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The ups and downs of working with industry to collect fishery-dependent data: the Irish experience

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Working with the fishing industry to collect fishery-dependent data for scientific and advisory purposes is essential in most countries, but despite the many advantages of working with fishers, it is not without challenges. The objectives and the ups and downs of 16 recent projects in Ireland are described, and four case studies are discussed in detail. Some common themes that characterize both successful and unsuccessful experiences are identified. One critical aspect is industry's sometimes unrealistic time-horizons and expectations when engaging in scientific data collection. Detailed communication of objectives, procedures, results, and relevance not only to industry representatives, but also to vessel owners and crew, is required throughout the life cycle of a project. For some projects, there is a clear need to include incentives in the design, but for others this is less critical. The critical needs for ongoing quality control and assurance, validation of data, and appropriate project design are discussed, along with the link between successful management systems and participatory research. Finally, comment is provided on how the expected reforms of the EU's Common Fisheries Policy will place new demands on joint research.

Keywords: data collection, discards, industry–science partnerships, participatory research, self-sampling, stakeholders.

Introduction

Working with the fishing industry to collect fishery-dependent data for scientific and advisory purposes is essential in Ireland, as it is in most other countries. Effective engagement between scientists and fishers is a key ingredient in successful fishery-management systems worldwide, and an integral part of the evolving policies for European fisheries (Hilborn *et al.*, 2005; Motos and Wilson, 2006; Mackinson *et al.*, 2011). In Ireland, there is a long history of scientific investigations, mainly using commercial fishing vessels, of Irish herring (*Clupea harengus*) and mackerel (*Scomber scombrus*) stocks dating back to the start of the 20th century, and perhaps even earlier (Molloy, 2004, 2006). Most early fishery research focused on developing productivity and elucidating the basic biology of species, but more recently, the research focused on stock assessments and gear technology. Two State agencies, the Marine Institute (MI) and the Bord Iascaigh Mhara (BIM, the Irish Sea Fisheries Board), have carried out much of the applied fishery research in Ireland, although there have also been some university-led projects. Most research costs have been borne by the State and the European Commission (EC), through various funding initiatives. Consequently, the majority of contemporary research has focused on servicing the needs of the management system, mainly that of the EU Common Fisheries Policy (CFP).

In 2010, the Irish fishing fleet consisted of slightly more than 2000 vessels (http://ec.europa.eu/fisheries/fleet/index.cfm). Most of the fleets (>70%) were inshore vessels (<10 m) engaged in small-scale coastal shellfish fisheries. Here, however, we focus on the larger vessels (>10 m) that catch shared demersal and pelagic stocks around Ireland, mainly in the Celtic Sea and west of Scotland, in ICES Divisions VI and VII. Such vessels operate in ~50 defined métiers using a broad range of gears (otter trawls, pelagic trawls, beam trawls, seine nets, gillnets, trammelnets, and longlines) targeting different areas and species assemblages.

Three common forms of cooperative research were defined by Johnson and van Densen (2007): fishery-dependent data collection, industry-based surveys, and gear-selectivity work. In Ireland, there are also examples of cooperative projects to inform and develop management plans, to develop research surveys, and to provide a research-oversight function. Here, focus is on specific case studies in detail, but common themes that characterize both successful and unsuccessful experiences are identified.

Irish industry–science projects over the past decade

Funding considerations are critical for any work on fishery-dependent information, but there is no ongoing funding mechanism for industry–science projects in Ireland. In contrast, the UK government has dedicated £1 million of funding annually since 2003 to involve fishers directly in the co-commissioning of scientific research, through its Fisheries Science Partnership in England and Wales. A similar programme exists in Scotland. A variety of

Table 1. Overview of funding models for some recent science–industry projects carried out in Ireland.

