# Evaluation of the Norwegian Reference Fleet

A Report to the Institute of Marine Research by an International Committee.

15 August 2011(Final Report)

# Contents

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Final Report, 15 August 2011

A Report to the Institute of Marine Research (IMR)

## Introduction

The Committee met at the Institute of Marine Research (IMR) in Bergen during the week of June 6-10, 2011. All of our facility and logistical requirements were organized by our host, Dr. Kjell Nedreaas, who also set up interviews for us with IMR Research and Programme Leaders and other users of the Reference Fleet data as requested. IMR staff were instrumental in providing assistance and information in a timely fashion which was greatly appreciated by the Committee. All discussions were open, constructive and conducted in a friendly manner.

The Committee addressed the Terms of Reference of the review and provides in this report a number of comments and recommendations. Prior to the review, a comprehensive package of background material describing the development and operation of the various components of the Reference Fleet was made available to the Committee in good time. Papers containing quantitative analyses were included in the background material which allowed some understanding of the required sampling intensity. However, only limited analysis of the Reference Fleet data was presented to the Committee to assist in addressing the Terms of Reference, especially with regard to Terms of Reference (a) concerning the representativeness of the reference fleet, (b) data quality, and (c) cost effectiveness.

Based on the material provided, the Committee was unsure as to the current objectives of the Reference Fleet. The Committee also noted that the Reference Fleet has been used to collect an increasing variety of data and samples, implying a significant change in focus over time. In order to protect the core functions of the Reference Fleet, its objectives should be clearly defined. This is not to prevent the focus of the Reference Fleet from being changed but to ensure that any change would happen in a planned manner, with full understanding of all implications.

### *Mandate for the Reference Fleet Evaluation Committee*

The Norwegian Reference Fleet Programme, a cooperative project between fishermen and scientists, was initiated in 2000 and has existed for more than 10 years now. This time span is a suitable basis for evaluation of the Programme, and an evaluation process has therefore been started. The evaluation will be performed by a Committee of 7 persons representing scientists and representatives from the most important stakeholders. The following were invited to participate in the Evaluation Committee.

## The Evaluation Committee

| | |
|---|---|
| **Ray Bowering:** | **Canada**, (Chair). |
| **Marie Storr-Paulsen:** | **Denmark**, DTU Aqua. |
| **Geoff Tingley:** | **United Kingdom**, Cefas, (Rapporteur). |
| **Maiken Bjørkan:** | **Norway**, University of Tromsø. |
| **Jon Helge Vølstad:** | **Norway**, IMR. |
| **Peter Gullestad:** | **Norway**, Directorate of Fisheries. |
| **Elling Lorentsen:** | **Norway**, Norwegian Fishermen's Association. |

### *Terms of Reference for the Evaluation Committee*

The group is requested to evaluate the following aspects of the high seas and coastal reference fleet:

a) Representativeness of the reference fleet: Can data from the reference fleet reasonably be extrapolated to the Norwegian fisheries with regards to:

- Retained and discarded by-catch and slipping,
- Species composition of catch,
- Age and length composition of catch,
- Effort and CPUE

b) Data quality with regards to all elements of the onboard self-sampling and data handling, e.g. quality assurance and quality control (QA/QC), including effective training of the fishers.

c) The organization and performance of the reference fleet monitoring program, including cost effectiveness, use of research quotas, cooperation with fishermen, and information exchange between researchers and fishermen.

d) Utility of the reference fleet as a source of information and data in a broader sense for different stakeholders including the Institute of Marine Research (IMR), the Ministry of Fisheries and Coastal affairs (FKD), the Directorate of Fisheries (FDIR), the National Institute of Nutrition and Seafood Research (NIFES), the International Council for the Exploration of the Sea (ICES), and the Norwegian Fishermen Organization (Norges Fiskarlag).

e) How does the contract tendering process and the legal aspects of the reference fleet concept affect its utility (e.g., how do the contracts protect fleet members, to ensure they can provide quality data with impunity).

f) Finally the committee is requested to provide recommendations for future developments of the reference fleet monitoring program.

## Background

Norway's Institute of Marine Research (IMR) has developed an innovative and cost effective approach to the collection of data from vessels involved in the offshore and coastal fisheries. They have developed a "Reference Fleet" consisting of a small group of active vessels in the fishery that are paid to provide the IMR with detailed information about their fishing activity, vessel details and catches on a regular basis. The Offshore Reference Fleet was established in 2000 as a way to collect sufficient biological samples by area, season and gear to estimate catch (landings and discards) at size and age in order to support stock assessments. It was decided politically to not use onboard observers, and IMR therefore decided to establish a Reference Fleet to get the necessary samples for assessment purpose etc. The Coastal Reference Fleet was established in 2005. For 2011 the Offshore Reference Fleet will consist of 16 to 17 large offshore vessels and the Coastal Reference Fleet will have 20 to 21 smaller (9-15 m) vessels. The coverage level (in vessel numbers) achieved by the Reference Fleet in 2009 was about 1% for the coastal fleet and ranged up to about 15% for offshore fleet gill netters.

The Norwegian fleet targets both groundfish (e.g. cod, haddock, and saithe) and pelagic species (e.g. herring, mackerel, blue whiting and capelin) using a range of gear types, including trawl, purse seine, gillnet, Danish seine, longline, hand line, pots and traps depending on the target species. The fisheries are managed through limited fishing licences or annual permits and vessel based quotas. A significant aspect of Norwegian management control systems is the prohibition on discarding. A discard regulation has been in place since 1987 and also applies to all foreign vessels fishing within the Norwegian EEZ. In 2008, this prohibition included 15 species and the list was expanded considerably in 2009.

The Reference Fleet self-sample their catch and provide the data directly to IMR. Their primary sampling goals are the collection of biological sample data and total catch estimation with both being submitted electronically from the vessel. Vessels were selected for the Reference Fleet based on their gear type, fishing pattern and geography as well as their reputation and demonstrated interest in the well-being of fish resources. After a starting phase with six vessels, the Reference Fleet was increased in number with a transparent publicly announced tender process. The sampling goal for the Reference Fleet Programme was to collect samples that would be representative of the general fleet activity. Once the participating vessels were identified, crewmembers were selected to receive initial training from IMR staff on proper sampling and data collection techniques, as well as ongoing dialogue and supervision on the vessel.

Other monitoring in place for the Norwegian fleet includes mandatory fishing logbooks for all vessels greater than 13m in length. Sales notes (dealer reports) are used to track all vessel landings and for quota tracking purposes. Government inspectors monitor landing sites. VMS is required on all vessels over 15m in length. At-sea monitoring is also carried

out by government inspectors who, for example, in 2010 provided 1,097 days at sea coverage , examining 1,173 hauls/sets.

**Table 1: Inspections at sea in 2010 by Norwegian Directorate of Fisheries Inspectors. Note that the main activity is during the first half of the year.**

| Fishery/gear | Number of different vessels | Days at sea | Number of hauls |
|---|---|---|---|
| Trawl codfishes | 12 | 168 | 370 |
| Danish seine | 13 | 179 | 156 |
| Longline | 4 | 74 | 58 |
| Shrimp trawl | 7 | 77 | 174 |
| Herring, purse seine/pelagic trawl | 14/1 | 202 | 97 |
| Capelin, purse seine/pelagic trawl | 16/8 | 232 | 160 |
| Saithe, purse seine | 9 | 155 | 149 |
| Mackerel, purse seine | 4 | 138 | 62 |
| Industrial trawl | 1 | 10 | 9 |
| Total | | 1,235 | 1,235 |

These inspectors have a control and enforcement role, their main tasks being the collection of data concerning real time closures (RTC) and monitoring compliance with closed areas and other fishing regulations.

**Cost and Cost Recovery**

The Reference Fleet Programme is funded through an annual quota set aside for IMR, which is allocated from the relevant species Total Allowable Catches (TACs) prior to calculation of vessel quotas. This innovative funding approach intends to share the cost for the Programme across the entire fleet in proportion to the fleet quota holdings. For example, in 2011, quota of 900t of cod, 515t of Greenland halibut, 780t of herring, 1,120t of mackerel, 80t of haddock, 4,250t of capelin and 1,570t of blue whiting was set aside to fund the Reference Fleet Programme. The total estimated landed value of this set aside was NOK 45.4 million. Of this, about 62% is paid out to vessels as quota by IMR to cover the cost of catching and selling the fish and the other 38% goes toward payment of administration costs, equipment and payment to the Reference Fleet to collect the samples and deliver the data. The value of the Norwegian capture fishery represented by the Reference Fleet in 2010 was about NOK 13.3 billion. Following discussion, the Committee treated the research quotas as the equivalent of money and thus did not consider the quota by species.

