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To catch or conserve more fish: the evolution of fishing technology in fisheries science

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From the beginning of the 20th century, ICES has been concerned about fishing technology, especially the use of trawls and the proportion of undersized fish in the catch. Investigations of otter trawling and catching efficiency began in the early 1900s and continued throughout the decades under the umbrella of various ICES committees and subcommittees until 1955, when these investigations gained full committee status under the newly formed Comparative Fishing Committee. During the 1950s and 1960s, technological advances in underwater photography, acoustics, and trawl-mounted instrumentation provided the first means to study fishing gear and fish behaviour in scientific detail. The consequent increase in research led, in 1967, to the establishment of the ICES Gear and Behaviour Committee and eventually, in 1983, to the creation of the Working Group on Fishing Technology and Fish Behaviour (WGFTFB). The evolution of fishing technology research throughout the history of ICES closely parallels that of the fishing industry, and it has played an important role in contributing to the development and implementation of theoretical and applied fisheries science. We examine the application of fishing technology in fisheries science in an historical account of its development and the origins of the WGFTFB within ICES.

Keywords: behaviour, fishing, ICES, selectivity, surveys, trawl, WGFTFB.

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Introduction

Even at the beginning of the 20th century, ICES was concerned about the ramifications of emerging fishing technology such as otter trawls. In 1904, the second volume of the ICES *Rapports et Procès-Verbaux* included an article entitled "Draft program for experiments with nets (trawls) by request of the Bureau". At that time, in response to a memorandum on the subject from Sweden, ICES formed a subcommittee to investigate comparative fishing of several types of trawls. This research continued under various subcommittees and groups until 1955 when it was included in the terms of reference for the "new" Comparative Fishing Committee.

The ability of ICES to make a significant contribution to the development of fishing technology has been governed, to a great extent, by technical advances. The development of underwater instrumentation for measuring the performance of fishing gears since the 1950s, the appearance in the 1970s of low-light underwater television to observe gears and particularly fish reactions to them, and the increasing power and availability of computers in the 1980s and 1990s has created great opportunities for scientists. Prior to the creation of the Working Group on Fishing Technology and Fish Behaviour (WGFTFB) in 1983, these contributions were investigated by a number of committees, working groups, and study groups (Appendix 1). The goals of fishing technology research have evolved over the decades as the priorities of the fishing industry, scientific, and ICES communities have changed. Initially, the emphasis was focused on improving the technology and design of fishing gears to catch more fish. However, with the decline of fish stocks worldwide, conservation of the resource has become a priority. Emphasis is now placed on designing gears that are both size- and species-selective to minimize both the by-catch of non-target species and the physical damage to the benthos. As a result, ICES fishing technology research has played an important role in contributing to the development and implementation of theoretical and applied fisheries science since its inception.

This paper presents an historical account of the origin of the WGFTFB and synthesizes the major applications of fishing technology research to the science of conservation, harvesting, and stock assessment during the 20th century. This historical synopsis begins in the 1940s.

1945–1960

In the late 1940s and the 1950s, with major advances in technology, there was a gradual recognition that the fish capture process could now be studied as a scientific discipline and that fishing gear design might not be so much a "black art", but more a science (von Brandt, 1954). The 1957 FAO International Fishing Gear Congress held in Hamburg reflected this new attitude: "we stand at the threshold of a new era where systematic gear research will be increasingly fruitful" (H. Kristjonsson, Introduction in Kristjonsson, 1959).

There was also a realism regarding the need for significant funds to be concentrated in national centres: "If rapid progress is to be made then Governments must set up and/or support gear research institutes"(D. B. Finn, Preface in Kristjonsson, 1959).

This new impetus may be traced back to the Special Scientific Meeting organized by ICES in 1948 on "The Comparative Efficiency of Fishing Craft, Their Gear and Modifications to Gear" (ICES, 1949). In the recommendations, Wimpenny first proposed studies on the reaction of fish to trawls, as well as a range of experiments to assess the factors affecting trawl catch. The North Sea Sub-Committee on Comparative Fishing was the vehicle for these discussions within ICES. Later in 1954, at an informal meeting in The Hague between experts from The Netherlands, Germany, England, and Scotland, it was agreed to propose to ICES the elevation of this subcommittee to full Committee status (von Brandt, 1954). The ICES Committee on Comparative Fishing was duly formed in 1955, consisting of assessment biologists, gear technologists, statisticians, fish behaviourists, and instrumentation engineers.

One of the major foci of the new committee was the measurement of gear performance (drag, speed, spread, height, depth, angles, and distances) which became possible with the development of underwater, self-recording trawl instruments (de Boer, 1954). The consequent full-scale data provided the first means to validate the mathematical descriptions of fishing gear which had been evolving, e.g., in Japan and Russia (reviewed by Steele, 1955). The technique of physical modelling of gear performance was also introduced (Dickson in Kristjonsson, 1959), stemming from the original work by Tauti (1934) in Japan. Photographic equipment for observation of fish reaction and gear behaviour complemented the engineering instrumentation. Television and cine film, as well as still photographs, of trawls and seines in action were taken in the early 1950s (Sand, 1959; Ben-Yami, 1959; Craig and Priestley, 1960). At this stage, divers were the principal means to deploy such equipment, which restricted the depth at which it could be used. The introduction of acoustic equipment such as the echosounder to locate fish, the netsonde to identify net position relative to fish schools, and the subsequent development of efficient midwater trawl doors were the catalysts for the growth of pelagic fisheries, particularly in Germany. This also opened up new opportunities for assessing pelagic fish stocks (Parrish, 1953). Such developments continued throughout the 1960s and 1970s.

Another focus of research during the 1950s was the selectivity of fishing gears – mobile gears, set nets, and traps. The difference in selectivity of codends made of natural and new synthetic materials was studied exhaustively during the 1950s and 1960s. By 1955, the techniques for measuring mesh size were under careful scrutiny, and the need for a standard method was recognized (Boerema, 1958). The work of Klust, von Brandt, and others within ICES culminated in the important reference book on netting materials (Klust, 1973). The selectivity of a range of finfish and shellfish species was investigated by international collaboration, with major selectivity experiments in the North Sea and the Arctic Ocean. In an effort to coordinate this work, the Comparative Fishing Committee formed short-term working groups, such as the ICES Mesh Selection Working Group, in the late 1950s and early 1960s. Much of this work was also presented at a 1957 joint ICNAF/ICES/FAO scientific meeting in Lisbon (Anon., 1963).

