have declined from about 19 000 t per annum in the late 1980s to less than 9 000 t per annum since 2012 (Figure 23), largely as a result of the decline in the number of active vessels mentioned above. Landings by the inshore sector are also dominated by hake, with horse mackerel and monkfish as the major retained bycatch species. Landings of Agulhas sole have typically been between 600 and 950 t per annum, although a gradual decline has been apparent since the mid-2000s.

Information on bycatch and discards is available from scientific observer data collected during a government-funded observer programme that ran from July 2002 to March 2011 in both inshore and deepsea sectors, and more recently from an industry-funded programme that has been running since 2006 in the deepsea sector. A short-term (2 months) programme was implemented in the inshore sector in 2016.

Attwood *et al.* (2011) analysed scientific observer data collected from the inshore trawl sector over the period 2003 to 2006, and estimated that 41 percent of the total inshore trawl catch (by weight) was bycatch and about 16.2 percent was discarded. Although 137 species were recorded from the catches over that period, the bulk of the catch (98 percent) comprised only 20 species. The target species (hakes and Agulhas sole) comprised 60.7 percent of the catch, while an additional 9.5 percent of the catch comprised the managed bycatch species (horse mackerel, monkfish and kingklip). Using scientific observer data collected from the deepsea trawl sector over the same period, Daneel and Attwood (2012) observed that 170 species were caught, with 38 species contributing to 95 percent of the total catch (by weight). These authors estimated that 27 percent of the deepsea trawl catch was bycatch. Analyses of more recent scientific observer data collected largely from the deepsea trawl fleet over the period 2008 to 2013 (Attwood 2015) indicated bycatch rates of between 12 percent and 16 percent by weight, with a total of 92 species appearing in the catches, but only 10 species (5 of which are managed bycatch limits) contributing to 99 percent of the catch. The differences between the estimates from the two time-periods (2003 to 2006 and 2008 to 2013) were largely attributed to the smaller number of trawls observed in the latter period (6 064 in contrast to the 12 491 trawls observed during 2003 to 2006), although a gradual increase in hake abundance, a decrease in abundance of other species or a shift in effort from shallow to deeper grounds were also suggested as possible reasons.

Management

The primary management measure in the hake trawl fisheries is the hake Total Allowable Catch (TAC). This is a "global" catch limit set annually for all fisheries targeting hake (primarily the hake trawl sectors, but also hake-directed longline and handline fisheries), and is set using an Operational Management Procedure based on a suite of annually updated assessment models. The hake TAC is divided among Right Holders according to proportions determined during long-term rights allocations (10 years for the inshore trawl sector and 15 years for the deepsea sector). A TAC of Agulhas sole in the inshore trawl sector is also set each year.

Further management measures are:

- Precautionary Upper Catch Limits (PUCLs) set for key bycatch species (horse mackerel, monkfish and kingklip), based on stock assessments of these resources
- "Move-on" rules and proportional landing limits placed on other bycatch species
- Restrictions on vessels and gear (see Table 4)
- Effort management (sea-day restrictions imposed on each vessel according to amount of hake quota "placed" on the vessel)
- Spatial management (no fishing outside the trawl footprint, no fishing in Marine Protected Areas, the spatial limits placed on the trawl fishery as described above and a time-area closure on the South Coast to protect a kingklip spawning aggregation).
- Mandatory deployment of bird scaring lines during fishing operations to minimise seabird mortalities.

Monitoring

- Annual demersal research surveys to monitor abundance and distribution of demersal fish species (since 1985) and benthic epifauna (since 2011).
- Shore-based monitoring of all landings by inspectors and monitors.
- Mandatory submission of logbooks (tow-level catch and effort data) by skippers after each fishing trip.
- Mandatory use of the Vessel Monitoring System (VMS) by all vessels in the hake trawl fleet.
- At-sea monitoring for compliance by the DAFF Environmental Protection Vessel fleet (3 inshore vessels and 1 offshore vessel)
- Monitoring of bycatch by scientific observers.

Benthic impacts

Research and available information/data for evaluating and managing the impacts of the SA hake trawl fleet on benthic habitats and biota are listed below:

- A comparative study of heavily and lightly trawled areas on the SA West Coast (and one site in southern Namibia) conducted by Dr. L.J. Atkinson (currently at the South African Environmental Observation Network, SAEON). The raw data collected during this research are available from Dr. Atkinson (lara@saeon.ac.za), and results of these data analyses are provided in Atkinson (2009), Atkinson *et al.* (2011a and 2011b), Atkinson *et al.* (2012) and Fleddum *et al.* (2013).
- A controlled experiment (the "Benthic Trawl Experiment") using the "press and release" approach of Kaiser *et al.* (2012) is currrently being conducted on the SA West Coast. A previously trawled area has been divided into 5 lanes, and following an initial (baseline) survey in 2014, three of the lanes have been closed to further trawling. All five of the lanes have subsequently been annually re-surveyed using a towed underwater camera (fish and epifauna) and van Veen grab (infauna and sediments). This project forms part of the MSC certification benthic habitats condition and a final report is expected in 2018. While data from this experiment are not available as yet, further information can be obtained from Dr. Atkinson (SAEON).
- Evaluation of the impacts of the SA hake trawl fishery on benthic habitats has been documented by Japp and Wilkinson (2005) and more recently by Sink *et al.* (2012) in reports commissioned by the South African Deep-Sea Trawling Industry Association. Maps of the distribution of habitat types that have most recently been developed for the 2011 National Biodiversity Assessment are available as shape files from the website of the South African National Biodiversity Institute (http://bgis.sanbi.org/nba/project.asp). In addition to providing a comprehensive review of the SA hake trawl fishery and gaps in knowledge concerning benthic impacts of the fishery, Sink *et al.* (2012) used these maps to evaluate the extent of each habitat that is impacted by demersal trawling. An earlier report (Sink and Samaai 2008) mapped the potential Vulnerable Marine Ecosystems in South Africa's offshore environment and discussed the interaction of the fishery with these sensitive ecosystems.
- Sink *et al*. (2013) advanced this work with a spatial management proposal (specifically a suite of proposed closed areas aimed at protecting a representative network of habitat types impacted by demersal trawling), which forms part of a larger network of proposed Marine Protected Areas that have been Gazetted for public comment through the South African Presidential initiative (Operation "Phakisa") that is aimed at developing South Africa's blue economy.
- A study using recently digitised historical scientific demersal trawl survey data collected over the period 1903 to 1904 is being conducted by J. Currie (Ph.D. candidate, University of Cape Town). The research aims to evaluate changes in demersal fish communities from a period prior to the onset of commercial/industrial fishing to the present and to establish pre-industrial baselines. Data are not available as yet.

- Fishery-independent demersal research surveys have generally been conducted annually since 1985. The surveys are primarily aimed at monitoring the abundance and distribution of key commercially exploited fish species, and the data are crucial inputs to the stock assessments routinely conducted for these species. The surveys use a swept area approach to estimate abundance within a stratified pseudo-random sampling design. Surveys are conducted separately on the West and South Coasts (typically in summer and autumn respectively), and aim to sample 100 – 125 sites during each survey. Prior to 2011, the survey area encompassed the continental shelf to the 500 m isobath, but this has subsequently been extended to the 1 000 m isobath. Benthic epifauna have been routinely monitored since 2011 and the data incoporated into the DAFF research database (a field species identification guide is surrently being developed for publication). Trawl and fish catch composition data are available from DAFF (contact Dr. M.D. Durholtz, DeonD@daff.gov.za), while the benthic epifauna data are available from SAEON (contact Dr. L.J. Atkinson, lara@saeon.ac.za).