# Response to the Terms of Reference

## a) Representativeness of the reference fleet: Can data from the reference fleet reasonably be extrapolated to the Norwegian fisheries with regards to:

### *Representativeness*

In order to be able to judge representativeness, at least the composition of the Reference Fleet in terms of numbers of vessels by length class and gear type, needs to be compared to the overall composition of the Norwegian fleet. Tables 2 to 4 show some simple comparisons of the Reference Fleet with the overall Norwegian fishing fleet based on the official statistics of the Directorate of Fisheries.

**Table 2: Number of vessels by narrow length-classes, landings weight and value for 2010.**

| | Vessel length-class (meters) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **<10** | **10-10.99** | **11-14.99** | **15-20.99** | **21-27.99** | **>28** | **Total** |
| **Norwegian Fleet** | 3,492 | 1,447 | 741 | 203 | 175 | 251 | 6,309 |
| **Landings (t)** | 114,007 | | 106,115 | 59,243 | 336,611 | 2,054,535 | 2,670,511 |
| **Value (mill NOK)** | 1,068 | | 917 | 486 | 1,432 | 9,377 | 13,280 |
| **Reference Fleet** | 1 | 3 | 15 | 1 | 2 | 14 | 36 |

**Table 3: Number of vessels by broad length-classes 2010.**

| | Vessel length-class (meters) | | | |
|---|---|---|---|---|
| | **<15** | **15-27.99** | **>28** | **Total** |
| **Norwegian Fleet** | 5,680 | 378 | 251 | 6,309 |
| **Reference Fleet** | 19 | 3 | 14 | 36 |

**Table 4: Number of vessels by fishing area and fish/gear type 2010.**

| | **Norwegian Fleet** | **Reference Fleet** | **Percentage** |
|---|---|---|---|
| **Coastal Demersal** | 5,884 | 20 | 0.3 |
| **Offshore Demersal** | 148 | 11 | 7.4 |
| **Coastal Pelagic** | 174 | 2 | 1.1 |
| **Offshore Pelagic** | 103 | 5 | 4.9 |
| **Total** | 6,309 | 38* | 0.6 |

* The vessel count includes two vessels that operate as both coastal pelagic (purse seine) and offshore demersal vessels (Danish seine). These are not representative of the coastal fleet as they are large (34 and 38 m) and cannot fish using demersal gear in the shallow coastal areas and fjords.

### *Retained and discarded by-catch and slipping.*

**Discards and by-catch**: it should be noted that the reliability of the Reference Fleet information on by-catch and discards has not been confirmed. In addition, it is also unclear whether the Reference Fleet vessels behave the same, in terms of discarding, as the majority of the fleet.

Limited analyses have been provided to establish whether the Reference Fleets are representative of the overall fleet components. If the Reference Fleets are representative of the overall fleet components, then these estimates of by-catch and discards could form the basis of estimating the by-catch and discard in the whole Norwegian fleet.

- The Pelagic Reference Fleet (with open systems[1]) report total catch of all species for about 80% of the sets which are systematically selected. That part of the Pelagic Reference Fleet with closed systems, are unable to record by-catch or discards at sea but by-catch is recorded onshore.
- The Coastal Reference Fleet report detailed daily by-catch and discard data, and therefore these data can technically be raised directly to cover the whole of the coastal fleet.
- The Offshore Demersal Reference Fleet appears to record reliable data on total catch for all species but, without port sampling, can only provide limited estimates of discards for commercial species.

It should be further noted that the methodology of how to raise the Demersal Offshore Reference Fleet fish by-catch and discard data to the overall fleet has not been fully developed. Without complementary port sampling of length (and age) distribution, the Demersal Offshore Reference Fleet is unlikely to provide any reliable method of estimating overall by-catch and discards for commercial species. However, approaches have been developed for some marine mammals, seabirds and some elasmobranch fish species that could be applied to other non-commercial fish species (Vollen, 2010, Bjørge, *et al*., 2011; Fangel., *et al*., undated).

Other sampling is conducted by Coastguard and Fisheries Directorate inspectors but these data cannot be used to address the larger by-catch and discard issues due to bias caused by the risk-based approach to determine which vessels to board, and to some extent, changes in fishing behaviour.

The Committee noted that, as part of the Programme, Reference Fleet vessels periodically carry IMR scientific staff. Analysis of data from Reference Fleet vessels with and without IMR scientific staff may provide information about the reliability of the reported data from the Reference Fleet vessels.

[1] An *'open'* system is one where samples can be taken once fish are on board, e.g. from an open conveyor. A *'closed'* system is where there are no accessible locations from which to take samples and fish are pumped directly into the hold.

While it is illegal to discard, discarding tends to continue as a practice. The Committee note that the ICES outputs for 2011 from the Arctic Working Group and ACOM, identified the lack of discard information from a number of fisheries as important.

**Slipping**: there is no quantitative information on slipping from the Reference Fleet prior to 2010 but there is some information on sets with no catch. There is no reason to believe that the Reference Fleet behaves differently from the rest of the fleet with respect to slipping. The Reference Fleet could be asked to report slipping (occasions/estimated amounts) including reasons for zero catch for sets, especially as slipping is not an illegal activity. One vessel in the pelagic fleet provides detailed diaries with qualitative information on all of their fishing operations including slipping. Video surveillance may be a method that would give better data on slipping.

### *Species composition of catch.*

**Species Composition of the Catch**: the Reference Fleet gives significantly improved detail of species composition from the commercial catches over any previous commercial species composition data. This is the case, even if there remain difficulties in the identification of some species. Data on species composition could form a very useful long-term time series through which to monitor changes in biodiversity (together with directed research). For example, the normal reporting for vessels in 2010 shows 32 species whereas the Offshore Demersal Reference Fleet (vessels, n=11) reported 83 species with about 280,000 individual fish measured for length in 2010 (see Appendix 1).

It is particularly useful that the Reference Fleet have real-time support of species identification using photographs and email to scientific taxonomists on-shore.

### *Age and length composition of catch.*

**Age and Length Composition of the Catch**:

***For assessment purposes***, the Reference Fleet is the primary source of age frequency and length frequency data for NE Arctic cod, saithe, haddock, two species of redfish, Greenland halibut, two herring stocks, mackerel, blue whiting and capelin, and is virtually the only source of age frequency and length frequency data for the coastal cod since the port sampling programme was ended during 2009. The quality of the data are apparently good and is believed to be representative but the small sample sizes are reported to lead to unacceptably high variance, especially for some gear types (ICES AFWG 2011 and ACOM 2011). The previous port sampling programme probably gave better data than the Reference Fleet mostly based on much larger sample sizes i.e. coverage of boats/trips.

> **ACOM for coastal cod 2011**
> *"Changes in the landings sampling programme has lead to increased uncertainty in the estimated quantity and age composition of commercial catches of coastal cod in 2010."*

**ACOM for NE Arctic cod 2011**

*"The biological sampling from some vessel groups decreased considerably and may have become critically low after the termination of the Norwegian harbour sampling program in mid 2009 e.g. for hand line in quarter 1 and gill net in quarters 2 to 4 in 2010."*

**ACOM for haddock in Subareas I and II (Northeast Arctic) 2011**

*"The present Norwegian sampling from commercial catches is believed to have become worse in recent years because of the termination of a Norwegian sampling programme in mid-2009. Poor sampling caused problems in estimating Norwegian catches for the oldest ages in 2010."*

**ACOM for saithe in Subareas I and II (Northeast Arctic) 2011**

*"The biological sampling from some vessel groups decreased considerably and may have become critically low after the termination of the Norwegian sampling programme in mid-2009, e.g. for all gears in the Lofoten area and for purse seine and hand line in all areas in 2010."*

Since 2009, the Reference Fleet is the sole source of information on the split between the coastal and NE Arctic cod stocks (based on otolith morphology and genetics). These data used to be available from the port sampling programme as well. The quality of the port sampling data would (probably) have been higher than that derived from the Reference Fleet due to the higher level of coverage of the port sampling programme, at least in terms of the number of vessels sampled. Some data to split these stocks is also available from research surveys.

The loss of data previously collected through the port sampling programme will not be adequately replaced by Reference Fleet data in a number of areas, including the species split and assessment of NE Arctic and coastal cod stocks. The number of vessels/trips sampled from the Reference Fleet are too small and not all gear types are covered by the Reference Fleet. Prior to 2010 there was about 300 vessels sampled north of 62° N in the port sampling programme. The sampling effort has now been reduced to ~13 vessels in the Coastal Reference Fleet, giving reduced precision since all sampled trips are nested within the few vessels in the Reference Fleet that form the primary sampling units.