1961–1970

Under the Comparative Fishing Committee, several short-term working groups were set up to deal with specific issues such as the development of pelagic and semi-pelagic trawls, high-opening bottom trawls, hooks, and bait selectivity, and their effect on catchability. In both Europe (MacLennan, 1970) and Canada (Carrothers *et al.*, 1969), many studies of the engineering and hydrodynamic performance of trawls led to the development of new instrumentation for trawl monitoring. In 1960, the first of many model experiments on fishing gears using the flume tank in Boulogne-sur-Mer took place (Portier, 1968). As a consequence, theoretical studies of gear performance were balanced by many papers on practical gear design and operation directly relevant to commercial fisheries. Much of this early research was also presented at the second FAO Fishing Gear Congress held in the United Kingdom in 1963 (Kristjonsson, 1964).

With the continuous developments in underwater instrumentation, many fish behaviour studies centred on improving fishing efficiency and the mesh selection process. At the 1963 FAO Congress, early experiments describing fish reactions to various components of fishing gears at different light levels were presented by Blaxter *et al.* (1964). During the next two decades, there was a proliferation of these studies using flume, swimming, and towing tanks in the laboratory and extensive underwater experiments in the field. These studies included fish attraction by light, the effect of netting of different colours, fish reactions to noises emitted by vessels, and echosounders. As the decade progressed, new observation techniques (frogmen, underwater photography, film and TV, towed vehicles, echosounder transducers mounted on the gear, electronic sector-scanning equipment) significantly increased the knowledge of fish behaviour and fishing gear performance. A prime example was the French development of the *Nephrops* and shrimp trawls to separate fish and shellfish (Kurc and Betus, 1969). Much of this fish behaviour research was presented at the FAO Conference on Fish Behaviour in Relation to Fishing Techniques and Tactics held in Bergen, Norway, in 1967 (Olsen, 1968; Ben-Tuvia and Dickson, 1968).

During the 1960s, international collaboration in selectivity studies continued. At the 1962 ICES annual meeting, the Comparative Fishing Committee formed the Icelandic Trawl Selection Working Group which oversaw a milestone in selectivity research: the creation of the 1962 International Selectivity Experiments in Icelandic waters in which Germany, Iceland, the UK, the USSR, Norway, and Canada took part (ICES, 1965). Further mesh-selection experiments comparing natural and synthetic yarns were carried out. Closely related to this selectivity work was the acceptance of the Westhoff gauge (Westhoff, 1961), renamed the ICES gauge in 1961 (ICES, 1962; Westhoff *et al.*, 1962) as the standard mesh gauge for research work. Mesh measurements using this gauge were frequently compared with those of the ICNAF gauge and the wedge gauge used by fisheries inspectors (Parrish and Pope, 1964). In 1969, the ICES/ICNAF Joint Working Group on Selectivity Analysis was tasked "to investigate further all factors which cause, or may cause, differences in mesh selection" (ICES, 1969). As a result, selectivity methodology over the previous decade was examined in two major reviews (Holden, 1971; Pope *et al.*, 1975).

Owing to the proliferation of fishing gear and behavioural studies, the Gear and Behaviour Committee was created at the 1967 ICES annual meeting (ICES, 1968). In 1970, the committee recommended that a new Working Group on Gear and Behaviour Methodology be established to "review research methods and techniques" and to "assess the priorities of study in gear and behaviour research" (ICES, 1970). Their findings set the direction of research for the next decade.

1971–1980

The decade was characterized by the so-called energy crises which led many ICES countries to undertake technical studies of energy consumption and fuel savings in the fishery. As a result, in 1972, the Gear and Behaviour Committee suggested the creation of a new Working Group on Research on Engineering Aspects of Fishing Gear, Vessel and Equipment (Engineering WG) to deal with this research (ICES, 1972). During the rest of the decade, the Working Group reviewed research related to on-board working conditions, processing, safety, and fuel consumption. This research included measuring gear geometry to reduce drag and decrease fuel consumption using trawl model studies in flume tanks (see Wileman, 1976), and direct observations using manned (Main and Sangster, 1981) and unmanned towed vehicles aboard research vessels. A code of practice for the conduct of engineering studies of fishing gears was developed by a subgroup of the Engineering WG chaired by D. MacLennan (1980). In midwater trawls, several new designs were investigated, such as rope trawls (de Boer, 1978, 1979, 1980), trawls with large hexagonal meshes (Jákupsstovu, 1979; Isaksen *et al.*, 1979), and trawls with large rhombic meshes (Brabant and Portier, 1978). The latter two types are still used today. In The Netherlands (de Groot and Boonstra, 1974), Scotland (Stewart, 1975), Germany (Horn, 1976), and Belgium (Vanden Broucke, 1973), efforts to reduce the drag of beam trawls and trawls used in the North Sea shrimp and flatfish fisheries revived an interest in using electric stimulation to replace the tickler chains. Their introduction into commercial practice was widely anticipated; however, this never happened.

Although fish behaviour studies were recognized by the Gear and Behaviour Committee as an integral part of fishing technology research, they were also viewed as a beneficial tool in the interpretation of fluctuations in survey abundance indices. This concept was formalized with the establishment of the Working Group on Reaction of Fish to Fishing Operations (Reaction WG) in 1972 under the Gear and Behaviour Committee (ICES, 1972). The membership attracted gear technologists and assessment biologists. Research focused on fish physiology studies such as swimming performance and reactions to fishing gears (Wardle, 1976), the effect of sound/vibrations on fish (ICES, 1974), and the development of methodology to study fish behaviour in large aquarium tanks (Wardle and Anthony, 1973). Field studies of fish behaviour reactions to towed gear benefited from the further development of scuba diving and television techniques.