References

Atkinson, L.J. (2009): Effects of demersal trawling on marine infaunal, epifaunal and fish assemblages: studies in the southern Benguela and Oslofjord. *Ph.D. thesis, University of Cape Town, South Africa.* 141 pp.

Atkinson, L.J., Leslie, R.W., Field, J.G. and Jarre, A. (2011a): Changes in demersal fish assemblages on the west coast of South Africa, 1986–2009. *African Journal of Marine Science* 33(1): 157 – 170.

Atkinson, L.J., Field, J.G. and Hutchings, L. (2011b): Effects of demersal trawling along the west coast of southern Africa: multivariate analysis of benthic assemblages. *Marine Ecology Progress Series* 430: 241 – 255.

Atkinson, L.J., Jarre, A., Shannon, L.J. and Field, J.G. (2012): Evidence for Shifts in Demersal Fish Populations on the West Coast of South Africa: 1986 to 2009. In: G.H. Kruse, H.I. Browman, K.L. Cochrane, D. Evans, G.S. Jamieson, P.A. Livingston, D. Woodby, and C.I. Zhang (eds.), "*Global Progress in Ecosystem-Based Fisheries Management"*, pp 45 - 64. Alaska Sea Grant, University of Alaska Fairbanks. (doi:10.4027/gpebfm.2012.03).

Attwood, C.G., Petersen, S.L. and Kerwath, S.E. (2011): Bycatch in South Africa's inshore trawl fishery as determined from observer records. *ICES Journal of Marine Science* 68(10): 2163 – 2174.

Attwood, C.G. (2015): Preliminary investigation into patterns of bycatch in the Hake-trawl fishery as determined from observer records: 2008 to 2013. *Unpublished report prepared for the South African Deepsea Industry Trawling Association.* 6pp.

Collie, J., Hiddink, JG, van Kooten, T, Rijnsdorp, AD, Kaiser, M., Jennings, S, Hilborn, R. (2016). Indirect Effects of Bottom Fishing on the Productivity of Marine Fish. Fish and Fisheries, DOI: 10.1111/faf.12193.

Daneel C. and Attwood, C.G. (2013) Bycatch in South Africa's offshore trawl fishery as determined from observer records. *Unpublished report prepared for South African Deep Sea Industry Association.* 45 pp.

Everett, B.I. (Ed.) (2014): Marine and estuarine fisheries along the KwaZulu-Natal coast: An inventory and brief description. *Oceanographic Research Institute Special Publication No. 11.* 106 pp. (ISBN 978-0-620-64146-3).

Fleddum, A., Atkinson, L.J., Field, J.G. and Shin, P. (2013): Changes in biological traits of macro-benthic communities subjected to different intensities of demersal trawling along the west coast of southern Africa. *Journal of the Marine Biological Association of the UK* 93(8): 2027 - 2038.

Lallemand, P., Bergh, M., Hansen, M. and Purves, M. (2016): Estimating the economic benefits of MSC certification for the South African hake trawl fishery. *Fisheries Research* 182: 98 – 115.

Sink, K.J. and Samaai, T. (2008) Identifying Offshore Vulnerable Marine Ecosystems in South Africa. *Unpublished report, South African National Biodiversity Institute, Pretoria.* 29 pp.

Sink, K.J., Wilkinson, S., Atkinson, L.J., Sims, P.F., Leslie, R.W. and Attwood, C.G. (2012): The potential impacts of South Africa's demersal hake trawl fishery on benthic habitats: historical perspectives, spatial analyses, current review and potential management actions. *Unpublished report, South African National Biodiversity Institute, Pretoria.* 75 pp.

Sink, K.J., Wilkinson, S., Atkinson, L.J., Leslie, R.W., Attwood, C.G. and McQuaid, K.A. (2013): Spatial management of benthic ecosystems in the South African demersal trawl fishery. *Unpublished report, South African National Biodiversity Institute, Pretoria*. 22 pp.

Wilkinson, S. and Japp, D. (2005): Description and evaluation of hake-directed trawling intensity on benthic habitats in South Africa. *Unpublished report prepared for the South African Deepsea Trawling Industry Association, Capricorn Fisheries Monitoring cc, Cape Town*. 69 pp.

Mozambique

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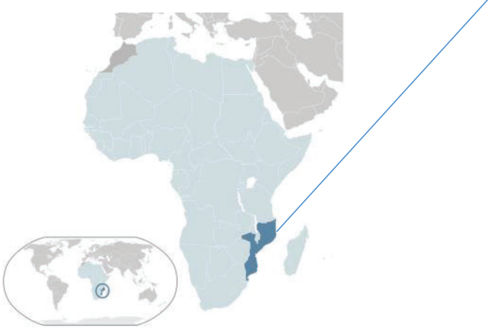
Introduction

Mozambique is located in South-eastern Africa with a coast stretching for 2 470 km and a marine shelf area of 103 400 square km. The marine habitats along the entire coastline harbour a variety of marine organisms.



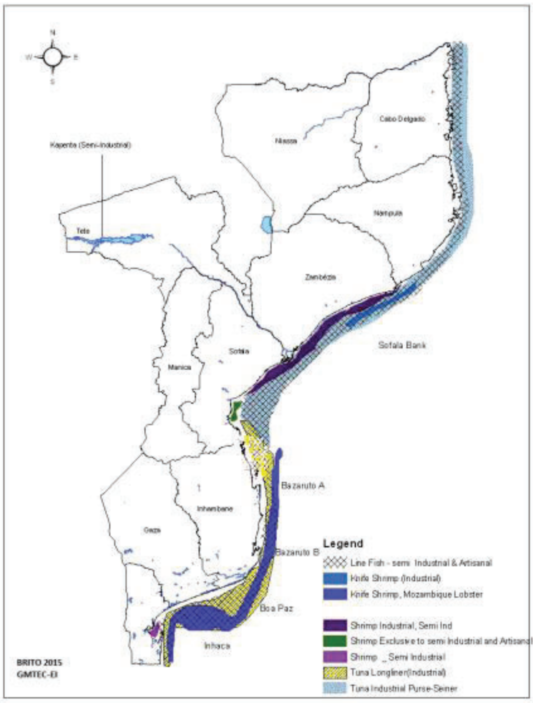


Figure 24. Mozambique location and coastline
Source: Ministério do Mar, Aguas Interiores e Pescas, Instituto de Investigação Pesqueira, Maputo, Mozambique

In Mozambique the bottom trawling fisheries operate in three main fishing grounds: Shallow water Shrimp fishery in Sofala Bank (Central Mozambique) and Maputo Bay (Southern Mozambique); Deepwater crustacean fishery along the Mozambican coastline operating in the deep waters of the continental shelf of Mozambique.