Funding model	Number of projects	Description
1	7	100% of costs borne by scientific agencies
2	2	Staff costs borne by fishing industry, vessel costs by scientific agencies
3	2	Partial vessel-cost recovery (i.e. selling of catch), with staff costs borne by scientific agencies
4	1	Vessel costs borne by fishing industry, staff costs by scientific agencies
5	1	Vessel and some staff costs borne by fishing industry
6	1	100% of costs borne by fishing industry
7	5	Scientific agencies and fishing industry share staff costs

different funding models have been used in Ireland (Table 1), ranging from scientific agencies paying for all the work to a few projects funded entirely by industry.

The main joint industry–science or participatory research projects informing the discussion are summarized in Table 2. The objectives, information, data collected, ups or positive outcomes, and downs or learning points across a range of projects vary. This broad diversity of projects illustrates the potential for interaction at many levels (as also noted by Mackinson *et al.*, 2011). Scientific and industry goals and objectives within individual projects are presented separately, because often they differ subtly. There are examples where one party was the main instigator and beneficiary, and the other cooperated (top–down) to truly collaborative endeavours (bottom-up). Some examples of Irish projects are provided in the four case studies below.

Case study 1: the demersal discard-sampling programme

In 1993, the MI established an on-board observer programme as a means of monitoring the levels of discarding by the Irish fishing fleet. Initial and subsequent work has been entirely or partly EC-funded and could be described as top-down cooperation. Data-collection protocols and management procedures were established at the outset, but have been refined over time. The collection of discard data at sea is performed by trained MI staff (Fisheries Assessment Technicians, or FATs), and since 2004 by trained seagoing contractors. Data are collected on board a commercial fishing vessel only with the agreement of its skipper, and no financial or other compensatory incentive is provided to encourage vessels to carry an observer. While on board, observers collect a range of metadata about the trip, sampling both retained and discarded portions of the catch, and taking otoliths for age estimation (detailed in Borges *et al.*, 2004, 2005a, b).

The selection of vessels for sampling trips is not random in the strict statistical sense. In early years, trips were carried out representatively on vessels operating from ports in the locality of the observer's base (Borges *et al.*, 2004). Currently, though, targets are stratified by métier and time, guided by recent levels of activity and the requirements of the EU's Data Collection Framework (DCF; EC, 2008). Trip selection within a métier is quasi-random, because practical considerations arise, e.g. is the vessel's skipper cooperative, and is accommodation for the observer suitable, safety issues, trip departure time, and duration? Such considerations compromise the estimation of true variance and bias, but completely random sampling is rare in discard programmes anywhere.

Data collected during the MI discard-sampling programme have been described and used in several scientific publications (e.g. Borges *et al.*, 2005a; Viana *et al.*, 2011). The data are reported routinely to ICES and the EU's Scientific, Technical and Economic Committee for Fisheries (STECF) for use in stock assessments and other work (STECF, 2008; ICES, 2010). Participating skippers receive direct feedback by way of a skipper's report that outlines the sampling results, i.e. the discard rates and length/age distributions observed.

The time-series of days-at-sea in the project is presented in Figure 1. Annual sampling effort for the first decade fluctuated around 150 days at sea, but increased to 300–400 days at sea from 2004 (except in 2006). This total is just <1% of the total days at sea of Irish vessels >10 m. The overall programme accounts for ~35% of Ireland's annual sampling budget, and although increased sampling levels would be desirable to increase the accuracy and precision of the data, doing so would entail a considerable increase in sampling effort and associated costs (Borges *et al.*, 2004). The increased sampling since 2004 was achieved mainly through partial outsourcing to MI-trained contractors. It is interesting that the scientific objectives of the programme, essentially the collection of reliable data, are very different from those of individual skippers, who regard cooperative engagement as an opportunity to learn about or to influence scientific perception (Table 2). Whether such industry objectives are sufficiently achieved with contract observers is an open question. The complexity of mixed demersal fisheries, scientific assessment procedures, and the current management framework essentially means that the relevance of the data collected during a single discard-sampling trip may appear very abstract to individual skippers.

In 2006, sampling levels dropped significantly as a consequence of non-cooperation by parts of the fishing industry with scientific programmes in general. The situation then affected both at-sea and shore-based sampling. There is a complex background to that problem, but essentially a confidential report that compared data collected by discard observers and logbook returns for the same trips in 2003 and 2004 was made public and indicated various mismatches between observed and reported landings. This was perceived by fishers to have contributed to the enactment of stricter legislation, namely the Irish Sea Fisheries Bill, and the establishment of a new control and enforcement agency (the Sea Fisheries Protection Authority).