During the 1970s, the effect of twine thickness on codend selectivity was widely discussed within the Gear and Behaviour Committee, and by the end of the decade, new research had proven that heavy twines adversely affected selectivity (ICES, 1971, 1981). Meanwhile, at the 1973 Gear and Behaviour Committee meeting, the discussion of species-selective trawling in the shrimp and *Nephrops* fisheries led to the conclusion that "such fishing gears and devices can help to reduce the wastage of by-catch" (ICES, 1974). Now the emphasis within ICES was shifting towards improving fishing technology not only to reduce the catches of small fish, but also to reduce the wastage of non-target species (ICES, 1974, 1975). From the mid-to-late 1970s, the Committee considered research on factors other than mesh size which may affect codend selectivity, such as weight of catch, trawling speed, and netting material and construction. By the end of the decade, two very successful species-selective technical devices had been introduced through legislation: the turtle excluder device (TED) used in shrimp fisheries in the United States (Watson and Seidel, 1980) and the "Nordmøre Grid" used in the Barents Sea shrimp fisheries to reduce catches of finfishes (Isaksen *et al*., 1990).

In 1978, the Gear and Behaviour Committee was renamed the Fishing Technology Committee and in 1979 was renamed the Fish Capture Committee (see Appendix 1).

1981–1990

As the decade began, the Engineering WG dealt with further studies on energy consumption and the potential for energy conservation in the fishing industry using full-scale instrumented sea trials and scale models tested in flume tanks (see Thorsteinsson, 1984; van Marlen, 1985). In 1982, problems encountered correlating the results from engineering studies of full-scale trawls versus scale-model experiments were resolved with the adoption of a standard technique for the measurement of twine diameter developed by the Study Group on Twine Thickness Measurement (Ferro, 1983). The Reactions WG began to address other low-energy fishing methods such as new hook designs, different sizes and types of bait, hanging ratios in gillnet, mesh sizes, and twine types, the effects of water flow on the performance of gillnets, and the distribution of olfactory stimuli from baited gears (see Stewart, 1986; Bjordal, 1987; Løkkeborg, 1987). The issue of bait shortages resulted in an *ad hoc* Working Group on Artificial Bait and Bait Attraction being established in 1984 to evaluate why artificial baits had not been as successful to date as natural baits in the developing longlining fishery (ICES, 1983, 1984, 1985).

Further development of species- and size-selective commercial fishing methods, such as square-mesh codends, benefited greatly from the use of video-camera-equipped, remotely controlled, underwater vehicles (Priestley *et al*., 1985). In the early 1980s, Scottish and Norwegian underwater observations of square-mesh codends showed that the meshes were fully open along their entire length and retained fewer small fish than diamond-mesh codends of the same mesh size (Isaksen and Valdemarsen, 1986; Robertson and Stewart, 1988). Underwater observations also led to extensive experiments in the middle and late 1980s to evaluate the use of horizontal separator panels to separate *Nephrops* from fish or to segregate different whitefish species within the trawl (see Main and Sangster, 1985; Valdemarsen *et al*., 1985).

At the 1983 ICES Statutory Meeting, the Working Groups on Research on Engineering Aspects of Fishing Gear, Vessel and Equipment, and on Reaction of Fish to Fishing Operations were combined into a single Working Group on Fishing Technology and Fish Behaviour (WGFTFB). Because of the developments in acoustic instrumentation, a second group was established and named the Fisheries Acoustic Science and Technology Working Group (WGFAST). Fernandes *et al.* (2002) provide a major review of the development of acoustics within ICES. Both working groups would hold joint sessions throughout the 1980s and 1990s to discuss common issues of fish behaviour and sampling gear selectivity.

Sampling and survey gear research became a major issue in the WGFTFB because population abundance indices from resource surveys were increasingly being used to calibrate fishery-dependent stock assessment models. At the 1984 inaugural meeting of the WGFTFB, there were concerns that differences in rigging of the ICES standard young fish trawl employed by vessels participating in the International Young Fish Survey might lead to differences in catching efficiency (Galbraith, 1982). Several contributions noted that trawl performance could be variable, resulting in an increase in the variance of abundance estimates based on swept-area techniques (Rush and Ferro, 1984; Wileman, 1984; West, 1984). Access to commercially available, hydroacoustic trawl instrumentation packages designed to measure trawl geometry *in situ* was an important development in monitoring and reducing variability in survey trawl performance (Galbraith, 1986; Hagstrøm, 1987). Extensive studies in the middle and late 1980s were conducted to quantify both bottom and pelagic sampling trawl performance and efficiency. These identified several factors which affected capture efficiency, such as the size and bottom contact of the ground gear (Dickson, 1988; Engås and Godø, 1989a; Walsh, 1989), sweep lengths (Engås and Godø, 1989b), and natural behaviour and vessel and trawl avoidance (Ona and Chruickshank, 1986). The need for more detailed and consistent specifications of survey gears led the

WGFTFB to recommend the establishment of the ICES Study Group on Net Drawing (ICES, 1989). As a result of these investigations, several ICES Member Countries began rigorous standardization of survey trawl design, rigging, and operational procedures in the late 1980s and early 1990s.

1991–1999

As the 1990s began, in response to a request for advice on the use of square-mesh codends in the Baltic Sea cod fisheries, the WGFTFB undertook a critical review of gear design features that improve size selectivity. However, the WGFTFB found few studies showing successful use of full square-mesh codends (ICES, 1991). Commercial acceptance was limited, and other devices such as square-mesh panels in the codend and shortened lastridge ropes in trawls (ICES, 1994, 1995) were being studied. In 1991, the UK introduced legislation for compulsory fitting of square-mesh panels in the top sections of *Nephrops* trawl codends to minimize finfish by-catch, followed by the EU in 2000.

