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REPORT OF THE

WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR

Seattle, USA
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International Council for the Exploration of the Sea

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1 INTRODUCTION

1.1 Terms of Reference

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In accordance with ICES C. Res. 2000/2B05 the Working Group on Fishing Technology and Fish Behaviour [WGFTFB] (Chair: D. Somerton) will meet in Seattle, Washington, USA on 23-24 and 26-27 April 2001 to:

a) review methods to reduce the variance of abundance indices obtained from assessment surveys using fixed and mobile fishing gears;

b) evaluate the selection properties of Baltic Cod trawls using double nettings made of twine exceeding ca. 4 mm in diameter [IBSFC];

c) consider current studies aimed at reducing by-catch and sea bed impact in fisheries;

d) consider the relationship between fishing mortality and fishing effort, especially the variables describing effort.

Justification:

a) Research on operating procedures and sampling designs of trawl surveys and on the analysis of trawl data has progressed considerably during the last decade. Because of declining budgets, fisheries agencies must be increasingly concerned with survey efficiency and obtaining the most precise abundance indices possible with available resources. This topic is intended to attract fishery technologists as well as statisticians and stock assessment scientists. (*Priority*: Trawl surveys provide necessary information for tuning fisheries management models. Producing more precise indices of abundance without an increase in survey costs is considered, by all fisheries agencies, to have a high priority.)

b) The request from IBSFC is to provide advice on possible alternatives to the practice used in the BACOMA project where a window in the trawl is suggested, with a special net material.

2 SPECIAL TOPIC A: REVIEW METHODS TO REDUCE THE VARIANCE OF ABUNDANCE INDICES OBTAINED FROM ASSESSMENT SURVEYS USING FIXED AND MOBILE FISHING GEARS

A catchability constant for the Namibian hake survey trawl. Ingvar Huse, Norway

Abstract: A method was developed and tested to establish catchability constants for the Namibian hake survey trawl. It was found that a catchability constant can be expressed as a simple relationship between hake area densities calculated from trawl catches and acoustic biomass estimates. Initial values found were in the order of magnitude of 0.8, meaning that the catch represents 80% of the hake available to the trawl. The methodology is dependent on attention to detail regarding area selection, following the same trawl lane during subsequent hauls in an area, and thorough acoustic post processing. A pronounced trend in catchability within the surface daylight hours of one day was found in the material. Early morning and early afternoon catches were low, while the highest catches of the day were found around noon. The results are discussed with regard to establishing useful species specific catchability constants.

Discussion: Effects of horizontal and vertical herding were discussed. Huse suggested that there was likely horizontal herding in front of the net itself since the trawl had three cod-ends and most of the catch went into the middle bag. However, there was little indication of herding by the bridles. Photographic and video observations indicated there was little vertical herding.

Effect of speed through water on bottom trawl efficiency. Ken Weinberg, USA

The effect of speed through water on the footrope capture efficiency of a survey bottom trawl was experimentally investigated by repetitively towing at three vessel speeds (2.5, 3.0, 3.5 knots) with an auxiliary net attached underneath the trawl footrope to capture fish escaping beneath the trawl. Length-dependent capture efficiencies were then computed from the number of fish caught in both the trawl and the auxiliary net. Capture efficiencies for Pacific cod, walleye pollock, and Pacific halibut were not affected by fish length or trawl speed. Capture efficiency for skates decreased with increasing trawl speed but were not affected by fish length. Capture efficiencies for arrowtooth flounder and flathead sole increased with fish length and decreased with increasing trawl speed. Our results indicate that in areas of variable current, variation in survey catch per unit effort could be reduced for some species by standardizing towing speed to speed through water or by reducing footrope lift by the addition of sufficient weight to the trawl footrope.

Discussion: It was suggested that changes to the weight or rigging of the gear might produce better bottom contact and thereby eliminate the problem of escapement under the footrope. It was emphasized that this trawl configuration has been used for many years in establishing a time series and that altering the catchability of the survey gear was not an option.

Retrospective Analysis of Suspiciously Small Catches in the NMFS West Coast Triennial bottom trawl survey. Mark Zimmermann, USA

A review of the National Marine Fisheries Service U.S. west coast triennial bottom trawl survey time series (1977-1998) revealed a large number of hauls with unusually small catches, particularly during the first three survey years (1977-1983). Beginning in 1986, technological advances in the equipment we use to monitor trawl performance have progressively improved our understanding of how our sampling trawl operates. This knowledge has led to a subtle evolution of trawling procedures and probably increased the rate at which we catch benthic fish and invertebrates. A minimum catch per unit effort value of a benthic species group (CPUEB), derived from the most recent and most technologically advanced survey in 1998, was used as a criterion to eliminate trawl hauls with poor bottom contact from earlier surveys. The truncated data sets produce significantly larger biomass estimates, especially in 1980, with increases of 40% for Dover sole (*Microstomus pacificus*), 42% for petrale sole (*Eopsetta jordani*), and 55% for Pacific sanddab (*Citharichthys sordidus*). Additionally, the CPUEB across each earlier survey was significantly less than in the 1998 survey, indicating that the impact was not just limited to a specific group of hauls with unusually low catches. Total catch of flatfish has also changed substantially during the time series, with the highest catches of flatfish occurring in the recent surveys, and the lowest catches occurring in the earlier surveys.

Discussion: In several established surveys the effect of improved technology had led to suspected changes in catchability as deviations from standard methodologies became more easily detected and corrected. Arriving at true standardization appears to have taken time, with early standardization focused on human factors and later standardization focused on technology. Anecdotal evidence from several participants indicated that the problem addressed by this study is wide spread. This raised the question, “Can adjustments be made to old data sets or should surveys be restarted with better methodology?” The answer is probably not the same for all species, because pelagic and semi pelagic species may not be greatly impacted by changes in bottom contact.

A preliminary investigation of swept area estimates of abundance derived from survey trawl geometry. Stephen J. Walsh (presenter), Barry R. McCallum, and David Orr, Canada

The Northwest Atlantic Fisheries Center, Department of Fisheries and Oceans Canada, Newfoundland region, have been carrying out annual instrumented bottom trawl surveys to estimate stock size since 1993. The survey trawl is rigged with SCANMAR acoustic trawl instrumentation package to measure wingspread, doorspread, opening, touchdown and depth. Standard swept area estimates traditionally use an average wingspread together with a fixed tow distance to calculate survey indices of abundance. Alternate swept area models were devised using SCANMAR trawl geometry data by adjusting the catch on a set-by-set basis and included 1) a varying wingspread model, 2) varying doorspread model, and 3) swept volume model. We examined changes in precision in the stratified mean catch per tow and also calculated differences in abundance and biomass indices for cod, American plaice, yellowtail flounder and shrimp using each model. Investigation of experimental comparative fishing data indicated that herding of flatfish by the sweeps is apparent implying that the standard swept area model, which uses a fixed wingspread, could overestimate the size of the stock. These investigations are at the preliminary stage.