### *Effort and CPUE.*

**Effort and CPUE**: From 2011 e-logbooks are compulsory for all vessels >15m, providing catch and effort data haul by haul (with gillnet and longline vessels aggregating data by day), covering about 85% of the catch value and 92% of tonnage for 2010. Therefore, information from the Reference Fleet >15m on catch and effort will have limited future use for the commercially targeted species, except as a tool to evaluate the representativeness of the Reference Fleet. CPUE for a number of non-target and non-commercial species will also continue to be available from the Reference Fleet which will not be collected by the e-logbook scheme.

CPUE data from the under 15m vessels remains a key output from the Coastal Reference Fleet.

The historical Reference Fleet time series of effort and CPUE may however be useful. Limited analyses of the Reference Fleet CPUE data have been made to establish the representativeness of Reference Fleet with respect to total fleet. Some analyses suggest representativeness (Helle and Pennington, 2004; Pennington *et al*., 2009) , other analyses, such as some of the figures in Anon (2010), do not support this view. There is valuable information in the data but this needs further investigation.

CPUE data derived from the Reference Fleet have been used to support management, for example, to track the status of the longline ling fishery (Helle, 2006).

The impact of technological improvements in the fishery (technology or efficiency creep) on the CPUE data is not clear, however, the Reference Fleet is reported to have collected detailed information on technological improvements that could be used to address this issue for use in interpreting effort and CPUE data.

### b) Data quality with regards to all elements of the onboard self-sampling and data handling, e.g., quality assurance and quality control (QA/QC), including effective training of the fishers.

Clear, written protocols for data collection by the Reference Fleet exist and are based on established and effective scientific procedures. The Committee was informed that the data collected by the Reference Fleet undergo the same quality assurance procedures as the other sources of scientific data. The Committee was fully supportive of the use of new technology including electronic measuring boards and electronic data capture which reduce data errors in transcription; the near-real time transmission of the collected data to IMR; and the use of digital cameras for species identification supported by email to scientific support ashore.

The Committee was informed that, preliminary analysis suggest there are no obvious data quality issues whether the Reference Fleet vessels have IMR scientific staff on-board or not. These analyses should be strengthened and become an integral part of the Programme.

There is a substantial programme implemented through IMR to train fishers in the Reference Fleet to collect appropriate data. The Committee was informed by IMR that fishers are only allowed to collect data once they had been fully trained to a scientific standard. The training provided to the Reference Fleet also includes:

- IMR scientific staff make between one and two visits each year to every Reference Fleet vessel at sea[2];
- Annual meetings between IMR and Reference Fleet participants;

[2] This represents the intended frequency of vessel visits by IMR but some vessels actually receive less than this.

- Subject-specific workshops;
- A programme of scientific mentoring.

Feedback from the fishers through the questionnaires delivered for this review and earlier work indicates that the vast majority of fishers consider the training useful and of high quality. The fishers also had a number of suggestions to improve the training, such as an increased frequency of contact and support from IMR and also more workshops. The Committee believes that these suggestions may be beneficial and should be considered within the context of cost, personnel and logistical constraints.

The Committee feels that the training programme is extensive and meets the fundamental needs of scientific training for the fishers to make the Reference Fleet Programme effective.

It is noted that port sampling is predictable and controlled by IMR, whereas sampling from the RF is controlled by the fishers. No analyses were presented to the Committee to inform them on this aspect of RF representativeness. Thus, all consideration was based on 'expert judgement'. The Committee accepted that the level of training and IMR supervision of sampling was good and would probably generate good data.

### c) The organization and performance of the reference fleet monitoring program, including cost effectiveness, use of research quotas, cooperation with fishermen, and information exchange between researchers and fishermen.

**Cost effectiveness**: although the costs of the Reference Fleet were provided, the Committee was not provided with information to be able to consider the relative cost of the reference fleet approach compared to other approaches that can provide the same range and detail of information, such as observer programmes. Nevertheless, it is difficult to fully evaluate the effective costs and benefits associated with the implementation of the Reference Fleet because of the intangible benefits of the cooperation generated between the Fisheries Directorate, IMR and the industry.

**Research quota**: the current model for obtaining samples from the Reference Fleet is a mix of allocated quota and direct purchase of samples at a fixed price. An alternative approach that could be taken would be to maximise funding from auctioning of the research quota currently directed at the Reference Fleet and directly purchase all samples. Depending on the auction price achieved, this may generate an increased number of samples overall for the same amount of research quota. Nevertheless, this would adversely affect the cooperative nature of the relationship between IMR and industry established by the Reference Fleet operation, and may also affect data quality. While the Committee is not in a position to evaluate this approach, it is of the opinion that should this be considered for use, *all* implications should be fully evaluated.

The Committee was informed about sampling cost differences between the Offshore Pelagic Reference Fleet and the Offshore Demersal Reference Fleet, where the current effective cost

of sampling is higher for the Pelagic Reference Fleet samples. The value for money of the data derived from the Pelagic Reference Fleet is clearly lower than that derived from the Demersal Reference Fleet (including sample costs and level of biodiversity information). It may be possible to source the same quality and quantity of data to support the management of the pelagic fisheries in a different and more cost effective way. The Committee recommends that this imbalance should be reviewed in order to determine the most effective and cost efficient approach to managing the Reference Fleet overall.

Providing adequate biological sampling for the pelagic fleet is considerably easier than for the demersal fleet as the fleet is less complex (vessel sizes, gear types, etc.) and the catches tend to be similar among the fleet. The RF provides a good method for collecting the information required from '*open'* systems but equally effective (and possibly cheaper) alternative approaches also exist. Such alternatives include sampling at the shore based processing sites, and having the vessels take samples of fish for delivery to IMR to biologically sample from ashore.

Due to the limited number of vessels, the Coastal Reference Fleet is currently unable to provide adequate effective sample sizes for age-length composition to support the assessment and management of some of the economically important stocks (ICES AFWG 2011; ICES ACOM 2011). Therefore, there is a case for either increasing the number of vessels in the Coastal Reference Fleet and/or supplementing the number of vessel/trip samples for age and length frequency through a limited and focussed port sampling scheme. For example, the patterns of sampling level by season in the NEA cod in 2008 and 2010 were very different (Appendix 2).

It is important to note that the Reference Fleet Programme has contributed to significant improvements in the mutual understanding and cooperation between the Fisheries Directorate, IMR and the participants of the Reference Fleet and also has the potential to impact the wider fishing community outside of the Reference Fleet.

**Cooperation and communication between fishermen and researchers**: communication between the fishers (fishers and owners) and IMR scientists participating in the Reference Fleet Programme occurs at a number of levels. This includes the tendering process, training of fishers in practical sampling, periodic updating of sampling training, technical workshops, annual Reference Fleet review meetings, and publication of some general brochures on the Reference Fleet.

Prior to the evaluation review there were two engagements with Reference Fleet stakeholders to gain an understanding of their views. The first of these was a questionnaire conducted in 2009 as part of research on the Reference Fleet Programme for a social anthropological PhD independent of the organisation or operation of the Reference Fleet. A second, shorter questionnaire addressed to both fishers in the Reference Fleet Programme and scientists with an interest in the Reference Fleet Programme was conducted within the

timeframe and as part of this evaluation review in 2011. This two stage approach permitted a perspective on how the views of the different stakeholders have developed over recent time. Issues relevant to the terms of reference covered by the semi-structured interviews included: trust and legitimacy, cooperation and information flow, and the effectiveness of training. A more comprehensive appraisal of this information is presented in Appendix 3.

It is clear from the outcomes of the two questionnaires that the perception of the fishers has remained relatively unchanged towards the Reference Fleet Programme. With minor exceptions, the overwhelming perception of the Reference Fleet Programme is a positive one from both fishers and scientists, with a high rating for the quality and effectiveness of the training of fishers within the Reference Fleet. Similarly, the perception of all parties was that the Reference Fleet Programme has had a measurable and highly positive influence on the relationship and level of trust between the scientists, managers and the fishers within the Reference Fleet.

Some perceptions suggest that there has also been some improvement in trust and understanding between scientists and the broader Norwegian fleet but this needs considerably more effort to develop. Appropriate ways and means to address this should be considered and implemented. For example, regular updates in the local fishing press on the Reference Fleet and what Reference Fleet data are used for in non-technical language.

Communication among all parties (scientists, vessel owners, and fishers on deck and on the bridge, etc.), in terms of the practical operation of the Reference Fleet, needs continued effort to be inclusive and effective. Based on comments from the Reference Fleet participants, the flow of information from IMR to the industry should probably be discussed in consultation with the Reference Fleet fishers and improved as appropriate.

Views expressed by some of the scientists in the questionnaires suggest that there needs to be a wider dissemination of information relating to the Reference Fleet among the scientific and fisheries management communities. This includes how the Reference Fleet operates, the types of data collected, and how the data are applied. This includes not only the basic catch and effort data but the other data that can be more widely used, including, for example, catches on non-commercial fish, seabirds and marine mammals, and data pertaining to biodiversity.