During the 1990s, the WGFTFB became more widely involved in ICES through joint study groups and the presentation of advice to other committees. The WGFTFB created five study groups and two subgroups to pursue these goals (Appendix 1). Advice was provided to the Advisory Committee on Fishery Management (ACFM) and the International Baltic Sea Fishery Commission (IBSFC) in 1995 and 1996 on appropriate mesh sizes for use in Baltic Sea cod fisheries, and, in 1995, to ACFM on the selectivity in the North Sea *Nephrops* trawl fishery (ICES, 1995, 1996a). Given the current emphasis on selectivity studies, the WGFTFB created a Sub-Group on Selectivity Methods in 1992 to re-examine experimental procedures and statistical techniques. In 1996, the Sub-Group published a comprehensive technical and statistical manual on the topic (Wileman *et al.*, 1996). A similar manual requirement has since been identified by the Static Gear Selectivity Study Group (ICES, 1999a). Because codend selectivity is affected by hydrodynamic, behavioural, and mechanical characteristics of netting and twine (Ferro and O'Neill, 1994), there was a concern in the fishing industry over the subjectivity of mesh measurement methods. This focus was on the lack of a standardized gauge for use by both EU enforcement personnel (EU wedge gauge) and scientists (ICES spring gauge). An EU-funded concerted action reviewed this whole issue of methodology, and progress was reported to the WGFTFB (Fonteyne *et al.*, 1998). At the 1999 WGFTFB meeting, members strongly recommended that scientists and inspection services should use the same technique to measure mesh opening and that a Study Group on Mesh Measurement Methodology be created (ICES, 1999b). In addition to these developments, successful research, notably in Norway, into the use of grids or grates in trawls and seines to reduce by-catch in the shrimp and groundfish fisheries led to the creation of the Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets in 1995 to detail progress and methodology (ICES, 1996b). In 1997, sorting grids (Larsen and Isaksen, 1993; Isaksen *et al.*, 1995) were legislated for use in the Barents Sea otter trawl fishery to reduce the by-catch of undersized groundfish. Grids are mandatory in many shrimp fisheries worldwide.

The question of whether fish survive after escaping from fishing gears was addressed thoroughly in the 1990s. Led by Scottish and Scandinavian research, the focus was on escapement mortality of haddock, whiting, herring, shrimp, and *Nephrops* from trawl and seine codends and eventually from static gears such as longlines (Sangster, 1992). A Sub-Group on Survival Experiments was set up by the WGFTFB in 1992 to review current research results and techniques (ICES, 1993, 1994). High mortality rates among juvenile gadoids and pelagic fish, but relatively low mortality of larger gadoids were suggested, but it was recognized that the experimental techniques needed to be refined. In 1994, the WGFTFB felt that further concerted action was needed. The Fish Capture Committee created a Study Group on Unaccounted Mortality in Fisheries (ICES, 1997a) that concluded there was a lack of data to estimate many of the mortality components for a wide variety of fisheries and more research was required. By the mid-1990s, it was also recognized that a considerable amount of research on codend selectivity was ongoing. The need for data that were representative of fleet selectivity for use in stock assessment was widely discussed at the 1995 WGFTFB meeting. The Study Group on the Use of Selectivity Measurements in Stock Assessment was created, which brought together gear technologists, statisticians, and biologists (ICES, 1998). The estimation of whole fleet selectivity and the incorporation of fish survival data into stock assessment were important issues to this Study Group. The possible significance of unaccounted mortality to stock assessment was recognized, e.g., in relation to the North Sea haddock stock (ICES, 1998).

In 1992, the WGFTFB was involved in the ICES Symposium held in Bergen on "Fish Behaviour in Relation to Fishing Operations" (Wardle and Hollingworth, 1993). The Symposium was orientated towards conservation issues and observed that "obtaining detailed fish behaviour knowledge was necessary to meet the needs of responsible fishing with regard to size and species selective gears, by-catch reduction and survival of non-target species" (Olsen, 1993). Although much of the fish behaviour research during the 1960s–1980s was qualitative, the emerging technologies in the 1990s, such as data storage tags, acoustic positioning tags, swimming flumes, acoustic transducers, and scanning laser systems, have permitted more quantitative studies of both natural and reactive fish and shellfish behaviour.

In the 1990s, the WGFTFB continued to focus on the evaluation of sources of variation and bias in the performance of survey trawls used in annual resource surveys for finfish and shellfish and provided expert advice to several committees. This research was led by Norway, Canada, Scotland, Germany, and the United States. In 1992, the WGFTFB evaluated the sources of variability in the fishing power of the GOV trawl used in the International Bottom Trawl Survey and suggested revisions to the current manual of operations (ICES, 1992). In 1995, the WGFTFB evaluated survey gears in the Baltic Sea and advised on the selection of an appropriate standard gear for the Baltic Sea demersal surveys (ICES, 1995, 1997b). At the 1997 ICES Annual Science Conference, the WGFTFB undertook a major review of this field in the Theme Session on "The Catching Performance of Fishing Gears Used in Surveys" (Walsh, 1999). The Session concluded that most countries were now in a position to standardize survey operations to reduce variability and measurement error of trawl performance and bring these biases to an acceptable level. A new Study Group was proposed in 1997 to integrate estimates of survey trawl performance and catchability into analytical models used in stock assessment (ICES, 1997c; Somerton *et al.*, 1999). This topic was absorbed by the Study Group on the Use of Selectivity and Effort Mea-surements in Stock Assessment (ICES, 1998).

In 1996, the terms of reference for the "new" Fisheries Technology Committee were expanded to include measuring the direct physical effects of fishing operations (ICES, 1997d). Although research into the impact of fishing gears on the seabed had an initial start in 1955, with efforts increasing in the late 1960s, the 1970s, and the late 1980s, it was not until the 1990s that these studies regained full momentum (Lindeboom and de Groot, 1998; Kaiser and de Groot, 1999). At the 1999 WGFTFB meeting, the collaborative results of research on the physical impact on benthos and benthic substrates were presented. The WGFTFB made the observation "that many studies have been done on impacts and the time may be ripe to shift research effort away from further description of impacts towards ways in which gear can be modified to reduce impact" (ICES, 1999b). Polet's (1999) work using electric pulses as an alternative stimulation and reduced bottom contact in the beam trawl as a method to reduce by-catch of juvenile flatfish in beam-trawl shrimp fisheries is a good example of doing just that.