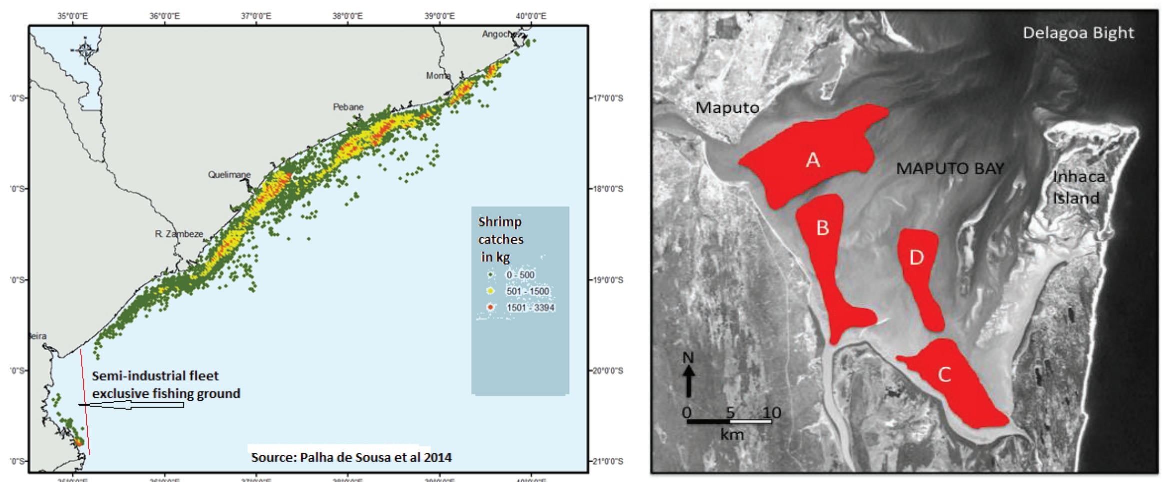


Figure 25. Fishing grounds for shallow-water shrimp In Sofala Bank and Maputo Bay
Source: Ministério do Mar, Aguas Interiores e Pescas, Instituto de Investigação Pesqueira, Maputo, Mozambique

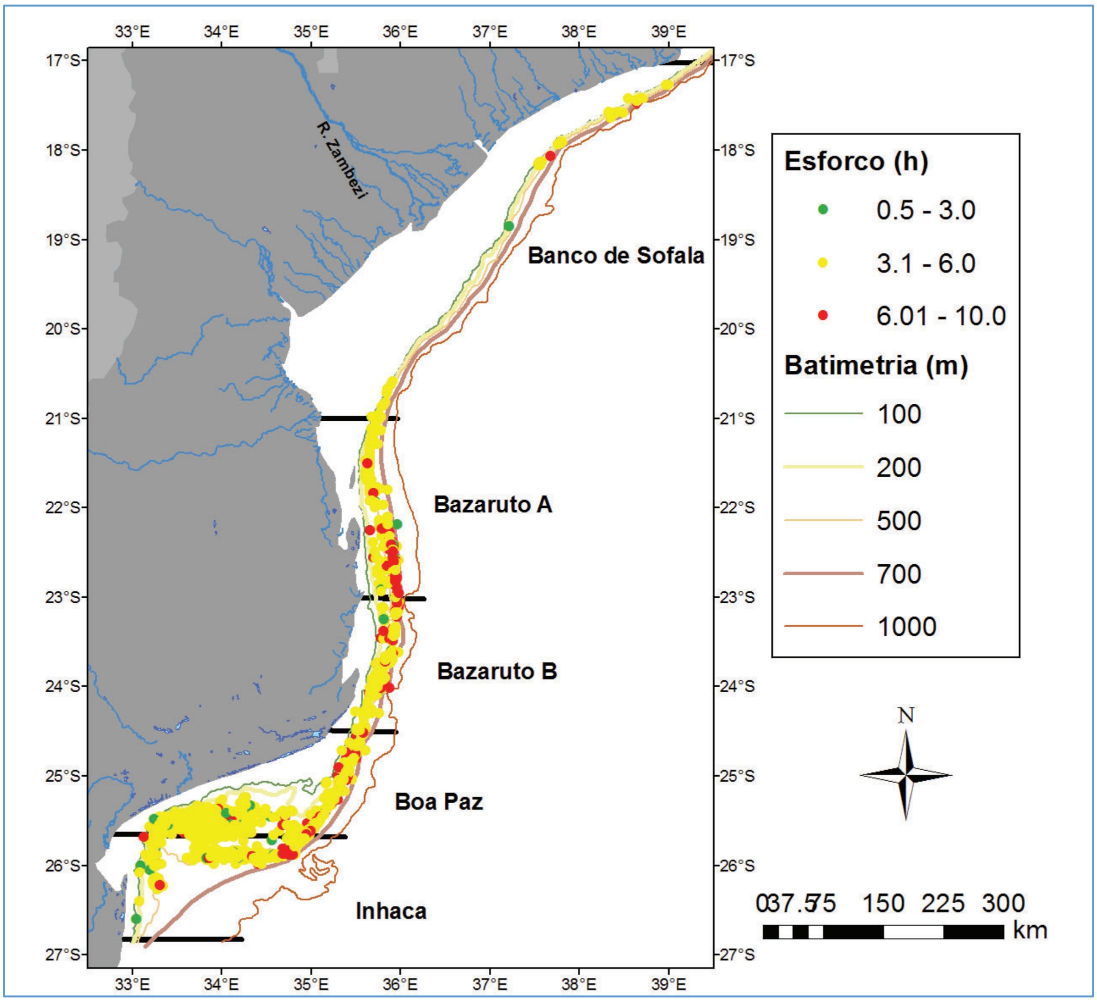


Figure 26. Fishing grounds for Deepwater Crustacean

Fishery description

The artisanal sector is the largest catching sector, operating with vessels less than 10 m in length throughout the coastline and contributing around 90 percent of annual landings which are composed of a variety of fish, crustaceans and molluscs. Shrimps taken by artisanal sector through beach seines has been growing and currently is estimated at around 50 percent of the total weight. Over 10 000 units of beach seines have been recorded in the entire country, although there are other fishing gears.

Semi-industrial trawl fishery uses vessels ranging from 10 m to 20 m in length, and preserves catch on ice. This fleet targets primarily shrimps of two main species *Penaeus indicus* and *Metapenaeus monoceros* in two main fishing grounds: the Sofala Bank off central Mozambique and the Maputo Bay to the south of the country. Currently this fleet contribution to the total landings is less than 20 percent and its capacity has been decreasing with around 43 vessels operating in total due to obsolete vessels.
The industrial shrimp trawling sector has been open since the early 1960's and has developed to a fleet peak of 95 vessels in mid-1980s but has now been reduced to around half of that due to depletion of stocks. These are freezer vessels with more than 20 m in length and operate for seasons of 6.5months - 7 months. Similar to the semi-industrial, this fleet primarily targets shrimps of two main species *Penaeus indicus*, *Metapenaeus monoceros* and *Penaeus monodon* in shallow waters, but also fishes deeper water species

such as *Penaeus semisulcatus*, *Penaeus latisulcatus* and *Penaeus japonicus*. This fishery lands around 5 000 tonnes of shrimp in recent years which is exported primarily to the European Union and Asia. The industrial fishery employs nets in two basic versions, namely the single-net trawl and quad-rig trawls, which are associated with large amounts of bycatch that represents around 70 percent-80 percent of the catch. At least 71 percent of the bycatch is discarded.

