# THE JOINT NAMMCO-ICES WORKSHOP ON BY-CATCH MONITORING

**28 June – 1 July 2010, ICES, Copenhagen, Denmark**

## REPORT

## EXECUTIVE SUMMARY

The Workshop was the result of an initiative from the North Atlantic Marine Mammal Commission who had expressed a wish to improve fishery by-catch monitoring among its Member States. Recognising that this is an area where the International Council for the Exploration of the Sea holds some expertise, a joint workshop was agreed with the aim of developing guidelines describing best practice for conducting marine mammal and seabird by-catch monitoring.

The workshop consisted of a series of informal invited presentations on a range of topics covering the agenda agreed by a joint NAMMCO/ICES steering group. Each presentation was followed by a group discussion focusing on the relevant topic. It was agreed that a manual providing guidelines for best practice would be drawn up after the workshop and would be published in the ICES Co-operative Research Report Series.

By-catch monitoring is mandated under several national and international laws and agreements on both sides of the Atlantic and further afield. Schemes to monitor by-catch play an important role in the development towards and process of managing the oceans from an ecosystem perspective.

Usually by-catch monitoring is addressed through direct on board observer schemes, but these can be expensive to implement, particularly in the early exploratory phase when by-catch levels are not known and costly sampling effort may be focused in inappropriate areas. In such cases there are a number of other less direct approaches that can be used to obtain some initial information about possible by-catch levels.

Indirect approaches include the collation of anecdotal accounts, the systematic examination of dead stranded animals or those found floating at sea, the examination of live animals by photo-monitoring for evidence of past entanglements, interviews of fishermen, collation of fishery logbook data, and through ‘parasitising’ or piggybacking on other research programmes.

Wherever possible, results from any of these methods should be compared with one another. An example was discussed from Iceland where porpoise by-catch rates from research surveys in a limited time and area were compared with results from a questionnaire survey and with official logbook data. In this case by-catch rates calculated from logbook data were considerably lower than those estimated using the other methods.

The workshop reviewed recruitment and training procedures using examples from the USA and the UK. Basic training and safety standards were outlined and the Workshop recommended that standardised training should be implemented at a European level for observers working on by-catch monitoring programmes in European fisheries.

Two further presentations examined the operational aspects of a marine mammal by-catch observer scheme in the USA and a seabird by-catch observer scheme in Chile. The Workshop was able to identify a number of useful and practical strategies and tactics for implementing such schemes.

Several alternative by-catch monitoring systems involving independent observations, but not relying on dedicated onboard observer programmes were discussed. A system of GPS-linked video surveillance was described on boats in Denmark, where by-catches of porpoises and seabirds had clearly been identified and recorded. In the USA a system employing an alternative platform has been developed, where two observers used a fast power boat to monitor fishing operations by inshore gillnet

vessels. Although daily costs were higher than using onboard observers, this approach enabled monitoring of a fleet sector that had been previously under-represented. Another scheme was described in which Norwegian fishermen were paid to complete detailed activity and catch logs which had provided useful information on porpoise by-catch in coastal gillnet fisheries. Integrating fishery effort data with information on cetacean strandings and at-sea acoustic monitoring of porpoises in Polish waters was also described as another means of monitoring by-catch. Finally, the discard sampling scheme mandated at a European level under the data collection framework was also described, and its advantages and disadvantages as a means of collecting marine mammal and seabird by-catch data were discussed.

The Workshop discussed data collection methods and aspects of data and sample storage, and agreed that the retention of biological samples, including wherever possible whole animals, whilst logistically challenging, should be an important aim.

The Workshop discussed how fishing effort data can be used to plan and stratify sampling at sea, and how it can be used to raise observed by-catch rates to the fishery or fleet level. Problems with the reliability of effort data were described and discussed. Some of the statistical methods for raising by-catch estimates were also reviewed. It was stressed that there is not a single preferred way to determine overall total by-catch for a fishery, and that generally caution is required because sampling levels tend to be low and by-catches of protected species are generally rare events. It was also noted that total by-catch estimates are highly dependent on the raising factor, and that a detailed knowledge of the fishery is important to obtain the most reliable estimates.

Finally the workshop considered relations between industry partners and by-catch monitoring programmes. It was stressed that transparency is critical to maintaining good relations with industry and examples from three EU funded projects were presented to demonstrate this point.

The workshop agreed that a summary report of the meeting would be produced but that a more detailed manual or set of guidelines on best practice would be drawn up and, with the prior agreement of ACOM, would be submitted to ICES for publication under its Co-operative Research Report Series.

# 1. INTRODUCTION

## 1.1 Opening of the Workshop

The workshop convened at 14:00 hr on 28 July. All participants were welcomed by the Co-Chairs, Simon Northridge and Droplaug Ólafsdóttir. There followed a round of introductions. The participants (Appendix 1) numbered 25 and represented geographical regions and countries worldwide, as well as governmental departments, universities, industry and non-governmental organizations, with a wide range of expertise on marine mammal and seabird by-catch monitoring. The draft agenda was adopted (Appendix 2), which allowed flexibility in the way the workshop proceeded and allowed for extended discussions and sub-group sessions when appropriate.

## 1.2 Overview – Origins of Workshop and Expected Outcomes

Northridge described the background to the workshop. NAMMCO had found progress on marine mammal by-catch monitoring issues unsatisfactory, and had made the decision to expand its work to include external experts. This had resulted in a proposal for a joint workshop with ICES which has a background and an established expertise in many aspects of by-catch. The invitation to involve ICES was addressed through the Study Group for By-Catch of Protected Species (SGBYC). By agreement between a joint NAMMCO and ICES steering group for the workshop, the terms of reference were expanded to include seabirds and the aim was to produce guidelines for best practice in monitoring and assessing by-catch. ICES had agreed to publish such guidelines as a cooperative research report. The deadline for completion of the guidelines would be in October 2010 with publication thereafter.

The agreed Terms of Reference for the Workshop were:

1. Review and describe the advantages and disadvantages of existing observation schemes for marine mammals and seabirds;
2. Recommend best practice when establishing and implementing by-catch observation schemes.

It was agreed that abstracts of all presentations and papers should be available before the end of the workshop, and these would be incorporated in a formal report of the workshop proceedings to ICES and NAMMCO. This report is to be submitted to the NAMMCO Council via the Scientific Committee of NAMMCO, and eventually be published in the NAMMCO Annual Report for 2011. This report is separate from the published guidelines.

## 1.3 The Motivation for By-catch Monitoring Schemes

The issue of ecosystem management has become an increasingly important concept both in fisheries management arenas and in international agreements concerning the marine environment. Driven most recently by public concerns over the poor management of the oceans, the drive for more integrated ecosystem management has been mandated or encouraged in several international, European, and national agreements or regulations.

The general principles for ecosystem based management were established during the 1980s in the United Nations (UN) Convention on the Law of the Sea (UNCLOS), where the management of fishery impacts on associated and dependent species is repeatedly addressed. Later, under the UN Food and Agriculture Organisation's (FAO) 1995 Code of Conduct for Responsible Fishing, the issue of minimising by-catch was explicitly addressed, and was taken further by the FAO in the development of an International Plan of Action (IPOA) on Seabirds. The Convention on Biodiversity also requires signatory states to identify processes and activities that are likely to have significant adverse impacts on the conservation of or sustainable use of biological diversity, and to monitor those effects (Article 7). Several Regional Agreements have been established under the Bonn Convention on Migratory Species that specifically address by-catch of marine mammals and seabirds, including ASCOBANS, (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas), ACCOBAMS (Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area) and ACAP (the Agreement on the Conservation of Albatrosses and Petrels).

Domestic legislation that underpins efforts to monitor by-catch include the U.S. Marine Mammal Protection Act, the Canadian Species at Risk Act, and within member states of the European Union, the Habitats Directive and Council Regulation 812/2004 concerning incidental catches of cetaceans in fisheries operations.

Although legislation has been important in driving the development of by-catch monitoring and assessment, commercial pressure has also been important. Public concerns about the impacts of fishing on the environment and specifically on non-target species has led to the development of labelling and accreditation schemes designed to ensure certain environmental or welfare standards are maintained during fishing operations. Such schemes require information on by-catch of protected species and may also require ongoing monitoring systems to ensure standards are maintained, and that by-catch rates are being minimised through the appropriate use of mitigation tools.