That experience highlights some of the issues and frailties within the discard-sampling programme. Before 2006, observers emphasized the difference between scientific and control agencies as well as the confidential nature of the scientific data collected. Notwithstanding data-protection laws, official observer data cannot be withheld from State bodies such as fishery control and enforcement agencies, and the police. Since 2008, the MI has developed a code of conduct for staff and contractors, both of whom must explain how the data are to be used and the limits on confidentiality.

Over time, trust has been re-established and the Irish at-sea observer programme now has widespread industry cooperation. A few skippers remain still reluctant to carry observers, although the DCF and related national regulations oblige vessels to carry

Table 2. A summary of selected recent science–industry projects carried out in Ireland.

Project or programme	Time- frame	Category/funding model	Scientific objectives	Industry objectives	Information collected	Ups (positive outcomes)	Downs (learning points)
Irish Fisheries Science Research Partnership	2008–present	Research oversight/7	To obtain industry input to scientific projects, to feed back the results of scientific work to the industry, and to understand and engage with industry priorities	To input to scientific planning, to align scientific to industry priorities, and to review scientific work	Information on priority stocks and issues	Good communication between scientists and industry representatives, better awareness of issues, better understanding of scientific activities by industry, longer-term strategic focus, mini-symposium held in 2010 well attended by industry	Lack of manager/policy input, limited funding opportunities since establishment, no national mechanism to commission joint projects, communication from the group to wider industry poor, lacking in transparency
Demersal discard sampling programme	1993–present	Fishery-dependent data collection/4	Collection of catch (landings and discards) data for assessment and advisory functions	To engage with scientists, to demonstrate low discard rates or large stock size (in some cases), to influence scientific perspective, and to learn about scientific activities	Landing and discard, numbers, lengths, weights	An excellent source of data, with concurrent data collection for the DCF, and data used extensively used by ICES; several scientific publications, excellent interaction with industry, but thus far voluntary	Depends on good cooperation, statistical sampling design compromised, relatively costly and a large administrative burden, expensive to optimize further, perceived abstract use, and a risk of becoming part of control
Irish Sea *Nephrops* sampling	1970–present	Fishery-dependent data collection/1	Collection of catch (landings and discards) data for assessment and advisory functions	Financial incentive, to engage with scientists	Catch, numbers, lengths, weights, and discard ogives	Sustainable, reliable, and cost-effective means of sampling, allowing for higher sampling levels, though requiring close communication with the industry through a very simple protocol	Some samples may be biased, only applicable to certain *Nephrops* stocks, difficult to obtain representative samples in other areas, legal grey area
Irish Sea data-enhancement project	2007–2009	Fishery-dependent data collection/4	To improve sampling levels and the precision of commercial catch (landings and discards) data	To supplement discard observer data with industry self-sampling data, to verify the usability and quality of the data, and to obtain payment for some samples	Diary information, discard samples, and raising information	Increased quantity and quality of data, improving efficiency, cost effectiveness, and improving relationships and trust between fishers and scientists	Difficult to maintain momentum and quality, incentives for self-sampling need to be integrated into monitoring and management of the fishery, protocols not adhered to in a large proportion of trips, need for strict quality-control procedures

