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Using qualitative and quantitative stakeholder knowledge: examples from European deep-water fisheries

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Abstract :

Stakeholder knowledge was collected through questionnaires and cognitive maps and used to summarize biological, environmental, technical, management, and socio-economic factors for several deep-water fisheries, identifying regional management issues and solutions. The questionnaires and cognitive maps revealed different technical, environmental, and management concerns in these fisheries. Dissatisfaction with management was more at an implementation than a conceptual level, because the existing management measures were mostly considered fit for purpose. Further, catch-and-effort data provided by the fishing industry were used to calculate standardized landings per unit effort. The results suggested different trends over time for three deep-water stocks exploited by the same fleet. The examples demonstrate how stakeholder involvement and use of qualitative knowledge and quantitative data might improve the management process and stock assessments when data are limited.

Keywords : closure ; control ; cpue ; regulation ; SWOT ; TAC ; technical measures

1. Introduction

Deep-water fisheries in European waters are diverse, exploiting a range of stocks with different life-history strategies and prosecuted by different fleet types in various geographic regions (Large *et al.*, 2003). Because of this diversity, a single set of management objectives and strategies cannot fit all fisheries, making it necessary to develop case-specific management approaches. Degnbol and McCay (2007) recognized the necessity for such approaches as a common characteristic of fishery systems, and further stressed the importance of understanding and accounting for linkages within fishery systems, such as conflicts between multiple management objectives and strategies. For example, a fixed catch-share scheme is difficult to implement with effort controls. Ignoring these linkages can lead to management failure, as demonstrated for cod (*Gadus morhua*) in Europe (Degnbol and McCay, 2007).

Case-specific fishery management requires case-specific knowledge and data. Deep-water fisheries are generally data-poor, only landing records and rarely scientific-survey data being available. Many deep-water species are also difficult to age reliably. Consequently, assessments of deep-water stocks in European waters have been mostly exploratory (Large *et al.*, 2003; ICES, 2008). However, stakeholders may hold important data and information that can be useful for stock assessment and fishery management. In particular, fishers possess knowledge and often data suitable for assessing changes in stock abundance (Neis *et al.*, 1999). The challenge is to evaluate this knowledge in a reliable way and to use it for management purposes. Rochet *et al*. (2008) compared fisher information on recent stock changes in the English Channel, collected by face-to-face interviews, with available survey data, and found good agreement between the two sources of information, with the fishers being more likely to detect stock trends than the noisy survey data. Large *et al*. (2010) used knowledge obtained with a questionnaire survey directed at fishers and biologists to map the spawning areas of blue ling (*Molva dypterygia*).

The definition of case-specific management objectives and strategies requires stakeholder participation (Caddy and Seij, 2005; Garcia and Charles, 2007; deReynier *et al.*, 2009). Various methods have been used for soliciting stakeholder inputs in a more or less formal manner. Raakjær Nielsen and Mathiesen (2006) used the so-called analytical hierarchy process, which consists of pairwise classifications to rank management objectives, for the Danish sandeel (*Ammodytes* spp.) and Norway pout (*Trisopterus esmarkii*) fishery. Mardle *et al*. (2002) validated fishery-specific management objectives with informal stakeholder inputs; their examples include the fishery on blackspot seabream (*Pagellus bogaraveo*) in the Strait of Gibraltar. Using interviews, Prigent *et al*. (2008) collated opinions of English Channel fishers on what they thought were effective management measures for that ecosystem. The results indicated desires for appropriate quotas, effective controls, and protection of juveniles and spawning areas. Cognitive maps provide another way to collect and compare stakeholder views on ecosystems, driving factors, and linkages (Özesmi and Özesmi, 2003; Prigent *et al.*, 2008). Such maps have been used in several domains, including security, environment, transport, policy, education, and interdisciplinary issues (Ülengin *et al.*, 2000; Mouratiadou and Moran, 2007; Hossain and Brooks, 2008).

Quantitative information is often missing for deep-water stocks. Although useful information is recorded in certain cases, e.g. in Iceland (Ragnarsson and Steingrímsson, 2003), haul-by-haul landings and effort data, and even haul-depth records, are rare. Depth is an essential explanatory variable for deep-water species, so it has a strong effect on commercial landings per unit effort (lpue). Fishers may have such information, because many keep tallybooks with haul-by-haul records. This is considered sensitive information because it encapsulates the personal knowledge and experience on which fishers rely. Only with mutual trust between scientists and fishers will the latter be prepared to share such data, which can be very useful (Shephard *et al.*, 2007; Dobby *et al.*, 2008; Lorance *et al.*, 2010).

Here, we present stakeholder knowledge and data for deep-water fisheries that were collected and used to (i) identify regional management and socio-economic issues and solutions for several deep-water fisheries, using cognitive maps and questionnaires, and (ii) calculate the standardized lpue as input to stock assessments, using tallybook data.

2. Material and methods

2.1. Regional management and socio-economic issues and solutions

2.1.1. Stakeholder community

A two-day workshop was held in Brussels in June 2009 involving 13 stakeholders concerned with deep-water fisheries. The workshop had been advertised to the relevant fishing sector, Regional Advisory Councils (RACs), non-governmental organizations (NGOs), national administrations, and by e-mail to a list of fishery stakeholders compiled by us and by colleagues working on other deep-water fisheries.

Two major outcomes of participatory sessions during the workshop, led by a facilitator, were the identification of the stakeholder community (Burkardt and Ponds, 2006) and a SWOT (Strengths, Weaknesses, Opportunities, and Threats; Horn *et al.*, 1994) analysis of the current deep-water management regime.