Discussion: Discussion again focused on changes in survey methodology and technology over time. Walsh raised the question, "Is there biological meaning to changes in abundance when there are changes in methodology?" Old data (before net mensuration) includes an element of variation that is over looked, that is, tow to tow variation net spread. For old data, such variability can be experimentally estimated but cannot be removed, while in cases where spread is measured on every tow this source of variability is eliminated from the data.

Reducing survey variance of highly aggregated species using Kriging. Jack Turnock, USA

Abundance estimates and their variances are important data used in fish stock assessment models to set fishing quotas and determine the relative health of populations. The estimation of abundance from surveys where animals are aggregated may be influenced by a few high catches when sample sizes are relatively small, resulting in large variances, and abundance estimates that may be far from the true value. Markov-Bayes indicator kriging is a method that is robust to large catches, and can be used to combine different sources of information to reduce variances and produce maps of abundance. An example of estimating abundance from Bering Sea red king crab fishery and survey data is presented. A spatial simulation model is used to simulate a population with characteristics similar to the highly aggregated Bering sea red king crab population. Several sampling methods are applied to the simulated population, including systematic trawl sampling, adaptive sampling, and a simulated fishery. Standard survey methods, an adaptive sampling method, and Markov-Bayes indicator kriging using survey data alone and combining survey and fishery data are used to estimate abundance. Reduction in the variance of abundance estimates resulted from combining survey and fishery data over using survey data alone.

Hook orientation and gangion length effects on setline CPUE of Pacific halibut. Stephen Kaimmer, USA

An experiment during summer 2000 investigated the effects of two gangion lengths, and the orientation of the hook on the gangion, on the catch rates of Pacific halibut, *Hippoglossus stenolepis*. ANOVA results showed significant differences between treatments for both sublegal and legal-sized halibut. Generally, threading the gangion through the front of the hook eye resulted in 30 to 40% higher catches of both size groups of halibut. While gangion- length by itself was not significant, there was a small additive effect to the larger hook-orientation effect. For legal-sized halibut, only the long gangion and front threading was significantly different from either of the back threading treatments. For sublegals, the only significant difference was between the extreme comparison of short gangions with back threading and long gangions with front threading. The experimental design for these experiments was constrained by a catch limit of 40,000 pounds for each experiment. In retrospect, and particularly in light of the observed variance within the setline data, a different protocol that allowed more replicates would have been more appropriate.

Discussion: Norwegian studies indicated similar results for cod and haddock in 1970s. Any hook that points toward the back of the mouth increases hooking percent. However, Kaimmer pointed out that this is true only if the orientation remains the same when the fish is pulling, but the effect is similar for both large and small fish.

Stratifying by Echosounder Signal to Improve Trawl Survey Precision for Pacific Ocean Perch. Jeff Fujioka, USA

In 1998, sonar signals were recorded during individual trawl hauls conducted in a study of rockfish, *Sebastes* spp., survey methods. Sonar categorization criteria were developed on a subset of the data based on signal patterns, shapes and colour. Individual scientists then conducted blind tests on a subset of 38 of these hauls. Between scientist-agreement of high and low categories varied from 76-87%. The trawl catch rates in the test subset were divided into low and high catch rates. High and low sonar categorizations corresponded with high and low catch rates 66-78% of the

time. Data was collected again in 1999 and categorized using the same criteria. Onboard scientists agreed with categorizations done by a shore side scientist on 65% of 49 categorizations. The trawl catch rates in the 1999 study were divided into high and low catch rates and the scientists sonar categorizations corresponded with catch rates on 59 and 61% of the hauls for the shore side and onboard scientists, respectively. The vessel captains were asked to rate the sonar signals and 61% of their categorizations corresponded with the catch rates. Variance estimates that would result from simple double sampling (Cochran 1977) using the sounder categorizations as strata definitions were predicted using the observed within-category variances at various levels of first stage (sonar) sampling. Sonar samples are considerably less expensive in time and cost than trawl sampling and if 10 times as many sonar samples are taken to stratify the trawl samples, variance improved 18-37% compared to simple random sampling, depending on the data set and the categorizer. If trawl hauls were allocated optimally, the improvement increased from 44%-60% over simple random trawl hauls. To match the variance obtained by double sampling with sonar primary sampling, the number of random trawl hauls would have to be increased 1.8-2.5 fold depending on data set and categorizer.

Discussion: Rough grounds can prevent the fishing necessary to corroborate sonar data, but in this case the sonar data was only collected during towing so the catch composition can be directly associated with the echogram data.

Improving the Precision of Survey Abundance Estimates with a Trawl Mounted Acoustic Bottom Typing System. Michael H. Martin, USA

Trawl surveys provide the most comprehensive source of fishery-independent information for the fisheries management process in the north Pacific. The imprecision of abundance estimates derived from these surveys is often quite high, compromising managers' abilities to effectively manage fisheries. To help address this problem, a comprehensive study of the effects of physical variables on the distribution and abundance of groundfish has begun with the aim of improving the efficiency of survey sampling design. A self-contained underwater bottom typing system has been developed to quantitatively examine the relationship between marine sediments and fish distribution. The system, comprised of an echosounder, computer, transducer and batteries housed in a pressure cylinder can be deployed at depths up to 1000 m. The advantages of this system over hull mounted shipboard systems are discussed.

Discussion: This application was done in the absence of ground truth data about the true bottom type, however there are plans to obtain such data by using the acoustic system in conjunction with video photographs. There are many other potential applications for this technology, including counting fish and studying footrope escapment.

Attempt to minimize trawl geometry variations with depth. Benoit Vincent, France

Survey bottom trawls are used in fisheries assessment as a sampling tool. Surveys indices can be estimated by using the derived data from the seabed area or volume swept by the trawl. Swept surface and volume are deduced from data given by sensors that measure vertical and horizontal opening. We propose different methods in order to minimise the variations of vertical and horizontal trawl openings. Results are obtained by numerical simulation on the 36/47-survey bottom trawl. In order to keep constant the vertical opening, we tried three different solutions. The first solution is based on the use of sweeps fitting with the depth and warp length. The second solution uses longer warp length for shallow water. The last solution consists in adjusting a bridle length for shallow water.

Discussion: This simulation software can be run to test other ideas for controlling gear, such as the physical restriction of door width. When Canadian researchers studied trawl geometry, variability of door and wingspreads, and warp to depth ratios, they used a CTD to determine on-bottom tow time. Ideally they attempt to quickly pull the trawl off the bottom, however one vessel took as long as 17 to 18 minutes to lift the net off-bottom. This vessel, which was smaller, lower powered and with history of engine problems, had its speed reduced to nearly zero during haulback. Canadian investigators learned that they needed to reconsider measurement of tow duration and vessel speed to determine effort. These findings were also reported in a poster brought to the session.