Albacore tuna fishery	1990–present	Gear-selectivity studies/1	Gear development initially, then bycatch monitoring and mitigation	Fishery development, with a financial incentive, to demonstrate reduced bycatches	Accurate catch rates and spatial data, monitoring and documenting gear and operational changes in the fishery	Good cooperation with industry, vessels being a platform for testing of deterrent devices	Perceived differences in observed and reported cetacean bycatch, differing perception of cetacean bycatch, difficult to access some vessels when no subvention is available, industry suspicion of motives, poor understanding by industry of the need for observation (burden of proof)
Boarfish research	2010–present	Fishery-dependent data collection/6	To collect the necessary data for carrying out a stock assessment and advising sustainable catch levels	To obtain realistic quotas as soon as possible	Age, growth, reproductive and length frequency data, and a planned acoustic survey	Good cooperation between industry and scientists, with fishers very good at collecting samples and also keen to contribute as much information to the project as possible	None
Cod recovery and management	2000 – present	Developing management Framework/7	To inform management system and strategies and to explain scientific advice	To maintain economically viable fisheries	Various data related to cod catch and effort in the context of the long-term plan	A ministerial group with high profile, developing shared understanding of issues, evolving towards shared and regional management, placing the burden of proof on industry, rewarding good fishing practice, and incentivizing accurate data and assessments through constructive dialogue	Lack of buy-in and trust, economically very damaging to non-cod-targeting fisheries, little progress towards CLTP objectives, very complex and stringent management arrangements, resource hungry for all, different interpretations of legislation
Celtic Sea herring management plan	2008–present	Developing management framework/7	To develop a sustainable long-term management plan	To develop a profitable long-term management plan	Management strategy evaluation, industry objectives	Very good vehicle for communication and building trust, with good buy-in by all to the process and the plan, and fully inclusive of industry sectors	Difficult discussions initially, but recognition that that was part of the process
Horse mackerel management plan	2009	Developing management framework/7	To develop a sustainable long-term management plan	To develop a sustainable long-term management plan	Management strategy evaluation, industry objectives	Very good vehicle for communication and building trust, with good buy-in by all to the process and the plan	First plan of this type, involving several iterations to achieve the outcome
Mackerel management plan	2010	Developing management framework/7	To develop a sustainable long-term management plan	To develop a sustainable long-term management plan	Management strategy evaluation, industry objectives	Good buy-in by all to the process and the plan	Complicated by political issues surrounding quota allocations
Exploratory deep water	1993–2000	Industry-based surveys/1 and 3	Baseline data collection	Fishery development, with a financial incentive	Catch, numbers, lengths, weights, information on fishing grounds	Baseline information on a little known developing fishery, allowing some vessels to diversify into new fisheries	Information did not result in sustainable fishery management

Continued

Table 2. *Continued*

Project or programme	Time- frame	Category/funding model	Scientific objectives	Industry objectives	Information collected	Ups (positive outcomes)	Downs (learning points)
Porcupine *Nephrops*	2010	Industry-based surveys/4	Baseline data collection, to provide some fishery data from a the closed area	To monitor the stock in the closed area, to try to demonstrate the benefit of the closure	By-haul catch, numbers, lengths, weights, sex, maturity, etc.	Industry-initiated closure and survey, with good dialogue on the need for and benefits of a closure, and recognition at the outset that a one-off survey would not be sufficient and continued interest in developing the survey	Limited control over vessel activities and gear specifications, over-ambitious expectations of what the survey might provide
Celtic Sea cod	2010	Industry-based surveys/3	To develop a quarter 1 survey for a relatively data-poor stock	To engage with scientists, to demonstrate cod abundance	By-haul catch, numbers, lengths, age, weights, sex, maturity, etc.	Industry-initiated survey, with good dialogue on the need and benefits, input to gear design, plus recognition at the outset that a one-off survey would not be sufficient	Long-term funding mechanism not in place
Mackerel egg	2002	Industry-based surveys/5	To assess egg production outside the standard area	To assess egg production outside the standard area	Egg distributions outside the standard area	Full survey costs borne by industry, and the results important for mackerel egg survey design	Somewhat unrealistic expectation by industry of how results might influence the formal assessment
Cod tagging and The Cape closure	2003-present	Industry-based surveys/1	To assess the behaviour of cod and to confirm growth rates	To help demonstrate the benefits of a closed area	Tag and recapture data, DST data	A project instigated by industry, excellent buy-in to voluntary closures and reporting of recaptures, with the project resulting in ongoing direct interaction	Lack of integration of tagging data into the assessment and advice, tagging data raising scientific questions on the source of mortality
Donegal Bay and Aran fisheries	2006–present	Gear-selectivity studies/1	Discard mitigation, assessing technical conservation measures (TCMs)	To test a range of conservation devices, e.g. square-mesh panels, codend mesh, sorting grids	For both, a mixture of observed and unobserved data collection, with detailed information on the fisheries, catch compositions, spatial coverage of gear, and operationally	Multiple vessels and extended periods, with good cooperation, interest, and input into the work, and testing a range of gear options for the fisheries	Differences between observed and unobserved data, discards in particular, interest linked in some cases to subvention, different perceptions of what the data show, expectation management, dissemination from science to industry, feedback from industry, uptake issues
Inshore atlas	2008	Fishery-dependent data collection/1	To map the distribution of mobile fishing gears in coastal waters	To map the distribution of mobile fishing gears in coastal waters	Spatial data on fishing and related activities	Useful atlas converting tacit knowledge into useable information.	Difficult to obtain accurate fisher information mainly because of competition and trust concerns