Future prospects: the next decade

In both commercial and scientific fishing gear research, emerging technologies such as new acoustic and imaging techniques will allow the tracking, species identification, and sizing of fish at greater ranges than are possible with current optical systems. These new imaging technologies should lead to improved fish behaviour research and benefit both the sampling trawl research and the rational development of more selective, environmentally friendly, commercial fishing gears. Including fish behaviour, catchability, and trawl performance data from surveys in the analytical modelling of stock assessment will be the big challenge. Closer collaboration between assessment biologists and gear technologists within ICES, the enforcement agencies, and the commercial fishing industry is needed to develop effective, enforceable, practical, and acceptable technical measures to further the aims of responsible fishing initiatives. Only then will there be greater success in introducing, through legislation, new technical devices to improve conservation.

The WGFTFB has a continuing strong role to play in the development of fisheries science within ICES. Its major activities should focus on discussions of current technological and scientific developments in fishing gear and fish behaviour research and include hands-on analysis of data in support of scientific advice to other ICES committees. To be highly effective in its goals, the WGFTFB must be proactive in liaising with other science committees, working groups, and study groups within ICES, and also with the fishing industry to advise them of technological developments related to their activities. The future will be challenging!

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References

Anonymous. 1963. The selectivity of fishing gear. Being Volume 2 of Proceedings of Joint ICNAF/ICES/FAO Special Scientific Meeting, Lisbon, 1957. International Commission for the Northwest Atlantic Fisheries, Special Publication, 5. 225 pp.

Ben-Tuvia, A., and Dickson, W. 1968. Proceedings of the Conference on Fish Behaviour in Relation to Fishing Techniques and Tactics. FAO Fisheries Report, 62(1). 47 pp.

Ben-Yami, M. 1959. Study of the Mediterranean trawl net. *In* Modern Fishing Gear of the World, pp. 213–221. Ed. by H. Kristjonsson. Fishing News (Books) Ltd., London. 607 pp.

Bjordal, Å. 1987. Testing of a new hook design in the longline fishery for tusk (*Brosme brosme*) and ling (*Molva molva*). ICES CM 1987/B:20. 8 pp.

Blaxter, J. H. S., Parrish, B. B., and Dickson, W. 1964. The importance of vision in fish reaction to driftnets and trawls. *In* Modern Fishing Gear of the World: 2, pp. 529–536. Ed. by H. Kristjonsson. Fishing News (Books) Ltd., London. 603 pp.

Boer, E. J. de. 1978. Report of the Working Group on Research and Engineering Aspects of Fishing Gear, Vessels and Equipment. ICES CM 1978/B:4, 98 pp.

Boer, E. J. de. 1979. Report of the Working Group on Research and Engineering Aspects of Fishing Gear, Vessels and Equipment. ICES CM 1979/B:3. 134 pp.

Boer, E. J. de. 1980. Report of the Working Group on Research and Engineering Aspects of Fishing Gear, Vessels and Equipment. ICES CM 1980/B:4. 166 pp.

Boer, P. A. de. 1954. Trawl gear measurements obtained by underwater instruments. ICES CM 1954/North Sea Sub-Committee on Comparative Fishing, 4. 20 pp.

Boerema, L. K. 1958. Note on the need for standardisation of mesh measuring methods. ICES CM 1958/Comparative Fishing Committee, 57. 6 pp.

Brabant, J. C., and Portier, M. 1978. Le chalut pélagique à très grande mailles. ICES CM 1978/B:18. 6 pp.

Brandt, A. von. 1954. Investigations on fishing technology and their importance for the International Council for the Exploration of the Sea. ICES CM 1954/North Sea Sub-Committee on Comparative Fishing, 39. 3 pp.

Carrothers, P. J. G., Foulkes, T. J., Connors, M. P., and Walker, A. G. 1969. Data on engineering performance of Canadian east coast groundfish otter trawls. Fisheries Research Board of Canada Technical Report, 125. 100 pp.

Craig, R. E., and Priestley, R. 1960. Some new applications of underwater photography. ICES CM 1960/Comparative Fishing Committee, 44. 4 pp.

Dickson, W. 1988. Size selectivity of trawl gear in Arctic surveys. ICES CM 1988/B:20. 16 pp.

Engås, A., and Godø, O. R. 1989a. Escape of fish under the fishing line of a Norwegian sampling trawl and its influence on survey results. Journal du Conseil International pour l'Exploration de la Mer, 45: 269–276.

Engås, A., and Godø, O. R. 1989b. The effect of different sweep lengths on the length composition of bottom-sampling trawl catches. Journal du Conseil International pour l'Exploration de la Mer, 45: 263–268.

Fernandes, P. G., Gerlotto, F., Holliday, D. V., Nakken, O., and Simmonds, E. J. 2002. Acoustic applications in fisheries science: the ICES contribution. ICES Marine Science Symposia, 215: 483–492. (This volume).

Ferro, R. S. T. 1983. Report by the Study Group on Twine Thickness Measurement. ICES CM 1983/B:26. 9 pp.

Ferro, R. S. T., and O'Neill, F. G. 1994. An overview of methods of measuring twine and netting characteristics and mesh size. ICES CM 1994/B:36. 7 pp.

Fonteyne, R., Link, U., Stewart, P., and Ward, N. 1998. Evaluation of mesh measurement methodologies for fisheries inspection and research. Final report of the EU Concerted Action FAIR CT96.1452. 177 pp.

Galbraith, R. D. 1982. Performance trials on Chalut 36/47 GOV constructed in both nylon and polyethylene twine. ICES CM 1982/B:21. 6 pp.

Galbraith, R. D. 1986. Full-scale instrumented gear trials on the ICES young fish sampling trawl (CHALUT GOV 26/47). ICES CM 1986/B:9. 10 pp.

Groot, S. J. de, and Boonstra, G. P. 1974. The development of an electrified shrimp-trawl in the Netherlands. Journal du Conseil International pour l'Exploration de la Mer, 35(2): 165–170.

Hagstrøm, O. 1987. Measurement of door spread and headline height of the G.O.V. trawl during IYFS 1987. ICES CM 1987/B:14. 10 pp.