There is also a deepwater industrial crustacean trawl fishery with around 22 vessels. They target species that include knife prawns (*Haliporoides triarthrus*), landing around 1 800 tons per year, and langoustines (*Metanephrops mozambicus* and *Nephropsis stewartii*), deepsea red crab (*Chaceon macphersoni*), and deepwater lobster (*Palinurus delagoae*).

Catch composition

Total landings have been estimated at 254 000 tons in 2014 with crustaceans being the most economically important for the country. Three fleet sectors operate in Mozambique which use bottom trawling: artisanal, semi-industrial and industrial. Figure 27, below show landings of shallow water and deep water bottom trawl fisheries.

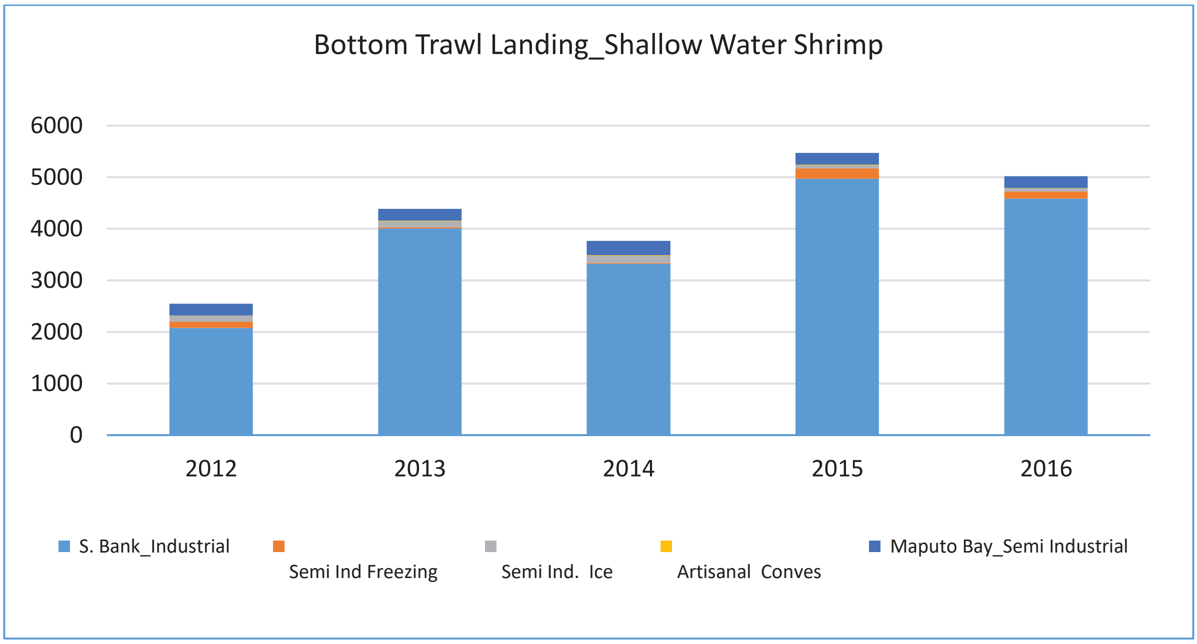


Figure 27. Landings of shallow water shrimp in Sofala Bank

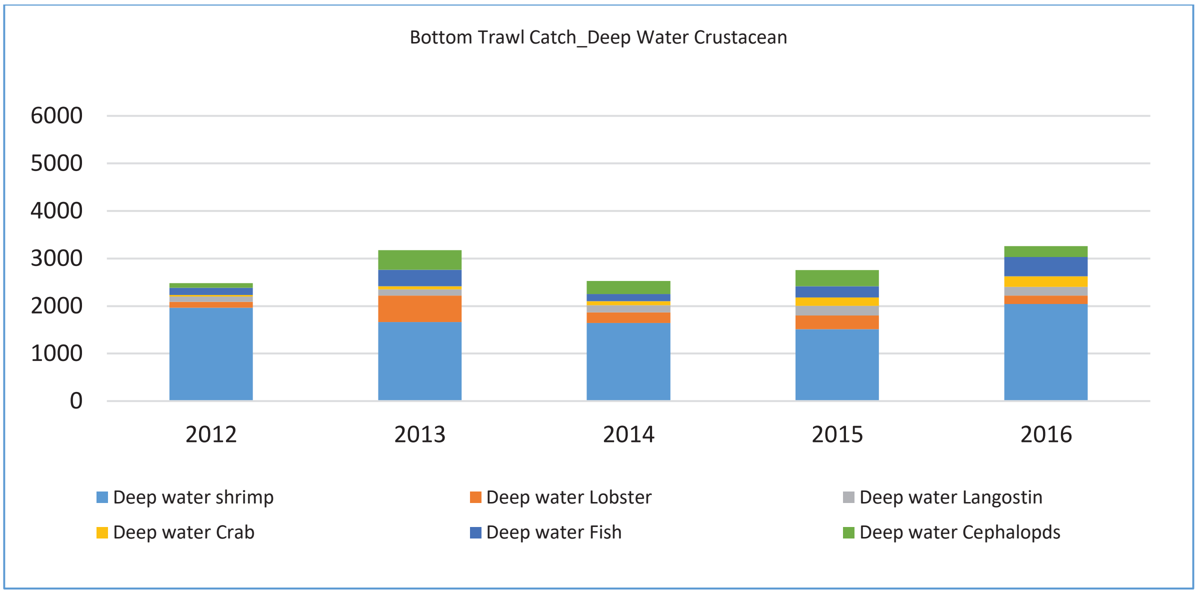


Figure 28. Landings of Deep water crustacean Fishery in Mozambique

Catch retained vs discarded

For the bycatch related to bottom trawl fisheries, about 70 percent are discarded and only about 30 percent are retained for commercial purpose (Figure 29). Bycatch of the fishery includes many fish (including sharks) and cephalopod species, of which some are retained, but most are discarded at sea.