2.1 Summary Discussion Of Topic A:

There are several sources of variation in survey data. Studies of sampling gear and sampling methods (e.g., survey trawling) were focused primarily on measurement error, which may be quite low relative to the background variability of the populations being sampled. The objective of studying trawl performance in this context is to increase the efficiency of a survey without an increase in cost. This, in turn, would lead to biomass estimates with lower variance. However, a trawl survey may be an application of a precise instrument to a highly variable system. Therefore, it can be difficult to determine when to stop studying the gear and measurement error and turn to studying the biology or other aspects of the population in question. If most of the variation in the estimates is due to population variability, then less effort should be spent on reducing measurement error and more should be spent on accounting for sources of variability inherent in the population under study.

Even so, some studies are beginning to show that surveys have a better history than population modelling in terms of precision. Despite unaccounted sources of variation in the population, survey results are becoming more precise than VPAs. This is not quite so clear-cut in North Pacific and Bering Sea fisheries where good observer coverage and consequently good catch data permit successful analytical modelling. Within this context, the precautionary principle (e.g., lower quotas for stocks with less precise biomass estimates) is motivating the Alaska Fisheries Science Center toward research leading to greater survey precision.

Much of the work presented under this topic was concerned with various aspects of trawl calibration. This indicates that WGFTFB might consider developing a manual on trawl calibration. After effort measurement, the assessment of trawl catchability is next in importance for assessment modelling. Perhaps efforts to develop methods for calibration could be done in conjunction with acoustics studies and also be applied toward the goal of developing methods and analytical procedures for estimating absolute abundance.

3 TOPIC B: EVALUATE THE SELECTION PROPERTIES OF BALTIC COD TRAWLS USING DOUBLE NETTINGS MADE OF TWINE EXCEEDING 4 MM IN DIAMETER

Review on use of escape windows in the Baltic Sea cod fishery. Niels Madsen, Denmark

A rapid decrease of the stock of Baltic cod (*Gadus morhua*) has provided the incentive to improve the size selectivity in the trawl fishery. Use of escape windows are permitted in the legislation for the Baltic Sea cod to give alternative approved means of improving the size selectivity of cod as opposed to a traditional standard cod-end. The history of the use of these escape windows in the Baltic Sea cod fishery is reviewed.

Discussion: Problems with the use of technical measures arise when fishers resist measures designed to select for larger fish or to otherwise reduce the efficiency of the fishing operation. This resistance takes various forms, but usually involve applying political pressure to have regulatory measures that either result in poor selection or measures that can be legally modified to make the selection process less functional. For example, fishers prefer escape windows to be made from knotted material because eventually the knots will slip and the shape of the mesh opening will distort, making escape through the mesh more difficult. This is why knotless escape windows are resisted, even though the reasons most often given have to do with the cost of knotless material or the desire to avoid legislating the use of a patented product. Enforcement is very weak with respect to technical measures, hence it is important to legislate measures that are more likely to work or remain functional without constant monitoring. Thus a robust solution is needed.

The basis for improving trawl size selectivity in Baltic cod demersal fishery. Vesa Tschernij and Petri Suuronen (presenter), Finland

The stocks of Baltic cod are currently being harvested at levels exceeding safe biological limits. Because of the poor size-selectivity and relatively high discards of undersized cod in the demersal trawl fisheries, a substantial increase in trawl size-selectivity has been considered as a potential alternative to improve the status of stocks.

The major objectives of the BACOMA project were to (1) provide measurements of the dominant factors that cause variability in trawl cod-end selectivity in the Baltic cod fishery, (2) develop practical cod-end modifications that will improve trawl size-selectivity, (3) estimate the escape survival of cod under commercial fishing conditions, and (4) to assess the short and long-term consequences of improved selectivity in the Baltic fishing fleet. The project was carried out in 1997–2000 by four partners from Denmark, Finland and Sweden. Only commercial fishing vessels were used in the trials. Altogether, 465 trawl tows were conducted in these experiments. The most essential results, observations and conclusions made in the BACOMA project are contained in a summary report.

The fundamental questions as to how, when and why fish escape, and how they survive, establish the foundation for understanding and improving the selectivity. With the help of Baltic fishermen and gear designers, many open questions behind trawl selectivity were explored in BACOMA. The selectivity properties of a trawl cod-end were shown to depend on many factors that are related not only to cod-end construction and mesh size but also to the type of fishing vessel, fishing operation and gear handling. Vessel hauling technique had the most consistent effect on selectivity. These observations offer a new platform for understanding the variation in selectivity and for developing better and more effective solutions.

Realistic assessment of the potential gains and losses is important from the fisherman point of view. The results of BACOMA project open up new possibilities to assess and predict the short and long-term impacts of changing gear selectivity. The eventual changes in commercial catches as a consequence of mesh size change are brought down on

individual vessel level. The short-term drawbacks are highlighted in a realistic way, and the importance of controlling the total fishing effort in concert with a mesh size increase is described. It is stressed that the potential long-term benefits of a mesh size increase may not be experienced if after a mesh size increase the fishing effort is allowed to increase without control.

Effects of double-yarn netting /yarn diameter exceeding 4 mm on the selectivity of Baltic cod. Erdmann Dahm, Germany

This paper presents the results of recent research carried out in the Baltic Sea by the Institute for Fishing Technology and Fish Quality, Hamburg, Germany, in collaboration with the Institute for Marine Research, Gdynia, Poland, Its aim was to investigate the effect of double netting yarn and of single yarn with diameters exceeding 4 mm on the selectivity for Baltic cod. A severe deterioration of the L50 was detected with increasing diameter and even worse with the use of double twine.

3.1 Summary Discussion Of Topic B:

A subgroup was formed to develop advice regarding escape measures in Baltic cod fisheries. The subgroup consisted of Petri Suuronen (Finland), Erdmann Dahm (Germany), Thomas Moth-Poulsen (Denmark) and P.O. Larsson (Sweden). Their report was presented to the WGFTFB and was discussed, amended, and adopted. The advisory report is provided in Annex 1.

4 TOPIC C: CONSIDER CURRENT STUDIES AIMED AT REDUCING BY-CATCH AND SEA BED IMPACT IN FISHERIES

An evaluation of the state of knowledge concerning selectivity of fishing gear. Andy Revill and Philip MacMullen (presenter), UK

This is a presentation on behalf of the author, Dr Andrew Revill. It describes work undertaken under contract to the European Commission. The objective was "to collate, review and assess the results of research on fishing gear selectivity". The study focuses on research supported in some way by the Commission but also includes other work. The study identifies 17 categories of selectivity information then, for each category, reviews relevant research, identifies knowledge deficits and recommends further work. The project was intended to assist in the further development of technical measures and regulations designed to minimise mortality rates of juveniles and non-target species.