Holden, M. J. (Ed.) 1971. Report of the ICES/ICNAF Working Groups on Selectivity Analysis. ICES Cooperative Research Report, Series A, 25. 144 pp.

Horn, W. 1976. Rationalization of sole fisheries by means of electrified beam trawls. *In* Report of the Working Group on Research on Engineering Aspects of Fishing Gear, Vessels and Equipment. pp. 63–66. ICES CM 1976/B:7. 66 pp.

ICES. 1949. Contributions to Special Scientific Meetings 1948. Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer, 125. 96 pp.

ICES. 1962. Procès-Verbal de la Réunion 1961, Comparative Fishing Committee, Recommendation B(2). Charlottenlund. International Council for the Exploration of the Sea, Copenhagen. 134 pp.

ICES. 1965. Report of the 1962 Iceland Trawl Mesh Selection Working Group. (ICES) Cooperative Research Report, 3. 42 pp.

ICES. 1968. Procès-Verbal de la Réunion 1967. International Council for the Exploration of the Sea, Copenhagen. 155 pp.

ICES. 1969. Report of the Joint ICES/ICNAF Working Group on Selectivity Analysis. Comparative selectivity of bottom trawls made of different materials. ICES CM 1969/B:13. 19 pp.

ICES. 1970. Procès-Verbal de la Réunion 1970. International Council for the Exploration of the Sea, Copenhagen. 128 pp.

ICES. 1971. Procès-Verbal de la Réunion 1971. International Council for the Exploration of the Sea, Copenhagen. 145 pp.

ICES. 1972. Procès-Verbal de la Réunion 1972. International Council for the Exploration of the Sea, Copenhagen. 142 pp.

ICES. 1974. Procès-Verbal de la Réunion 1973. International Council for the Exploration of the Sea, Copenhagen. 143 pp.

ICES. 1975. Procès-Verbal de la Réunion 1974. International Council for the Exploration of the Sea, Copenhagen. 176 pp.

ICES. 1981. Procès-Verbal de la Réunion 1980. International Council for the Exploration of the Sea, Copenhagen. 163 pp.

ICES. 1983. General Report of the Joint Meeting of the Fish Capture Committee's Working Groups, 2–6 May 1983. ICES CM 1983/B:5. 6 pp.

ICES. 1984. Report of the *Ad Hoc* Working Group on Artificial Bait and Bait Attractance. ICES CM 1984/B:7. 8 pp.

ICES. 1985. Report of the *Ad Hoc* Group on Artificial Bait and Bait Attraction. ICES CM 1985/B:31. 12 pp.

ICES. 1989. Report of the Study Group in Net Drawing. ICES CM 1989/B:44. 17 pp.

ICES. 1991. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1991/B:28. 36 pp.

ICES. 1992. Report from FTFB Subgroup: Evaluation of Sources of Variability in the Fishing Power of the GOV Trawl. ICES CM 1992/B:39. 33 pp.

ICES. 1993. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1993/B:2. 15 pp.

ICES. 1994. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1994/B:2. 28 pp.

ICES. 1995. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1995/B:2. 75 pp.

ICES. 1996a. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1996/B:2. 47 pp.

ICES. 1996b. Report of the Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets. ICES CM 1996/B:1. 87 pp.

ICES. 1997a. Report of the Study Group on Unaccounted Mortality in Fisheries. ICES CM 1997/B:1. 19 pp.

ICES. 1997b. Report of the Workshop on Standard Trawls for Baltic International Fish Surveys. ICES CM 1997/J:6. 18 pp.

ICES. 1997c. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1997/B:2. 47 pp.

ICES. 1997d. 1996 Annual Science Conference, 84th Statutory Meeting, Iceland. International Council for the Exploration of the Sea, Copenhagen. 323 pp.

ICES. 1998. Report of the Study Group on the Use of Selectivity and Effort Measurements in Stock Assessment. ICES CM 1998/B:6. 26 pp.

ICES. 1999a. Report of the Study Group on Methods for Measuring the Selectivity of Static Gears. ICES CM 1998/B:4. 2 pp.