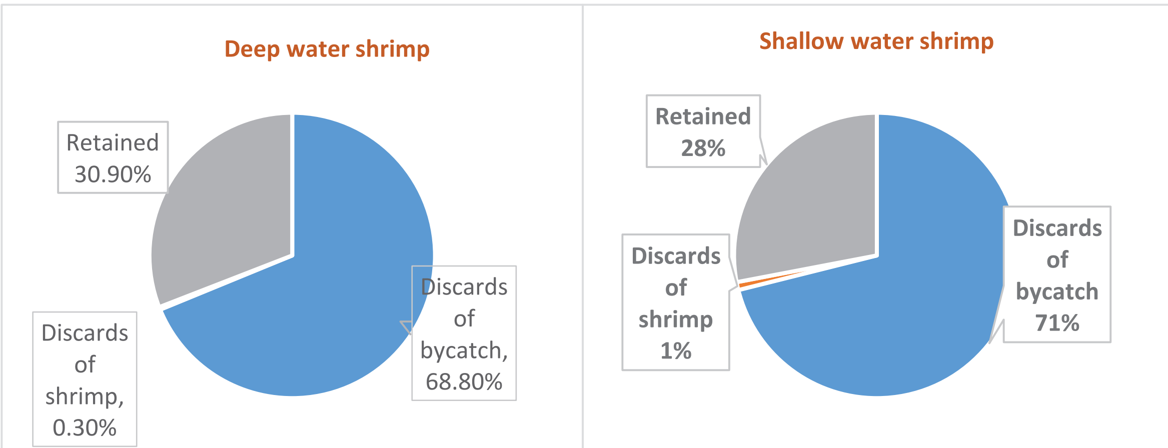


Figure 29. Catch retained versus discards

Stock status

SW Shrimp Sofala bank	2012-2013	2014-2015	Source
Indian White shrimp (Penaeus indicus) speckled shrimp *Metapenaeus Monoceros*	Overfished	Overfished	IIP, 2014; Palha de Sousa *et al.*, 2016
DW Shrimp (Gamba)			
knife shrimp (*Haliporoides triarthus*), giant red shrimp *(Aristeomorpha foliacea)*	Fully Exploited	Fully Exploited	IIP, 2014; Dias, 2016
SW Shrimp (Maputo bay)			
Indian white shrimp (*Penaeus indicus*)	Fully Exploited	Overfished	IIP, 2014; Samucidine *et al* ., 2015

Management

The fishery for shrimps in Sofala Bank is subject to a seasonal closure annually that is aimed at protecting the recruitment of the main species *P. indicus* juveniles from the estuarine waters. This closed season was expanded in 2008 from previously three to currently six months, and takes effect from September or October to February or March, resulting in a shorter fishing season, as a tool to help control effort and soaring operating costs. The industrial and semi-industrial shallow water shrimp fishery is managed at the national level and as such there are no administrative or local boundaries (province or district) and specific roles of the local authorities except if delegated.

Monitoring

- Mandatory submission of logbooks (catch and effort data) by skippers after each fishing trip.
- Monitoring of bycatch by scientific observers.
- Annual demersal research surveys to monitor abundance and distribution of shallow water crustaceans in Sofala Bank.
- Shore-based monitoring of landings by inspectors and monitors.
- Mandatory use of the Vessel Monitoring System (VMS) by all trawl fleets in Industrial and Semi Industrial Fisheries.
- At-sea monitoring.

Table 5. Availability and applicability of data

Type of data	Availability	How	Who involved
Fleet description	Yes	Licences, Loogbooks	ADNAP, IIP
Effort Information	Yes	Loogbooks, Onboard Observers, VMS	ADNAP, IIP, MIMAIP
Spatial distribution of effort	Yes	Loogbooks, Onboard Observers, VMS	IIP MIMAIP
Catch landing quantity	Yes	Comercial Production, Loogbooks	ADNAP, IIP
CPUE Data	Yes	Loogbooks	IIP
Landing composition	Yes	Comercial Production, Loogbooks	ADNAP, IIP
Bycatch	Yes	Loogbooks, Onboard Observers, Research Surveys	IIP
Sediment data	Partial	Research Surveys	IIP
Hatitat mapping	Partial	Research Surveys	IIP
Regulation that can minimize seabed impacts	No		

Kenya

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The semi-industrial prawn trawl fishery within the Malindi-Ungwana Bay is the most important commercial bottom trawl fishery in Kenya. The fishery began after FAO/GOK surveys of the 1960s and 1970s which showed the existence of shallow water prawn stocks within the bay. Every year, between 4 and 20 medium semi-industrial trawlers have operated in the area since trawling began. The main targeted species are five shallow water penaeid shrimp species: *Fenneropenaeus indicus, Penaeus monodon, Metapenaeus monoceros, Penaeus semisulcatus* and *Penaeus japonicus* that contribute approximateley 46 percent, 21 percent, 20 percent, 12 percent, and 1.3 percent to the total landing respectively. The annual prawn landings vary between 300 Mt and 650 Mt annually, which are mainly exported. The fishery is also associated with about 400-670 MT fish bycatch annually, which contributes directly to fish consumption at the coast. The fishery was closed in 2006 after experiencing management challenges around the issues of the perceived destruction of the sea bottom habitat, waste of the bycatch, killing of species of special concern (mainly turtles), contributing to declining small-scale catches (fish and prawn) and resource use conflicts involving the shared fishing grounds with small-scale fishers leading to destruction of fishing gear, and contravention the fishery regulation of 5 nm off shore.

The fishery was re-opened in 2010 under a new Prawn Fishery Management Plan developed through consultations among stakeholders aimed at reducing the impact of the fishery on the sea bottom habitat, reduction and use of bycatch, and increasing the benefit of the fishery to the fishing community around the bay. The key regulations in the plan include the mandatory use of TED to reduce bycatch, mandatory fishery observers onboard the vessels, mandatory use of VMS, an annual closed season between 1 November and 31 March the following year, trawling restriction to between 6 am and 6 pm only to reduce incidence of destruction of small-scale fishing gear, the changed trawling limit from below 5 nm to 3 nm where most of prawns biomass occur, complete elimination of discards to ensure all bycatch is landed for consumption, development a benefit-sharing mechanism for the community, a review of prawn export tax earnings to increase revenue from the fishery. The fishery has attracted between one and three trawlers since 2011.

The fishery is monitored by logbook landing data and scientific fishery observers onboard the fishing vessels. A newly installed VMS system starting 2017 will be an important addition to the monitoring of the fishery. Analysis of the total catch records generated by the industry showed lower landings ranging from 20 000 Mt to 213 000 Mt after the fishery was re-opened (2011-2016) compared to 90°000 Mt-550 000 Mt (2011 and 2016). However, the landed catch to bycatch ratio improved from 0.6-2.4 to 1.8-6.9 after the implementation of the fishery management plan. Mapping of the distribution of fishing operations shows that about 42 percent of the catch is used below the 3 nm trawling limit. Data Gaps include the effect of trawling on bottom environment. Availability and applicability of data on habitats, benthos, bycatch and ecosystem impacts of bottom trawl fishing.

Tanzania

An Overview of Demersal Trawl Fishery in Tanzania
Baraka Kuguru.
Tanzania Fisheries Research Institute, P.O. Box 9750, Dar es salaam, Tanzania.

Tanzania bottom trawling is mainly semi-industrial in nature with vessel lengths ranging from 24 to 35 m, and engine sizes up to 600 hp. The fishery uses twin-rigged outrigger trawls (Figure 1) to target prawns, and finfish to less extent.

Figure 30. Shrimp trawler used to exploit prawn in Tanzania.
Source: Baraka Kuguru. Tanzania Fisheries Research Institute.

Due to the nature of continental shelf which is narrow and steep, and interrupted by coral reefs, widened areas near river deltas are where shrimp trawling concentrated (Figure 31). Therefore, the industrial prawn/shrimp fishery is located in three trawling areas (zones) totalling around 2 000 nm^2: Zone I, Saadani to Bagamoyo (5°25′– 6°30′S), Zone II, Rufiji delta or Kisiju fishing area; 6°30′–8°S), and Zone III, Jaja and Kilwa (8°–10°S; Figure 2). Trawling depths are typically between 4 and 10 m (Richmond *et al.,* 2002, Bwathondi *et al.,* 2002, Mwakosya *et al.,* 2009).