To complement the workshop discussions, a questionnaire was used to obtain the opinions and management preferences of stakeholders. This included nine multiple-choice questions and space for comments. Three questions were about the evolution of fisheries in terms of catch rates and profit, comparing past and future perspectives. Another three were on management tools: which should be changed, which offer the best protection for deep-water ecosystems, and which are appropriate in the case of multispecies fisheries. Two more questions were on the scope of the ecosystem impact and ecosystem components impacted by deep-water fisheries, and the final question asked who should be responsible for the management regime. The questionnaires were distributed via a website, by e-mail, during a RAC meeting, and completed during face-to-face interviews in the case of two artisanal fisheries. Overall, 44 questionnaires were returned, with one giving the common view of several individuals from the same fishing company.

2.1.2. Stakeholder perceptions

A second one-day workshop was held in Lisbon in December 2009. It was attended by 21 stakeholders including representatives of Spanish and Portuguese fishers (n = 7), Portuguese national and regional administrative authorities (n = 7), NGOs active at international and regional levels (n = 3), scientists (n = 3, excluding those organizing the workshop), and one student.

Cognitive maps were used to solicit stakeholder views on driving factors and regional management issues for the deep-water fisheries in which they were involved. These maps are bubble diagrams of a situation or problem, with arrows indicating the main determining factors. The workshop participants were first shown a fictitious example to teach them the basic technique. Then they were asked to consider relevant bubbles and connecting arrows, and to add arrow strength as low (1), medium (2), or high (3), and the time-frame (1, within a year; 2, 1–10 years; 3, >10 years). Next, 1–4 participants from the same stakeholder group met to draw a cognitive map, assisted by a scientific facilitator. The maps started with a blank sheet, the only suggestion being to draw the main variable in the fishery at the centre. The facilitator drew the map according to participants' ideas, but did not intervene by defining any variables (bubbles) or connections. The drawing session occupied 90 min.

Given the particular interests of the participants, maps were drawn for four cases: black scabbardfish (*Aphanopus carbo*) fisheries around Madeira, and off mainland Portugal, Greenland halibut (*Reinhardtius hippoglossoides*) in the Northwest Atlantic, and blackspot seabream around the Azores. These are diverse in terms of fleet size, vessel size, and gears used (Table 1). Two maps were produced for the black scabbardfish fishery around Portugal, one by three NGO representatives and one by four stakeholders from the catching sector. Two additional groups formed by scientists and a fishery consultant drew generic fishery maps, which are not considered here.

Therefore, five cognitive maps were analysed in terms of the number of variables (N), connections (C), conceptual categories, and a density factor ($D = C/[N(N–1)]$). The variables were grouped *a posteriori* into nine conceptual categories: ecosystem, fisheries, management system, management measures, other factors, other fisheries, socio-economics, stakeholders, and fish stock. The category fisheries covers variables relevant to fleets, effort, bycatch, discards, gear selectivity, and seasonality of fishing. The category management system covers the management bodies, policies, and controls, and management measures are the actual rules in force. The average strength of connections per category and their time-frame was calculated. The variables negatively influencing each fishery or stock were considered to be regional problems, whereas those with a positive influence indicate solutions. Both are management levers if they can be manipulated by management action.

2.1.3. Individual contributions

The stakeholders varied between consultations. The SWOT analysis was based upon discussions by a few stakeholders who had a broad understanding of fisheries, extensive experience of management at national and international levels, and scientific expertise. The questionnaires were completed mainly by fishers involved in regional fisheries. A few from the French fishing industry contributed to the SWOT analysis and also replied to the questionnaires. The cognitive maps were drawn for several regional fisheries. A few from the Spanish and Portuguese catching sectors contributed to the cognitive maps and replied to the questionnaire.

2.2. Tallybook data for abundance indices

Standardized catch rates based upon fishery data are often essential for stock assessment. These require the availability of relevant explanatory variables for catch and effort data (Maunder and Punt, 2004). Through the establishment of a partnership between Ifremer and the French fishing industry involved in deep-water fishing west of the British Isles, an industry database containing haul-by-haul landing and effort information, provided by volunteer trawlers since the late 1990s, became available for analysis (see description in Lorance *et al*., 2010). This is a mixed trawl fishery exploiting depths from the shelf down to 1500 m. Over the continental slope, fishing depth depends on the target species and has changed over time (Lorance *et al*., 2010); it is therefore important to take account of the depth when deriving abundance indices from commercial landings. This information is not available in EU logbooks, because the average depth of an ICES rectangle is meaningless over the continental slope where a single rectangle can span depths from 200 to 2000 m. However, tallybooks provide depth for each haul. These data were used to calculate abundance indices as standardized lpue covering the period 2000–2009 for blue ling, roundnose grenadier (*Coryphaenoides rupestris*), and black scabbardfish.

2.3.

2.3.1. <u>Data preparation</u>

Different data subsets were used for each species in order to restrict the study to the relevant depth range for a given species, taking account of whether or not it was targeted. Only hauls with durations from 30 min to 10 h were selected. For blue ling, only hauls between 200 and 1100 m and with blue ling as a bycatch (defined as hauls with <50% of that species by weight) were used, to avoid misinterpreting population time-trends, which might transpire if data from the spawning season when these fish aggregate were included (Lorance *et al*., 2010; *n* =11 119 hauls). For roundnose grenadier, hauls conducted between 700 and 1700 m (*n* = 15 114), and for black scabbardfish, those between 500 and 1700 m (*n* = 20 400) were selected.