Independent monitoring schemes are now widespread in many fishery management areas, not only to ensure compliance with fishery regulations, but also to improve fish stock management and to address concerns about impacts on non-target species. While observer schemes have usually been regarded as the most reliable way to obtain information on catch composition and on biological aspects of the catch, other monitoring methods are gaining acceptance in several areas, and these were considered further during this workshop.

Monitoring schemes in the present context – monitoring by-catch – are primarily designed to determine how frequently animals of specific groups get caught in specific fishing operations, but they are also useful in determining how and why animals of specific groups get caught, which may be an important factor in developing technical means of reducing by-catch. Monitoring schemes need to be augmented by an assessment process that determines whether the by-catch rates observed present a significant concern. How such 'significant concerns' are defined is an important issue, that may depend variously on the conservation status and population dynamics of the species involved or on other societal values that over-ride conservation concerns.

It is important at the outset to understand that monitoring schemes will always have their limitations. They cannot be used to prove that no by-catch of a certain species will ever occur in a fishery, and in most cases they can only be used to sample a proportion of total fishing effort in order to make a probabilistic assessment of how prevalent by-catch may be. Where very rare animals are concerned the by-catch rate may be too low to be quantifiable by any realistic monitoring scheme. The monitoring scheme must also be underpinned by an appropriate assessment of the significance of any quantified by-catch, and this depends on knowing something about the conservation status of the species concerned, and also on having agreed conservation goals. These are often poorly-defined in legislation, and are driven largely by societal values.

By-catch monitoring schemes enable us to quantify the effects of fishing operations on non-target as well as on target species, and as such have an important role to play in the development of multi-species management approaches. They can also provide useful biological information on both target and non-target species, and technical information on aspects of gear use that can inform management decisions. Schemes to monitor by-catch can also be integrated with other aspects of independent monitoring that help improve both information flow and the development of more reliable ecosystem management tools.

## 2. INDIRECT MEANS OF MONITORING BY-CATCH

### 2.1 Overview of Indirect Means of Monitoring By-catch

Although direct observations are the preferred means of estimating by-catch rates, these are sometimes impractical, usually because they are expensive or because space on small vessels limits the acceptance of observers onboard. Several other ways to estimate by-catch rates indirectly have been proposed.

**Anecdotal accounts**

Anecdotal accounts of marine mammal and seabird by-catches in fisheries may provide the initial evidence that high by-catch rates occur in an area. Anecdotal accounts are usually not random as news of exceptional rather than common events are more likely to be spread. The information may not be very detailed and may be biased. Anecdotal information may increase awareness of the potential for high by-catch risk in a fishery which may then lead to more specific monitoring measures.

**Stranding/floating**

The presence of dead animals on coasts or at sea may highlight the fact that some by-catch is occurring in a region. As a quantitative measure such observations are not usually of much use because the number of dead animals that wash ashore is not necessarily directly related to the number of animals that are by-caught in any given region. Byrd *et al.* (2008), however, showed that observer-generated annual estimates of bottlenose dolphin (*Tursiops truncatus*) by-catch in a gillnet fishery for spiny dogfish (*Squalus acanthias*) in North Carolina (USA) were correlated with numbers of stranded animals. Large-scale strandings of porpoises (*Phocoena phocoena*) in England and in the Netherlands and Belgium have also been used to highlight the existence of by-catch in coastal fisheries, but have not been directly linked to any change in fishing effort or actual by-catch rates. Care must be taken not to over-interpret data from stranded animals, and protocols for establishing cause of death must be followed. Strandings can help augment other data sources and raise awareness of by-catch in an area. However, low stranding rates do not provide proof of low by-catch rates in an area and furthermore, strandings of small animals on remote or inaccessible shores are likely to go unnoticed.

**Photo-identification studies**

Studies of scars and injuries on cetaceans resulting from fisheries interactions can provide information on exposure risk to different fishing gears and help identify species at high by-catch risk in a fishing area (Kiszka *et al.* 2008). These studies can be taken a step further by estimating the entanglement mortality rate. Estimation of the ratio of lethal versus non-lethal entanglements can be carried out by monitoring eye-witnessed entanglements to grade each event on the scale of seriousness (Robbins *et al.* 2009). Such studies are suitable in small areas were fishing effort and entanglement risks are relatively high. Migration of animals between areas with different levels of fishing effort may however lead to erroneous interpretations. Photo-identification studies are not always suitable for obtaining information on "shy" species such as harbour porpoises that rarely expose large parts of the body at the surface. Furthermore, photo-identification studies may show injuries on dorsal fins well, whereas injuries to jaws and beaks, which are frequently affected by fishing gears but are less often exposed at the surface, may not be visible for photography.

**Interviews**

Interviewing fishermen is a relatively inexpensive means of collecting information on by-catch of non-target species in comparison to dedicated by-catch observer programmes. Interviews can serve as a first step to gain an impression of the scale of by-catch and/or damage to fishing gears in a region before decisions are taken to implement more detailed but expensive monitoring measures. Limitations of interviews are that they are based on fishers' memory or interpretation of events, their skills in species identification, and require a willingness to cooperate. There may be strong incentives in some areas for the scale of by-catch to be misrepresented when public or legal censure is possible. Error-checking strategies such as call-back interviews provide a means to assess the variability and reliability of responses.

**Fishery Logbooks**

Reporting of detailed fishery data in official logbooks is practiced widely in many fisheries. Large quantities of detailed information on the catch, fishing effort, and by-catch can be extracted from logbook data and can be used for estimating removals of animals other than the targeted species. However, while in theory all catch should be recorded in the logbooks, such systems rely on the cooperative spirit and awareness of the fishers and there are many examples where fishery logbooks have been shown to be inconsistent with data collected by independent observations. In practice it is impossible to interpret logbook data without investigating the fishers' response rates and correct the data for possible "non-reporting".

**Discard/ biological sampling /research survey programmes**

Monitoring of by-catch in discard and biological sampling schemes or fishery research programmes can approach dedicated by-catch observer programmes in terms of data quality. Survey personnel can be trained in identification of by-catch species, and reporting of fishery data may be expected to be of high quality and can provide an opportunity to extrapolate observed by-catch events to the entire fishery or fleet. The main drawbacks regarding by-catch monitoring under these circumstances is that the research programme and the personnel on board will have other priorities which could impact on their ability to carry out effective by-catch monitoring. For example, observers may not be located in a suitable place when the gear is being hauled and may therefore not observe animals falling out of the nets. This particular problem can be solved if the rate of "drop-outs" is known and the by-catch data are corrected retrospectively. It is more difficult to address the fundamental problems associated with sampling stratification when combining different research or monitoring schemes, because the aims of a by-catch monitoring programme may compromise the aims of the other programme or vica versa.

## 2.2 Optimising Indirect Observations by Synthesis of Different Surveys

Large quantities of detailed data on by-catch and fishing effort are often available in logbooks and may give estimated by-catch levels with good precision and low CVs. However good precision estimates may be misleading in terms of the accuracy of by-catch estimates if the analyses are based on biased assumptions. Logbook data, for instance, may be detailed and extensive, but not necessarily reliable. There are also concerns about the representativeness of by-catch data obtained from indirect observations and with the selection of appropriate raising procedures in order to minimise biases in by-catch estimates. When indirect means of quantifying by-catch in particular are adopted, it is important to keep these concerns in mind. Ideally more than one method should be applied and a comparison of the results may help to evaluate and optimize the best practice of monitoring and estimating by-catch in each particular fishery.

Droplaug Ólafsdóttir presented information on marine mammal by-catch, in a bottom-set gill-net fishery in Iceland, that had been obtained by several methods: fishery logbooks, a questionnaire, and fishery research surveys. The estimated numbers of the most frequently by-caught mammal species, harbour porpoise, were compared to evaluate the reliability of these three different methods.

gill-netIn Iceland, fishers are obliged to record incidences of marine mammal and seabird by-catch along with detailed information on fishing effort and associated commercial catch in official logbooks. In the years 2002-2008 by-catch data were reported by about 5% of all operating vessels. However, it was difficult to determine for the remaining vessels which had actually had no by-catch and which had simply neglected their by-catch reporting obligations. In October 2004, a questionnaire was therefore sent to captains of all operating gill-netters asking whether any by-caught marine mammals had been observed on their vessels during the three previous fishing years. The results revealed that 81-96% of the vessels had observed some marine mammals in the nets in 2002-2004. This information was used in analyses of by-catch data from logbooks. The assumption was made that fishers who report marine mammal by-catch in logbooks at least once do so consistently and all their fishing effort regarded as "reporting effort". The by-catch data from the reporting vessels were corrected for the proportion of vessels that had by-catch but didn't report it. The corrected by-catch data were then extrapolated over the entire fleet where fishery data were stratified by years, two seasons and 10 areas. Unit of effort was fishing days.
In the questionnaire, the captains were also asked to estimate the total number of harbour porpoises observed in their nets in the previous fishing year. The results provided estimates of 2,012 and 2,600 animals with simple calculations using the number of vessels and number of nets as units of effort, respectively (Table 1 below).