Target species are *Penaeus indicus, Metapenaeus monoceros, Penaeus monodon*, and common bycatch are finfish of about 100 species, commonly dominated by *Gazza minuta, Leiognathus spp., Hilsa kelee, Terapon spp, Upeneus spp, Thryssa vitrirostris*.
The vessels are freezer trawlers that is blast freeze catch on board. The vessels typically have a hold capacity of around 30 mt, and crew size is up to 25. Most vessels are equipped with standard range of electronic aids such as GPS, track plotters, and radar.

The commercial trawling commenced in 1969 with a Japanese joint-venture company. Over the years, a combination of locally-owned, private (foreign-ownership) and joint-venture ownership of licenses has existed. The numbers of licenses increased to 20 in the mid-1990s and up to 25 licenses were issued in 2004. The fishery was closed in 2007 due to declining catch rates and user-conflict with artisanal fishers (Figure 32; Rudy and Benardine 2015).

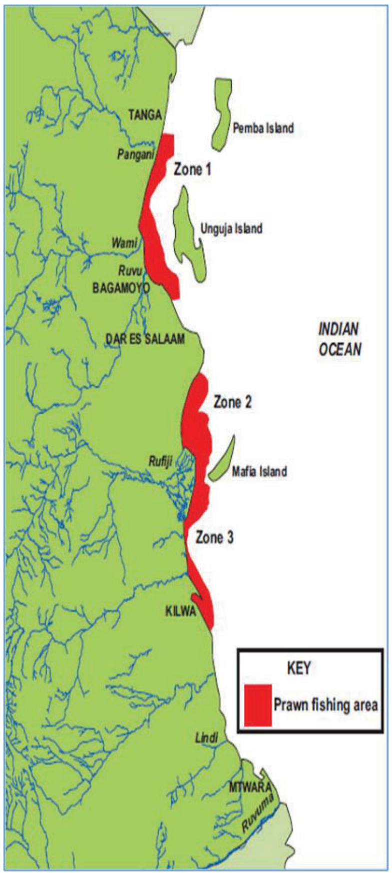

Figure 31. The industrial prawn/shrimp fishery is located in three trawling areas (zones). Total area is around 2 000 nm^2

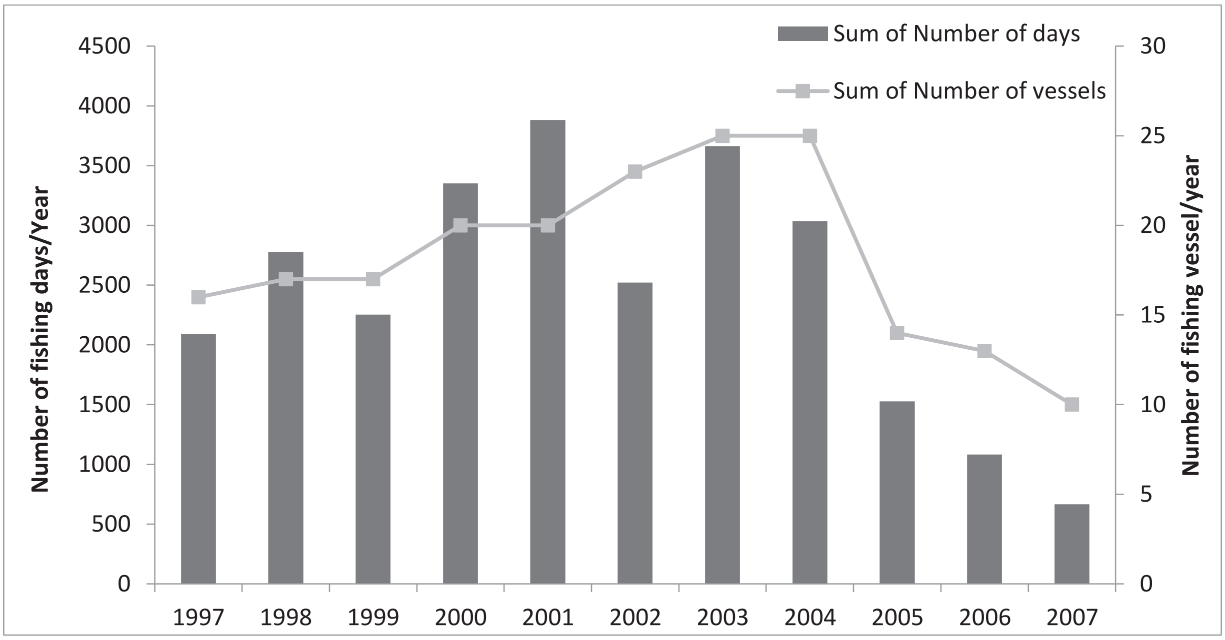

Figure 32. Fishing effort in terms of number of vessels and fishing days for the semi-industrial bottom twilling in Tanzania from 1997 to 2007 (Source: Fisheries Department).

The average number of tows for a day was between 5 and 6, operating from 6:00 am in the morning to 6:00 pm in the evening with an average tow duration of 2 hours and towing speed between 2.4 knots and 2.6 knots. The trawl net has a 21 m head rope and a 23 m foot rope, a codend with a minimum mesh size of 50 mm stretched. Tickler chains are used at times.

The Figure 32 summaries effort for the semi-industrial bottom trawl fleet in Tanzania. The effort in terms of number of fishing vessels registered increased from 11 vessels in 1997 to 25 vessels 2003. Due to low productivity of the ecosystem which resulted in reduced marginal profit, some industrial operators left the fishery. Consequently, the number of vessel registered was reduced from 25 in 2003 to 10 in 2007 when the fishery was closed.

P. indicus and *M. monoceros* generally dominated prawn trawl catch (~ 80-90 percent) with *P. monodon, P. semisulcatus* and *P. japonicus* together contributing the remainder. At times, and depending on the area being trawled and the time of day, these other species can assume greater prominence. Catch rates are highest from April to June (coinciding with the rainy season), declining towards the end of the year; Zone 2 consistently produces the highest catches. Continuous trawl catch records (no. of boats and catch) are available from 1982; but prawns might not be identified to species level. Trawling effort (in terms of numbers of boats and fishing days) increased steadily from the mid-1990s, despite recommendations to the contrary, and despite declining CPUE, until the mid-2000s, when effort and catch dropped sharply. The trawl fishery was closed in 2007 in order to allow the stock to recover.