Reduction of by-catch, discard and habitat impact in Massachusetts's squid fisheries. Christopher Glass, USA

Small-mesh fishing for squid (*Loligo pealeii*) in Nantucket and Vineyard Sounds during the spring seasonal fishery result in high catch and discard of undersized flounder (summer flounder *Paralichthys dentatus*, winter flounder, *Pseudopleuronectes americanus*) and scup (*Stenotomus chrysops*), all of which are important commercial and recreational fishery species. Recent studies (Glass et al 1998, 1999) have shown that catch rates vary spatially and temporally but overall more than 30% by weight of total catch are discarded at sea. Videotape recordings and behavioural analysis of squid reactions have shown that squid display classical herding behaviour and considerable swimming endurance in the forward part of the net. Loligo are shown to rise when dropping back towards the cod-end and in some cases to turn and rise on tiring. Glass *et al* (1999) demonstrated that these behaviour patterns could be exploited using a separator trawl to separate squid in the top cod-end from other species in the lower cod-end. They also suggested on the basis of the observed behaviour patterns, that a raised footrope trawl design might successfully capture the target species (squid), reduce by-catch and reduce bottom impact. This paper reports on sea trials undertaken to assess the relative effectiveness of raised footrope and separator trawl designs in reducing by-catch as compared to standard fishing gears. The implications with regard to management strategies are discussed.

Discussion: Squid in the lower bag of the separator trawl tended to be smaller. Much of the discard species are rough and spiny which abrades the squid catch and reduces its value. In this case, reducing the by-catch led to increased per unit value of the target species. Overall catch rate appears unaffected by slightly raising the footrope. Management witnessed voluntary acceptance in the fleet and many vessels are already rigging raised footrope trawls. Footrope height depends on the length of the dropper chains and is sometimes surprisingly large. Comment: the northern Irish cod fleet has long tradition of fishing just off bottom to minimize by-catch.

Halibut excluders for trawls used in Alaska groundfish fisheries. Craig S. Rose, USA

Trawl fishers and fisheries researchers have developed and tested a range of modifications to bottom trawls to reduce the by-catch of Pacific halibut (*Hippoglossus stenolepis*) in the cod and sole fisheries off of Alaska. These developments are motivated by halibut by-catch restrictions that often close these fisheries before quotas of the target species can be harvested. The excluders consist of panels across the intermediate section of the trawl with openings large enough to accommodate the target fish, but not the larger halibut. Panels are sloped so that fish that do not pass through are herded to an escape opening. Varying features of the panels, including hole size and shape, slope, rigidity and materials, have been tested to adapt to different fishing operations and to achieve a range of catch and by-catch rates. Similar excluders have been modified for cod fishing by using circular holes on the panel and adding devices to release small halibut and to avoid blockage of selectivity panels by skates.

Discussion: This study showed that the halibut excluder is cost effective and simple, but further work is needed to show its durability and efficiency. Some vessels are already using earlier versions of these separator modifications. The management objective is to provide tools to allow fishers to reduce by-catch rather than to impose mandatory gear regulations. Because of good observer coverage in the North Pacific, enforcement issues are best dealt with fishery-wide limits to by-catch and accurate by-catch reporting. Industry pressure is then placed on individual vessels that produce exceptionally large by-catch. Such individual accountability stimulates fishermen to devise ways to minimizing by-catch that works best for themselves.

A preliminary assessment of the effects of introducing a sorting grid into the trawl fishery for North East Arctic cod (*Gadus morhua* L.). Cecilie Kvamme, Norway

Abstract. Many studies have dealt with the testing of alterations of existing gears meant to reduce by-catch of non-target species or sizes. Such alterations can for example be changes in mesh size, mesh shape or introduction of sorting devices (grids, outlets etc.). Some of these gear alterations have also been implemented in the fishery. In the fishery for North East Arctic cod, e.g., the use of an approved sorting grid became mandatory in 1997. However, an assessment of what one should expect to gain concerning stock size, stock composition and thus yield by introducing a new gear has usually not been adequately emphasized. Lately, however, there has been an increasing demand for studies dealing with these aspects. The aim of the present work is to simulate the effects on stock size, stock composition and yield of introducing a sorting grid in the trawl fishery for North East Arctic cod. Results from selectivity studies with ordinary commercial trawls with mesh size 135 mm in the cod-end, both with and without a sorting grid (Sort-X, single grid) mounted in the extension, are used in a length- and age-based stock model, (Fleksibest), to simulate these effects. The selection curves from the selectivity studies were be compared to selection curves fitted to reported catches.

Discussion: Cod in the North East Arctic mature at older ages and larger sizes than in the Baltic. In regions where maturity is reached earlier, the effects of grid selection would be even greater.

Grid selection in the North Sea industrial trawl fishery for Norway pout: sharp size selection reduces by-catch. Kurt Kvalsvik, Norway

Experiments were carried out during three cruises in the period 1997 to 1999, to develop and test a sorting grid system in the North Sea industrial trawl fishery. The system should separate by-catch species like haddock, whiting and other human consumption species from target species like Norway pout, blue whiting etc. During the first cruise a prototype of the grid system was developed and tested with different mountings of guiding panel in front of the grid and with different spacing (25, 22 and 19 mm) between bars. The two last surveys tested if the mesh size in the grid section and the thickness of the bars influenced the selectivity of the grid system. Two different mesh sizes and three different thicknesses of bars were tested. Based on the results from the 1997 experiments, only a bar space of 22 mm were used in the later experiments. The 1998 and 1999 experiments were carried out in different seasons (May and September/October) to test the system on different size distributions of target and by-catch species. Hydrodynamic studies of the grid system using the two different mesh sizes and the three different thickness of bars were conducted in a flume tank, and a 25% difference was found in water flow speed behind grids with 22 mm bar spacing but with different thickness of bars (15, 10 and 5 mm). During the 1998 experiment a total of 94.6% (weight) of the by-catch species was sorted out with a 32.8% loss of target species. In the 1999 experiment 62.4% of the by-catch species were sorted out and the loss of target species was 22%. When testing selectivity parameters for haddock, the main by-catch species, the parameters indicated a sharp size selection in the grid system. This sharp size selection may be used to separate target and by-catch species differing in size. Differences between different configurations of the grid system are discussed.

By-catch reduction devices in the European Crangon fisheries. B. van Marlen (presenter), D. de Haan, A.S. Revill, K.E. Dahm, H. Wienbeck, M. Purps, J. Coenjaerts

EU-Study 98/012 “Reduction of discards in Crangon trawls (DISCRAN)” aimed at collecting catch and by-catch data, comparing various designs and further developing effective and acceptable selective devices (veil nets and sorting grids) in the European Crangon fisheries. The project started with a literature review and model tests. Over the years 1999 and 2000 a total of 547 valid hauls were carried out in German, Dutch, Belgian and British fishing grounds on research vessels and/or commercial fishing boats. The project was guided through National Advisory Groups consisting of scientists, fishermen's representatives and practical fishermen. Both the sieve net and the grid are devices that can effectively sort out by-catch fish species, but they have to be rigged properly and blockage due to seaweed or jellyfish may impair their effectiveness. The loss in commercial shrimps in the German, Dutch and UK trials was between 5-20%. However, commercial trials in Belgian waters showed higher losses on average 37% probably caused by the unique Belgian catch composition and seasonal differences. A mesh size of 70mm and a grid bar distance of 20mm demonstrated proper sorting. Some general trends were observed. Grids and sieve nets work well on plaice, flounder, smelt, cod, and to a somewhat lesser extent on dab, bib and whiting. Fishermen expressed a preference for the non-rigid sieve or veil net.