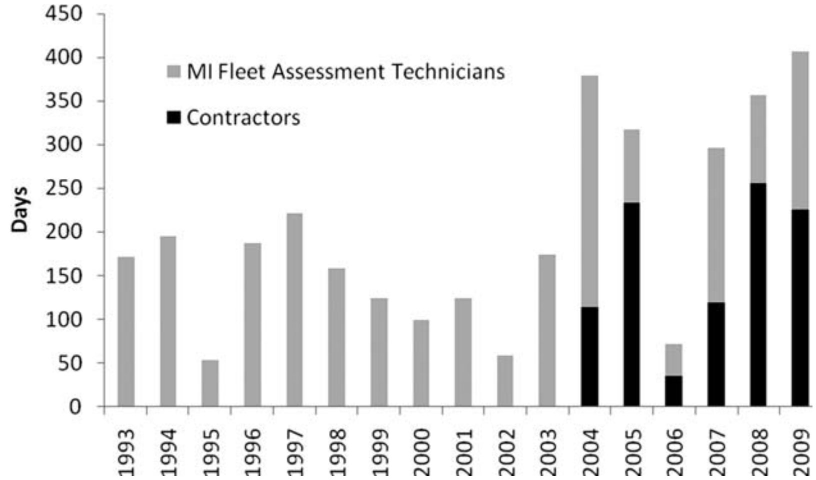

Figure 1. Time-series of observed days at sea per year for the Irish discard-observer programme in the years 1993–2009. Since 2004, the programme has involved external trained contractors as well as MI staff.

observers on request. Considering the need for data to be reliable, and the duty of care for staff, trip selection remains focused on cooperative vessels. External factors such as stricter controls on reported landings may make fishers less willing to carry observers, but other external drivers such as legislation with evidence-based provisions have resulted in industry demanding more discard-observer coverage. The cod (*Gadus morhua*) long-term management plan (CLTMP; EC regulation 1342/2008, see below) is a good example of this, where in the face of increasingly stringent fishing effort restrictions, vessels need to demonstrate by an enhanced scientific-observer coverage that their cod catches (as opposed to landings) are $<1\%$ of their total catch to obtain and maintain exemptions.

Case study 2: working with industry on cod assessment and management

Two of the three cod stocks around Ireland (in ICES Divisions VIa and VIIa) are severely depleted and have been subject to formal recovery measures since 2002. Mortality rates in all three stocks (as above, and VIIe–k) remain high despite the introduction of various management measures aimed at reducing fishing mortality (ICES, 2010).

Restrictive total allowable catches (TACs) and effort controls have resulted in changing fishing practices, increased discarding, and various types of misreporting. The deterioration in the quality of landing records, in particular, has meant that all three cod assessments are now conducted without commercial landings or catch data, so the assessments themselves and the management advice derived from them are highly uncertain (ICES, 2010). This situation has been the catalyst for several initiatives, including industry-based surveys and tagging studies, as outlined in Table 2. Despite close collaboration, however, the different perceptions of cod-stock status have been the source of diverging opinion between industry and scientists.