### d) Utility of the reference fleet as a source of information and data in a broader sense for different stakeholders including the Institute of Marine Research (IMR), the Ministry of Fisheries and Coastal affairs (FKD), the Directorate of Fisheries (FDIR), the National Institute of Nutrition and Seafood Research (NIFES), the International Council for the Exploration of the Sea (ICES), and the Norwegian Fishermen Organization (Norges Fiskarlag).

A variety of Norwegian Government departments and agencies, as well as inter-governmental agencies (e.g. ICES), are either primary or end users of the outputs of the Reference Fleet.

The Reference Fleet is a potentially useful tool for monitoring environmental change, e.g. for biodiversity studies or indicators of climate change. The Reference Fleet only covers those geographical areas that comprise the commercial fishery, with complementary data from the research surveys. For the coasts and fiords, there are difficulties in some aspects of surveying by research vessels.

The development of the ecosystem-based approach to fisheries management will require the monitoring of stocks of low or no commercial value directly impacted by the fisheries. Data from scientific research cruises and the Reference Fleet, constitute very important, and in many cases, the only sources of data for the development of time series that can monitor trends in such resources. In this respect, the Reference Fleet provides a very cost effective way of collecting such data compared to establishing separate data collection programmes to cover such needs. This information has a broad range of uses to support research and policy development across government.

For non-target and non-commercial species, the Reference Fleet collects detailed information on the length of all species caught in one haul per day from each vessel. This provides considerable information about the species composition (see discussion above and Appendix 1) and also length information of the non-target species including many non-commercial species. Complementary data are available from research surveys. It is important to note that these data will not relate directly to the commercial catches as the Reference Fleet data do. If the demersal component of the Offshore Reference Fleet is representative of the overall offshore demersal fleet, then it is not unreasonable to infer that the by-catch species taken by the Reference Fleet will also be representative of the whole fleet.

The Reference Fleet is also a source of data used in the assessment of other ecosystem components, for example, assessments of seabird by-catch in the fishery by The Norwegian Institute for Nature Research (NINA) (Fangel, *et al*., undated), by-catch of marine mammals (Bjørge, *et al*., 2011) and some elasmobranch fish species (Vollen, 2010).

Preliminary analyses of data originating from the Reference Fleet appear to have significantly improved the precision of some stock assessments in those areas where the other sampling programmes had not provided adequate coverage. This is the case, for example, for NE Arctic haddock (Aanes & Vølstad, 2010).

NIFES gave a presentation to the Committee describing how samples of fish collected by the Reference Fleet was applied in pollution monitoring in relation to food safety. The Reference Fleet is a useful and important source of data and samples for this work conducted by NIFES. Without the Reference Fleet, it is unclear as to how NIFES would address its sampling needs for fish.

### e) How does the contract tendering process and the legal aspects of the reference fleet concept affect its utility (e.g., how do the contracts protect fleet members, to ensure they can provide quality data with impunity).

There exists an understanding with the Coastguard, IMR and the Directorate of Fisheries not to prosecute Reference Fleet vessels over data provided under the Reference Fleet Programme. This provides a good measure of protection for the vessels of the Reference Fleet and to date there have been no issues in this regard. This is included within the contract with the Reference Fleet vessels:

> *"All information collected by the Reference Fleet project, which is not included in official catch diaries and landing notes, are the property of the Institute of Marine Research. This information is subject to rules of confidentiality as stated both in the Public Administration Act §13, and in the Freedom of Information Act §13. All such information collected solely for the Institute of Marine Research shall be entered on board in a separate journal and /or PC, and marked "property of the Institute of Marine Research", along with "Reference Fleet Project, only for use by the Institute of Marine Research for research purposes". The Directorate of Fisheries, Coast Guard and the Institute of Marine Research have agreed that such information shall not be used by these agencies for inspection or enforcement purposes. The ship owner or his staff shall not give any person or institution any of the data collected for the Institute of Marine Research without the permission of the Institute of Marine Research. The Institute of Marine Research will for its part, not provide detailed information to a 3rd Party.*
>
> *The Shipowner and his staff shall not divulge details of results, or other information to which they become privy during the charter, without the permission of the Charterer."*

There is a legal requirement to have an open tender for services such as vessel provision for the Reference Fleet. Thus, the selection of vessels that make up the Reference Fleet cannot be random and is unlikely to be fully representative of the whole fleet, implying possible bias in the make up of the Reference Fleet. Nevertheless, the openness of the tendering process assists in the engagement of the industry and may prevent other types of bias in vessel selection. Approaches to address this include stratification of Coastal Reference Fleet distribution by area and gear type. The Offshore Demersal Reference Fleet is also 'stratified', amongst other factors, by gear and processing type, access to target species and vessel characteristics. This may require further analysis to inform the selection of vessels in order to improve the representativeness of the Reference Fleet.

According to the current contract, there is no provision for extension or renewal. This has some implications for consistency of the time series data and training costs.

With the upcoming re-tendering for participation in the Reference Fleet, this is an appropriate time to reconsider the number of vessels and most appropriate composition of the various components of the Reference Fleet (demersal, pelagic, offshore and coastal) to

define the best make up of the fleet. This could then be applied through the approach to tendering and selection of vessels. Issues that should be addressed include (i) rotation of vessels to enable a wider involvement of the Norwegian fleet in the Reference Fleet Programme and help ensure that the Reference Fleet keeps up-to-date with general fleet developments; (ii) having a tendering process such that not all of the vessels are changed at one time to help promote consistency in the time series aspects of the Reference Fleet data. This should be developed in consultation with the industry representatives.

In order to fully evaluate the utility of the Reference Fleet, there is a need to understand how representative the Reference Fleet is with respect to the whole Norwegian fleet. The Committee was informed that several analyses are currently in progress and are expected to be completed by the end of 2011 (primarily by the Fisheries Dynamics Group at IMR) that should address these issues.

**f) Finally the committee is requested to provide recommendations for future developments of the reference fleet monitoring program.**

## Principle Recommendations

- The Evaluation Committee recommends that, with appropriate improvements, the Reference Fleet Programme should be continued.
- The objective(s) of the Reference Fleet Programme for the next five to ten years should be formally defined.
- A comprehensive, analytical review of the existing Reference Fleet data should be conducted to establish whether the sub-sectors of the Reference Fleet (offshore demersal, coastal demersal and offshore pelagic) are representative of the equivalent Norwegian fleet sub-sectors. For example, this could be addressed by considering catch, CPUE, spatial distribution, targeted species/stocks by gear type.
- There is a need to increase the effective sample size (no of vessels/trips sampled) for estimating the age-length composition of the commercial catches from some economically important stocks. Therefore, there is a case for either increasing the number of vessels in the Coastal Reference Fleet and/or supplementing the number of vessel/trip samples for age and length frequency through a well designed, limited and focussed port sampling scheme. The options for increasing the appropriate number of samples need urgent review with a timely implementation of a cost effective solution.
- It is important that quantitative analyses pertinent to the Reference Fleet Programme with respect to evaluation of the Programme and its application to stock assessment should be conducted in a timely manner with adequate funding.
- In developing the forthcoming tender round for the Reference Fleet, IMR in consultation with industry representatives, should try to address issues of fleet size and composition. The aim should be to develop a tendering process such that not all of the vessels are changed at one time. This will help promote consistency in the time series aspects of the Reference Fleet data. This may require further analysis to inform the selection of vessels in order to improve the representativeness of the Reference Fleet.

## Secondary Recommendations

- Develop and fund an outreach programme to promote a wider societal understanding of the Reference Fleet and its uses. This should include, at least, consideration of website development, material for industry, presentations to the wider fishing community by Reference Fleet participants at annual

meetings of fishers organisations (with scientific support as required) and database access.

- The split of the coastal and NE Arctic cod stocks should be investigated by analysis of data from the Reference Fleet and the port sampling programme where data were collected from both sources in the same years. This will inform on the adequacy of the current Reference Fleet to support the splitting of catches from these stocks in the future.
- An effective methodology to raise the Demersal Offshore Reference Fleet fish by-catch and discard data to the overall fleet should be developed and applied.
- Assess the utility of the Reference Fleet data to assist in managing some of the minor species or stocks (e.g. angler fish and wrasse).
- The use of Reference Fleet data on commercial and non-commercial species should be promoted to address research on biodiversity and the ecosystem approach to fisheries management.
- As part of the process of assuring the quality of the basic Reference Fleet data, analyse the data collected from Reference Fleet vessels during trips with and without IMR scientific staff. This will further build trust in the reliability of the reported data from the Reference Fleet vessels.
- More detailed reporting of slipping should be required from the Pelagic Reference Fleet. This should cover the range of possibilities for null catches for a set, slipping all or part catches and burst nets.
- Evaluate data collected by the Reference Fleet for technological developments to define, for example, the annual rate of technology-creep in the Reference Fleet over time. This will assist in addressing issues in the interpretation of effort and CPUE though time.