2.3.2. <u>Modelling</u>

Landings per haul were modelled using generalized additive models (GAMs) with haul duration, depth, month, vessel, statistical rectangle, and an area–year interaction factor as explanatory variables (Lorance *et al*., 2010). Five areas were defined with reference to the exploitation history. Landings were modelled using a Tweedie distribution, which allows datasets to contain many values of zero.

The Tweedie distribution has mean μ and variance $\varphi \mu^p$, where φ is a dispersion parameter and p is called the index; the last could not be estimated simultaneously with the other model parameters. Therefore, p was fixed after some trial runs at 1.7 for roundnose grenadier and black scabbardfish, and at 1.3 for blue ling. The model fits and assumptions were judged by visual inspection of residual plots.

The model provided lpue time-trends for the five areas. In order to derive standardized estimates for the whole study zone, lpue values were predicted for January in all years, for all rectangles in each area (with reference to the average haul depth in each rectangle), a 5-h haul duration, and a vessel that operated during the whole period as prediction variables. Predictions for the entire study zone were then derived as the weighted average of the five area (rectangle average) estimates, with the weights being the number of rectangles in each area.

3. Results

3.1. Stakeholder community

The 13 participants in the first workshop identified 43 types of stakeholder with an interest in deep-water fisheries, although not all were examined in detail because of a lack of time. The participants themselves belonged to eight stakeholder groups (marked with asterisks in Table 2). Each stakeholder was categorized according to its institutional characteristics and geographic scale of intervention (Table 2). Only three stakeholder groups were identified as important in their capacity as individuals: crew members, consumers, and citizens. All others were considered to act as part of a publicly funded institution, a business, an association, or a NGO. The geographic scale of intervention was identified as varying between groups. Scientists and experts may be active at both national and international levels. Private-enterprise stakeholders, including the fish-catching sector, producer organizations (POs), fish buyers, fish transporters, and fish processors are active at all levels, sometimes through multinational, vertically integrated companies. Associations may be involved mostly at regional level (crew, consumers), but the fishing industry professional bodies, POs, and NGOs are organized and important at all levels, from local to national and European.

3.2. Stakeholder opinions and management preferences

The SWOT analysis carried out during the first workshop identified five categories of management measures potentially applicable to deep-water fisheries: (i) total allowable catches (TACs), (ii) effort limitations, (iii) control measures, (iv) technical measures, and (v) spatial or temporal closures (Table 3). Three types of control measure were considered: (a) licencing, (b) port state controls, designated ports, and vessel monitoring systems (VMS), and (c) enforcement observers. All these measures are in force to some extent in North Atlantic deep-water fisheries.

Returned questionnaires came from two large-trawler fisheries (Greenland halibut in the Northwest Atlantic, and the mixed-trawl fishery west of the British Isles), and three artisanal ones (the longline fishery for black scabbardfish off Portugal, and the blackspot seabream fisheries in Greek Ionian waters and the Strait of Gibraltar). The results are presented for the two trawl fisheries combined and for the three artisanal ones separately.

Respondents engaged in the trawl fisheries thought the current catch rates were better than or similar to those in the past (similar, 2/8; better, 6/8; worse, 0/8; Figure 1a), but they generally considered profits to be similar or worse (better, 1/8; worse, 4/8; similar, 3/8; Figure 1b). They mostly thought that future fisheries would be similar to or better than the current situation, reflecting their viability (better, 5/8; worse, 1/8; similar, 2/8; Figure 1c). Respondents engaged in the blackspot seabream fisheries mainly considered current catch rates and profits to be less than in the past, and that the future of those fisheries not to be viable. There were different thoughts about the black scabbardfish fishery, although past, present, and future conditions were mainly adjudged to be similar to the present situation (Figure 1).

Respondents seemed generally dissatisfied with current management arrangements. No individual selected the reply "nothing should change" (Figure 2a), but about half the responses suggested that revised rules on TACs, licences, closures, and gear bans were needed. Nevertheless, these responses might represent a mixture of radical changes and minor adjustments. For example, some comments suggested slight TAC increases or more flexibility in the licencing scheme and seasonal closures. Unsurprisingly, no TAC changes were suggested for the Greek fishery, where TACs are not used at present (Table 1). Changes in licencing, spatial/seasonal closures, gear bans, and controls on recreational fishing were favoured in the blackspot seabream fisheries, and TAC changes in the Strait of Gibraltar.

Overall, most respondents considered licencing, effort restrictions, spatial/seasonal closures, and gear bans suitable for protecting the ecosystem (Figure 2b). Control of recreational fisheries also yielded a high score in the fisheries for blackspot seabream owing to the seasonal coastal distribution of juvenile fish caught by anglers (Lorance, 2011). Catch controls (TACs and individual quotas) yielded low scores, reflecting their use as single-species rather than ecosystem management tools.

Respondents from mixed demersal and deep-water trawl fisheries in which bycatch or discards of protected deep-water species are made, thought the most suitable technical measures were the reduction of bycatch/discards to an agreed level, and bycatch-reduction devices (respectively 6 and 5 of 9 responses; Figure 2c). Respondents from artisanal fisheries mostly suggested bans on certain fishing practices (22/35 responses), spatial and/or temporal closures (19/35), bycatch-restriction measures, and/or gears with bycatch-reduction devices (19/35).