Discussion: The discussion focused on technical measures for escapement and selectivity and the urgent need for WGFTFB to develop advice for EU and ICES managers considering by-catch and its influence on cod. A subgroup was formed to develop a summary statement which is provided in Annex 2.

Research on diminishing impact in demersal trawling - the experiments in The Netherlands. B. van Marlen (presenter), M. J. N. Bergman, S. Groenewold, and M. Fonds, The Netherlands

Recent research in beam trawling is directed to reducing impact on benthic infauna and epifauna and by-catches of non-target and juvenile target species, whilst remaining the catch levels of target species. EU-funded project REDUCE (FAIR-CT97-3809, "Reduction of environmental impact of demersal trawls") aimed at reducing benthic trawl mortality by altering the design of the nets through drop out zones made of large meshes in the belly of the net, and/or modifying the rigging of the tickler chains, and using alternative stimulation techniques such as water jet injection and electrotrawling. Drop-out zones made by cutting large meshes in the lower panel can be effective in reducing by-catch of benthic fauna, but the penalty is also a loss of marketable flatfish (sole, plaice, dab). Heavy benthic organisms (shellfish) seem to drop out of the gear. An alternative type of parabolic tickler chain increased catches of flatfish but also catches of benthos, which was not the aim. Parallel chains seem to offer more potential in reducing benthos by-catches, particularly shellfish, but losses in commercial flatfish might occur. The replacement of tickler chains by an array of parallel electrodes caused a decrease in direct benthic mortality, but in the prototype used the catches of flatfish, particularly plaice, were less than with the conventional tickler chain. It is recommended to pursue further development of the electrotrawl.

Discussion: The question of control and treatment and the question of magnitude of effect were considered. Compared to parabolic tickler chains, hanging chains sweep less area but may sink deeper into the bottom. It was noted that by-catch could be reduced in two ways, through increasing escapement or through avoiding capture. Electrotrawls provide a fishing method in which initial capture of non-target species is avoided, making post-capture selectivity less critical. Electrotrawls also have much reduced contact with the bottom, and therefore have lower impacts.

Reducing juvenile cod by-catch in demersal longline fishing in the Northwest Atlantic. **Marianne Farrington, USA**

Two approaches were employed to improve the survival of by-catch: gear selectivity and developing management techniques after capture. For gear selectivity, the catch of cod using 11/0 circle hooks was compared to modified 15/0 circle hooks. Results showed that both retained the same number of legal sized cod, yet the 15/0 caught significantly fewer juveniles. To study the effects of handling, we determined the baseline survival rates of sublegal-sized cod caught using 11/0 circle hooks. The worst survival was documented for fish wounded by mechanical dehooking. The greatest survival was found in fish that were carefully and laboriously removed from the hooks. Transferring the hauling operations to a foot pedal device permitted a much quicker two-handed flip manoeuvre and generated less traumatic injuries. Survival will be documented this summer. Biochemical analyses revealed that juvenile cod showed significant changes in their blood profiles after being removed from longline fishing gear. Except for potassium ion concentration, all parameters were elevated upon being taken from the gear. Seventy-two hours later, all parameters except potassium had either recovered to normal values or were not significantly different than controls. Whether the loss of potassium ion affects survival will also be examined this summer.

Discussion: It was noted that these blood data were all taken from survivors in the survival experiment, and not from the entire population.

A way to reduce impact of trawl doors on the sea bed. Benoit Vincent, France

Trawl doors can be responsible for an intensive impact on the seabed, even if the surface swept by the door shoe is small. In order to reduce this impact, we propose to examine a solution based on a smaller warp length ratio: if the warp angle increases, the force of doors on the seabed decreases. We use numerical simulation software to determine a new shooting ratio in order to have a nearly constant force of doors applied on the seabed. The simulation does not take into account the problems of adjustment of doors. Doors are supposed to have a constant behaviour whatever the warp angle is. Trawl gear geometry, using the original and the new shooting chart, is compared.

Discussion: Further development of the simulation procedure was suggested to account for sea state and currents. It was noted that changes to mitigate gear impact might also affect fishing efficiency.

Engaging the industry - putting 'partner' and 'ships' together. **Philip MacMullen**, **UK**

Technical measures are necessary to reduce non-target catch. Identifying the 'real time' need for technical measures in a given fishery and achieving effective feedback is a perennial problem. Successful examples from New Zealand and Australia were examined to determine why they work well. Several factors are critical. One is the existence of a broad-based and fisher-centred fishery data acquisition system, which, in turn, depends upon training and other, structural aspects. A second factor is the relationship between fishers, scientists and technologists. It is proposed that a long-term strategy involving these factors is necessary if the results of selectivity research are to produce a greater conservation benefit than hitherto.

Discussion: It was noted that motivations for industry members to cooperate in developing conservation measures included increases in profitability as stocks become less heavily exploited. Also, fishers may have a better chance of negotiating the best possible deal for the next year-s quota if the data are the best available and if the fishers had a hand in collecting the data, thus having greater familiarity. Barriers to cooperation include voluntary elimination from the industry in the wake of mandated reductions in effort or fishing efficiency. Manipulation of data by industry members may not be a significant problem because many parties with competing interests scrutinize the data and the analyses.

By-catch reduction through avoidance: Trawl fleets utilize NMFS-supplied observer data to see by-catch trends in season and distribute fishing effort to avoid areas of high by-catch. Karl Halfinger, USA

Trawl fisheries are conducted in the Bering Sea and off the Pacific USA coast for pollock, cod, whiting and various flatfish. Between 1.0–1.5 million metric tons of fish are usually harvested in these fisheries each year. In all of these fisheries, significant by-catch concerns have led to the formation of cooperative use of observer information to assist vessel operators in avoiding areas exhibiting high by-catch rates. Observers employed by private contractors and trained by the National Marine Fisheries Service are placed on vessels and monitor the catch volume and composition for the NMFS. All observer data is made available to the vessel owners, who in turn make it available to a separate contractor, Sea State, Inc., for analysis. Sea State typically produces a range of maps and commentary concerning by-catch trends, and these products are passed back to all vessels so that captains can use the information to direct their fishing operations to areas of lowest by-catch. The recent establishment of fishing cooperatives for pollock and whiting has decreased the previously intense competition for fish and promises even greater reductions in by-catch as captains have more freedom to utilize the by-catch trend information.