## References


Aanes, S. & Vølstad, J. H. (2010). Sampling errors in catch-at-age of Northeast Arctic haddock and the implications for quota setting. Abstract and PowerPoint Presentation to meeting in Galway, 2010.

Anon. (2010). The Norwegian Reference Fleet – a trustful cooperation between fishermen and scientists. Focus on Marine Research 1-2010. IMR. 12pp.

Bjørge, A., Gody, H. and Skern-Mauritzen, M. (2011). Estimated by-catch of harbour porpoise *Phocoena phocoena* in the two coastal gillnet fisheries in Norway. Draft report to the scientific committee of the IWC. 11 pp.

Fangel, K., Wold, L. C., Aas, O., Christensen-Dalsgaard, S., Qvenild, M. and Anker-Nilssen, T. (undated). Bifangst av sjofugl I norske fiskerier. Draft NINA Report 719. 63pp.

Helle, K. (2006). Tracking changes in the ling and tusk populations using CPUE estimates from logbook data. ICES CM 2006/N:17.

Helle, K. and Pennington, M. (2004). Survey design considerations for estimating the length composition of the commercial catch of some deep-water species in the northeast Atlantic. Fisheries Research 70, 55-60.

ICES (2011) AFWG. www.ices.dk/workinggroups/WorkingGroups.aspx

ICES (2011) ACOM. www.ices.dk/advice/icesadvice.asp

Pennington, M., Helle, K. and Kleven, S. (2009). Assessment of the precision of the reference fleet estimates of the length composition of mackerel, blue whiting, North Sea herring and spring spawning Norwegian herring. Internal IMR document June 2009. 16 pp.

Vollen, T. (2010). The Norwegian Reference Fleet 2007-2009: Catch and discard of elasmobranchs. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010 10pp.

# Appendix 1: Species compositions recorded from the Reference Fleet in 2010.

**Table A1.1: Species recorded as being caught by the Offshore Demersal Reference Fleet, including non-fish species.**

| Common name | Scientific name | # individuals | # samples | Recorded on sales slips |
|---|---|---|---|---|
| Anglerfish (monk) | *Lophius piscatorius* | 1,093 | 354 | Y |
| Arctic skate | *Amblyraja hyperborea* | 189 | 21 | Y |
| Argentine | *Argentina sphyraena* | 18 | 2 | Y |
| Arctic rockling | *Onogadus argentatus* | 1 | 1 | |
| Atlantic catfish | *Anarhichas lupus* | 5,110 | 539 | Y |
| Atlantic cod | *Gadus morhua* | 43,962 | 1,693 | Y |
| Atlantic halibut | *Hippoglossus hippoglossus* | 2,758 | 578 | Y |
| Norwegian spring spawning herring | *Clupea harengus* | 1,025 | 70 | |
| Atlantic herring | *Clupea harengus* | 202 | 8 | |
| Atlantic salmon | *Salmo salar* | 4 | 2 | Y |
| Blackmouthed dogfish | *Galeus melastomus* | 4,362 | 187 | Y |
| Blue ling | *Molva dypterygia* | 277 | 71 | Y |
| Blue skate | *Dipturus batis* | 37 | 23 | Y |
| Blue whiting | *Micromesistius poutassou* | 711 | 42 | Y |
| Blue-mouth redfish | *Helicolenus dactylopterus* | 922 | 50 | |
| Brill | *Scophthalmus rhombus* | 1 | 1 | Y |
| Common mora | *Mora moro* | 244 | 48 | Y |
| Cuckoo ray | *Leucoraja naevus* | 7 | 4 | |
| Cusk | *Brosme brosme* | 21,518 | 1,078 | Y |
| Dab | *Limanda limanda* | 20 | 8 | Y |
| Deepwater redfish | *Sebastes mentella* | 3,777 | 272 | Y |
| E. Atlantic gurnards | *Triglidae* | 61 | 2 | |
| Esmark's eelpout | *Lycodes esmarkii* | 512 | 85 | |
| European conger eel | *Conger conger* | 3 | 3 | Y |
| European flying squid | *Todarodes sagittatus* | 3 | 2 | Y |
| European hake | *Merluccius merluccius* | 2,238 | 212 | Y |
| European plaice | *Pleuronectes platessa* | 352 | 94 | Y |
| European seabass | *Dicentrarchus labrax* | 1 | 1 | Y |
| Flounder | *Platichthys flesus* | 67 | 4 | Y |
| Golden redfish | *Sebastes marinus* | 19,835 | 972 | Y |
| Greater argentine | *Argentina silus* | 1,118 | 121 | Y |
| Greater forkbeard | *Phycis blennoides* | 3,469 | 218 | Y |
| Greenland halibut | *Reinhardtius hippoglossoides* | 8,446 | 456 | Y |
| Grey gurnard | *Eutrigla gurnardus* | 1,916 | 113 | Y |
| Haddock | *Melanogrammus aeglefinus* | 41,846 | 1,633 | Y |
| Horse mackerel | *Trachurus trachurus* | 59 | 17 | |
| Jelly catfish | *Anarhichas denticulatus* | 4,922 | 486 | Y |
| John dory | *Zeus faber* | 14 | 4 | |
| Leafscale gulper shark | *Centrophorus squamosus* | 54 | 4 | |
| Lemon sole | *Microstomus kitt* | 186 | 49 | Y |
| Ling | *Molva molva* | 16,829 | 1,013 | Y |

| | | | | |
|---|---|---|---|---|
| Long rough dab | *Hippoglossoides platessoides* | 9,280 | 536 | |
| Longnose velvet dogfish | *Centroscymnus crepidater* | 1 | 1 | |
| Longnosed skate | *Dipturus oxyrinchus* | 38 | 6 | Y |
| Lumpsucker | *Cyclopterus lumpus* | 149 | 51 | Y |
| Mackerel | *Scomber scombrus* | 671 | 84 | |
| Megrim | *Lepidorhombus whiffiagonis* | 3,085 | 156 | Y |
| Norway pout | *Trisopterus esmarkii* | 1,573 | 51 | |
| Norway redfish | *Sebastes viviparus* | 556 | 124 | |
| Polar sculpin | *Cottunculus microps* | 1 | 1 | |
| Pollack | *Pollachius pollachius* | 1,389 | 215 | Y |
| Rabbitfish | *Chimaera monstrosa* | 5,784 | 313 | Y |
| Ray's bream | *Brama brama* | 36 | 9 | |
| Red king crab | *Paralithodes camtschaticus* | 18 | 9 | Y |
| Rockfishes | *Anarhichadidae* | 2 | 2 | Y |
| Rough rattail | *Macrourus berglax* | 2,166 | 145 | Y |
| Round skate | *Rajella fyllae* | 7,734 | 410 | Y |
| Roundnose grenadier | *Coryphaenoides rupestris* | 98 | 18 | Y |
| Sailray | *Dipturus linteus* | 384 | 40 | Y |
| Saithe | *Pollachius virens* | 23,045 | 1,093 | Y |
| Scaldfish | *Arnoglossus laterna* | 4 | 4 | |
| Scorpionfishes | *Scorpaenidae* | 166 | 14 | |
| Shagreen ray | *Leucoraja fullonica* | 1 | 1 | |
| Sharks, skates and Rays | *Euselachii* | 1 | 1 | |
| Skates and rays | *Rajidae* | 939 | 61 | Y |
| Smallspotted catfish | *Scyliorhinus canicula* | 16 | 6 | |
| Smooth-hound | *Mustelus mustelus* | 4 | 1 | |
| Sole | *Solea vulgaris* | 1 | 1 | Y |
| Spanish mackerel | *Scomber colias* | 2 | 1 | |
| Spinytail skate | *Bathyraja spinicauda* | 1,397 | 126 | Y |
| Spotted catfish | *Anarhichas minor* | 6,824 | 560 | Y |
| Spurdog | *Squalus acanthias* | 88 | 63 | Y |
| Starry skate | *Amblyraja radiata* | 20,942 | 869 | Y |
| Thornback ray | *Raja clavata* | 36 | 14 | Y |
| Threespot eelpout | *Lycodes rossi* | 9 | 3 | |
| Tope shark | *Galeorhinus galeus* | 2 | 1 | Y |
| Tub gurnard | *Chelidonichthys lucernus* | 41 | 7 | |
| Turbot | *Psetta maxima* | 17 | 14 | Y |
| Vahl's eelpout | *Lycodes gracilis* | 2 | 2 | |
| Velvet belly | *Etmopterus spinax* | 3,137 | 154 | Y |
| Whiting | *Merlangius merlangus* | 3,827 | 307 | Y |
| Witch | *Glyptocephalus cynoglossus* | 195 | 38 | Y |
| | *Coleoidea* | 36 | 14 | Y |

