Theme Session N on Elasmobranch Fisheries Science

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Elasmobranchs comprise a group of fishes having cartilaginous skeletons, internal fertilisation and a range of reproductive modes ranging from oviparity to viviparity. In total, about 800 species of sharks and rays (or skates) exist, with around 100 present in the ICES area. These fish are usually characterised as being vulnerable to fishing pressure. Despite their being widespread in most of the world's seas, they are poorly understood. Even the most basic data for quantitative studies of stock status are lacking for most species. This is particularly true of the ICES area (NE Atlantic or FAO Area 27). Yet available data shows that many ICES elasmobranchs are depleted.

Elasmobranchs are exploited for commercial fisheries (meat, livers, fins, teeth, jaws, aquarium trade), recreational fisheries and ecotourism ventures. Some elasmobranchs are highly valuable, others are a low value by-catch or discard in commercial fisheries. Catch and landings data are typically of poor quality, even in the ICES area (FAO area 27). Although general biological parameters are available for some species in particular areas, most elasmobranch stocks are poorly studied. Stock assessments are often hampered by this lack of data. Nevertheless, methodologies suitable for these species have been well developed. Basic growth, reproduction and mortality data can be used in powerful demographic type analyses. Another useful, though under-utilised source of information is fishery independent surveys.

ICES work on elasmobranchs is to develop scientific knowledge of these fish, and also provide the management advice that has been sought by clients and stakeholders. This theme session was timely, because 2005 is the first year that ICES has been asked to provide formal advice on elasmobranch stocks. The ICES Working Group on Elasmobranch Fishes (WGEF) has produced a series of reports that have improved our knowledge of these species in the ICES area. The more recent studies of WGEF were facilitated by the EU-funded DELASS project (2000–2002). Additional information was brought forward by the ICES-NAFO-CSIRO (Australia) Elasmobranch Symposium in 2001.

This theme session was the first elasmobranch theme session ever held by ICES, and filled important gaps in our knowledge. It attracted a wide participation, from within the ICES member states, but also from the northwest Atlantic, Mediterranean, South Atlantic, Pacific and Indian Oceans. In total 25 papers and 4 posters representing studies from 16 countries were presented, spanning one and a half days of the ICES Annual Science Conference.

For the purposes of fisheries management, we can consider four broad categories of elasmobranchs.

1) Demersal elasmobranchs, including rays (and/or) skates, small dogfishes and demersal sharks that are caught in mixed fisheries in most parts of the ICES area, though also in small scale targeted fisheries, often using gillnets.

2) Pelagic sharks, such as blue shark, shortfin mako and thresher shark, that are caught in tuna/billfish fisheries or in small scale directed fisheries.

3) Spurdog, which is a small widely ranging dogfish and is targeted in directed longline and gillnet fisheries, and also taken in mixed demersal fisheries.

4) Deepwater elasmobranchs, mainly squaliform sharks, that are caught in trawl, longline and gillnet fisheries that have developed since the early 1990's.

This theme session contained papers on all four groups. The following thematic areas were covered;

- Basic life history studies (age, growth, maturity, fecundity and mortality) that have been or can be incorporated into population assessments:.

- Survey abundance and biomass indices.
- Fundamental biological studies of spatial and bathymetric distributions, feeding ecology and morphometric studies.
- Fisheries descriptions and incorporation of fisheries dependent data.
- Population assessment techniques.
- Possible management strategies
- Policy framework for fisheries management.

The following report aims to summarise and provide a synthesis of the work that was presented, and to provide an overview of how ICES' goals in elasmobranch research have been advanced. In the report, shark names are given as common names, whilst rays and skates are given their scientific names, because common names often differ between countries.

Demersal species

Several papers were presented on demersal elasmobranchs, particularly rays, in different parts of the world. Age, growth, maturity, feeding ecology, and trends in biomass and abundance were reported on for a number of species, with detailed studies of the ray assemblages in Portugal, Barents Sea, North Sea, Tyrrhenian Sea, Falkland Islands and Gulf of St. Laurence emerging from the theme session.

In Portugal, as in most European countries, rays are an important component of the demersal mixed fishery. The four main species in landings are *Raja clavata*, *R. brachyura*, *R. montagui* and *Leucoraja naevus*. The metiers in which the species were caught was also described, and it was shown that *R. brachyura* was the major catch in gillnets, whilst *R. montagui* was caught mainly by longline (Doc. N:18). The feeding ecology of these species was described, with decapods and bony fishes the main prey items (Doc. N:28). Similar studies of the composition of landings of rays in other ICES Sub-areas are required.