In 2008, a new CLTMP (EC Regulation 1342/2008) was agreed for several EU cod stocks. The CLTMP is the most significant and potentially restrictive instrument in Irish demersal fisheries management since the implementation of the CFP. The plan aims to reduce fishing mortality to a target level ($F = 0.4$) through regulating TACs and national effort allocations across a range of gear types. A key feature is that the management responsibility for achieving the required reduction in F has been devolved to the Member State. In Ireland, fishery authorities established a steering group to make proposals on national management of effort and on practical options to reduce F, e.g. cod-avoidance measures (for further details, see Davie and Lordan, 2011). The group includes policy-makers, fishery managers, industry representatives, control agencies, and scientists. Its work, although mainly co-implementation, because the EC is responsible for CLTMP regulation and policy context, could be considered a small step towards co-management.

Intense interaction between scientists, industry representatives, managers, and control authorities resulted in a high degree of shared understanding of the different issues and perspectives. The group has worked to provide an equitable basis for allocating the limited fishing effort stipulated by the CLTMP. In addition, technical measures to reduce cod catches were developed and implemented in consultation with industry to avail of increased effort allocations or exemptions from the effort regime, as allowed for under regulation. Hopefully, this will result in better uptake and compliance. The shift in the burden of proof to Member States and fishers has stimulated collaborative projects to develop the scientific cases needed to prove cod avoidance and bycatch reduction (as discussed in case study 1).

Case study 3: cod tagging

A comprehensive cod-tagging programme has been in place in Ireland since 2003. It focuses on a cod nursery ground in ICES Division VIa off the coast of Donegal, known as "The Cape", and the juvenile and spawning components of the Celtic Sea stock in VIIg and VIIa South (ICES Division VIIa south of 52°30′N). The Cape project was instigated by local fishers who called for the closure of a traditional winter fishery for juvenile cod. Industry defined an area to be closed to all fishing from October 2003 to February 2004 under national legislation, and only vessels involved in tagging operations were permitted within the area. Subsequently, fishers requested that the closed area be extended. Over three seasons, $>13\,000$ cod were tagged, with a tag-return rate of $\sim10\%$ (Ó Cuaig and Officer, 2007), yielding valuable information on cod migration patterns and growth rates. The closure itself had notable conservation benefit, because spatial analysis revealed that a large part of the Irish VIa cod catch was taken traditionally from the area. The project was very much a collaborative initiative, because fishers were consulted regularly during its development, design, and execution. Moreover, industry provided ship time when official funding was scarce. The project was widely reported in the trade press as an excellent example of close cooperation between fishers and scientists.

The Celtic Sea cod-tagging project was another fisher-led tagging initiative. This joint study investigated two components of the Celtic Sea stock; juvenile cod residing in Waterford Estuary in spring, and the offshore spawning component. Since its inception in 2007, more than 9000 cod have been tagged, including 291 with a data storage tag (DST; Bendall *et al.*, 2009). From a scientific perspective, the programme has yielded important new data. Migration patterns deduced have revealed that many of the juvenile cod released in VIIa South are recaptured in VIIg and that many of the cod tagged offshore in VIIg were recaptured within the Celtic Sea (VIIg, VIIj, VIIh, and VIIf), and only a few in the Irish Sea (VIIa). The high growth rates reported historically for Celtic Sea cod (Brander, 1995) have been confirmed.

An important element of the tagging work is the enthusiastic response and participation of the fishers. Apart from those involved directly in the tagging, fishers often call scientists from the wheelhouse to report a tagged cod. Fishers often take the opportunity to relay other information to scientists, such as biological observations, perspectives on the stocks and fisheries, or thoughts about the management regime. Scientists also feed back information on the recovered fish, the project, and scientific findings. This type of direct interaction and sharing of knowledge is uncommon in fishery science; often the information exchange has a significant time delay, associated with analysis of data collected, or is one-sided. Tagging studies give tangible and easily interpreted results—Where did the fish go? How much did it grow? How do they behave? They enable stakeholders to actively participate in and understand the application of science.