The impact of deep-water fishing activities on the ecosystem was mainly considered large (insignificant, 7/43; medium, 12/43; large, 20/43; irreversible/permanent, 3/43; only one choice allowed). Unexpectedly, a great impact was often noted by respondents from the Greek (6/10) and Gibraltar (12/18) blackspot seabream fisheries. It is unclear whether those replies refer to deep-water fishing in general or the stakeholders' own regional experience. Respondents from the trawl fisheries mainly recorded a medium environmental impact (insignificant, 2/9; medium, 5/9; large, 2/9).

The question on impacted ecosystem components returned cold-water corals as the component most affected (marine invertebrates, 16/43; non-commercial fish species, 20/43; corals, 23/43; seabed, 19/43; other, 4/43; several choices permitted). Nevertheless, as for the preceding question, the choices may have been made from a general rather than a fishery-based perspective, because comments were passed to the effect that the impacted components depended upon the fishing gear. Stakeholders from trawl fisheries mentioned the seabed as the most impacted ecosystem component. The comments reported a very small quantity [of coral] in one questionnaire, that there were now few vessels in the fishery as a result of EU restrictions, and that no new fishing grounds had been explored in recent years, so there had been no new habitat disturbance.

Self-management (by fisher associations or POs) was the most favoured management scheme (20/43). Scientists, national administrations, and the European Commission only scored 10–12/43 (several responses permitted; Figure 2d). Comments with the “other” replies (n = 13) and in the comment box (n = 3, addressing management) called for some combination of the proposed management options (6/16), management at a regional level (6/16), more involvement of RACs (2/16), and having a dedicated Ministry of Fisheries (1 respondent from the Greek fishery).

Figure 3 shows as examples the cognitive maps for the NW Atlantic Greenland halibut fishery (Figure 3a), and for the black scabbardfish fishery around Madeira (Figure 3b). For clarity, the positions of variables were changed to group them by conceptual category, and the connection-strength and time-frame details were removed. In both maps, there are many variables that influence the fishery. The complexity of the management system and management measures in the map for the Greenland halibut fishery is rather striking.

The number of variables in the five cognitive maps ranged from 9 to 22, and the density of connections from 0.08 to 0.25 (Table 4). The number of conceptual categories varied between maps, with 7 or 8 in four maps and just 4 for the blackspot seabream fishery of the Azores. The latter map had the strongest connections (average 2.9). The average time-frame of connections was 2–2.9 (Table 4), i.e. more than one year, so the effects were thought to be medium or long term. Considering the connection strengths by conceptual category across the maps, stocks and management system were seen to have the greatest impact on each fishery (average 2.5), whereas ecosystem (2.0) and stakeholders (2.05) had the least. This was consistent over all maps, with the exception of that drawn by NGO participants, where ecosystem and fishery (averages 3.0 and 2.7, respectively) had the greatest impact and stakeholders (1.4) and stocks (2.0) the least.

Considering the direct or indirect impact of each variable on the fishery or the exploited stock, various management measures that might positively influence the fishery were collated (Table 5). These differed somewhat between stocks, although spatial closures and more selective gear were recurrent themes.

3.3. Abundance indices

Standardized values of lpue for the period 2000–2008 showed an initially decreasing trend for roundnose grenadier, an increase and then a decrease for black scabbardfish, and an increasing trend in later years for blue ling (Figure 4). Therefore, despite being exploited by the same fishery, often in mixed-species hauls, the three species followed different trends during the past decade. These abundance indices can now be used either as inputs to stock assessment models or on their own as a basis for management recommendations.

4. Discussion

Here, we have demonstrated how stakeholder data and experience can be collected and applied in fishery management, an approach essential in data-poor situations such as deep-water fisheries. Another important benefit is the direct involvement and dialogue with stakeholders that the technique offers.

Despite recent progress in formal arrangements to include stakeholders at European and national levels (Pita *et al.*, 2010), there is still a need for new methods allowing the structured involvement of individual stakeholders beyond their professional representatives. We have shown here that SWOT analyses, cognitive maps, and questionnaires are suitable for soliciting opinions and structuring a consultation process. Collection of these data implies time and financial costs for stakeholders, so the results presented using these methods involved just a few of the stakeholder groups identified as being interested in deep-water fisheries. Hence, the results are indicative but not necessarily representative of all such groups, nor of all individual stakeholders.

The identified SWOTs of the management options are generally not specific to deep-water fisheries, although technical measures appeared to be less appropriate for deep-water fisheries than for others, but there could be some opportunities here (Table 3). For example, although the mortality of small fish that escape through trawl meshes is generally thought to be high for deep-water species (Koslow *et al.*, 2000; Lorance *et al.*, 2008), this may not be true for deep-water sharks, in which case excluding devices may be an option.