Discussion: There is a lag time of about a day for observers to process data prior to sending it in via satellite transmission. Data are available for analysis within 20 minutes of being sent from the boat. A concern was raised that observers might be pressured to alter data collection methods or to alter the data themselves. The speaker stated that there were very few reports of observers being pressured to cheat. Private companies provide observers. NMFS is concerned that some boats have been able to influence whether they receive only inexperienced observers that are more easily deceived. There is a strong call for catch subsampling that is less prone to either bias or very high random error. Some vessels suspect that observers permit their personal biases to affect the catch subsampling processes. For example, observers are perceived as waiting for the rare prohibited by-catch species before taking a sample from the catch.

The Selective properties of sieve nets. Rene Holst (presenter) and Andrew Revill

By-catch of fish in the shrimp (*Crangon crangon*) fishery is a well-recognised problem. Sieve nets have been introduced as a technical measure to reduce the by-catch. As a part of a EU funded study four different designs of sieve nets were tested in UK (The Wash) and compared for their selective properties. The question of efficiency of the target species is also assessed. Four species of fish were measured in the control-gear and the test-gear. Only few fish were observed in the test-gear at the majority of the hauls. It was therefore not possible to use standard analysis techniques to obtain release curves by individual hauls. The paper demonstrates the use bootstrapping techniques in combination with the SELECT model.

Discussion: It was noted that the variance in whiting was high when it was low in two other species and visa versa. This was probably not due to data collection problems, but more likely do to biological differences. Concerns were raised regarding the paucity of data and limits to the estimation methods. The limit is the number of fish observed, not the number of tows. The problem in this study was too few fish, not too few hauls. An extended discussion ensued in which it was made clear that experiments need to have either very solid observations or very many observations; otherwise conclusions will be tentative and couched in too many caveats. In the high-pressure field of fisheries management such conclusions can easily be applied inappropriately or with insufficient caution.

4.1 Summary Discussion Of Topic C:

It is necessary to cultivate a cooperative climate in the fishing community so that the goals of fishers are more consistent with those of management. If this could be achieved, then fishers would likely not circumvent technical measures designed to protect by-catch species or the undersized component of the targeted population. Unfortunately, it is very difficult to cultivate such a climate.

Such a change in attitude, however, is necessary because North Sea cod stocks are in a severe crisis. ICES must be equipped to affect a change in attitude about technical regulations, not just imposing fishing restrictions on regions or seasons. It is urgent that the WGFTFB make specific recommendations for the North Sea regarding technical measures to protect cod.

Unfortunately, the time to introduce conservation measures is before they are needed When stocks are in crisis the fishing industry is also usually in crisis and, in times of poor catches, the impacts of conservation measures on short term profitability are unacceptable. To work effectively, technical conservation measures must cover all European fishers. This adds complexity to the problem because the legal specification of such measures must be flexible enough to be applied across a variety of fishing systems. Fishers need to have freedom to tailor what is known to work for their own particular fishing system. Right now, the ingenuity of fishers is not being utilized.

Ideally, if fishermen are penalized for bad results and rewarded for good results they will develop their own solution. Thus there is a need to legislate the result rather than the means to the result. Such legislation should give fishers ownership of the results: direct benefit or direct loss depending on an individual fisher-s achievement of legislated results. This involves passing the ownership of the resource to the harvesters. However, neither individual quotas nor observer programs are likely to be put in place, which leaves technical modifications of fishing gear and fishing methods as the only conservation tool short of time and area closures. Fishers need to be convinced that it is in their best long term interest to adopt such technical measures.

To promote use of technical conservation measures, it is necessary that the WGFTFB actively advocate the use of the measures studied and developed by so many of its members. There is a perception that managers and fish population modellers are not aware of many of the technical measures that have been developed. Furthermore, managers and modellers appear to believe technical measures are ineffectual. The WGFTFB must take the lead in changing these views among managers, modellers, and fishers. Successful work in developing technical conservation measures must be made better known outside the circle of the WGFTFB. To that end, the group charged Bob van Marlen with drafting a statement of advice regarding technical conservation measures. Dr van Marlen brought that statement before the Working Group and it was discussed, modified according to that discussion, and adopted as a statement by the WGFTFB. The statement can be found in Annex 2.

5 REPORT OF THE STUDY GROUP ON MESH MEASUREMENT

The Study Group on Mesh Measurement Methodology (SGMESH) met 21–22 April 2001 in Seattle, Washington, USA.

The study group participants were:

Gerald Brothers	Canada
Arnold Carr	USA
Erdmann Dahm	Germany
Ronald Fonteyne	Belgium (Chair)
Derek Galbraith	UK (Rapporteur)
Bjoernar Isaksen	Norway
Per-Olov Larsson	Sweden
Bob van Marlen	Netherlands
Thomas Moth-Poulsen	Denmark
Michael Pol	USA
J. Gramaxo	Oberserver from EUROCARD

5.1 Terms of Reference for the Study Group on Mesh Measurements Methodology [SGMESH] (Chair: R. Fonteyne, Belgium)

a) advise on improvements and further standardization of current mesh measurement practices in view of the netting types now in use in ICES Member Countries,

b) consider whether the current definition of mesh size is still appropriate for scientific and industrial purposes,

c) compile an inventory of commercially available netting associated with the selectivity process, identifying the fisheries in which they are used

d) consider the need to define groups of netting types for which the same measurement conditions (e.g., tension) can be applied,

e) propose the specification of a suitable mesh measurement methodology and the conditions under which mesh measurements for all fishing gears in ICES area are made.

5.2 Ronald Fonteyne (Chair) presented the following to the WGFTFB:

The SG confirmed last year's agreement on the definition of mesh opening (it was decided to continue using the existing ISO definition). The SG Chair gave results of an on-going inventory of cod-end materials commonly used in ICES area. The SG Chair summarized interlaboratory mesh measurement experiments comparing existing mesh measurement methods for a variety of materials, constructions, and diameters. The Chair presented the SG's preliminary recommendations for a new mesh measurement methodology.

5.3 Ronald Fonteyne (Chair) presented the following proposals for future work:

a) Extend SGMESH activities by one year

b) Work by correspondence

c) Perform further interlaboratory tests

d) More detailed analysis of experimental results

e) Keep in touch with other relevant groups (CEN, development of new mesh gauge project).

The Chair proposed that the next meeting will occur on the three days preceding the 2002 WGFTFB meeting. Final recommendations will be made at the conclusion of this meeting.

Discussion of SGMESH report by WGFTFB: It was suggested that there might be enough material in the SGMESH studies to justify a cooperative research report, which would provide a much wider circulation of the conclusions and recommendations. The report is document number CM2001/B01.

6 REPORT OF A SUB-GROUP ON METHODS FOR MEASURING THE SELECTIVITY OF STATIC GEAR

This sub-group met on 22 April in Seattle, Washington, USA. Participants were:

Rene Holst
Thomas Moth-Poulsen
Ole Arve Misund
Gerald Brothers
Arnold Carr (Chair)
Stephen M. Kaimmer
Marianne Farrington

The Sub-group tasks are to:

a) write a manual of methods for measuring the selectivity of static gear;
b) review selectivity studies on fish traps, fyke nets and pots to determine whether the information available on techniques for studying the selectivity of these gears is sufficient to warrant inclusion in the methods manual.