Case study 4: self-sampling of *Nephrops*

A self-sampling programme for *Nephrops* catches, including landings and discards, has been operating in the western Irish Sea functional unit (FU15) for more than three decades. The programme developed because in the early years of the fishery, vessels typically returned to port with a large volume of unsorted catch which was then sorted and tailed (the tail detached from the rest of the body and landed separately for human consumption) by fishing families alongside. Scientists had access to unsorted catch and discard samples, so could estimate on-board retention ogives. Over time, this practice has virtually ceased, and much of the catch is now processed at sea. The self-sampling programme is voluntary. The fisher is paid for samples at the current market price. The number of participating vessels varies. In the Irish Sea, for example, up to 15 vessels or ~40% of the current fleet have engaged in self-sampling. The number of samples for each FU (or stock area) determined by DCF targets and sampling intensity is temporally stratified based on recent landings patterns.

The success of the scheme is largely down to the simple protocol involved. For each trip, vessels retain one representative box (~40 kg) of the unsorted catch, and one representative box of the discards from a haul selected randomly. On-board discard observers assist with the self-sampling, providing a quality-control benchmark and training the crew in sample selection. The protocol works particularly well in fisheries with high discard rates of small *Nephrops* and where the length at 50% retention (L_{50}) is close to the modal length in the unsorted catch. Occasionally, samples may be biased by removing larger *Nephrops* from the sample box, but this problem appears to be uncommon, and in any case can be cross-checked against observer samples or the size distribution of heads in the discard box. The mean size, sex ratio, and discard rates estimated through self-sampling, together with abundance estimates from an underwater television survey are used to derive catch advice (ICES, 2009). This assessment method is conceptually simple and easy to explain to the industry, compared with the general analytical assessment and forecasting procedures of fishery science.

Discussion

Effective engagement in collaborative research is not a prerequisite for successful fishery management, but often is a significant by-product (Motos and Wilson, 2006). Hilborn *et al.* (2005) give a good example from the Canadian sablefish (*Anoplopoma fimbria*) fishery, where fishers are actively engaged in the research. Collaborative stakeholder engagement is a cornerstone of the ecosystem approach to fisheries management. Such engagement is intrinsically and intractably linked to the current and evolving fishery system. Here, we reflect on the Irish experiences in the context of ongoing CFP reform, then consider how to make the most of fisher information and collaboration in future.

The motivation to engage in research often differs between scientists and industry. As one Irish fisher representative put it: "Fishers are in the business of catching fish and making money. Scientists are in the business of carrying out research and writing papers". Both sectors have a key stake in the sustainability of the marine ecosystem, however. One of the main challenges in participatory research is to ensure that goals or objectives are complementary, although not necessarily aligned. Our experience is that industry objectives are often short term and motivated, for example, to derive financial gain, to demonstrate a perspective, to increase quota, or to influence perceptions. Science objectives, while also motivated, tend to be neutral in perspective and longer term, e.g. to obtain unbiased data at lower cost and high precision. Since the last CFP-reform process, longer term, strategic objectives have become more apparent in industry thinking, e.g. "we need better information on the state of the stock and the best way to fish it in the longer term". This is particularly evident in projects such as those supported by the Irish Fisheries Science Research Partnership, and in the development of long-term management plans, e.g. the Celtic Sea herring-management plan.

The EC Green Paper (EC, 2009) states that: "In a mostly top-down approach, which has been the case under the CFP so far, the fishing industry has been given few incentives to behave as a responsible actor accountable for the sustainable use of a public resource". This top-down management framework also led to a culture of top-down research funding. The effectiveness of the approach must be called into question, given that an instrument such as the DCF spends ~€64 million on data collection annually, while the state of around 60% of the stocks is considered unknown because of the poor data (EC, 2010). In New Zealand, the seafood industry is an intensive generator and user of knowledge of the sustainable use of fishery resources. Some 2.5% of the value of seafood landings is spent on sustainability-related research

(Harte, 2001), and the provision of incentives to fishers to engage constructively in fisheries management, including collaborative research, together with rights-based management, has contributed to a larger proportion of sustainable fisheries in New Zealand than in other countries (Beddington *et al.*, 2007).