**Table A1.2: Species recorded by the Pelagic Reference Fleet (pelagic trawl) , including non-fish species.**

| Common name | Scientific name | # individuals | # samples | Recorded on sales slips |
|---|---|---|---|---|
| Argentine | *Argentina sphyraena* | 584 | 44 | |
| Blue whiting | *Micromesistius poutassou* | 3,285 | 89 | |
| Capelin | *Mallotus villosus* | 739 | 11 | Y |
| E. Atlantic gurnards | *Triglidae* | 54 | 13 | |
| European hake | *Merluccius merluccius* | 17 | 14 | |
| Greater argentine | *Argentina silus* | 1,369 | 47 | Y |
| Grey gurnard | *Eutrigla gurnardus* | 1 | 1 | |
| Haddock | *Melanogrammus aeglefinus* | 29 | 20 | |
| Horse mackerel | *Trachurus trachurus* | 58 | 6 | Y |
| Mackerel | *Scomber scombrus* | 196 | 31 | Y |
| Norwegian spring spawning herring | *Clupea harengus* | 451 | 24 | Y |
| North sea herring | *Clupea harengus* | 1,776 | 28 | Y |
| Norway pout | *Trisopterus esmarkii* | 4,146 | 91 | Y |
| Saithe | *Pollachius virens* | 20 | 7 | |
| Sand eel | *Ammodytes marinus* | 649 | 13 | |
| Silvery pout | *Gadiculus argenteus* | 610 | 42 | |
| Sprat | *Sprattus sprattus* | 1,059 | 17 | Y |
| Squids and octopus | *Cephalopoda* | 2 | 2 | |
| Unidentified | *Indeterminatus* | 25 | 15 | |
| Velvet belly | *Etmopterus spinax* | 59 | 15 | |
| Whiting | *Merlangius merlangus* | 67 | 24 | |
| Witch | *Glyptocephalus cynoglossus* | 36 | 9 | |

**Table A1.3: Species recorded by the Pelagic Reference Fleet (purse seine, open system).**

| Common name | Scientific name | # individuals | # samples | Recorded on sales slips |
|---|---|---|---|---|
| Anglerfish (monk) | *Lophius piscatorius* | 1 | 1 | |
| Atlantic cod | *Gadus morhua* | 140 | 21 | |
| Blue whiting | *Micromesistius poutassou* | 181 | 8 | Y |
| Capelin | *Mallotus villosus* | 2,105 | 34 | Y |
| Deepwater redfish | *Sebastes mentella* | 2 | 2 | |
| European flying squid | *Todarodes sagittatus* | 2 | 1 | |
| European hake | *Merluccius merluccius* | 8 | 3 | |
| European plaice | *Pleuronectes platessa* | 54 | 6 | |
| Flounder | *Platichthys flesus* | 2 | 1 | |
| Garfish | *Belone belone* | 19 | 10 | |
| Golden redfish | *Sebastes marinus* | 6 | 5 | |
| Golden redfish | *Sebastes norvegicus* | 6 | 5 | Y |
| Greenland halibut | *Reinhardtius hippoglossoides* | 2 | 1 | |
| Grey gurnard | *Eutrigla gurnardus* | 63 | 7 | |
| Haddock | *Melanogrammus aeglefinus* | 248 | 18 | |
| Horse mackerel | *Trachurus trachurus* | 408 | 13 | Y |
| Lemon sole | *Microstomus kitt* | 1 | 1 | |
| Long rough dab | *Hippoglossoides platessoides* | 3 | 1 | |
| Lumpsucker | *Cyclopterus lumpus* | 18 | 14 | |
| Mackerel | *Scomber scombrus* | 1,468 | 38 | Y |
| North sea herring | *Clupea harengus* | 848 | 24 | Y |
| Norwegian spring spawning herring | *Clupea harengus* | 3,202 | 52 | Y |
| Norway pout | *Trisopterus esmarkii* | 101 | 3 | |
| Norway redfish | *Sebastes viviparus* | 2 | 1 | |
| Ray's bream | *Brama brama* | 5 | 2 | |
| Saithe | *Pollachius virens* | 154 | 12 | |
| Spurdog | *Squalus acanthias* | 19 | 4 | |
| Stone crab | *Lithodes maja* | 1 | 1 | |
| Whiting | *Merlangius merlangus* | 106 | 4 | |

**Table A1.4: Species recorded by the Pelagic Reference Fleet (purse seine, closed system).**

| Common name | Scientific name | # individuals | # samples | Recorded on sales slips |
|---|---|---|---|---|
| Atlantic cod | Gadus morhua | 64 | 5 | |
| Norwegian spring spawning herring | *Clupea harengus* | 5,579 | 103 | Y |
| North sea herring | *Clupea harengus* | 1,776 | 34 | Y |
| Blackmouthed dogfish | *Galeus melastomus* | 6 | 2 | |
| Blue whiting | *Micromesistius poutassou* | 1,402 | 28 | Y |
| Capelin | *Mallotus villosus* | 2,949 | 55 | Y |
| Deepwater redfish | *Sebastes mentella* | 1 | 1 | |
| European flying squid | *Todarodes sagittatus* | 2 | 1 | |
| European hake | *Merluccius merluccius* | 6 | 1 | |
| Garfish | *Belone belone* | 4 | 3 | |
| Grey gurnard | *Eutrigla gurnardus* | 3 | 2 | |
| Haddock | *Melanogrammus aeglefinus* | 34 | 5 | |
| Horse mackerel | *Trachurus trachurus* | 1,165 | 26 | Y |
| Lumpsucker | *Cyclopterus lumpus* | 7 | 3 | |
| Mackerel | *Scomber scombrus* | 4,353 | 84 | Y |
| Norway pout | *Trisopterus esmarkii* | 10 | 1 | Y |
| Pollack | *Pollachius pollachius* | 2 | 2 | |
| Ray's bream | *Brama brama* | 3 | 1 | |
| Saithe | *Pollachius virens* | 567 | 22 | |
| Saury pike | *Scomberesox* | 4 | 1 | |

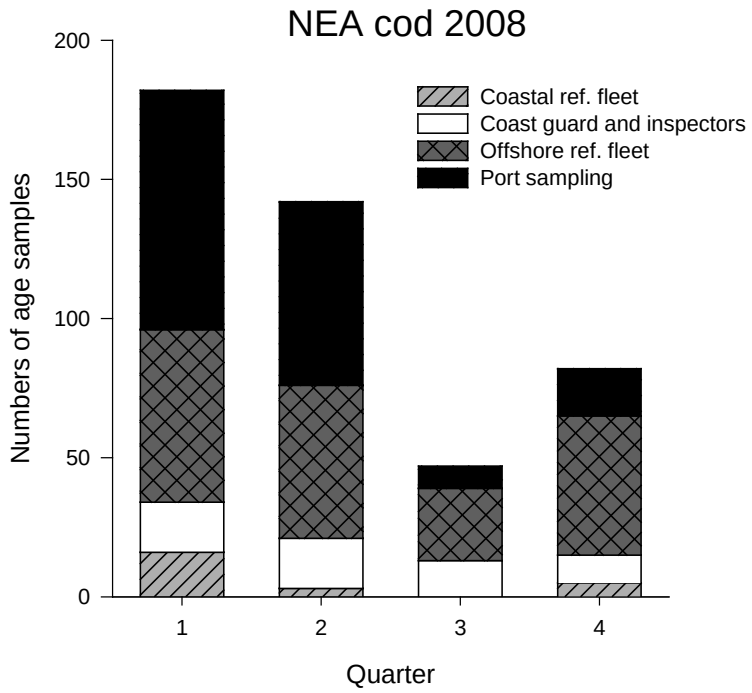
**Table A1.5: Species recorded by the Coastal Reference Fleet, including non-fish species.**