In the Barents Sea, the ray assemblage is composed of seven species, but *Amblyraya radiata*, *A. hyperborea*, *Rajella fyllae*, *Dipturus batis* and *Bathyraja spinicauda* are the most abundant (Doc. N:11). Most of these are discarded, with only a small proportion landed, and very large reported landings in the late 1980's are considered to have been for reduction to fish meal. *A. radiata* is the most abundant species, and it was concluded that fishing mortality is lower than natural mortality at the present levels of exploitation.

In the Falklands Islands, the ray fishery catches *Bathyraja brachyurops*, *B. griseocauda*, *B. albomaculata*, and *B. scaphiops*. These papers covered age, growth and reproductive parameters. Such data have been used in the assessment and management of this fishery. The largest, slowest growing and latest maturing species, *Bathyraja griseocauda* has been depleted and the area in which it dominates catches has been closed since 1996. These trends are comparable to those described for North Sea rays, showing temporal variations in the relative status of the species along a gradient of increased vulnerability (Docs. N:02 and N:21) within the species assemblage.

Several rays occur in the Gulf of St. Laurence, Canada (NAFO area), including *Amblyraja radiata*, *Leucoraja ocellata* and *Malacoraja senta* (Doc. N:13). Information from trawl surveys indicate that the biomass and abundance of mature rays has declined since 1971, though the trend for immature rays suggested an increase from the mid 1980's to the mid 1990's. This was accompanied by a collapse in the biomass of large-bodied demersal teleosts, a decline in fishing effort, an increase in the seal population and a cooling of bottom waters in the southern Gulf.

The demersal elasmobranchs assemblage in the Tyrrhenian Sea, west Italy was described in a number of papers. The spatial and bathymetric distributions were described. Abundance and

biomass trends, over a period from the 1890's to the present, were modelled using GLM (Doc. N:25). *Raja polystigma*, the smallest species, displayed a clear increasing trend in biomass and abundance (Doc. N:20). In contrast, several large, coastal, late maturing species are reported to have disappeared from the study area, such as the large rays, *Dipturus batis* and *Rostroraja alba*. Abundance of *Raja asterias* appears stationary, and this may be explained by its small size and early age at maturity, and generally more productive life history strategy (Doc. N:12). Exploration of the linkages between this and adjoining areas may explain some of these trends, and it is hoped that studies in adjoining and other areas of the Mediterranean, such as have been conducted in the Tyrrhenian Sea will ensue.

Several studies of age in rays using the caudal thorn method were presented. Thorns provided better age estimation precision for *Raja clavata* in Portugal than did vertebrae (Doc. N:17), though thorn and vertebral age estimates did not produce differing perceptions of growth in 2 ray species from the Falkland Islands (Doc. N:02). For *Bathyraja griseocauda* in the Falkland Islands, thorns produced growth parameters that were in good agreement with maximum observed weight (Doc. N:14), though not length (Docs. N:14 and N:21). It will be necessary to convene a worldwide workshop to deal with ageing of rays using caudal thorns, as this new technique is enjoying a wide and increasing usage. The technique is non-destructive and does not require the dissection of landed carcasses. In addition it is hoped that further validation studies of this technique will be conducted.

Pelagic species

The blue shark is one of the most widespread elasmobranchs in the world, including the ICES area. Several papers on aspects of its biology were presented at this meeting. A study of the blue shark from the eastern Mediterranean showed lower maximum size and size at maturity than displayed in the Atlantic (Doc. N:09) and supports the decision taken in ICCAT and ICES to consider blue sharks in the Mediterranean as a separate stock. A strong predominance of males in eastern Mediterranean was also noted. A study of west African blue sharks (Doc. N:27) demonstrated the changes that occur in tooth morphometry, highlighting the need for awareness of such ontogenetic changes and sexual dimorphism when considering stock identity, and systematics and taxonomic studies of elasmobranchs.

Deepwater species

Studies of the ecology of elasmobranchs, particularly the poorly understood deepwater species, from diverse areas were presented. These studies covered littoral to deep sea areas off Guinea and Sierra Leone (Doc. N:26); the Azorean sector of the Mid-Atlantic Ridge (Doc. N:31) and mainland Portugal, (Doc. N:30) adding to available information on these areas. The biology and ecology of the gulper shark was described from the eastern Mediterranean (Doc. N:29), agreeing with previous studies that this is one of the least productive of all sharks, with a fecundity of one and an unknown gestation period. In a multi-disciplinary study, Pacific sleeper shark was shown to prey mainly on planktivores, and pinnipeds were shown not to be important items in their diet (Doc. N:05). Results from this study accord with others, that deepwater squalid sharks scavenge on dead cetaceans.