The third source of information was obtained from fishery research surveys carried out annually during April by the Marine Research Institute, Reykjavik. Data on marine mammal by-catch have been collected since 2003. Harbour porpoise by-catch data were extrapolated over all the gill-net fisheries in March and April using fishing days as unit of effort. Confidence limits in all porpoise by-catch estimates discussed above were obtained by the bootstrap method.

The results for the estimated number of entangled harbour porpoises in the gill-net fishery in Iceland obtained by various methods are shown in Table 1 below. All sources of by-catch data gave estimates of harbour porpoise entanglements within the same order of magnitude. The data presumably of highest quality are the data collected by research personnel during fishery research surveys. The drawback of these data is however, a narrow time frame, and can therefore only reflect the situation in the spring. The logbook data show similar levels of harbour porpoise by-catch for the entire year compared to the March/April scope in the survey data. This may indicate under-evaluation derived from the logbook data even after correcting for vessels not reporting their by-catch. The assumptions that fishermen who report by-catch once do so consistently may therefore not be valid.

| **Source of Information** | **Season and estimated by-catch of porpoises** | | |
|---|---|---|---|
| **Questionnaire**<br>Total with unit of effort:<br>N vessels / N nets | | **Sept 2003 - Sept 2004** | |
| | | 2012 / 2600 | |
| **Logbooks:**<br>Total (95% CL) | **2002** | **2003** | **January-June 2004** |
| | 839 (488-1,216) | 1049 (505-1,599) | 989 (673-1,310) |
| **Research surveys:**<br>Total (95% CL) | | **March-April 2003** | **March-April 2004** |
| | | 929 (291-1,418) | 958 (296-1,472) |

**Table 1.** Estimated number of harbour porpoises by-caught in the bottom-set gill-net fishery in Iceland obtained from 3 sources of information.

The questionnaire produced the highest estimate of porpoise by-catch of the 3 data sources and thus supports the indication from the research survey data of under-estimated by-catch derived from the log book data. The information from the questionnaire is however based on fishers' memories of events in the previous year. Secondly, no stratification was feasible for the questionnaire data and the data were extrapolated over the entire fleet, regardless of potential seasonal and regional differences.

The significance or importance of strandings in relation to by-catch events was discussed extensively by the workshop. Clearly some stranded cetaceans may be discarded by-catches, but there were varying opinions as to the usefulness of collating strandings data in order to assess the scale of by-catches, especially if there were no clear indications on the carcasses that could link them to fisheries by-catch. The importance of reliable post mortem diagnostics is therefore crucial. Increases in the number of recorded stranding events may indicate a by-catch problem, but quantifying the scale of the overall by-catch is generally not possible.

The workshop agreed that the Icelandic study provided a useful example of how integrating information from more than one source can help shed light on the nature and scale of a by-catch issue. It was also noted that the reliability of logbooks and other forms of self reporting are likely to depend on differences in views of marine mammal by-catch. In some countries, *e.g.* USA, there may be legal or other consequences to by-catch, whereas in Iceland, there are not. In Iceland and Norway, it is mandatory to report by-catches, whereas reporting is voluntary in most European countries. There are differences in attitudes to by-catches that are dependent on culture. In Iceland, Norway, Greenland, and other countries by-catches may even be consumed locally, whereas in some other countries the retention and consumption of protected species such as cetaceans would be illegal. In Norway the general lack of reporting may be because discarding of any catches is illegal, so that mammals should be landed and reported, but such by-catches are generally undesirable and in fact very few are landed or reported. The fear of repercussions from conservation and animal welfare groups in some countries may also prevent reporting. However, the workshop was informed that in Brazil logbooks are given to

fishery vessel captains for seabird by-catch recording and the method was found useful after a couple of years trial.

The workshop noted that some opportunistic observer schemes – for example those based on fish discard or biological surveys – can provide very good data, especially if personnel are specially trained to observe and identify by-catch, and there is clearly no rigid dividing line between such surveys and dedicated by-catch observer schemes.

The Workshop noted that, in guidelines of best practices in monitoring, it may be useful to point out common pitfalls and specify which practices in particular should be avoided. A flow chart designed to help the process of selecting the appropriate monitoring scheme may also be a useful tool in the guidelines.

## 3. DIRECT OBSERVATIONS OF BY-CATCH

### 3.1 Observer Qualifications, Training, Reliability, and Liaison

Sara Wetmore and Grant Course explained how observers are recruited and trained in the USA and the UK.

**Recruitment**

In the USA the National Marine Fisheries Service has developed nationally recognised minimum educational, general and safety standards for observer programmes. The Northeast Fisheries Observer Program (NEFOP) recommends hiring of observer candidates following minimum eligibility standards and then provides appropriate training. In the UK selection of observer candidates is seen as the first and most critical step of the whole process of using observers. The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) observer scheme prefers to employ candidates that have seagoing experience on small commercial vessels rather than recent graduates with no practical seagoing experience, so that the potential observers are fully aware of the conditions they would face. Working conditions at sea can be dangerous and may involve long hours in an unpleasant and sometimes unfriendly environment. Interviewers have to be certain that potential observers do not suffer from such things as chronic seasickness or have an unrealistic or rose-tinted view of the marine working environment. The interview process should be used both to inform candidates about what to expect when working at sea and to determine their suitability for the role of an observer.

**Training and Safety Equipment**

In the USA, the Northeast Fisheries Observer Program conducts 3-week training sessions for observer candidates that cover a broad range of skills including fish, mammal, seabird and sea turtle species identification, fishing gear information, sampling protocols, electronic data collection and safety. Insurance costs, conflict of interest and confidentiality standards are discussed and implemented during training sessions. Observers are trained, certified, then deployed, and collect by-catch and other fisheries data onboard vessels fishing with multiple gear types along the Northeast Atlantic coast of the United States.

In the UK there are four main subject areas that are targeted for training observers; these are safety, sampling, company and data procedures, and species specific training (for example, in this case cetaceans). Safety takes equal priority with all work objectives and managers of the observer programmes work on the basis that all observers should be provided with at least the minimum safety training required for a general deck hand on board a fishing vessel. This includes training in: -

- Personal Survival Techniques (basic sea survival)
- Fire fighting and prevention at sea
- Personal and social responsibilities
- Elementary first aid
- VHF Radio operators course.

A Seafarers medical Certicate (“ENG1”) is also required of all observers to ensure they are fit to work at sea safely.

In addition, the observers receive further formal safety training in manual handling, defensive driving, vessel visual safety checking, and will then have at least four accompanied sea trips with a competent trainer/observer to evaluate safe practice as well as sampling best practice.

Training to take samples obviously depends on what the objectives of the specific programme are but safety and principles of randomising sub-sampling need to be considered at all steps. Data quality is one of the most important issues facing observer programmes and it is important that correct procedures are established at the outset.

In the UK, the CEFAS discard survey observer programme was set up to monitor finfish and commercial shellfish by-catch as prescribed under the EU Data Collection Framework (DCF). However observers also collect data on cetacean, seal and seabird by-catch. The training on cetaceans however, has been limited to a one-week identification course in 2006, and has never been renewed. Thus all recruits since have not had any formal training in cetacean identification and no staff have been trained in seal or bird identification. This lack of training is due to these species groups not being a requirement of the DCF, and that there is no available funding for these additional observations. Unless the training is formalised and given frequently, then the skills base will be lost and the data will become less reliable.

A list of suggested essential safety equipment was presented and included in the items listed below. In addition it was felt that when it came to safety equipment, managers should provide observers with whatever they think is necessary, as they are more likely to utilise equipment they have insisted on, rather than had forced on them.

- Wet and cold weather clothing and gear (oilskins, jumpers, hats, steel-toed rubber boots, etc.)
- Life jackets –(twin-chambered 275N and 150N are used in the UK)
- EPIRB (emergency position-indicating radio beacons)
- Flotation Suit (*not immersion suit)*
- First Aid Kit
- Flashlight
- Fire Extinguisher
- Flares (mini rockets, day/night)
- Safety Harness
- Portable Life Raft for under 10m vessels, if required
- Risk assessments, operating procedures, communication instructions, emergency response plans
- Anything else an observer requires and can justify.