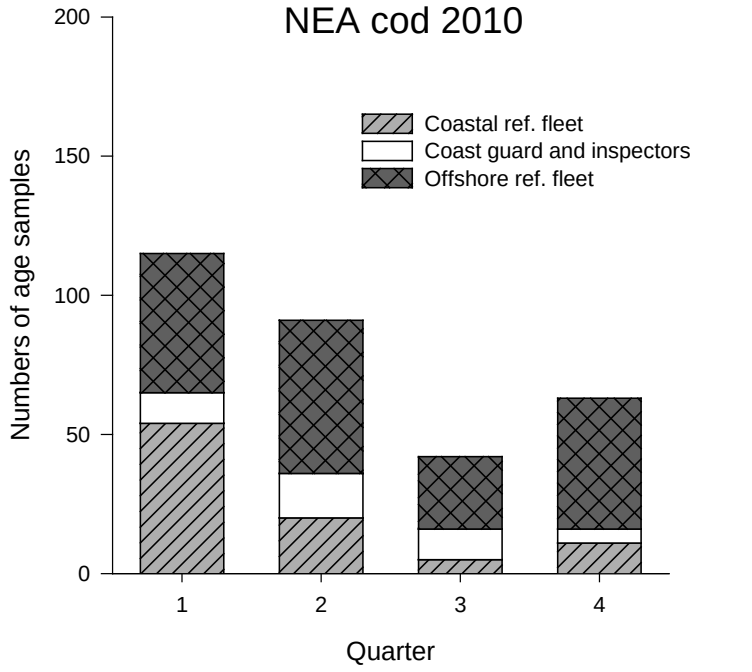
| Common Name | Scientific name | Recorded on sales slips |
|---|---|---|
| Alfonsino | *Beryks decadactylus* | |
| American mink | *Mustela vison* | |
| Anglerfish (monk) | *Lophius piscatorius* | Y |
| Argentine | *Argentina sphyraena* | Y |
| Atlantic catfish | *Anarhichas lupus* | Y |
| Atlantic cod | *Gadus morhua* | Y |
| Atlantic halibut | *Hippoglossus hippoglossus* | Y |
| Atlantic herring | *Clupea harengus* | Y |
| Atlantic salmon | *Salmo salar* | Y |
| Ballan wrasse | *Labrus bergylta* | Y |
| Basking shark | *Cetorhinus maximus* | |
| Black guillemot | *Cepphus grylle* | |
| Black-legged kittiwake | *Rissa tridactyla* | |
| Black-mouthed dogfish | *Galeus melastomus* | |
| Blue ling | *Molva dypterygia* | Y |
| Blue skate | *Dipturus batis* | Y |
| Blue whiting | *Micromesistius poutassou* | |
| Brill | *Scophthalmus rhombus* | Y |
| Bullheads and sculpins | *Cottidae* | |
| Butterfish | *Pholis gunnellus* | |
| Common eider | *Somateria mollissima* | |
| Common harbour seal | *Phoca vitulina* | |
| Common murre | *Uria aalge* | |
| Corkwing | *Symphodus melops* | Y |
| Cormorants | *Phalacrocorax* | |
| Cuckoo wrasse | *Labrus mixtus* | |
| Cusk | *Brosme brosme* | Y |
| Dab | *Limanda limanda* | Y |
| Edible crab | *Cancer pagurus* | Y |
| Edible sea urchin | *Echinus esculentus* | |
| European eel | *Anguilla anguilla* | |
| European flying squid | *Todarodes sagittatus* | Y |
| European hake | *Merluccius merluccius* | Y |
| European lobster | *Homarus gammarus* | Y |
| European otter | *Lutra lutra* | |
| European plaice | *Pleuronectes platessa* | Y |
| European seabass | *Dicentrarchus labrax* | Y |
| Flounder | *Platichthys flesus* | Y |
| Four-bearded rockling | *Rhinonemus cimbrius* | |
| Garfish | *Belone belone* | Y |
| Golden redfish | *Sebastes marinus* | Y |
| Goldsinny wrasse | *Ctenolabrus rupestris* | Y |
| Great black-backed gull | *Larus marinus* | |
| Greater argentine | *Argentina silus* | Y |
| Greater forkbeard | *Phycis blennoides* | Y |
| Greater weever | *Trachinus draco* | |

| | | |
|---|---|---|
| Green shore crab | *Carcinus maenas* | |
| Greenland halibut | *Reinhardtius hippoglossoides* | Y |
| Grey gurnard | *Eutrigla gurnardus* | Y |
| Grey seal | *Halichoerus grypus* | |
| Haddock | *Melanogrammus aeglefinus* | Y |
| Hagfishes and lampreys | *Petromyzontiformes* | |
| Harbour porpoise | *Phocoena phocoena* | |
| Hermit crabs | *Pagurus* | |
| Horse mackerel | *Trachurus trachurus* | Y |
| Jelly catfish | *Anarhichas denticulatus* | Y |
| John dory | *Zeus faber* | Y |
| Lemon sole | *Microstomus kitt* | Y |
| Ling | *Molva molva* | Y |
| Long rough dab | *Hippoglossoides platessoides* | |
| Long-nosed skate | *Dipturus oxyrinchus* | |
| Lumpsucker | *Cyclopterus lumpus* | Y |
| Mackerel | *Scomber scombrus* | Y |
| Megrim | *Lepidorhombus whiffiagonis* | Y |
| Northern fulmar | *Fulmarus glacialis* | |
| Norway lobster | *Nephrops norvegicus* | Y |
| Norway pout | *Trisopterus esmarkii* | |
| Norway redfish | *Sebastes viviparus* | |
| Norwegian skate | *Dipturus nidarosiensis* | |
| Pilot whale | *Globicephala melas* | |
| Pipefish and seahorses | *Syngnathidae* | |
| Pollack | *Pollachius pollachius* | Y |
| Poor cod | *Trisopterus minutus* | |
| Porbeagle shark | *Lamna nasus* | Y |
| Rabbitfish | *Chimaera monstrosa* | |
| Ray's bream | *Brama brama* | |
| Razorbill | *Alca torda* | |
| Red crab | *Geryon trispinosus* | |
| Red king crab | *Paralithodes camtschaticus* | Y |
| Red mullet | *Mullus surmuletus* | |
| Right-eye flounders | *Pleuronectidae* | |
| Right-handed hermit crabs | *Paguridae* | |
| Rockfishes | *Anarhichadidae* | Y |
| Rough rattail | *Macrourus berglax* | Y |
| Round-nose grenadier | *Coryphaenoides rupestris* | Y |
| Sail-ray | *Dipturus linteus* | |
| Saithe | *Pollachius virens* | Y |
| Sandeels | *Ammodytidae* | |
| Sandy ray | *Leucoraja circularis* | |
| Scorpion fish | *Scorpaeniformes* | |
| Scorpion fish | *Scorpaenidae* | Y |
| Sea stickleback | *Spinachia spinachia* | |
| Seaweed pipefish | *Syngnathus* | |
| Skates and rays | *Rajidae* | |
| Skates and rays | *Rajiformes* | Y |

| | | |
|---|---|---|
| Small-mouthed wrasse | *Centrolabrus exoletus* | Y |
| Small-rayed wrasse | *Acantholabrus palloni* | |
| Small-spotted catfish | *Scyliorhinus canicula* | |
| Sole | *Solea vulgaris* | Y |
| Spotted catfish | *Anarhichas minor* | Y |
| Sprat | *Sprattus sprattus* | Y |
| Spurdog | *Squalus acanthias* | Y |
| Squid and octopus | *Cephalopoda* | |
| Starry skate | *Amblyraja radiata* | |
| Stone and king crabs | *Lithodidae* | |
| Stone crab | *Lithodes maja* | |
| Swimming crab | *Macropipus dupurator* | |
| Thornback ray | *Raja clavata* | Y |
| Tope shark | *Galeorhinus galeus* | |
| Trout | *Salmo trutta* | |
| Turbot | *Psetta maxima* | Y |
| Velvet belly | *Etmopterus spinax* | |
| White anglerfish | *Lophius budegassa* | |
| White-beaked dolphin | *Lagenorhynchus albirostris* | |
| Whiting | *Merlangius merlangus* | Y |
| Witch | *Glyptocephalus cynoglossus* | Y |
| Wrasses | *Labridae* | |
| | *Hyas* | |
| | *Stichopus tremulus* | |
| | *Lagenorhynchus* | |
| | *Coleoidea* | |
| | *Munida* | |
| | *Anomura* | |

## Appendix 2: Observed change in sampling intensity




An example of the changes in sampling intensity between 2008 and 2010 following the termination of the port sampling programme: Northeast Arctic cod. Sampling intensity declined sharply in the first half of the year, with a less marked decline in the second half of the year.

## Appendix 3: A summary of semi-structured interviews with fishers and scientists in conjunction with the evaluation of the Norwegian Reference Fleet.

As part of this evaluation of the Norwegian Reference Fleet, semi-structured interviews with fishers participating in the Reference Fleet and scientists who use the data collected by the Reference Fleet were conducted in order to respond to particular elements of the Terms of Reference (ToRs). Particular focus is given to how fishers perceive the training they are given (ToR (b)); how the Reference Fleet affects the relationship between fishers and scientists regarding legitimacy in general, and cooperation and information flow in particular (ToR (c)); and the utility of the Reference Fleet in a broader sense for different stakeholders ToR (d)). Here, "in the broader sense" is interpreted to be related to the notions of trust and legitimacy; hence ToRs (c)) and d) are interrelated. Below, these are summarised under one heading.