ICES. 1999b. Report of the Working Group on Fishing Technology and Fish Behaviour. ICES CM 1999/B:1. 37 pp.
Isaksen, B., Jensen, H., and Olsen, S. 1979. Recent developments on blue whiting trawls in Norway. ICES CM 1979/B:24. 7 pp.
Isaksen, B., Lisovsky, S., Larsen, R. B., and Sakhnoe, V. 1995. Results from the joint Russian-Norwegian selectivity experiments on cod (*Gadus morhua* L.) in the Barents Sea with 55 mm sorting grid systems. *In* Report of the Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets, p. 12. ICES CM 1996/B:1. 87 pp.
Isaksen, B., and Valdemarsen, J. W. 1986. Selectivity experiments with square mesh codends in bottom trawls. ICES CM 1986/B:28. 18 pp.
Isaksen, B., Valdemarsen, J. W., and Larsen, R. B. 1990. Reduction of fish bycatch in shrimp trawls using a solid separator grid in the aft belly. ICES CM 1990/B:47. 13 pp.
Jákupsstovu, S. H. í. 1979. Faroese experiments with very big meshed trawls for blue whiting fishery. ICES CM 1979/B:16. 11 pp.
Kaiser, M. J., and Groot, S. J. de. 1999. Effects of fishing on non-target species and habitats: biological conservation and socio-economic issues. Blackwell Science, Malden, Massachusetts, USA. 399 pp.
Klust, G. 1973. Netting Materials for Fishing Gear. Fishing News (Books) Ltd., Oxford. 175 pp.
Kristjonsson, H. (Ed.). 1959. Modern Fishing Gear of the World. Fishing News (Books) Ltd., London. 607 pp.
Kristjonsson, H. (Ed.). 1964. Modern Fishing Gear of the World: 2. Fishing News (Books) Ltd., London. 603 pp.
Kurc, G., and Betus, J. 1969. Etude préliminaire d'un chalut sélectif pour la pêche des langoustines et des merlus. ICES CM 1969/B:11. 5 pp.
Larsen, R. B., and Isaksen, B. 1993. Size selectivity of rigid sorting grids in bottom trawls for Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). ICES Marine Science Symposia, 196: 178–182.
Lindeboom, H. J., and Groot, S. J. de. (Eds.). 1998. The effects of different types of fisheries on the North Sea and Irish Sea benthic eco-systems. EU-project AIR2-CT94-1664 (IMPACT-II), Final Report ISSN 0923-3210. Netherlands Institute for Sea Research NIOZ Rapport 198-1. RIVO-DLO Report C003/98. 404 pp.
Løkkeborg, S. 1987. Fishing experiments with an alternative longline bait based on nylon bags. ICES CM 1987/B:19. 26 pp.
MacLennan, D. N. 1970. Evaluation of gear performance by physical measurement; state of the art and a forward look. ICES CM 1970/B:14. 5 pp.
MacLennan, D. N. 1980. Code of practice for the conduct of fishing gear experiments. ICES CM 1980/B:16. 39 pp.
Main, J., and Sangster, G. I. 1981. A study of the fish capture process in a bottom trawl by direct observations from a towed underwater vehicle. Scottish Fisheries Research Report, 23. 24 pp.
Main, J., and Sangster, G. I. 1985. Recent studies in species separation with a two-level trawl in three different fisheries. ICES CM 1985/B:14. 7 pp.
Marlen, B. van. 1985. Report of a seminar on electro-fishing at RIVO-IJmuiden on 24 January 1985. ICES CM 1985/B:37. 6 pp.
Olsen, S. 1968. Report on FAO Conference on Fish Behaviour in Relation to Fishing Techniques and Tactics, Bergen, 19–27 October 1967. ICES CM 1968/B:7. 2 pp.
Olsen, S. 1993. Introduction. *In* Fish Behaviour in Relation to Fishing Operations, p. 1. Ed. by C. S. Wardle and C. E. Hollingworth. ICES Marine Science Symposia, 196. 216 pp.
Ona, E., and Chruickshank, O. 1986. Haddock avoidance reactions during trawling. ICES CM 1986/B:36. 13 pp.
Parrish, B. B. 1953. A proposal for the introduction of organised echo-research in North Sea herring investigations. ICES CM 1953/Pelagic Committee, 30. 6 pp.
Parrish, B. B., and Pope, J. A. 1964. Report on comparisons between the ICES and standard enforcement mesh-measuring gauges. ICES CM 1964/Comparative Fishing Committee, 133. 3 pp.
Polet, H. 1999. Possibilities for discard reducing in shrimp (*Crangon crangon*) fisheries by means of electric pulses as an alternative stimulation. *In* Report of the Working Group on Fishing Technology and Fish Behaviour, p. 12. ICES CM 1999/B:1. 37 pp.
Pope, J. A., Margetts, A. R., Hamley, J. M., and Akyüz, E. F. 1975. Manual of methods for fish stock assessment. Part III. Selectivity of fishing gear. FAO Fisheries Technical Paper, 41 (Revision 1). 65 pp.
Portier, M. 1968. Caractéristiques et possibilités de la veine d'expérimentation de maquettes d'engins de pêche de Boulogne-sur-Mer. ICES CM 1968/B:8. 8 pp.
Priestley, R., Wardle, C. S., and Hall, C. D. 1985. The Marine Laboratory remote controlled fishing gear observations vehicle. ICES CM 1985/B:10. 17 pp.
Robertson, J. H. B., and Stewart, P. A. M. 1988. A comparison of size selection of haddock and whiting by square and diamond mesh codends. Journal du Conseil International pour l'Exploration de la Mer, 44: 148–161.
Rush, R. A., and Ferro, R. S. T. 1984. Variation of towing speed during survey cruises with the GOV and Aberdeen 48 ft Trawls. ICES CM 1984/B:31. 7 pp.
Sand, R. F. 1959. Midwater trawl design by underwater observations. *In* Modern Fishing Gear of the World, pp. 209–212. Ed. by H. Kristjonsson. Fishing News (Books) Ltd., London. 607 pp.
Sangster, G. I. 1992. The survival of fish escaping from fishing gears. ICES CM 1992/B:30. 9 pp.
Somerton, D., Ianelli, J., Walsh, S. J., Smith, S. J., Godø, O. R., and Ramm, D. 1999. Incorporating experimentally derived estimates of survey trawl efficiency into the stock assessment process: a discussion. ICES Journal of Marine Science, 56: 299–302.
Steele, J. H. 1955. Review of theoretical studies on trawl. ICES CM 1955/Comparative Fishing Committee, 15. 8 pp.
Stewart, P. A. M. 1975. Catch selectivity by electrical fishing systems. Journal du Conseil International pour l'Exploration de la Mer, 36(2): 106–109.
Stewart, P. A. M. 1986. Measurement of the headline heights of gill nets in tidal flows. ICES CM 1986/B:11. 10 pp.
Tauti, M. 1934. A relation between experiments on model and full scale of fishing nets. Bulletin of the Japanese Society of Scientific Fisheries, 3(4): 171–177.
Thorsteinsson, G. 1984. Recent development in the Icelandic seine fishery. ICES CM 1984/B:2. 9 pp.
Valdemarsen, J. W., Engås, A., and Isaksen, B. 1985. Vertical entrance into a trawl of Barents Sea gadoids as studied with a two level fish trawl. ICES CM 1985/B:46. 16 pp.
Vanden Broucke, G. 1973. Further investigations on electrical fishing. ICES CM 1973/B:14. 6 pp.
Walsh, S. J. 1989. Diel influences on fish escapement beneath a groundfish survey trawl. ICES CM 1989/B:23. 22 pp.
Walsh, S. J. 1999. The 1997 Theme Session on the catching performance of fishing gears used in surveys. ICES Journal of Marine Science, 56: 251.
Wardle, C. S. 1976. Fish reaction to fishing gears. Scottish Fisheries Bulletin, 43: 16–20.
Wardle, C. S., and Anthony, P. D. 1973. Experimental methods used for the study of fish behaviour in large tanks. ICES CM 1973/B:22. 6 pp.
Wardle, C. S., and Hollingworth, C. E. (Eds.). 1993. Fish Be-