Arnold Carr reviewed the status of the effort to draft a manual as per reference (a). A comprehensive outline with text has been developed for the manual sections that focus on gillnet and longline selectivity. Complete "table of contents" has been drafted for sections on pots and traps as per reference (b).

The participants agreed to meet at the FTFB meeting in 2002 and at that time to review a first draft of the manual. The draft is planned to be completed and distributed to the all interested participants by 15 January 2002. This would allow time for an initial review prior to the intended meeting associated with FTFB.

Teams were considered as a means to write various sections of the manual. Four teams were identified. They and agreed-upon team leaders follow:

Gillnet Section	Thomas Moth-Poulsen, Denmark
Longline Section	to be announced
Traps Section	Pingho He, Canada
Pots Section	Gerald Brothers, Canada
Statistics Section	Coordinator: John Foster, Canada

The team composition is being developed.

7 TOPIC D: CONSIDER THE RELATIONSHIP BETWEEN FISHING MORTALITY AND FISHING EFFORT, ESPECIALLY THE VARIABLES DESCRIBING EFFORT

Effort mapping in the Clyde *Nephrops* fishery. Authors: Marrs, Tuck, Arneri, Atkinson, Santojanni, Stevenson. Presented by Derek Galbraith

The Norway Lobster (*Nephrops Norvegicus*) has annual landings of 60,000 tonnes, making it the biggest lobster fishery in the world. A third of total landings are made in Scotland, where it has been the most valuable species landed in recent years. The aim of this project was to map *Nephrops* population parameters, fishing effort and landings and carry out analytical assessments at appropriate scales. Effort mapping was based on methods developed by Rijnsdorp, but using GPS. Antennae and combined receiver / data loggers were fitted to 20 representative vessels from a fleet of 130 (i.e., 15% of total). Data was downloaded from each vessel at 4 to 6 week intervals. Landing data was recorded by skippers in logbooks provided for the project. Individual fishing tows were tracked and accurate maps of removals made. This technique has considerable potential in investigating fishing power and could also prove very useful for stratified assessments or examining fishing effort in fragile areas.

Discussion: In a similar situation, US scallop beds were closed, then reopened only when vessels became willing to carry observers and satellite tracking systems. Galbraith commented that technology exists to track vessels and get geo-referenced catch data, but there are still changes in fishing methods that go unmonitored by such technology. He noted that towing speed and horsepower appear to have increased in recent years. These are elements of effort that affect fishing efficiency of a boat but cannot be monitored simply by knowing where and when a boat fished.

Relation between swept volume and towing speed of a bottom trawl. **Benoit Vincent**, **France**

Survey bottom trawls are used in fisheries assessment as a sampling tool. Surveys indices can be estimated by using the derived data from seabed area swept and / or swept volume by trawl. As a mater of fact, the way swept area or volume are calculated is essential. We propose to verify that the swept water volume can be expressed as the product of a constant (a shape coefficient), the vertical opening and the horizontal opening. We calculate the swept volume of two different bottom trawls, using a numerical simulation software, for different parameters (depth, rigging, speed). We verify that the shape coefficient is almost a constant and especially is almost independent from the towing speed.

7.1 Summary Discussion of Topic D:

Meetings have been going on in Europe to consider ways of reducing effort. Although there is a clear need to reduce effort, developing effective methods of doing so are hampered by uncertainty in the link between fishing effort and the fishing mortality it generates. Therefore research on the influence of such factors as vessel size, gear type, fishing style, seasonality and area on the fishing mortality generated by each nominal unit of effort (i.e., hour trawling) is critically needed.

8 SUGGESTED WORK ITEMS

8.1 Review Techniques Which Can be Used to Evaluate the Effectiveness of Introduced Technical Measures

"On-deck" Short-Term Impacts of Mesh Size Increase. **Andy Revill, Norman Graham, and Petri Suuronen (presenter)**

Summary: The On-Deck Model forecasts the catch (number of boxes of fish) that would be obtained by various vessel classes after the establishment of a technical conservation measure. The model is designed for short term forecasts on local populations and therefore can be configured with more realistic parameters. Short-term simulated results, on a month-by-month basis, are possible because cod grow so fast in the areas where the model is applied. Forecasted cod catches decrease immediately after the imposition of technical conservation measures. But, for some fisheries, forecasted catches return to initial levels in as little as one year. The intent of this model is to provide the information needed to persuade the industry accept increases mesh size. Although the first simulations did not address the question of effort increases in response to the initial drop in catch, but in subsequent simulations this more realistic assumption was used. Under that assumption, the benefits of regulation take longer, perhaps five or six years, to arrive.

Discussion: A common perception of fisheries scientists is that neither fishers nor managers have faith in the effectiveness of technical measures. The mechanics of gear selectivity is poorly understood by ICES decision makers and WGFTFB needs to better demonstrate and promote the efficacy of technical conservation measures. Based on his BACOMA experience, Suuronen indicated that information provided to stakeholders should include the short term drop in catch as well as the projected longer term recovery so they can better judge the consequences of such a measure on their livelihood. The "on deck" model requires better data on catches than is normally obtained in most ICES areas and could not have produced meaningful results without the recent improvement in catch data from the Baltic Sea. In various model configurations considered it was clear that strategic use of time and area closures could increase the effectiveness of technical conservation measures.

8.2 Review Whether Chafing Gear and Net Strengtheners on Cod-ends Impact Selectivity

Survey of chafing gears. Yoshiki Matsushita, Arnold Carr (co-presenter), and Chris Glass (co-presenters)

No abstract available.

Discussion: The study was an attempt to determine if the use of chafing gear and lifting bags reduces the effectiveness of technical measures to control trawl selectivity. Although size, shape and behavioural differences among species makes it possible to build gear with species specific selectivity, obstruction by chafing gear and lifting bags can render such selectivity measures useless. In many cases it is not clear if fishers use chafing gear strictly for gear protection or if they are also taking advantage of its protective features to circumvent technical conservation measures. If the latter is true then it may be useful to develop fishing methods that offer gear protection without reducing gear selectivity. One example of this is to configure a trawl so that the cod-end rides off the bottom and therefore does not need chafing gear.

9 NEW BUSINESS

9.1 Place and Time for the 2002 FTFB Working Group Meeting

At the 2000 meeting of the WGFTFB, Prof. Jozef Swiniarski, Dr Otto Gabriel, and Dr Matthias Paschen proposed that the 2002 WGFTFB meeting be held in Insko, Poland, in June at the model research station of Sczeczin University, or, alternatively, in Rostock, Germany, in April at the University of Rostock and the Federal Research Centre of Fisheries. Confirmation of these invitations was not available by the conclusion of the 2001 WGFTFB meeting. Meanwhile, Francois Theret invited the WGFTFB to meet at Sete, France, immediately before the 2002 hydroacoustics symposium in the nearby city of Montpellier. The WGFTFB voted to first contact the representatives from Insko and Rostock to confirm either of those sites. If neither was available, then the French proposal should be accepted. It was suggested, based on the number of anticipated special topics and work items, and based on estimates of numbers of presentations, that 3 days would be required for the meeting. The proposed topics and meeting venue for the 2002 WGFTFB meeting are presented in Annex 3.