Since the author has followed the Reference Fleet for an extended period of time, contact could be made with the fishers directly for this evaluation. In-depth interviews were conducted by phone in a relaxed environment. Since work already conducted for the author's PhD thesis is relevant for the interviews in both practical and analytical terms for this evaluation, the methods used are presented below together with those used for the present evaluation.

**Methods:**

The author has followed the Reference Fleet from 2005 to 2010 as a case study for a PhD thesis, which is a contribution to Science and Technology Studies. Participatory observation has been the main method, which means that the researcher immerses herself in the lives of people who are studied to varying degrees, ranging from total participation to simple observation, or something in between. She has followed the Coastal and Offshore Reference Fleet fishers collecting data at sea both with and without their IMR mentor present, was directly associated for eight months with the IMR, Fisheries Dynamics Group, where the Reference Fleet project is located, and followed most Reference Fleet annual meetings from 2005 to 2010. During her fieldwork, interviews were conducted with persons who were related to the process of data collection in some way. All questions have evolved around getting responses to aspects related to the Reference Fleet: the data production, the cooperation between fishers and scientists and how both groups understand and relate to this in practice. It should be noted that all fishers were invited to be part of the survey either by phone or e-mail. Five Offshore Reference Fleet fishers/vessel owners and seven Coastal Reference Fleet fishers were interested in participating in the interviews. Since most answers are consistent with the findings for her PhD work, the results from the present investigation seem representative.

In order to determine how the users of the data perceive the Reference Fleet, five IMR scientists were interviewed. Preferably, representatives from all research groups and programmes should have been interviewed; however, time and cost constraints did not allow this. Emphasis was given to interviewing the following research groups: "pelagic fish", "deep-water species" and "demersal fish" as well as a representative for the North Sea Programme. These were semi-structured interviews, where the aim was to let the scientist describe their perception and relation to the Reference Fleet. The interviews were structured around five main issues: 1) how the Reference Fleet affects the management of fisheries; 2) if they use the data, and if they do; 3) for what and the reason for either choice; 4) if they trust the data in the same way as any other data source; 5) suggestions for improvement. The interviews of IMR scientists and other users of the Reference Fleet data were conducted by phone, in their office or during the evaluation meeting in Bergen (6$^{th}$ of June). In addition, an interview was conducted with a representative of the National Institute of Nutrition and Seafood Research (NIFES). The Norwegian Institute for Nature Research (NINA) provided its general impression of Reference Fleet data, its utility and challenges by e-mail. Several of the evaluation committee members have worked or are working with the International Council for the Exploration of the Sea (ICES), the Directorate of Fisheries (FDIR), Norwegian Fishermen's Association (NFA) and the IMR, hence, their participation in this evaluation is ensured through these individuals.

**Summary of Findings:**

### *b) Effective training of the fishers.*

With regard to the training that fishers receive to participate in the Reference Fleet, all thirteen individuals interviewed responded positively. All fishers underlined the importance of the mentor's visit on board, and that the annual meeting is an important arena for continued training and workshops. Suggestions for improvement were made from both the coastal and offshore fishers: more visits, more workshops and making the data-handling software (Reg-Fisk) more accessible.

### *c) Cooperation with fishermen, and information exchange between researchers and fishermen.*

### *d) Utility of the reference fleet as a source of information and data in a broader sense for different stakeholders including the Institute of Marine Research (IMR), the Ministry of Fisheries and Coastal affairs (FKD), the Directorate of Fisheries (FDIR), the National Institute of Nutrition and Seafood Research (NIFES), the International Council for the Exploration of the Sea (ICES), & the Norwegian Fishermen Organization (Norges Fiskarlag).*

In order to determine how fishers perceive the cooperation with the IMR scientists through the Reference Fleet and how the information flow between fishers and scientists is affected several questions were asked related to these issues as presented in the following. Note that these issues are interrelated.

**Fishers:**

All thirteen fishers find that the cooperation between fishers and scientists within the Reference Fleet is good. With regard to the information flow, ten find that it is improved with the Reference Fleet. Typical comments during the PhD fieldwork and in the interviews conducted for this evaluation are that "*the Reference Fleet has opened a huge door into the IMR [for fishers]*", and "*we are more aware of their [IMR] challenges*". One of the Coastal Reference Fleet fishers expressed that the information flow is not improved, and he related this specifically to the IMR's work with the Norwegian Redlist, and the lack of communication with fishers in this process. Two suggested that the information flow could be better. While most fishers found that the information flow has improved with the Reference Fleet, they also believe that there is room for further improvement. Several of the fishers would like more information about what actually happens to the data they collect in addition to the information they get about the otoliths collected.

In order to investigate the issue of the utility of the data as a source of information in the broader sense, the PhD work was especially informative. Here, it was found that fishers underline two issues in particular with regard to how the Reference Fleet improves management in the broader sense – and hence its legitimacy: that the IMR has access to more and improved data with the use of the commercial fleet, and that it generates trust between fishers and scientists. For the questionnaire, all interviews were opened by asking: What do you think about the Reference Fleet in general; is it improving fisheries management? Dependent on their answers, they would be asked more in depth about the reason why or why not. In line with the PhD findings, fishers are overwhelmingly positive towards the Reference Fleet, and again, they related this to the issue of improved data base and trust. Twelve responded that they find that the IMR's data base is improved, while one answered "*both yes and no*". Those that underline the positive aspects point to how fishers provide the IMR with "*more and better data*", and that the Reference Fleet data provide the IMR with a "*better picture of the fisheries from the Reference Fleet, rather than the IMR going their routes*". The one fisher that was more negative towards the utility of the Reference Fleet data relates this to his lack of knowledge about what happens to the data. Hence, this scepticism is related to the information flow, an issue discussed above.

Eleven of thirteen fishers found that they trust fisheries management more after they joined the Reference Fleet. They explain this as related to improved communication, better dialog and mutual respect between fishers and scientists. Comments worth noting are related to how fishers' perception of management is changed when they get an insight into how science works. For example, one fisher stated that "*I trust the management more because before I started, I did not have a clue. Now, I understand what you [scientists] are doing. Some get angry when the quota is low. This has changed*". Another fisher said that "*we feel that the scientists are listening to us, and they take our observations with them. We do trust the advice to some degree, I understand more, and I have become more observant*". Two

fishers were more ambivalent with regard to the trust generated through the Reference Fleet. Both fishers are part of the Offshore Reference Fleet, and both gave very similar answers: "*Yes, because I see the amount of resources they [IMR] use, and no because I see the system inertia*". It is important to note their comments indicate that the Reference Fleet does generate trust. Both fishers also underline that the Reference Fleet is an important source for better data and that it improves cooperation between fishers and scientists. However, they find the bureaucratic system of IMR sluggish in comparison with the private market in which they operate.

**Scientists:**

With respect to the IMR scientists, four of the five interviewed expressed a positive attitude towards the Reference Fleet. As expressed by one of the IMR scientists: "*The large bonus is that we get an even stream of data. We get information from people that are in contact continuously with the fishers: they can contribute with their experiences*". He also added that the access to fisheries dependent data is helpful in meetings with fishers, especially with regards to the coastal cod: "*It is useful to have the samples from the Reference Fleet. In all the meetings with fishers, it is useful, since they often ask about data from marginal areas*". In general the scientist/research groups use the data and they trust the data collected. The one scientist that was somewhat negative towards the Reference Fleet nevertheless uses the data collected by the fishers, but stated that "*I am very sceptical to the Reference Fleet. (…) The main problem with Reference Fleet data is probably that it is difficult to know how well they represent the whole fishery on each species*".

As a general observation, there seems to be an increased knowledge of the existence of the Reference Fleet and the use of the data collected after 2009, possibly due to the cancelling of the port sampling programme. When approaching scientists in 2007-2008 in conjunction with the PhD study of the Reference Fleet, there was little knowledge about the project outside the IMR, Fisheries Dynamics Group. The Reference Fleet has been operated by IMR for about ten years and with the longer time series and increased knowledge about the Programme in general, the utility of the Reference Fleet seems to have more potential than is currently realised.

NIFES is also an active user of the Reference Fleet data. According to the NIFES representative the samples collected by the Reference Fleet are trusted as much as any other data that they use, and are appreciated greatly since they are often taken in areas where the IMR otherwise has little access due to time and bottom structure.

NINA uses the by-catch data from the Coastal Reference Fleet, and according to its representative, the data are very important. However, NINA researchers find the data base difficult to access as it is old, difficult to work with and complicated.