Preliminary investigations on the relative abundance of deepwater sharks in ICES Sub-area VI were undertaken using Scottish trawl surveys (1998-2004). This is the only series of fishery-independent, deepwater trawl surveys that is still continuing in this area (Doc. N:16). The surveys showed strong declines in the deepwater sharks, particularly Portuguese dogfish, where CPUE has decreased to about 1 fish per haul. This confirms data presented at WGEF for this species, and highlights the importance of such surveys.

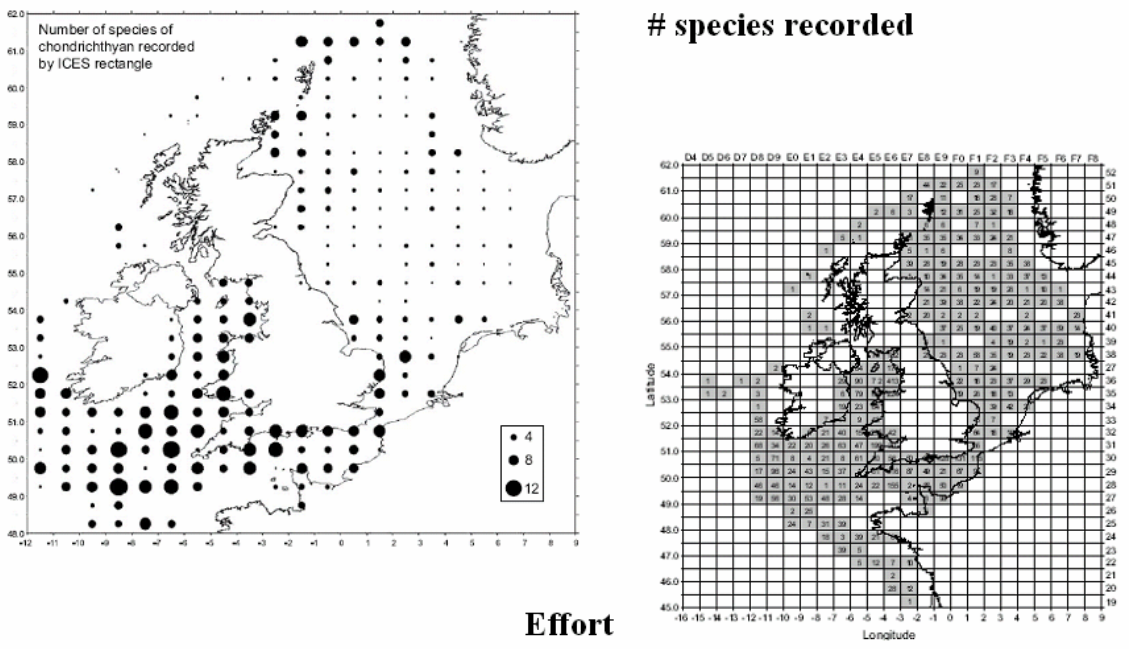

Figure 1. Utility of survey data for assessment of elasmobranch stocks. Comparsion of number of species recorded and trawl survey effort (N:06).

Fisheries Independent Surveys

Surveys have been identified as one of the few sources of information available, with which to assess elasmobranch stock status. Such data have been used in the North Sea area (Figure 1) and are now being applied used elsewhere. A particular success of this theme session was the inclusion of 8 papers on the use of fisheries independent surveys to assess status of elasmobranch stocks. In particular, the inclusion of French and Russian survey data was welcomed, filling gaps in our knowledge of species composition and stock abundance in these ICES areas.

Scottish survey CPUE data were standardised using GLM in order to generate an abundance index for spurdog (Doc. N:01). Results of this study supported conclusions of ICES WGEF that the stock is depleted. This was further supported by analyses of the IBTS North Sea survey (Doc. N:06). These IBTS analyses support earlier work on declines in larger rays, and show new information that smooth-hounds may well be increasing in relative abundance.

Studies of French survey data from Bay of Biscay and Celtic Sea (Doc. N:04) show increasing trends in the relative abundance of lesser-spotted dogfish, blackmouth dogfish and *Leucoraja naevus.* However the downward trend in spurdog was also confirmed in this area. Interestingly, there appears to be an upward trend in abundance of the starry smooth-hound, similar to that described in the North Sea (Doc. N:06).