The management tools most favoured by fishers responding to the questionnaires (licencing, effort, closures, and gears bans) are consistent with the SWOT analysis. The weaknesses identified for licencing were the reliance on a reference level of catch that cannot be landed without the licence and the initial allocation of licences. The allocations were decided some years ago in the trawl fisheries and the Portuguese black scabbardfish fishery, but for the blackspot seabream fisheries which currently have no licencing scheme, the fishers responding to questionnaires might expect to be granted licences if they were introduced, whereas the licencing scheme would restrict bycatches in other fisheries. Clearly, stakeholders already or potentially excluded by the licencing scheme did not participate in the consultations. This explains why only a few stakeholders from the trawl and Portuguese black scabbardfish fisheries suggested that the licencing scheme should be changed, and why stakeholders from the seabream fisheries suggested that licences should be introduced. Stakeholders from the trawl and Portuguese black scabbardfish fisheries were clearly more likely to favour changes in TACs and effort restrictions which directly regulate their activity. Note that no respondent from any fishery suggested dropping these measures. Also, although there may be conflicting issues between conservation objectives and fishing (Klein *et al.*, 2008), spatial and seasonal closures were identified as suitable management measures to protect the ecosystem in responses to the questionnaire. The overall consistency of the SWOT analysis and questionnaire replies, together with the fact that most respondents were dissatisfied with current management practices, suggests that management issues in deep-water fisheries are at the implementation rather than the conceptual level. Finally, the SWOT analysis examined particular management measures in isolation. The stakeholders participating in the SWOT analysis commented that these weaknesses may be remedied to some extent by combining measures, in accord with several management tools being selected in the responses to questionnaires.

The three questions on catch rates and profits yielded contrasting answers across fisheries, with different changes between past and current periods as well as different future perspectives. Socio-economic factors could be relevant here. For example, respondents engaged in the Greek blackspot seabream fisheries thought that they were non-viable, whereas survey indicators show increasing abundance of the target stock in recent years (D. Damalas, unpublished data). Understanding the socio-economic reasons behind such different perceptions could benefit fishery management.

An important outcome of the stakeholder consultations was the diversity of technical, environmental, and management issues about deep-water fisheries. These were reflected in the diversity of opinions on suitable management measures as well as in the factors considered to be important. The stakeholders did not think a “one size fits all” approach was satisfactory. The SWOT analysis also suggests that any single management tool on its own is insufficient. The questionnaires and cognitive maps supported this view, suggesting that some combination of management measures is required. The deep-water fisheries interact with others at several levels: technical (allocation of effort), spatial (area closures that impact other fisheries), and biological. For example, the blackspot seabream fisheries interact with recreational fisheries because the juveniles live near the coast. The concentration of juveniles in shallow or shelf waters also applies to blue ling and greater forkbeard (*Phycis blennoides*). Consequently, in the case of blackspot seabream, the stakeholders suggested management measures be applied to recreational fisheries, although such measures were not mentioned in the SWOT analysis. Although well known, these biological, technical, and management interactions have received little attention in the assessment and management of deep-water fisheries and their environment (Holley and Marchal, 2004; Sissenwine and Mace, 2007).

Cognitive maps visualize the elements and interactions within a complex problem. Their analysis may misinterpret the intended message. Therefore further consultations with the same or additional stakeholders are necessary before the results are suitable for use for management purposes, which would be a further step in the ongoing communication with stakeholders.

The sign of some interactions between the variables in cognitive maps depends upon the time-frame. For example, a TAC reduction would negatively impact a fishery in the short term by reducing income, but has a positive impact in the long term if it brings sustainability. The interaction may also depend upon the magnitude of a variable. For example, energy cost was considered a strong positive impact on the fishery for Greenland halibut, probably because if low it would allow excessive fishing effort, but if high it would prevent economic profitability.

Haul-by-haul landings and effort information from the French mixed-species deep-water fishery west of the British Isles showed different time-trends for three stocks (Figure 4). These are consistent with the known life histories, the declining stock (roundnose grenadier) being long-lived and black scabbardfish and blue ling having longevity similar to that of large demersal fish on the shelf. The number of vessels providing haul-by-haul information for that deep-water fishery has fluctuated over the years, mainly because of vessels leaving or entering the fishery (Lorance *et al.*, 2010). The continued availability of haul-by-haul data (its reporting is not compulsory) depends upon the maintenance of trust between scientists and the catching sector.

The use of stakeholder data and knowledge as done here can be regarded as some progress towards the proposals in the EU Green Paper on the Reform of the Common Fisheries Policy (Brussels, Com 2009, 163 final). The diversity of deep-water fisheries and the need for a combination of management measures identified here support the call in the Green Paper to incorporate stakeholder knowledge in fishery management. The use of tallybook data improves the knowledge base available to managers and is a promising approach to furthering stakeholder involvement in research projects. Alternatively, analyses of tallybooks can indicate the factors that might be recorded in electronic logbooks, an approach that would replace the present voluntary cooperation with a mandatory reporting scheme that would more readily provide the data needed for management purposes.

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Tables

Table 1. Fleet characteristics and management measures in 2009 for deep-water fisheries covered by the questionnaires and cognitive maps.

Fishery characteristic	**Fishery**						
	BSF Madeira[a]	**BSF Portugal**	**GHL Northwest Atlantic**	**French multispecies west of British Isles**	**SBR Azores**	**SBR Greece**	**SBR Gibraltar**
Number of vessels	30	17	60[b]	15[c]	820[e]	280[f]	100
Mean vessel length (m)	13	17.5	60	33	12	10	10
Total number of crew	180[d]	121	1440[b]	180	2759[e]	500	400
Fishing gear	Bottom longline	Bottom longline	Bottom trawl	Bottom trawl	Handlines and longlines	Longlines and gillnets	Handlines
Management measure in force							
TAC	*	*	*	*	*		*
Effort limitation	*	*	*	*	*		
Licences	*	*	*	*	*		
Seasonal closure				*			
Spatial closure			*	*			
Banned fishing practice/gear	*	*	*	*	*		
Minimum landing size					*	*	*
Restriction of recreational fishing						*[g]	

[a] Bordalo-Machado *et al.* (2009).
[b] These vessels may also prosecute other fisheries.
[c] 50 vessels (with 450 crew members) are licenced in the fishery. In recent years, 15 vessels (with an estimated 180 crew members) produced 95% of the French landings of deep-water species.
[d] Assumed 6 per vessel based upon the number of crew for mainland Portuguese vessels of the same size (Gordo *et al.*, 2009).
[e] Total number of vessels and crew in the Azores (Portuguese national statistics, 2009).
[f] Vessels targeting SBR on a seasonal basis; an additional 1100 vessels take it as bycatch.
[g] The use of nets is restricted. Longlines and handlines are allowed, with a daily maximum catch per fisher of 5 kg.
BSF, black scabbardfish; GHL, Greenland halibut; SBR,: blackspot seabream.