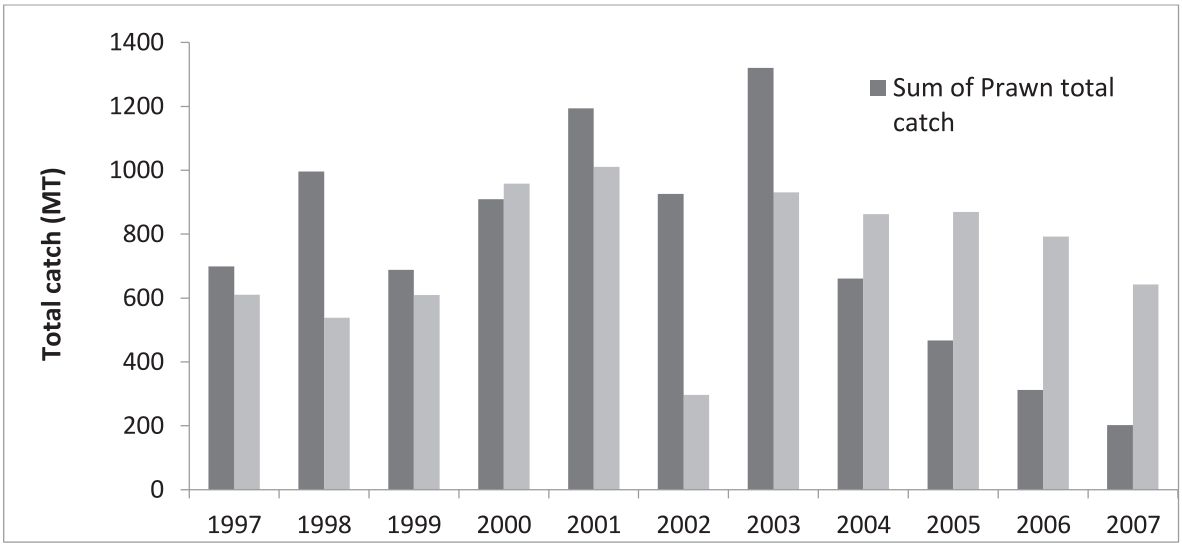

Figure 33. Estimate of total landings (in weight Mt) by each bottom fisheries from 1997 to 2007.

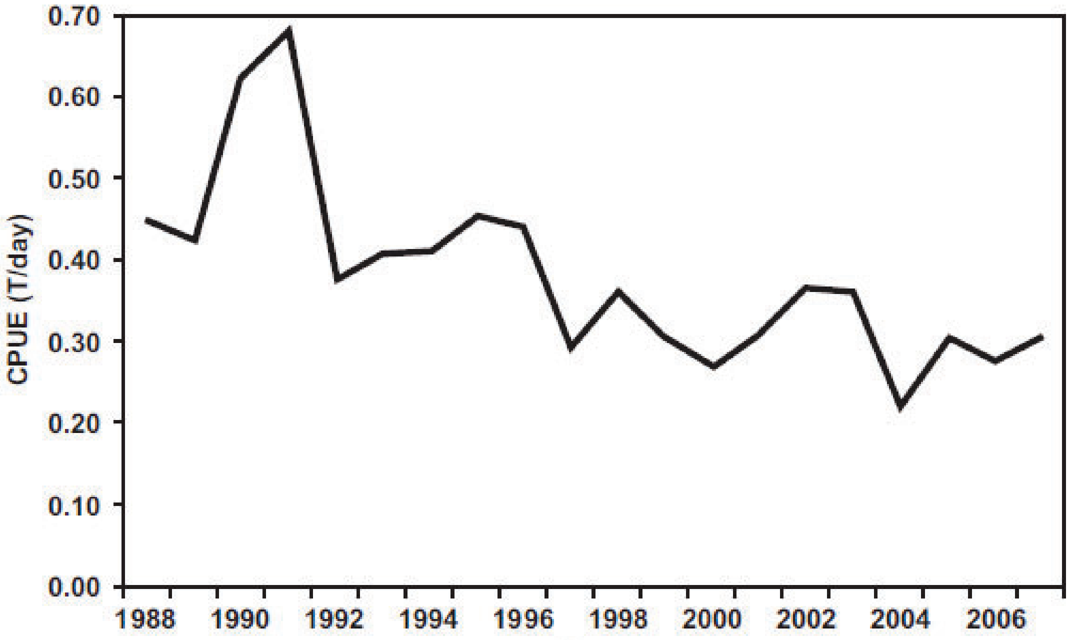

Figure 34. Estimate of average Catch per Unit of Effort (CPUE) of prawn trawl fisheries from 1997 to 2007(Source: Fisheries Department).

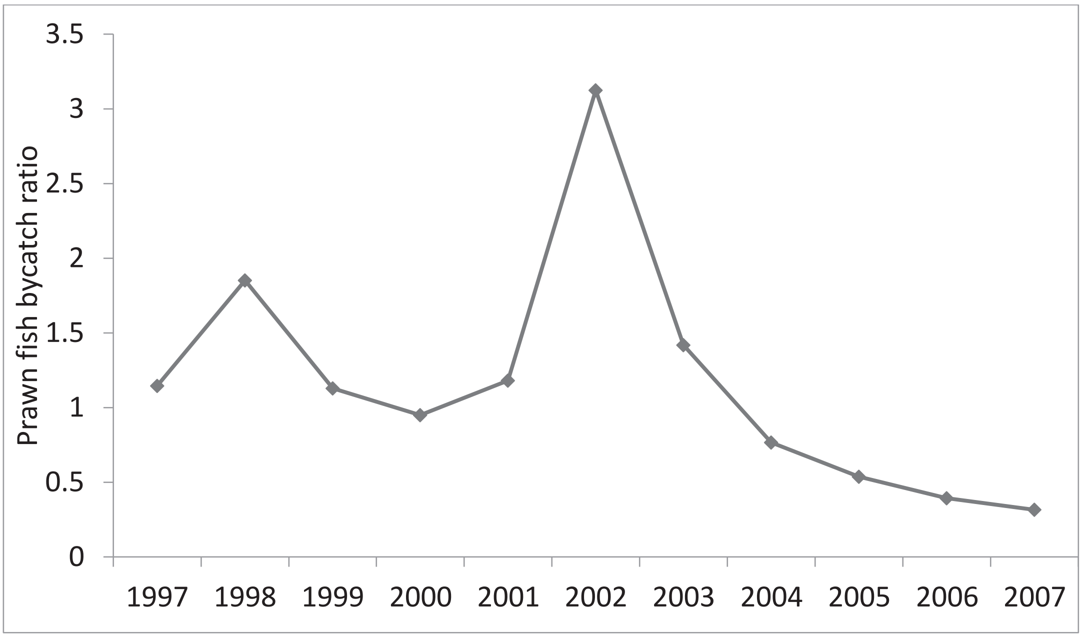

Figure 35. Estimate of total prawn to fish bycatch ratio from 1997 to 2007.
Source: Tanzania Fisheries Research Institute.

There is no data or information on discards from the trawl operations, however the photos such as in Figure 36 show there were discards. There is no data or information of species composition in bycatch and discards.

There is no data and no clear understanding of the impacts of trawling on the environment in the SWIO region, although it is widely perceived to be damaging (Rudy and Benerdine, 2015). There is no data on habitats, benthos, bycatch and ecosystem impacts of bottom trawl fishing.

Figure 36. Sponge caught by a trawl net

Management measures in place in trawl fisheries

All penaeid prawn species are managed jointly. There are no output controls (quotas or TACs) in place. Based on the various estimates of biomass and MSY levels (all species combined), recommendations for reduction in effort have been made at times, e.g., a proposed effort reduction of 14 vessels to 8 was made in 1992, and from 20 to 8 vessels of standard size (500 HP) in 2002 (the latter to attain a recommended exploitation level of 60 percent of the MSY), but few management recommendations have been implemented, other than minor input control measures such as seasonal and diurnal closures.
The fisheries regulations in place:

- zoning and rotation of fishing vessel on fishing grounds;
- Vessel observers;
- Restricting fishing time to 12 hrs during the day
- Closed fishing season and area;
- Mesh size regulation – minimum mesh size of 50 mm
- Restriction on vessel capacity at maximum of 500 mt
- Fishing licence and registration fees;
- Logbook fishing information;
- Stock assessment;
- Prawn management plan in place not yet implemented.