English and French survey data from the eastern English Channel were used to describe essential fish habitats for *Raja clavata* and lesser-spotted dogfish, and elucidate migratory patterns related to spawning and nursery areas (Doc. N:23). An apparent trend for lesser-spotted dogfish distribution to be increasing towards the Straits of Dover and into the North Sea was evident over the period 1990 to 2004. It is also apparent that the SE English coast is an important habitat for *Raja clavata*.

As an alternative means of population studies, cameras and baited traps have been receiving increased attention in recent years. The use of baited cameras was shown to provide a low cost, non-destructive means to assess shark abundance of sharks on tropical reefs (N:03). Low

cost disposable cameras have been used to collect observations data in these reefs. Future work will focus on using the data to assess stock abundance.

Elasmobranch fisheries

Catch data for elasmobranchs in the ICES area are poor, and there are several reasons for this. Landings data are not indicative of catch levels because of the high discarding of some species (Figure 2). Even the available landings data for elasmobranchs are unreliable. Elasmobranchs are often not considered of high commercial importance, and consequently not always recorded in official records (Doc. N:11), many fisheries are unregulated (Doc. N:07), some commercial species may be misreported as elasmobranchs (Doc. N:22), and the use of the more inappropriate, generic reporting categories hampers analyses (Docs. N:18; N:22; and N:28).

Methods to estimate elasmobranch catch data included sampling of mixed landings (Docs. N:12 and N:18); establishing ratios of elasmobranch to target species, based on observers data (Doc. N:11), interviews with fishermen, processors and/or gear manufacturers (Docs. N:07 and N:12); and correlating generic landings data with indicator species in official data (Doc. N:22).

In order to assess stock status in ICES areas, it is necessary to have better landings statistics. The process of collating these data only began in ICES in 2003, and continues. Available data show striking downward trends in several cases. Best estimates of the main elasmobranch stocks in ICES area were presented (Doc. N:22). A particular problem is the use, by many countries of generic categories such as “cartilaginous fishes not elsewhere identified”. The number of such reporting categories has risen. A portion of these generic landings was allocated to ICES estimates for deepwater sharks, spurdogs or porbeagle. Of the remainder, it was shown that a large component of Spanish landings were positively correlated with tuna like fish, indicating that they represent pelagic species such as blue and shortfin mako shark. Future work will focus on these species, as current available data are considered underestimates of real catches.

A study of gillnet fishing for deepwater sharks off the British Isles, based on collecting information from the industry, sightings and boardings by naval vessels and anecdotal information was presented (Doc. N:07). This study showed alarming levels of ghost fishing, long soak times and high rates of discarding of rotten shark carcasses. This study has stimulated the EU to introduce emergency measures to regulate this fishery, including a proposed ban on gillnetting in waters deeper than 200 m. This report allowed for the first description of this fishery, that has been in operation since about 1992 with almost no information being available on catch, effort or fleet activity. Gillnet, trawl and longline fisheries have depleted these deepwater sharks in the ICES area.

Stock assessment and management

Many approaches to elasmobranch stock assessment have been used, and several varying methods were presented here, including demograhic analyses (Doc. N:19), GLM standardisation of CPUE series (Docs. N:01; N:16 and N:25), relating known species biomass (cod) using catch efficiency ratios (Doc. N:11), estimation of F from ratio of average catch to stock biomass (Doc. N:11); and simulations of populations under differening selection patterns (Doc. N:24).