**Communications**

A useful management and safety tool that the CEFAS United Kingdom discard observer programme has employed is a formalised Checking In Procedure for observers on field work. Before going on a sea trip an observer must complete a safety file that details all expected movements for the time away from the office, including details of sea trips (dates at sea, etc.), boats being sampled, hotels residing in, other useful contact numbers *e.g.* the local fish agent, skippers' home telephone number and expected time out of the office. The observer also provides an estimate of docking time with a trigger period, which if exceeded alerts the manager to start tracking down an observer and if necessary start an emergency response procedure. Trigger times though should be treated with caution as all docking times are subject to change depending on fishing, weather conditions etc.

At all times the programme has an on-call shore-based contact, and observers are required to text on sailing, text on landing, and text on returning to base/home. The shore-based contact should always send a response to reassure the observer that the message was successfully communicated and that someone out there is mindful of where the observer is.

In the USA observers are managed by contractors who must have adequate insurance for observer, boat owner and company. The NEFOP has been running since 1989, and it is overseen by two committees – one focusing on training and the other on safety.

The workshop learned that in Denmark training courses are not so comprehensive as in the United Kingdom and United States. Norway has detailed courses for contracted fishermen but not safety at sea certification. In Spain observers who were employed before as fisheries /discards inspectors or at-sea personnel are used for by-catch reporting. In Spain, training is not as detailed as CEFAS.

During discussions the question of costs was raised. In the NEFOP there are usually about 8-16 trainees per course and costs are about 5,000 USD per trainee. In the UK, training courses funded by CEFAS cost about 20,000 UKP per trainee over a 3-month programme. It was noted that many aspects of training can be brought in from other training sources and need not be exclusively developed for marine mammals or seabird by-catch monitoring.

The Workshop recommended that training programmes and collection procedures for data and samples in European fisheries need to be standardized: it is important to have common European training standards as there are shared common waters, and it was agreed that this point should be introduced into the guidelines.

It was further suggested that there might be a case for two types of courses – a general core course for sampling at sea, and another specifically for sampling marine mammal by-catch which should include biological sampling.

It was suggested that identification booklets for species should be provided, and it was also suggested that video footage may be helpful.

### 3.2 Direct Observation Schemes of By-catch – Marine Mammals

Amy van Atten described the working of the US by-catch monitoring scheme in some detail. There are 9 regional areas in the United States with Federally-managed fisheries observer programmes: Northeast, Southeast (3), Northwest, Southwest, Pacific Islands, and Alaska (2). Some observer programmes may be fishery-specific, and others are multi-fishery within specific geographic areas. There is one coordinating office, called the National Observer Program (NOP), based at National Oceanic Atmospheric Administration (NOAA) Fisheries Headquarters in Silver Spring, Maryland. The NOP has several staff members working on funding, political aspects of observer programmes and monitoring, agency priorities, characterization of Federal use of funds, and coordination of national efforts to form working groups in order to share information and have a unified approach to nationally important issues. The NOP organizes the activities of the National Observer Program Advisory Team (NOPAT), which is made of the programme manager of each observer programme, including staff from the NOP and representatives from Protected Resources, General Counsel, Office of Law Enforcement, and US Coast Guard. The NOPAT meets, usually every 3 months, around the United States, to address common issues and challenges of observer and monitoring programmes, such as contract structure, sampling protocols, safety issues, training requirements, data management and access, and outreach and education. Having this team of programme experts share their experiences in managing observer programmes has helped to develop new or evolving programmes, to promote fair treatment for observers, and to pro-actively address industry, management, and other stakeholders' concerns.

The Northeast Fisheries Observer Program (NEFOP) covers several fisheries in the Northeastern USA. NEFOP offers certifications for NEFOP observers, at-sea monitors, and dockside monitors. It is a multi-purpose scientific data collection programme, collecting data that can be used for enforcement purposes and to test general compliance with certain regulations – in both state and Federal waters, out to the edge of the E.E.Z. from Maine through North Carolina. There are approximately 80 NEFOP observers, 110 at-sea monitors, and 100 dockside monitors, expecting to accomplish more than 15,000 days at sea per year. The majority of the funding is from congressional funds (Federally supplemented), although one fishery, a component of the Atlantic scallop fleet, has an industry funded observer programme that is also managed by NEFOP.

The source of funding for NEFOP and other such programmes is critical as this will have a major influence on operational plans – and may in some cases restrict observations to certain fisheries or areas or times. Regular, even, smooth, and predictable funding is strongly desired for observer programmes, as start up costs can be high, and cyclic funding makes it hard to maintain an experienced cadre of observers and programme staff.

Other key undertakings are to define the programme objectives, design the sampling strata, determine vessel selection methods, set standards while maintaining the ability to adapt as mandates and needs change, and allow for a process for stakeholder input. It is also important to assess and evaluate what platforms to use (e.g., deploying onboard observers, using an alternative platform alongside the fishing vessel, doing beach-based observations, using electronic monitoring), what level of funding is available, how much time is available to pre-plan and develop, and what legal structure there is to support programme goals.

Observers are great multi-taskers, but it is important not to "over-task" them. Data collection should focus on observable, quantifiable traits, and avoid subjective judgment calls. The importance of tagging dead animals so as not to double count mortalities should be stressed. It is also important to acknowledge the limiting factors of the sampling platform (storage space, size of vessel, sleeping accommodation, lighting conditions, mobility, length of time out at sea, lack of refrigeration or fresh water, etc.). Clearly it is necessary also to prioritize and streamline data collection and reporting, and quick reference waterproof guides can help.

In gill-net operations in the Northeastern US, harbour porpoises are occasionally by-caught, mostly resulting in their mortality. During haulback, the porpoises often get dislodged from the gill-net twine and are freed from the gear. The carcasses float in some cases, and sink in others. NEFOP data have shown that if observers are not focusing their view on the gill-net string during haulback, they will probably not observe such porpoise by-catch. For this reason, observers are instructed to do a marine mammal haul watch and limit fish sampling during a portion of the trips. On other trips, they would record the known takes of porpoise, but they do not do a dedicated "marine mammal haul watch" as they are sampling and recording retained and discarded fish. It is important to explain the difference between these two sampling methods to the industry, or they just think they have a lazy observer if they are not sampling fish. The results of such data collection can be used to calibrate marine mammal watch hauls with fish sampling hauls.

Regular outreach with industry members can help with cooperation in obtaining and retaining samples for further processing onshore. Things that the NEFOP has done include a Shadow Trip Program, captain interviews, Fishermen Comment Cards, invitations to necropsies or special sample workups, providing copies of research findings, and sending letters of appreciation for sample retention. It is great to find a benefit to collecting the data back to the fishing industry, such as perhaps providing summaries on where unwanted by-catch can be avoided in order to extend the opening of their fisheries. Open and transparent operations and offering opportunities to share data are important to the overall success of the programme.

### 3.3 Direct Observations of By-catch – Seabird Monitoring

Oliver Yates provided an overview of seabird by-catch monitoring based on experience from BirdLife International's Albatross Task Force which is active in 7 countries in South America and southern Africa. It was noted that by-catch during fishing operations is widely recognised as the main cause of declining populations of albatrosses and many vulnerable petrel species. When developing monitoring programmes to detect and quantify by-catch in these fisheries it is important to consider appropriate operational factors that may be associated with by-catch. Interactions with seabirds can be cryptic and as such may go unnoticed or unrecorded if the protocol is not orientated to dedicated observation of specific fishing gear and aspects of its operations.

Mortality events result from four main factors: entanglement in nets, collisions with fishing gear, drowning on hooks during setting and, although less frequently, fatal injuries incurred as hook lines are hauled. Such mortality occurs as fishing gear is set or throughout the fishing operation. However,

it is not until gear is retrieved that mortality can be recorded (caught on hooks, entangled in nets or on trawl cables).

The most appropriate means of collecting seabird mortality data is therefore through observations during hauling operations; the hook line in longline fisheries, the trawl warp cables and net in trawl fisheries and the mesh in net fisheries. Observer programmes should therefore include dedicated periods of observation of these operational procedures to a degree that by-caught species are accurately detected and registered. This monitoring needs to be reported in terms of fishing effort and gear type (configuration) so that by-catch estimates can be raised to the fleet level.