Table 2. European deep-water fishery stakeholders at international, national, and regional levels.

Stakeholder type	Geographic level		
	International	**National**	**Local**
Public	UN, RFMOs*, OSPAR Commission, RACs*, European institutions*, scientists*, monitoring agencies	National government and administrative services*, enforcement agencies, experts and scientists*,	Local government and administrative services, including at first point of sale, harbour authorities, training enterprises
Private/ businesses	Fish-catching sector, commercial buyers and sellers, fish transport, processors, education and training, banks		
	POs, fishmongers, gear manufacturers and suppliers, other seabed users (mining, oil and gas, offshore renewables, communication cables, aggregate dredging), fishery scientists, standard certifiers		Local fish markets, shipyards, restaurants, crew unions, harbour services, consumers
Associations/Groups/ NGOs	Fishing industry associations (catchers*, buyers, processors) and POs*		
	1.1.1. Environmental non-governmental organizations, MSC		Crew, consumers
Individuals		Citizens	

* Stakeholders present at the first workshop

UN, United Nations; RFMO, regional fishery management organization; OSPAR, Oslo and Paris Convention (an intergovernmental mechanism to protect the marine environment of the Northeast Atlantic); RAC, Regional Advisory Council; PO, Producer Organization; MSC, Marine Stewardship Council.

Table 3. SWOT (strengths, weaknesses, opportunities, and threats) analysis of current management measures applied to deep-water fisheries.

Management measure	Strengths	Weaknesses	Opportunities	Threats
TAC	Simple and easy to allocate; simple to monitor and control; establishes a track record; effective for small fleets of large fishing vessels	Implementation stock by stock; relationship between *F* and catches; efficiency linked to effort management; accounting of discards and bycatch; discarding; monitoring and control costs	Can be improved by taking discards into account and/or with better fishery data	Total allowable landings, not TAC; unrealistic if based on unrealistic assessments; does not allow for changes in fish-size distribution
Effort limitation (days at sea, days fishing)	Adapted for monospecific fisheries and on a single-gear basis; easy to monitor and control; potentially good because most relationships between *F* and fishing effort are believed to be linear	Allocation by fishery and métier; effort is a vector with several inputs; monitoring for passive gears; effort track records; control; difference between logbook effort units and regulations; technology creep	Management at international (fishery) rather than national level could lead to simplification (unification); could be controlled; controls fleet capacity and therefore profitability	Technology creep
Control measures (a) Licencing (b) Port State Control, designated ports, VMS (c) Enforcement observers	Easy monitoring and control; (a) caps the fishery (b) transparent (c) collection of fishery and biological data; validates catch-data accuracy	(a) Relies on a reference level; depends on initial allocations (b) Cost (c) Cost; conflicts between scientific and enforcement duties	(b) Improvement of fishery data; if industry-led improves governance; RAC-based management; EU-led enforcement	(b) Non-compliance; IUU
Technical measures (gear, MLS, mesh size, escapement devices)	Easy to monitor and control	Not adapted to shape and size of deep-water species; high escapee mortality	Regionalization; non-centralized control; shark-excluding devices	Lack of implementation; easy to mitigate effects[a]
Area closures (a) Spatial aspect (b) Temporal aspect	Protection of habitat, spawning aggregations, nurseries; easy monitoring and control; simpler for fishers than technical measures	Impact on other fisheries; lost fishery data from the area; redistribution of effort; definition of area and gear allowed	Effective in real-time (adaptive); (a) opportunities for sentinel fisheries. (b) closure times can be well defined	Appropriateness may change over time; non-compliance (a) definition of closure and reopening conditions

[a] For example, the benefits of a larger mesh size in the codend may be offset by changes in trawl rigging.

MLS, minimum landing size; TAC, total allowable catch; VMS, vessel monitoring system; *F*, fishing mortality; IUU, Illegal, Unregulated, and Unreported fishing

Table 4. Indices for cognitive maps drawn by stakeholders for a selection of deep-water fisheries.

Stock	Fishery	Stakeholder	Participants	Number of categories	Number of variables	Number of connections	Connections without sign[a]	Density	Mean strength	Mean time-frame
BSF Madeira	Longline	Admin	1	7	17	22	6	0.08	2	2
BSF Portugal	Longline	NGO	3	8	14	39	8	0.21	2.2	2.2
BSF Portugal	Longline	Catch	4	7	20	33	6	0.09	2.3	2.3
GHL NW Atlantic	Trawl	Catch	2	7	22	41	3	0.09	2.3	2.3
SBR Azores	Longline and nets	Catch	1	4	9	18	0	0.25	2.9	2.9

[(1)] Number of connections for which the sign of the impact was not determined, because it depended on the time-frame considered or other factors.

BSF, black scabbardfish; GHL, Greenland halibut; SBR, blackspot seabream.