Tunisia

Marouene BDIOUI (INSTM)
National Institute of Marine Sciences and Technologies (INSTM), Department of Fisheries Science, Port de peche de la Goulette, 2060 Tunisia.

Gulf of Gabes is the most important trawling area. It has a large shallow shelf and high abundance of commercially valuable species. The Strait of Sicily has some high value commercial species such as rose shrimp, European hake, and red mullet. The main bottom trawl in use is the shrimp (prawn) bottom trawl with a minimum mesh size of 48 mm in the wings and 40 mm in all the other parts, including codend. Mediterranean bottom trawls for finfish have 52 mm mesh size in wing, 60 mm in the trawl belly, and 40 mm in the other parts, including codend. There are high-opening bottom trawls.

Total fish production in 2015 in Tunisia were 131 661 tonnes. Small pelagic purse seiner landed 41 percent, coastal and artisanal vessels (gillnets, trammel nets, longline) 24 percent, bottom trawlers 21 percent (28 000 tons), aquaculture 11 percent, and others 3 percent of the total production.

According to official statistics in 2015, there were 398 active bottom trawlers (80 percent of wooden construction). The number of active trawlers in Sfax Harbor (Gulf of Gabes) was 226. The major part of these trawlers are 21-27 meters in length (Figure 37).

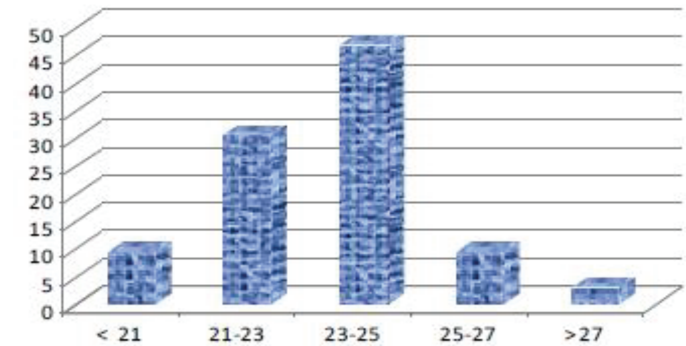

Figure 37. The length distribution of trawlers (LOA).

Trawl fishing is highly multispecies and has significant amount of discard, including juvenile red mullet (*Mullus barbatus) and* common pandora (*Pagellus erythrinus).*

Management measures in place include minimum mesh size (40 mm), minimum landing size (for 37 species), minimum trawling depth (50 m depth), time restrictions, and zoning (3 nm). Trawling is prohibited if the amount of small (juvenile) fish is more than 20 percent of the total catch. Trawling is banned for two months each year (July and August) in the Gulf of Gabes. Trawling is banned for 11 months each year in the Gulf of Tunis (the period may be extended to the whole year depending on scientific results). There are several exceptions for these measures.

Vessel Monitoring System (VMS) is under the process of development. It will be compulsory for vessels 15 m and larger. In 2017, 1 000 vessels will have to be equipped with VMS.

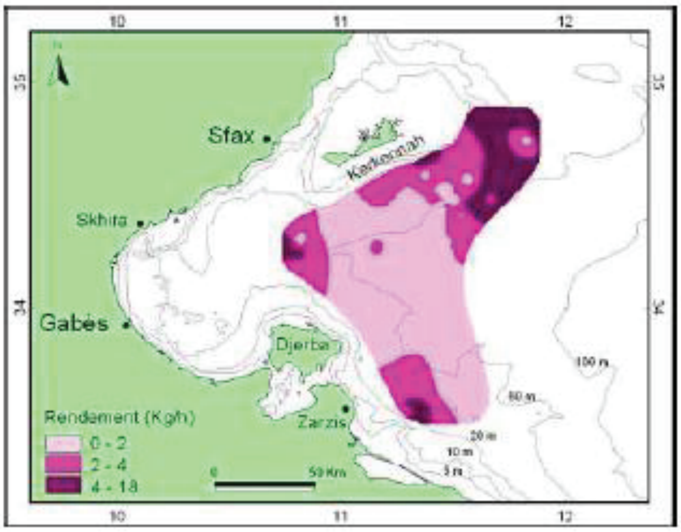

Figure 38. Distribution of discards of commercial species in December 2011 – January 2012 (kg/h) in the Gulf of Gabes.

Annex 2. Agenda of the Workshop

20-25 March 2017

Day 1: Monday 20 March - Trawling Best Practices (TBP) Group

1. Welcome/project update
2. Status Report TBP Phase I: Footprint of trawling (Ricardo Amaroso, Simon Jennings)
3. Status Report TBP Phase II: Impacts on biota (Mike Kaiser, Jan Hiddink)
4. Status Report TBP Phase III: Risk analysis and update on habitat data collation (Roland Pitcher, Bob McConnaughey)
5. Status Report TBP Phase IV*: No report*
6. Status Report TBP Phase V: Best practices (Bob McConnaughey, Ray Hilborn)

Day 2: Tuesday 21 March - Trawling Best Practices (TBP) Group

1. Status reports continues
2. Plenary discussion of TBP Phase V and project summary paper
3. Small group meetings around each of the papers in draft:
   - TBP Phase I: footprint of trawling (leads Ricardo Amaroso, Simon Jennings)
   - TBP Phase II: impacts on biota (leads Mike Kaiser, Jan Hiddink)
   - TBP Phase III: risk analysis (lead Roland Pitcher)
   - TBP Phase IV: *No report*
   - TBP Phase V: best practices (Bob McConnaughey, Ray Hilborn)

Day 3: Wednesday 22 March - Trawling Best Practices (TBP) Group

1. Wrap up TBP Group; next actions, responsibilities
2. Publication strategy and funding strategy for TBP
3. Preparation for the joint meeting with African expertss

Day 4: Thursday 23 March - TBP Group and African experts

1. Welcome addresses and introductions
2. Review TBP approach and key results (Ray Hilborn)
3. Presentations of African Experts
   - Each participant will have a presentation about what is known regarding trawl fisheries and their impacts on benthic biota in their area of knowledge

Day 5: Friday 24 March - TBP Group and African experts

1. Presentations of African Experts continue
2. Wrap up of lessons learned and availability of data

Day 6: Saturday 25 March - TBP Group and African experts

1. Identification of key issues in Africa
2. Definition of collaboration opportunities between TBP group and African colleagues
3. Identification of programs for collaboration

Annex 3. List of Participants

Name	Country	Title and Address
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This document contains the Report of the "Workshop on the Use of Best Available Science in Developing and Promoting Best Practices for Trawl Fishing Operations in Africa" held in Marrakech, Morocco, from 20 to 25 March 2017. The workshop was arranged in collaboration with FAO and the Trawl Study Committee. A total of 27 fisheries experts from Africa and other parts of the world participated in the workshop. The workshop was to identify and evaluate data on trawling distributions and impacts in Africa, develop and propose collaborative arrangements for sharing expertise, and evaluate best practices for trawling to enhance sustainability of food security, livelihoods and ecosystems. This report summarizes presentations made in the workshop and conclusion from the discussions.

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