Significant efforts are currently being made to work on monitoring in developing countries, with a focus on fisheries impacting vulnerable seabird populations. Onboard observers were encouraged to work together with crews and develop a suitable monitoring protocol for the fleet.

In accurately recording the extent of by-catch, there are 3 stages: setting, soak time, and hauling up in the demersal and pelagic longline and trawl fisheries. Gear configurations on vessels are important factors in calculating by-catch and monitoring tasks will vary depending on the gear type and specific use.

**Longlines**
Birds are attracted to baited hooks on longline gear and offal discards. Incidental capture of seabirds occurs during setting operations as birds take baited hooks, become hooked and drown. To monitor this impact, dedicated observation is needed during the hauling operation when birds can be accurately recorded as they are recovered with the fishing gear. Longline hooks number in the thousands (pelagic) and tens of thousands (demersal) and while 100% of fishing gear can be monitored in pelagic longline fleets, it is more challenging to observe all hooks in demersal fleets. In such cases, observation of 40% of the longline gear that was set is achievable.

**Trawling**
In trawl fishing fleets, seabirds are attracted to offal discards and fishery remains in nets. Vessel design and offal discard procedures lead to foraging seabirds being in close proximity to trawl warp cables and fishing gear. As the vessel pitches and rolls, birds collide with trawl cables, are forced underwater and drown. In fleets with large mesh sizes, birds are also captured in nets during both the setting and hauling of fishing gear. The key time for observing by-catch on trawlers is during the hauling operation as birds that have been trapped on trawl cables can be counted. However, it must be taken into consideration that due to the nature of the interaction, this provides an underestimate of total mortality. During setting and trawling operations, observers can record contact rates between birds and cables – light touch, collision, dragged underwater - and relate this to the dead birds that are recovered during the haul.

### 3.4 Use of CCTV to Monitor By-catch
Lotte Kindt-Larsen reported on Danish trials of CCTV to monitor by-catch. Between September 2008 and July 2009, 6 Danish commercial fishing vessels, (4 trawlers, 1 seiner, and 1 gill-netter) had an Electronic Monitoring System installed onboard. The aim was to test whether a "fully documented fishery" could help develop a fisheries control system in which all catches (including discards of fish above and below minimum landing size) are counted against the vessels' catch quotas rather than the present landings quota system. As a premium for carrying out a fully documented fishery, the participating vessels got additional quota opportunities based on the fact that there was complete catch documentation and records of both retained and discarded cod (*Gadus morhua*). The total catch report was audited by use of a sensor system and 4 CCTV cameras, each filming different angles of the catch handling as well as the hauling of the gear. Since the system was recording all catch events it was expected that the Electronic Monitoring System could also be used for recording by-catch of marine mammals and seabirds. All 732 hours of video recording from the gill-net vessel were therefore analyzed in order to record the number of by-caught marine mammals and sea birds. A total of 3 harbour porpoises (*Phocoena phocoena*), 1 harbour seal (*Phoca vitulina*), 2 cormorants (*Phalacrocrax carbo*) and 1 seagull (*Laridai*) were caught. The quality of the images showed that by-catch of marine mammals and seabirds could easily be verified on the images and the images could be processed at the

highest possible speed. In Denmark the project is now continued onboard 6 gillnet fishing vessels. All vessels will be monitored by use of CCTV cameras for one year and data will be analyzed for both discards of cod and of marine mammal and seabird by-catch.

### 3.5 Direct Monitoring using a Separate Observation Platform

Barbie Byrd reported on an Alternative Platform Observer Program (APOP) in North Carolina (NC), USA that was implemented between March 2006 and May 2009 to increase overall observer coverage of ocean gill-nets and to ensure coverage was representative of NC's diverse gill-net fisheries. Prior percent observer coverage by the National Marine Fisheries Service, Northeast Fisheries Observer Program (NEFOP) had been low (<3%) and skewed to larger vessels (>7.2 m) fishing in federal waters (5.6 – 370.4 km from shore), whereas the majority of fishing effort and observed by-catch of bottlenose dolphins (*Tursiops truncatus*) occurs within 5.6 km of land. This disparity was, in part, due to challenges associated with the large proportion (~50%) of small gill-net vessels (<7.3 m) in the fleet. The small size of some of these vessels does not allow accommodation of an onboard observer. Additionally, fishers using small vessels can be difficult to locate because they often launch from private or public ramps in contrast to larger vessels that are docked at seafood dealers. Conducting observations using an alternative platform (i.e. a separate vessel) can potentially mitigate those challenges. As a result, 2 people were hired to conduct observer trips in the NC APOP: an observer trained by the NEFOP and a biologist with extensive boating experience. The observer used NEFOP's methods and data logs so that the data could be integrated with those from traditional observers for subsequent by-catch estimation. Allocation schedules were developed from previous years' fishing effort data with a 10% coverage goal and, after intensive outreach in the fishing community, observer coverage began. Initial requests for observer trips were made in advance through outreach activities, or in person at public boat ramps and on the water. Information on fishers (*e.g.* contact information and homeport) was then compiled in a database to aid in scheduling future trips. Although 10% coverage of small vessels was not achieved, a large proportion (25 – 48%) of observed vessels had never carried a traditional observer indicating that overall (APOP + NEFOP) coverage was more representative of the fleet. In addition, APOP trips resulted in a 21 – 40% increase over NEFOP in ocean gillnet trips. No by-catch of marine mammals or sea turtles was observed by the APOP; however, 20 by-caught seabirds were observed. Although using an alternative platform was more advantageous for observing small vessels, it may not be applicable in all situations. For example, the APOP in NC observed fisheries close to shore and it may not always be feasible (e.g., cost, logistics) to use an alternative platform far from shore. In addition, the daily running costs of the APOP ($3,500 USD) were more than double that of a traditional trip ($1,200 USD) due to the need for 2 crew members per observation as opposed to one. The cost for the APOP, however, included additional tasks by APOP crew for the programme and other research projects. Finally, funding may constrain a programme's ability to maintain an alternative platform vessel (if one is already available) or to purchase a vessel. Unfortunately, funding issues led to the termination of the APOP for NC ocean gill-nets in May 2009.

### 3.6 Monitoring Marine Mammal By-catch in Small Boat Fleets

A general problem for monitoring marine mammals or bird by-catch is found where there are inshore fleets of very large numbers of small vessels each of which may take relatively few animals per year. Sampling such fleets presents very particular logistical problems.

Arne Bjorge described work in Norway aimed at monitoring marine mammal by-catch without the use of independent observers in a 'modern artisanal fleet'. The Norwegian coast spans an area from 58°N to 71°N. The extremely convoluted shoreline including islands is more than 83,000 km long, (more than twice the earth's circumference at the equator). About 5,000 commercial small vessels (length less than 15 m) are operating a variety of gears in these coastal waters. The long coastline, the large number of vessels and the inability of the small vessels to carry an observer for multi-day trips were constraints faced when designing a marine mammal by-catch monitoring programme. Landing statistics for target species are generally good for fisheries in Norway. However, information on the fishing effort and catch composition of non-target fish species is poor for coastal fisheries. Therefore, improvement of monitoring and management of takes of non-target species was needed. Starting in 2006 2 fishing vessels were contracted in each of 9 domestic fishery statistical areas to provide detailed statistics of effort, target species catch, by-catch of all non-target fish and marine mammals.

The value of the contract is a significant proportion of the annual revenue of the contracted vessels. Each of the vessels is visited regularly by scientific staff, and they stay onboard on day trips. Any discrepancy between statistics of trips with and without scientific staff on board will result in cancellation of the contract. The first 2 years of monitoring revealed frequent takes of 3 marine mammal species: the annual takes by the contracted vessels were in the low hundreds for harbour porpoise, and less than one hundred for harbour and grey seals. The collected data from contracted vessels in combination with landings statistics of target species from the same vessel category and gear types will enable extrapolated marine mammal by-catch totals in entire fisheries to be produced. Extrapolation to the entire fisheries will be made when data from the third year of monitoring becomes available.