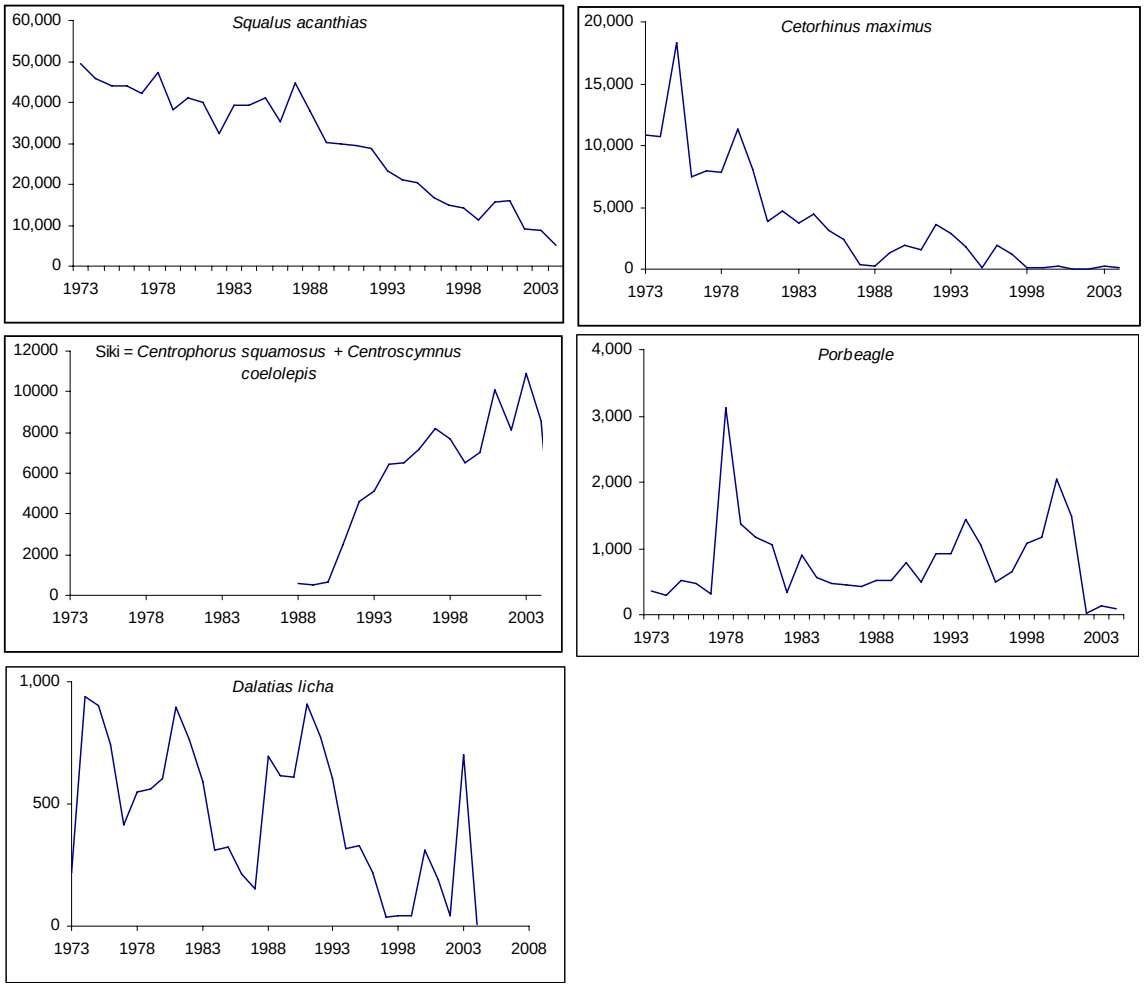

Figure 2. Best estimates of landings of the main shark species (*Squalus acanthias* or spurdog, *Cetorhinus maximus* or basking shark; deepwater siki sharks; *Lamna nasus* or porbeagle and *Dalatias licha* or kitefin shark) in the ICES area (N:22).

The simulations approach taken in Doc. N:24 compared theoretical populations of a long lived shark stock (K-strategist) and a short lived teleosts (r-strategist). Simulations suggested that higher fishing mortality was attainable for the shark by targeting juveniles only and that sustainable harvesting was unattainable if the mature component was targeted. This agrees with simulations in WGEF that a maximum landing size for spurdog is a possible means to manage fishing mortality. Interestingly, yield was not greatly different whether targeting juveniles or adults.

A good example of a demographic analysis, using available biological data, was shown for *Dipturus chilensis* in Chile (Doc. N:19). Changes in population dynamics were described under a three scenarios of fishing mortality. It was demonstrated that juveniles contributed most to population growth rate variations, agreeing with results of Doc. N:24, and suggesting that protecting larger females is a valid management strategy for elasmobranch stocks. This can be achieved by maximum landing sizes, closed areas or seasons. The applicability of such measures depends on a number of factors including survivorship of discards, and whether adult females are spatially or temporally discrete from the rest of the stock. It should also be noted that harvest strategies that aim to protect the mature female component of the stock are widely used for the management of exploited terrestrial mammals.In 2004, ICES was asked to comment on proposals for conservation measures for porbeagle and spurdog, and this is a growing area of work. Representatives from the non-governmental organisation sector described alternative approaches to management (Doc. N:08). The International Union for the Conservation of Nature (IUCN) Red List, provides a forum to cite species according to their conservation status. Red lists for elasmobranchs in various parts of the world, though not as yet the ICES area, have been drawn up and are subject to periodic review. Listing of elasmo-

branch species on CITES, an international convention regulating trade of endangered species, was cited as