The Irish experience has been that industry can sometimes be persuaded to engage with, and even to pay for, research, e.g. the mackerel egg survey, boarfish (*Capros aper*) research, and cod-tagging surveys (Table 2). More often, however, profit margins are too tight, fishing rights unclear, and the outputs of research too vague for fishers to risk financial or time investment in research. Fishery-management policies need therefore to be reformed to promote and facilitate participatory research initiatives. Bottom-up results-based initiatives can be used to achieve management objectives if carefully designed. For instance, when fishers call for a seasonal closure to protect juvenile or spawning aggregations, a dedicated research project utilizing fisher knowledge creates a sense of ownership, leading to better compliance and a more successful outcome. Quota access and additional or unrestricted fishing effort can be used to incentivize responsible behaviour, including industry support for research or data collection. In the context of CFP reform, the evolution towards long-term regionalized management plans, and clear rights-based management, should place the burden of proof on fishers as the key stakeholder.

Maintaining scientific integrity and independence through appropriate scientific designs, standards, and protocols, together with transparent reporting, are critical in any joint data-collection exercise. For fisher self-sampling, the design considerations in ICES (2008) need to be adhered to. For such schemes, it is also essential that almost real time quality control, assurance, and validation of data occur. Concessions on the ideal sampling design and statistical methods may be inevitable when carrying out programmes reliant on fishers and commercial vessels, e.g. the discard-observer case study above. It is critical that no bias be introduced by making such concessions, however; keeping protocols simple is critical to programme success.

Useful guidelines on developing and carrying out participatory research projects are given in Mackinson *et al.* (2008). Clarity and transparency on project objectives, and any expectation differences that may exist between scientists and fishers, are critical from the inception of joint projects. Detailed communication of objectives, procedures, results, and their relevance, not just to industry representatives, but also to vessel owners and crew, is essential throughout a project's cycle. As mentioned above, it is not necessary that industry and scientific objectives be the same, although it does help if they are. It is also important to be clear on the sometimes unrealistic time-horizons and output expectations that industry may have when engaging with scientific data collection. This is particularly true for fish surveys on commercial vessels. Such surveys typically require a time-series over several years before the information can be integrated formally into the assessment; it is important to be clear about that constraint at the outset. A clear benefit of engaging with industry on bottom-up collaborative projects is that it prioritizes effort and encourages maximum utility of outputs, which may not always be the case in top-down, data-collection frameworks.

Another important message from the Irish experience is that there may well be institutional and regulatory challenges to be overcome. Increasingly, scientific information has been integrated into control aspects of EC regulations, e.g. the catch-control rules in the CLTMP. In future, it may not be possible to maintain the differentiation between science and control as has been the practice historically. Evidence-based decision-making is central to modern fisheries management. This in turn results in new demands for and uses of scientific data. Precautionary actions such as reducing TACs and effort allocations are an increasingly likely consequence of data deficiencies (EC, 2010), and such policies shift the burden of proof to fishers.

Various diverse participatory research projects have been carried out and are ongoing, in Ireland. Commercial vessels have been used as research platforms, and fishers have contributed to research surveys or even commissioned research projects. There are many opportunities for engagement across a continuum from consultation to full engagement in joint projects, as noted by Mackinson *et al.* (2011). The value of participatory research is multifaceted and certainly offsets the extra time required. Priority areas for future participatory research in Ireland include:

- fisher self-sampling of catches (landings and discards);
- developing reference fleets and/or fully documented fisheries;
- improved quantification of effective fishing effort by enhanced recording of gear parameters and integrating/changing fishing strategies and practices;
- developing useful, cost-effective industry-based fishing survey series; further tagging studies;
- promoting responsible fishing practices and selective gears through results-based projects;
- most importantly, developing long-term management plans that integrate biological, ecosystem, economic, and social objectives.

Reform of the governance system through regionalization, results-based management, and reversal of the burden of proof have all been suggested in CFP-reform discussions and are likely to increase further the need for participatory research in future.

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