Krzystof Skóra described an alternative approach in the Baltic. In Poland the small scale fleet activity is monitored in one reference area of the Puck Bay where over 40% of harbour porpoise by-catch was reported between 1990 and 1999. Gill-nets are the main fishing gear used by this fleet and on occasions over 1,200 nets are in place in Puck Bay. There had been a much larger area of gillnet fishing in the period after World War II but previous fishing effort levels have been restricted around Puck Bay, and there has also been a decline in fishing effort in Puck Bay over the past 30 years. The fishing activity is monitored *in situ* by a separate vessel rather than relying on logbooks. Fishing effort (*e.g.* number of fishing nets, area of fishing, fishing strategy, seasonal changes) has been estimated and an attempt has been made to compare this with information on by-caught and stranded porpoises as well as live porpoises in Puck Bay detected by passive acoustic monitoring. The overall aim is to correlate areas and times of highest fishing effort with those of highest porpoise density. If the SAMBAH project (Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise) delivers information on the number and distribution of harbour porpoise in the entire Baltic Sea and the fishing sector provides reliable data on set gillnet fishing in Polish waters, it will be possible to identify when and where by-catch is most likely to occur. A part of the background for obtaining data from the small boat fishery is good cooperation with fishermen through information and education. While cooperation was good in the past, the ban on the use of driftnets in the Baltic has resulted in the cessation of voluntarily by-catch reporting.

### 3.7 Using Other Monitoring Programmes: EU Data Collection Framework

The workshop had noted that one less direct means of monitoring by-catch could be through other ongoing research programmes (see 2.1 above). A major relevant programme in European waters is conducted under the European Data Collection Framework (DCF) to collect data on fish discards and biological data on fish caught in European fisheries, which was reviewed at the workshop by Jørgen Dalskov.

In 2008 the EU Council had adopted a regulation 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 (CFP) for the period 2009-2013.

Data collected under the DCF should be collected for the purposes of scientific evaluation and therefore include information on fleets and their activities, biological data covering catches, including discards, survey information on fish stocks and the environmental impact that may be caused by fisheries on the marine ecosystem. Another aspect of the regulation, unrelated to by-catch monitoring, is that it also has provisions for the collection of economic data which may facilitate an assessment of economic and employment trends in this sector.

In general, data are to be collected in order to protect and conserve living aquatic resources and ensure their sustainable exploitation, following the ecosystem-based approach to fisheries management. Data collection under the DCF should therefore facilitate an assessment of the effects of fisheries on the marine ecosystem. However, it should be noted that in order to streamline collection and use of these data throughout the CFP and to avoid any duplication of collection of data, other regulations such as Council Regulation (EC) No 812/2004 of 26 April 2004 laying down measures concerning incidental catches of cetaceans in fisheries should be taken into account.

Each EU coastal Member State is required to establish a multi-annual national programme including the following modules:

1. **Module of the evaluation of the fishing sector**
   - General description of the fishing sector
   - Economic variables
   - Biological metier related variables
   - Biological recreational fisheries
   - Biological stock-related variables
   - Transversal variables
   - Research surveys at sea

2. **Module of the evaluation of the economic situation of the aquaculture and the processing industry**
   - Collection of economic data for the aquaculture
   - Collection of data concerning the processing industry

3. **Module of the evaluation of effects of the fishing sector on the marine ecosystem.**
   In order to monitor total catches which include both landings and discards, data collection programmes at the landings sites as well as at-sea observer programmes have to be established under the DCF. These programmes should be métier-based, where a métier is defined as a combination of fishing gear, mesh size and target species (*e.g*. demersal fish or small pelagic).

   The métiers are ranked according to their share in the total commercial landings. The shares should be added up, starting with the largest, until a cut-off level of 90% is reached. All métiers within the top 90 % are selected for sampling (landings and discards). A minimum of 2 fishing trips per quarter year is then sampled for discards (unless there is a justified reason for derogation). The data collection includes weight and length per species. For at-sea observer sampling both the retained and discarded parts of the catch have to be sampled.

   Because most by-catch of cetaceans are recorded in gillnet fisheries, which usually do not land a large proportion of total commercial catches, the opportunity for cetacean by-catch monitoring under the DCF is limited. Nevertheless the DCF can provide a useful means of determining even low level by-catch rates in those fishery sectors that are monitored.

## 4. DATA COLLECTION AND MANAGEMENT

### 4.1 Data Collection, Collation, Control

Sara Wetmore described the approach to data management within the Northeast Fisheries Observer Program. NEFOP covers a variety of fisheries ranging geographically from Maine to North Carolina, USA. Observers onboard commercial fishing vessels collect confidential information that is utilized by multiple end-users. Data are collected electronically and are used in marine mammal and fish stock assessments, marine mammal, seabird and sea turtle by-catch estimations, in-season quota and total allowable catch management. Data are collected at the trip, haul and individual incidental take level including biological sampling of takes of marine mammals, seabirds and sea turtles. Specific fields are collected that aid in the estimation of by-catch and those fields include: DNA sample, species identification, tagging, entanglement and animal condition. Data quality is related to the level of training, editing, auditing and IT support process and relies on diligent observers, editors and programme staff that must be knowledgeable in regard to fishing practices, gear and operations in order to improve the accuracy of the data real-time.

The Workshop discussed the relative merits of paper and electronic records. A well-organised electronic data collection system can greatly facilitate data management, but there are many technical difficulties to overcome. Paper has the advantage of being durable, cheap, and easy to use.

The Workshop discussed the desirability of returning by-caught marine mammals and seabirds to shore. While this should clearly be a priority in most cases, it can also be difficult to organise logistically The NEFOP usually collects whole cetaceans, but in the case of birds, the head and feet should be collected where possible.

## 5. RELATED FLEET DATA FOR RAISING BY-CATCH RATES

### 5.1 Describing Fleet Effort and Reliability of Effort Data

Al Kingston addressed the ways in which fishing effort data can be used in by-catch monitoring programmes for designing surveys and for raising by-catch observations to fishery or fleet level. Understanding and quantifying fishing effort is usually critical to the estimation of by-catch at a fleet level.

Within the European Union all vessels of more than 10m in length are required to complete official logbooks, which in theory include information on fishing effort. Vessels over 15m are also required to carry an electronic Vessel Monitoring System (VMS) that uses a GPS to report the vessels location at regular intervals. VMS data are widely used for enforcement of area based fishery regulations. Fishery Inspection agencies also collect data on vessel activities through aerial and ship based patrols, but again this information is generally used solely for enforcement purposes. Questionnaires can be used to describe and assess fishing effort (as well as by-catch – see 2.1), while observer programmes can provide detailed information on fishing activity but generally only for a portion of the fleet's effort.

Logbook effort data can provide detailed information on net sizes and deployment times, but more usually provides only the number of fishing operations or simply the number of days at sea. It is usually possible to at least determine the general area of fishing (for example the ICES rectangle) and the gear type used. Where monitoring programmes are being planned, such data can provide a basis for planning which vessels, gear types or areas should be sampled and when, and can provide a basis for determining the amount of sampling required. Once data on by-catches have been collected, the same data provide a means of raising the by-catch observations to produce fishery or fleet level estimates of by-catch.

In reality, all fishing effort data recording systems have flaws or shortfalls. Many of the fields in the European official logbook are not mandatory, and so may be left blank, or may be completed by port officials. There is considerable evidence of human error in data collected from logbooks, and it is common that the data lack the necessary detail that would make them most useful. Furthermore, effort data reflect what has happened and cannot necessarily be taken as an accurate guide to what might occur in the future, which complicates planning of monitoring schemes. Much of the more detailed electronic data (such as VMS) are collected primarily for enforcement purposes and, if they can be obtained for assessment purposes, can be difficult and time consuming to interpret in a useable way.

Typical errors in effort data may include observed trips that are simply not found in official logbook records or trips with incorrect landing dates, and trips with missing information on gear types or the number of fishing operations. Pair trawling represents another problem as either one or the other or both of a pair team may file logbook records, and such records need to be reconciled. Where polyvalent vessels are concerned it is often very difficult to determine how much effort should be attributed to which gear type, and gear types may be incorrectly specified. In the UK this is a particular problem for under 10m vessels, which are not legally obliged to keep official logbooks, and as a result effort data for this fleet are often aggregated into relatively meaningless catch-all categories.

Inaccuracies in effort data can lead to a sampling plan that is unrepresentative of the fleet that is being studied, can increase uncertainty due to poor stratification and can ultimately bias by-catch estimates in unpredictable ways. This could in turn lead to inappropriate management decisions.

Exactly these sorts of problems with records of effort data have led to the use of records of landed catch being used to raise by-catch estimates in the US fishery observer programme and in Denmark.