Stakeholders are: Admin, national government and administrative services; NGO, non-governmental organization; Catch, fishing industry catching sector.

Table 5. Potential management levers derived from cognitive maps drawn for stocks by stakeholder groups.

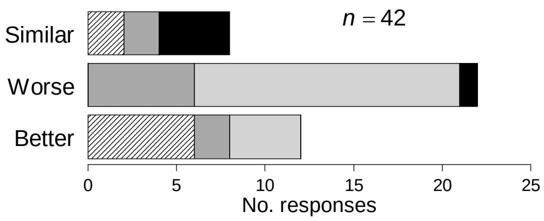
Stock	**Possible management levers for improving fishery conditions**
BSF Madeira	Knowledge of life cycle (increase), temporal closure (during spawning season), restrict fishing for immature fish in other fisheries, prefer nearby fishing grounds, contaminants (reduce), allow for regional management measures
BSF Portugal	Bycatch in all fisheries (reduce), subsidies (reduce), spatial closure, fleet size
GHL NAFO	Crew availability (increase), imports (reduce)
SBR Azores	Spatial closure (juveniles), gear selectivity (hook size)

BSF, black scabbardfish; GHL, Greenland halibut; SBR, blackspot seabream; NAFO, North Atlantic Fisheries Organization.

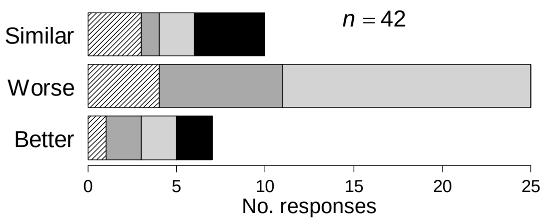
Figures

Figure 1. Questionnaire results on the perceptions of current vs. past (a) catch rates, (b) profits, and (c) future fishery prospects. SBR, blackspot seabream; BSF, black scabbardfish.

(a) How do current catch rates compare with 10 years ago?



(b) How do current profits compare with 10 years ago?



(c) Do deep-water fisheries have a better, worse, or similar future than they do currently?

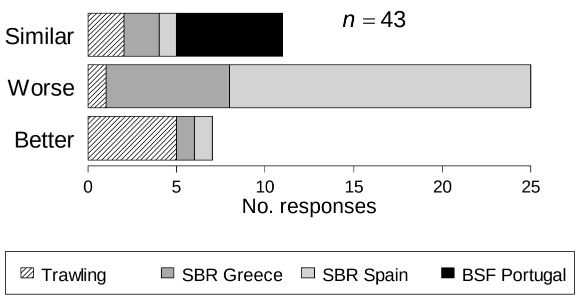


Figure 2. Questionnaire results in terms of opinions of stakeholders on management tools that (a) should be changed, (b) are best suited to protect the deep-water ecosystem, (c) are best for demersal or deep-water fisheries with bycatches or discards of protected deep-water species, and (d) the favoured authority to be responsible for the management of deep-water fisheries, showing results for four fisheries (see text for detail). *n* is the number of responses to the question; all four questions allowed more than one response. SBR, blackspot seabream; BSF, black scabbardfish.