haviour in Relation to Fishing Operations. ICES Marine Science Symposia, 196. 216 pp.
Watson, J. W., and Seidel, W. R. 1980. Evaluation of techniques to decrease sea turtle mortalities in the southeastern United States shrimp fishery. ICES CM 1980/B:31. 8 pp.
West, C. W. 1984. Measurements of variability in bottom trawl performance during resource assessment surveys. *In* Report of the Working Group on Fishing Technology and Fish Behaviour, p. 22. ICES CM 1984/B:3. 26 pp.
Westhoff, C. J. W. 1961. Description of the latest version of a longitudinal spring-loaded mesh measuring gauge with automatic stop. ICES CM 1961/Comparative Fishing Committee, 40. 5 pp.
Westhoff, C. J. W., Pope, J. A., and Beverton, R. J. H. 1962. The ICES mesh gauge. Charlottenlund Slot, Charlottenlund, Denmark. 15 pp.
Wileman, D. A. 1976. Flume tank facility – net modelling techniques. ICES CM 1976/B:23. 5 pp.
Wileman, D. A. 1984. Model testing of the 36/47 GOV young fish sampling trawl. *In* Report of the ICES Fishing Technology and Fish Behaviour Working Group, p. 21. ICES CM 1984/B:3. 26 pp.
Wileman, D. A., Ferro, R. S. T., Fonteyne, R., and Millar, R. B. 1996. Manual of methods of measuring the selectivity of towed fishing gears. ICES Cooperative Research Report, 215. 126 pp.

Appendix

Chronology of related ICES committees, working groups, study groups, and subgroups.

Committee	Chair	Country	Years
Comparative Fishing Committee	A. von Brandt	Germany	1955–1958
	R. J. H. Beverton	United Kingdom	1959–1963
	S. Olsen	Norway	1964–1965
Gear and Behaviour Committee	S. Olsen	Norway	1966–1967
	A. von Brandt	Germany	1968
	A. R. Margetts	United Kingdom	1969–1971
	J. G. de Wit	The Netherlands	1972–1974
	P. J. G. Carrothers	Canada	1975–1977
Fishing Technology Committee	G. Kurc	France	1978
Fish Capture Committee	G. Kurc	France	1979–1980
	E. J. de Boer	The Netherlands	1981–1983
	G. Thorsteinsson	Iceland	1984–1986
	D. N. McLennan	United Kingdom	1987–1989
	K. Olsen	Norway	1990–1992
	R. Fonteyne	Belgium	1993–1995
Fisheries Technology Committee	P. A. M. Stewart	United Kingdom	1996–1998
	O. A. Misund	Norway	1999–2001

Chronology of related ICES committees, working groups, study groups, and subgroups.

Working Group	Chair	Country	Years
Mesh Selection Working Group	G. Sætersdal	Norway	1959
Icelandic Trawl Selection Working Group	J. A. Pope J. Jónsson	United Kingdom Iceland	1960 1962–1963
ICES/ICNAF Joint Working Group on Selectivity Analysis	A. I. Treschev	USSR	1969–1970
Working Group on Gear and Behaviour Methodology	A. R. Margetts	United Kingdom	1970–1971
Working Group on Data Collection	J. J. Foster D. N. MacLennan	United Kingdom United Kingdom	1972–1977 1978
Working Group on Standardization of Scientific Methods for Comparing the Catching Performance of Different Fishing Gears	H. Bohl J. A. Pope	Germany United Kingdom	1972–1974 1975
Working Group on Research into Sound and Vibrations in Relation to Fish Capture	K. Olsen A. D. Hawkins	Norway United Kingdom	1972–1975 1976
Working Group on Technical Aspects of Electrical Fishing	G. Vanden Broucke	Belgium	1975
Working Group to Study the Characteristics of Fishing Vessels in Terms of their Effect on Fishing Effort Measurement	J. G. de Wit	The Netherlands	1960–1970
Working Group on Reaction of Fish to Fishing Operations	G. Kurc C. C. Hemmings C. Wardle	France United Kingdom United Kingdom	1973 1974 1975–1983
Working Group on Research and Engineering Aspects of Fishing Gear, Vessel and Equipment	J. G. de Wit E. J. de Boer S. Olsen G. Thorsteinsson	The Netherlands The Netherlands Norway Iceland	1972–1975 1976–1980 1981–1982 1983
Joint Meetings of the Fish Capture Committee's Working Groups	E. J. de Boer	The Netherlands	1983
Ad Hoc Working Group on Artificial Bait and Bait Attraction	Å. Bjordal	Norway	1984–1985
Fishing Technology and Fish Behaviour Working Group (WGFTFB)	D. N. MacLennan B. van Marlen S. J. Walsh A. Engås	United Kingdom The Netherlands Canada Norway	1984–1986 1987–1993 1994–1997 1998–2000

Chronology of related ICES committees, working groups, study groups, and subgroups.

Study Group / Subgroup	Chair	Country	Years
Study Group on Twine Thickness Measurement	R. S. T. Ferro	United Kingdom	1983
Study Group on the Effects of Bottom Trawling	P. A. M. Stewart	United Kingdom	1988
Study Group on Net Drawing	B. van Marlen	The Netherlands	1988–1989
Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seines	B. Isaksen	Norway	1995–1997
Subgroup on Selectivity Methods	D. A. Wileman	Denmark	1993–1996
Subgroup on Survival Experiments	G. I. Sangster	United Kingdom	1992–1993
Study Group on Unaccounted Mortality in Fisheries	A. Fréchet	Canada	1994–1997
Study Group on the Use of Selectivity Measurements in Stock Assessment	R. M. Cook	United Kingdom	1995–1997
Study Group on the Use of Selectivity and Effort Measurements in Stock Assessment	R. M. Cook and D. Somerton	United Kingdom and United States	1997–1998
Study Group on the Selectivity of Static Gears	A. Carr	United States	1999–2001
Study Group on Mesh Measurement Methodology	R. Fonteyne	Belgium	2000–2001