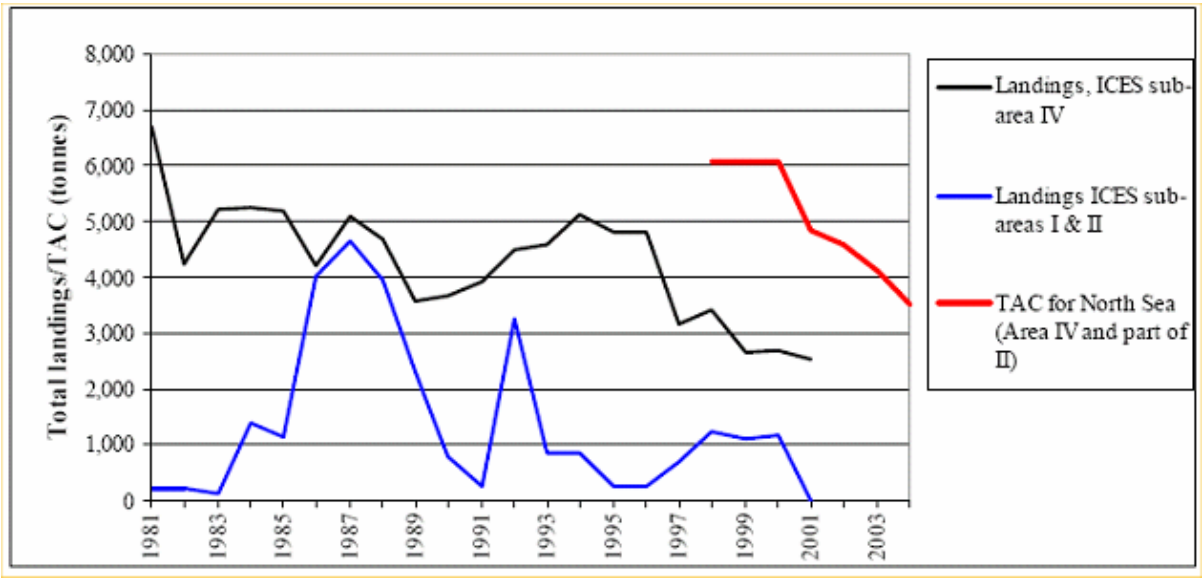

Figure 3. Comparison of skate and ray TAC and landings in the North Sea, data after 200 are preliminary (N:08).

another possible option. The global trade in shark fins and frozen shark products was shown to be increasing. In view of the depleted nature of many high value elasmobranch stocks, managers should be aware of the options available outside the traditional fisheries management regime. In any case, the current elasmobranch TAC's in Europe do not cover all species, nor do they correspond to the distribution areas of the stocks to which they apply (Figure 3).

Summary discussions

The theme session was summarised and discussions ensued. Participants made a number of recommendations:

- Photographic material needs to be better utilised as a resource in species identification and maturity manuals. Many instances of species misidentification were noted in the session. This should also apply to the egg cases of rays and dogfish.
- An international ageing workshop should be convened, particularly to deal with the new thorn method for rays. The best forum for this may be the American Elasmobranch Society that is having a ray symposium in 2006.
- For assessment of stock status using survey data, it is often the case that data are noisy with contagious distributions. Methods need to be developed to deal with such noisy data, particularly for aggregating species such as spurdog and species that are recorded only occasionally in surveys.
- Visual census methods should be explored as a means of estimating population abundance for certain species or habitats.
- ICES trawl survey data have been used for many areas. Areas where such analyses still need to be conducted are: Spanish coast, west of Ireland, Porcupine Bank, Faroe Plateau, Iceland, east Greenland and Norwegian coast.
- The approach taken to describing demersal elasmobranch status in the Tyrrhenian Sea should be applied to other areas of the Mediterranean. The MEDITS survey is a valuable source of data in this regard.

The material and methodologies presented in this theme session will be a valuable addition to our knowledge of elasmobranchs. In particular it will reinforce the work of ICES WGEF. It is intended to publish the work of WGEF and this theme session as an ICES Cooperative Research Report on the status of elasmobranch. The first step is to fill in the gaps that exist in particular parts of the ICES area. This theme session has helped to fill these gaps. ICES has much to learn from workers in other regions and it is hoped that future cooperation between elasmobranch biologists around the world can be facilitated by ICES and other organisations.