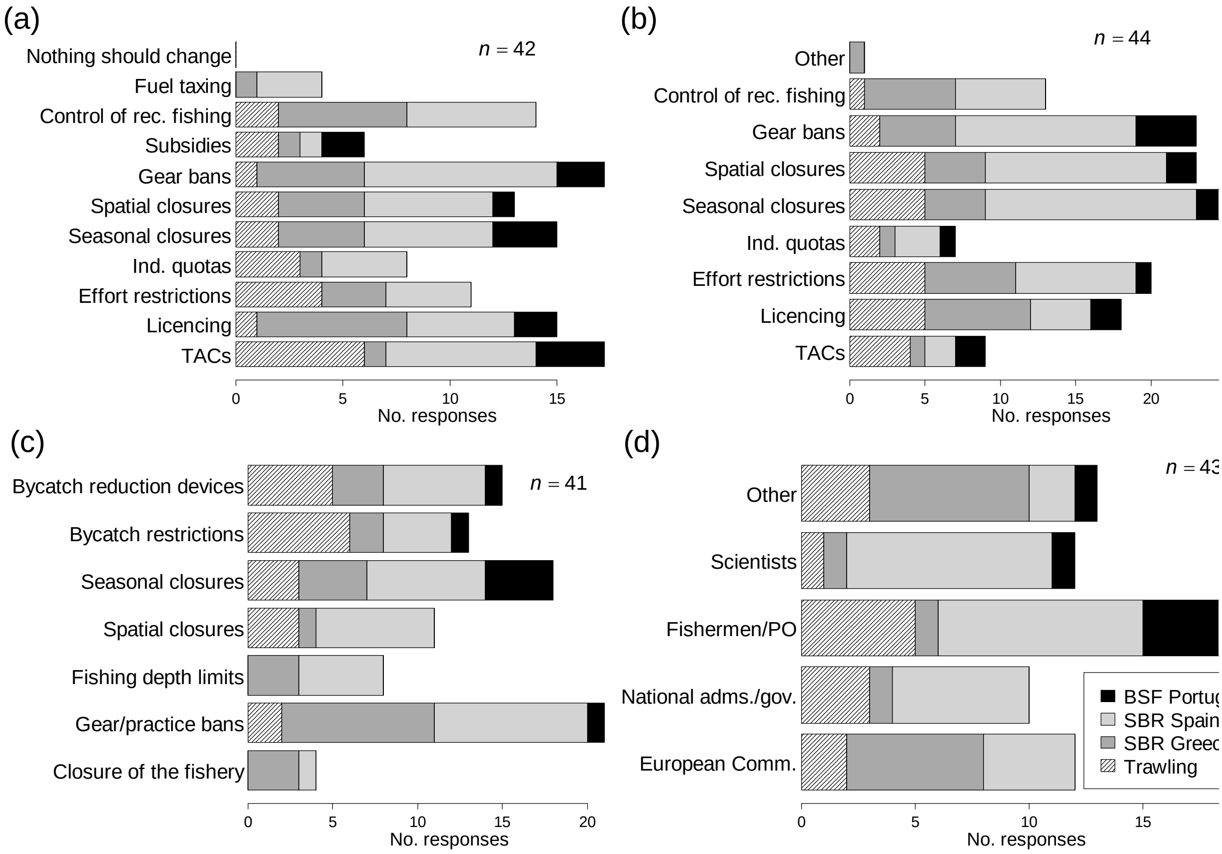


Figure 3. Cognitive map of (a) the deep-water trawl fishery for Greenland halibut in the NW Atlantic, and (b) the longline fishery for black scabbardfish around Madeira. Solid and dashed ellipses indicate variables and conceptual categories of variables (see text), respectively.

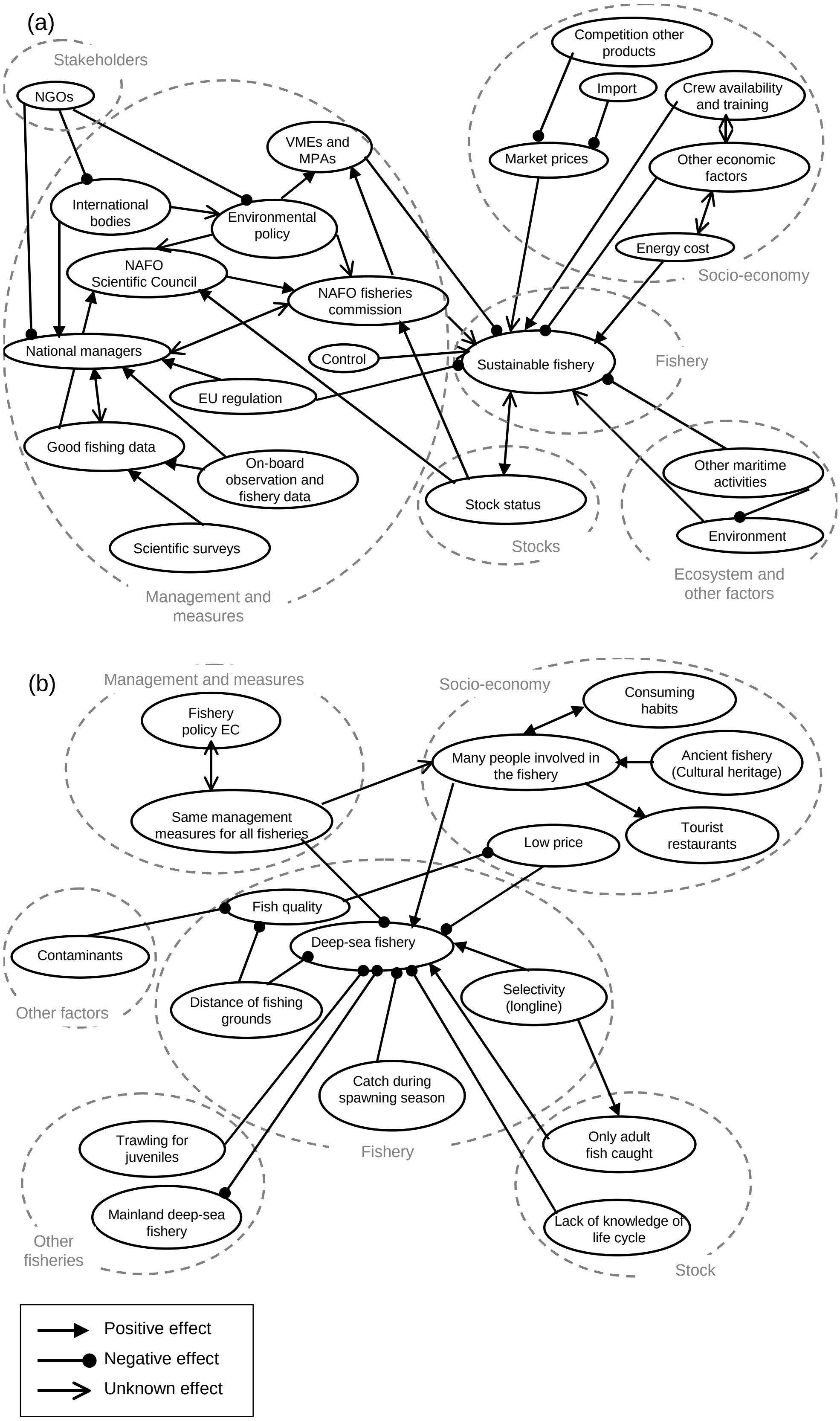


Figure 4. Standardized lpue biomass indices for (a) roundnose grenadier, (b) black scabbardfish, and (c) blue ling west of the British Isles. The results are derived from tallybook data from volunteer vessels in the French trawl fishery. Vertical bars indicate 95% prediction intervals.