# 6. RAISING PROCEDURES

## 6.1 Accuracy and Precision Issues Associated With By-catch Estimation

Charles Paxton described some of the issues surrounding bias and precision of estimates. Before considering how to assess bias and precision, the questions of interest have to be identified as this directly relates to the statistical methods to be employed. For example, questions can vary from "What is the overall level of (relative or absolute) by-catch?" to "What level of effort is required to estimate total (absolute or relative) by-catch with a certain degree of precision?" The exact data to be used in answering the question have to be identified as well as the appropriate sampling unit. Typically inferences from the samples are generated up to fleet level. Sampling units can thus vary from individual nets, through hauls to trips to vessels. Users should be aware of potential biases in the data and collect the data in such a way that those biases can be minimised. Biases can exist in the collection of data because observer deployment may not be representative (different gears, temporal discrepancies, observers may miss drop-outs, *etc*). Precision can be increased by increasing sample sizes but there are diminished returns and it may not be economic to massively increase sample sizes. The fundamental problem with most by-catch data is that by-catches occur at low frequencies meaning that the data are often over-dispersed.

Estimates of by-catch are raised by design or model-based methods. Model-based estimation, whilst more complicated than more standard design-based estimation, allows interpolation of by-catch into combinations of variables that have been little sampled. Often by-catch data are highly over-dispersed and here zero-inflated models can deal with the over-dispersion in the models. The data are often hierarchical and with random effects. A mixed modelling approach can deal with this. By-catch data may be spatially correlated. This can be dealt with by modelling the spatial autocorrelation or consideration of independent spatial units only, by omitting data.

Existing spatial density estimates could be built into by-catch estimation models or density estimates could theoretically be used to identify hotspots for megafauna which should be avoided by fishermen.

One final point of consideration in cetacean by-catch in enclosed environments such as bays etc., is that the probability of by-catch is a product of the probability of encounter with the net and the probability of capture given encounter. Probability of encounter is not necessarily a simple function of fishing effort but the *concentration* of the effort in time. The risk of by-catch in an enclosed area can be a higher for effort that is concentrated in time rather than the same level of effort spread in time.

## 6.2 By-catch Estimation Techniques for Rare Events: Case Studies in North Atlantic Fisheries

Kimberly Murray described three different analytical approaches used by staff at the Northeast Fisheries Science Center to estimate by-catch of sea turtles, seabirds and marine mammals in commercial sink gill-net gear. Prior to estimating total by-catch, observer data are evaluated with respect to the choice of sampling unit (*i.e.* hauls or trips), and the choice of the raising variable (*i.e.* hours fished or total landings). The choice will likely affect the amount of total estimated by-catch and uncertainty around the estimates. Commercial data are evaluated for comprehensiveness (*i.e.* do the data represent a complete census of all commercial effort?) and representativeness (do the data represent the general spatial and temporal distribution of all commercial effort?), with respect to the fishery or gear type of interest.

Techniques presented here to estimate by-catch include Generalized Additive Models (Murray 2009), Generalized Linear Models with model averaging (Warden, in press), and ratio estimators (Orphanides 2009). Uncertainty around by-catch estimates (CVs and CIs) are generally computed via bootstrapping routines. Each of these methods was briefly described to workshop participants and compared.

There is not a single preferred method to estimate by-catch; suitable models are developed based on the structure of the data and the quality and quantity of data available. In general when estimating total by-catch of a rare event, one needs to proceed cautiously with inference from observer data, which often represent low levels of sampling (*i.e.* <5%).

### 6.3 By-catch Estimation in Atlantic Canada – Influences of Data Characteristics, Data Credibility, and Scale of Analysis

Jack Lawson addressed certain aspects of by-catch estimation using examples from Canada. He noted that in general the processes by which these estimates are derived are rarely consistent across studies. Two incidental catch estimates for the same fishery, using different metrics to approximate fishing effort and incidental catch rates, may differ in magnitude of both the estimates and their associated variability. To assess the differences of incidental catch estimates based on different methods, researchers at Fisheries and Oceans Canada had calculated incidental catch estimates for harbour porpoise in the nearshore gill-net fishery for Atlantic cod (*Gadus morhua*) in Newfoundland, Canada, based on several types of official fisheries statistics, and on data collected directly from fishers through interviews and logbooks (Benjamins *et al*. 2007). Incidental catch estimates were lowest when using net-days as a measure of fishing effort, likely due to the considerable day-to-day variability in landed catches due to small-scale changes in cod distribution. When using net-days, the use of trips per fisher as sampling units also contributed to lower overall estimates. Performing the analysis at the coastline scale, rather than per fisher, or over larger geographic areas, appears to be a reasonable compromise between the need for geographic detail and the realities of imperfect data collection.

The results of this study, and similar efforts undertaken to estimate seabird (Benjamins *et al*. 2008) and shark (Benjamins *et al*. 2010) by-catch in Newfoundland gillnet fisheries, confirm the importance of accounting for underlying variability of landed catch and fishing effort-related data when estimating incidental catch, and reiterate the importance of collecting credible information on fishing effort. The sometimes large differences between these various by-catch estimates indicate the extent to which estimations of by-catch are influenced by characteristics of available data (e.g., sample size and coverage, skewness) and underlying methodology (*e.g.* scale of analysis, sampling unit). The harbour porpoise example illustrates the benefits of a more comprehensive monitoring approach to obtain information, including mandatory logbook programmes and focused observation of fishing effort, particularly on nearshore, small-boat fisheries (*e.g.* using post-fishery interviews and digital imagery to confirm species identity and train observers). Deploying dedicated observers on every boat is impractical for many fisheries as most vessels are small and the cost of such a programme would be prohibitive. At the moment, fostering a long-term, trusting relationship with a number of representative fishers appears to be the best strategy to obtain information on incidental catch in these fisheries.

The Workshop reiterated the importance of reliability of effort data in the need for adequate stratification. The Workshop also noted that extrapolated by-catch estimates are only useful if they can be compared with an estimate of total population size.

## 7. INDUSTRY COOPERATION AND OUTREACH

### 7.1 A View from Industry

Alec Wiseman presented a perspective on by-catch monitoring schemes from the perspective of the Scottish Pelagic trawl fleet. This fleet consists of 25 vessels between 60 and 75m, and lands 85% of the total UK quota for pelagic species. Mackerel alone is the highest earning fishery by value in the UK. The fleet has been hosting observers from the Fisheries Laboratory in Aberdeen and from the Sea Mammal Research Unit for many years. In general the fleet has no reason not to take observers as there are no by-catch problems of concern. One exceptional case is the midwater pair trawl fishery for bass, a very seasonal and local fishery that takes place in the English Channel during winter. In this fishery by-catch of common dolphins was a concern, and the Scottish Pelagic Fishermens Association collaborated with the Sea Mammal Research Unit to combine monitoring with attempts to minimise dolphin by-catch, and this programme has led to a dramatic decrease in dolphin by-catch rates.

More generally the potential problems that may arise with such schemes include the misuse of data collected on board vessels and the personal behaviour of observers. An example was given where skippers had been unaware that data were being collected on discards as well as on the biology of the fish. Discard data were then used in a way that the industry felt was inappropriate where unwarranted assumptions had been made, and this led to a breakdown in trust between skippers and the agency

collecting the data. Subsequently an observer code of conduct has been established which defines broadly what data will be collected, how discards will be assessed and what the data will be used for. In addition, observer reports are sent to the skipper for comment, observers have to have the relevant certification and their general behaviour is also guaranteed. However, there is a remaining problem that the monitoring agency is now a part of the same organisation as the compliance agency, so that any data collected for monitoring purposes is now also available to enforcement officials, and this makes industry uneasy.

The benefits that can be derived from collaborating with a protected species by-catch monitoring scheme are important where environmental certification is sought ('eco-labelling') as in such cases the presence of an ongoing observer programme can validate industry claims that by-catch rates are low. Observations of fish biology can also help in stock assessment work, which benefits industry, and indeed many industry vessels have also been involved in chartered surveys of fish stock so that industry has become more involved in the entire assessment and management process.

Certification schemes are clearly an important factor in driving the need for observer schemes to document levels of by-catch. The Workshop noted that such schemes are usually driven by the processing or retail sectors, but that once a fishery has become certified it is usually very important to keep that certification from a commercial perspective. As more and more fisheries become certified it becomes less and less attractive to remain 'uncertified'. The Workshop noted therefore that certification schemes can play a highly significant role in validating by-catch monitoring schemes and can in some cases even insist upon their establishment.

### 7.2 Reconciling Industry and Scientific Views of By-catch Estimates

A growing number of experiences worldwide have demonstrated the programmatic benefits of collaborative research involving fishers and scientists. Doug Wilson presented a summary of the results of 3 relevant EU Framework projects.

The UNCOVER project was asking what kinds of governance arrangements were needed for species recovery plans and found that, under certain conditions, these plans had resulted in effective partnerships with concrete benefits for recovery plans. In these cases collaborative research programmes increased the overall resilience of fisheries management under the difficult circumstances of reducing fishing effort for species recovery. The support of science and government at all levels was important in each successful case and this is an important lesson for future management policy.

The JAKFISH project investigated the kinds of institutional arrangements that allow stakeholders and scientists to work together in dealing with uncertainty. These arrangements are also helpful in encouraging effective collaborative research.

The GAP 1 project linked 12 fisher-scientist partnerships in 11 European countries, gave their efforts opportunities to pool their experiences, and carried out an in-depth analysis of three of them. The project found that both partners recognised the benefits of working together, but also identified a number of factors that influence the effectiveness of cooperation, as well as some ongoing dilemmas that affect these programmes that are difficult to fully resolve.

The Workshop noted that in reconciling industry and scientific views of by-catch estimates, it was always best to communicate and be honest with fishers about the situation. It is usual that fishers and scientists may place different values on resources. In dealing with the industry, scientists should not be selective about which facts are conveyed. Transparency is most important even if it is unpalatable.

Ideally, data should be used only for purposes for which they are collected. However, data have sometimes been used in a subversive way. The Workshop agreed that transparency is best and that it should always be made clear to industry that there will always be a possibility that information may not be used as intended or expected.

The Workshop also discussed at some length the problem that observers may also be required to collect data that can be accessed and used by enforcement and regulatory bodies. There is a tension

here that representative data quality may be compromised if the data that are collected are available to enforcement bodies, and this may compromise the scientific integrity of the sampling programme. This is an issue that all observer programmes need to be aware of and is not one that can easily be resolved.

The Workshop also acknowledged that working conditions for observers are not always ideal. For example EU regulations on working hours are very hard to abide by when observers are at sea, and it is likely that working hour limits are often exceeded by observers, so that in practice a flexible approach needs to be taken. It is unusual for observers to actually work by the hour, but rather it is left to their own discretion to try to cover the task that needs to be done (e.g., monitoring net hauls) whilst ensuring they have adequate rest.

In the US, observer hours have not been challenged. In general observers are content to work long hours but problems start if precise hours have to be documented on paper as these may exceed the regulations.

## 8. GENERAL CONCLUDING DISCUSSION

The Workshop agreed to some interim conclusions and recommendations but agreed that more substantive recommendations would be laid out in the proposed guidelines for the development of by-catch monitoring schemes in the ICES Cooperative Research Report.

The Workshop agreed that although independent observer schemes are usually the best way to determine by-catch levels, where financial constraints make this impossible there is a range of other options, including the use of logbooks, interviews and research surveys. It was agreed that results from such methods should be interpreted with caution and that it is best to integrate the results from several different methods to obtain a range of possible estimates.

The Workshop agreed that standardised training is an important aspect of the development of by-catch monitoring schemes and recommended that training programmes and data collection procedures for marine mammal and seabird by-catch monitoring should be standardised at a European level. Further work was therefore definitely needed on defining region wide standards and also in establishing appropriate training schemes.

The Workshop recognised that there are several alternative measures that still involve independent monitoring, but that do not necessarily involve a dedicated on board observer scheme. The workshop agreed that several of these showed promise, especially on board video monitoring as has been trialled in Denmark.

The Workshop agreed that returning whole animal carcasses to port for further biological examination is always desirable though not always straightforward for various logistical and legal and social reasons.

The Workshop agreed that raising by-catch observations to the fleet level could best be achieved with accurate fleet effort data, but also recognised that these data are rarely reliable. Caution in interpreting results is always necessary.

The Workshop noted that scientific data collection is frequently confounded by the fact that such data may be available to enforcement agencies, and this can jeopardise relations with industry.

Finally, the Workshop agreed that building trust with industry is crucial at all stages and that the key issue is transparency at all times.

**REFERENCES**

Benjamins, S., Lawson, J.W., and Stenson, G.B. 2007. Recent harbour porpoise by-catch in gillnet fisheries in Newfoundland and Labrador, Canada. *J. Cetacean Res. Manage*. 9(3):189-199.

Benjamins, S., Kulka, D.W., and Lawson, J.W. 2008. Incidental catch of seabirds in Newfoundland and Labrador gillnet fisheries, 2001–2003. *Endangered Sp. Res*. 5:149–160.

Benjamins, S., Kulka, D.W., and Lawson, J.W. 2010. Recent incidental catch of sharks in gillnet fisheries of Newfoundland and Labrador, Canada.. *Endangered Sp. Res*. 11:133-146.

Byrd, B.L., Hohn, A.A., Munden, F.H., Lovewell, G.N. and Lo Piccolo, R.E. 2008. Effects of commercial fishing regulations on stranding rates of bottlenose dolphin (*Tursiops truncatus*). *Fishery Bulletin* 106(1): 72-81.

Kiszka, J. , Pelourdeau, D. and Ridoux, V. 2008. Body Scars and Dorsal Fin Disfigurements as Indicators of Interaction Between Small Cetaceans and Fisheries Around the Mozambique Channel Island of Mayotte. *Western Indian Ocean J. Mar. Sci.* Vol. 7(2): 185–193.

Murray, KT. 2009. Characteristics and magnitude of sea turtle by-catch in U.S. Mid-Atlantic sink gillnet gear. *Endang. Sp. Res.* 8:211-224.

Orphanides, C. 2009. Protected species by-catch estimating approaches: estimating harbor porpoise by-catch in U.S. Northwestern Atlantic gillnet fisheries. *J. Northw. Atl. Fish. Sci*., Vol. 42:55-76.

Robbins, J. Landry, S. and Mattila, D.K. 2009 unpublished. Estimating entanglement mortality from scar-based studies. Scientific Committee Meeting of the International Whaling Commission, 2009 SC/61/BC3. (Avaialble form the office of the IWC.)

Warden, M. in press. By-catch of wintering common and red-throated loons in U.S. Atlantic gillnets, 1996-2007. *Aquatic Biology*.

**Appendix I**

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**Appendix 2**

**AGENDA**

**Monday 28th June 2010:**

14:00 Welcome and Introductions
14:15 Overview discussion – origins of workshop and expected outcomes
14:30 Introduction: Why do we need by-catch observer schemes and what are they good for? - Simon Northridge
14:40 Indirect means of quantifying by-catch: Overview of indirect means and integrating different approaches. - Droplaug Ólafsdóttir
15:00 DISCUSSION – ALL focusing on the merits and problems associated with indirect means
15:45 Break

Direct observations of by-catch: session 1
16:00 Using Observers – Sara Wetmore
Observer training – some general issues: - Grant Course
18:00 Break for the evening

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**Tuesday 29th June:**

Direct observations continued: session 2
09:00 On board observer schemes 1: marine mammals –Amy van Atten
09:30 On board observer schemes 2: birds –Oliver Yates
10:00 Use of CCTV to monitor by-catch – Lotte Kindt-Larsen
10:30 Separate observation platforms – Barbie Byrd
11:00 Break
11:15 Contracted fleet - Arne Bjørge
11:45 Monitoring the Baltic small boat fleet – Krzystof Skora
11:45 DISCUSSION –All: focusing on issues surrounding observations schemes Strandings schemes, photo-id, ....
13:00 Lunch

Data management issues
14:00 Discard sampling and by-catch observations – Jørgen Dalskov
14:30 Data collection, collation, control – Sara Wetmore
DISCUSSION – on data management issues
15:30 Break

Related fleet data
16:00 Describing fleet effort and reliability of effort data – Al Kingston
DISCUSSION on fleet effort data
18:00 Break for the evening

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**Wednesday 30th June:**

Raising procedures
09:00 Checking for accuracy and estimating precision – Charles Paxton
09:45 Extrapolation measures – Kimberly Murray
10:30 Break
11:00 Extrapolation measures – Jack Lawson
11:30 DISCUSSION on raising procedures, modelling etc
13:00 LUNCH

Industry Cooperation and Outreach

14:00 Industry Liaison – Alec Wiseman
14:30 Reconciling industry and scientific views of by-catch estimates – Doug Wilson
15:00 Break
15:30 DISCUSSION and catch up over-running topics
18:00 Break for the evening

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**Thursday 1st July:**

09:00 Discussion on the Guidelines
Including further work needed
13:00 Meeting ends.