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11 NATIONAL REPORTS

ICES FTFB Working Group Meeting, Seattle

CANADIAN NATIONAL REPORT, 2000

Stephen J. Walsh

Northwest Atlantic Fisheries Center Dept. of Fisheries & Oceans, Fisheries Management Branch, St. John's, Newfoundland, Canada

Turbot Otter Trawl Size Selectivity: Three offshore Turbot selectivity trips were carried out onboard 50 to 60-meter vessels. On the first trip data was gathered to generate selectivity curves for a 145-mm mesh cod-end with 160-mm mesh in the forepart of the trawl. The second and third trips gathered data to generate selectivity curves for 145-mm mesh cod-ends with small mesh (80-mm) in the forepart of the trawl. These studies were carried out to reduce meshing in the forepart of the trawl without increasing the catch of small turbot. Trouser trawl arrangement was used on the first trip, while the alternate haul technique was used on the other trips.

Awareness of Gillnet Environmental Impacts: A local video production company was contracted and produced videotape highlighting the effect that 'ghost fishing' by lost gillnets has on fish stocks and the marine environment. A commercial fishing vessel was contracted and retrieve six lost or abandoned gillnets during a six-day period. The retrieval of gillnets was filmed and is contained in the videotape. The video also contains interviews with local fishers.

Lobster By-Catch in Rock Crab Pots: Lobster and Rock Crab were placed in tanks with various design baited pots. The pots found most effective in reducing Lobster by-catch in tank testing were then tested at sea. These pots will be used in the commercial fishery in 2001.

Interaction between Shrimp Trawling and the Snow Crab Resource: This project is being carried out over two years. In 2000 a commercial crab and shrimp vessel was contracted for three five-day fishing trips. The first and third trips were crab pot fishing trips, while the second trip was a shrimp-trawling trip in the same area. Two Fisheries Observers were onboard the vessel to checked each crab caught for missing legs and other injuries. The condition of crab caught during trip one was compared to the crab caught during trip three. In 2001 three five-day shrimp fishing trips will be carried out. A standard shrimp trawl will be fished with three retainer bags under the trawl to catch any crab, which go under the footrope of the shrimp trawl. Flume Tank testing was used to design and test models of retainer bags attached to a model of a shrimp trawl.

Danish Seine Selectivity: Four <20-meter Danish seine vessels tested the effectiveness of 130-mm dia. to 155-mm dia. and 155-mm square mesh cod-ends. The purpose of the experiment was to reduce the catch of juvenile (<30 cm.) American Plaice and Cod. Each vessel fished for a period of time with each cod-end. Fishery Observers were onboard each vessel to collect data.

Redfish Otter Trawl Size Selectivity: During a ten-day trip, an Icelandic EX-IT fish size-sorting system was tested onboard a 20-meter otter trawl vessel. The objective of the experiment was to reduce the catch of Redfish below 22-mm to less than 15%. A retainer bag was placed over the fish escape opening for some sets. The EX-IT system with both 30-mm and 35-mm bar spacing was tested. Fishery Observer onboard collected data on the amount and size of fish caught.

By-Catch Reduction in Shrimp Beam Trawls: The objective of this project was to determine whether longer toggles and chains on shrimp beam trawls will reduce the by-catch without the loss of shrimp. Prior to at-sea testing, a model shrimp beam trawl, was tested in the flume tank with toggle and chains of the standard 30-cm. and compared to 71-cm and 91-cm. Adjustments made to the model to ensure there was good bottom contact were also made to a full size shrimp beam trawl. A Fishery Observer and a Gear Technologist were onboard to collect data and make adjustments to the trawl as required.

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Northwest Atlantic Fisheries Center, Department of Fisheries and Oceans, Science, Oceans and Environment Branch, St. John's, Newfoundland

*Comparative fishing experiments to determine catchability and selectivity of the survey trawls of Canada and Spain***.** In 2000, 14 side-by-side parallel hauls were carried out by Spain and Canada on the southern Grand Bank off Newfoundland. The catches by the Spanish trawl, Pedreira otter trawl were generally 10 times higher than the Canadian Campelen due to the herding effect of 240 sweep lines. Further experiments will be carried out in 2001.

Tracking the movements of yellowtail flounder on the Grand Banks using archival data storage tags. In 2000, a 5 year joint DFO and fishing industry project was initiated to track movements of yellowtail flounder. Two hundred fish were tagged with dummy transmitters to determine return rates (6%) and as a result in 2001 300 real tags will be used.

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ICES FISHING TECHNOLOGY AND FISH BEHAVIOUR WORKING GROUP
Seattle; 23–27April 2001

Report of Activities 2000 – Germany

Erdmann Dahm

A. Institute for Fishing Technology and Fish Quality, Hamburg

Technical- biological investigations:

Selectivity of codtrawls in the Baltic

Experiments carried out in this context on FRV "Solea" aimed at the examination of the selective cod-ends with increased netting yarn diameter and at the continuation of the trials with cod-end designs of improved selectivity. The research demonstrated a clear deterioration of the selective properties when using double yarn 6 mm instead of the usual 4 mm. Contrary to this, the multipanel design and the cod-end made of meshes turned 90° degrees showed clear advantages to the present legal diamond mesh irrespective of constructional modifications and material.

A cruise with FRV "Walther Herwig III" provided an opportunity to test the new "Bacoma" cod-end design with one large square mesh exit window in the top panel and to compare it to other proved designs as the turned meshes cod-end or to an innovative type as provided by the Russian participants of the cruise (textile grid). The two first showed similar good selective properties whereas the later still needs further development. The turned meshes cod-end, particularly, demonstrated good selection also for flatfish, thereby diminishing the by-catch problem existing in the southern Baltic.

Underwater video observations were made of all cod-ends tested.

A comparative fishery with two cutters of equal design provided an opportunity to test the presently legal cod-end with square mesh exit windows against a cod-end with turned meshes. The length distributions of the cod catches showed only insignificant deviations, thus proving nearly equal selective properties for both cod-ends.

Selectivity and by-catch in the shrimp beam trawl fishery.

The experiments concerning the improvement of by-catch reduction in the shrimp beam trawl fishery (EU-Project DISCRAN) were continued. 70 mm sieve nets are compared with sorting grids with 20 and 30 mm bar distance. Results of the project are bound to be delivered in 2001. An investigation carried out in context to this program revealed a possible negative influence of the by-catch retaining collector bag.

Flatfish selectivity in the Baltic

A more detailed investigation on the by-catch-problem with flatfishes of the cod fishery revealed possible ways to reduce this unwanted by-catch. They seem to lie in the introduction of escape windows made from meshes turned 90 degrees in the lower panel of the cod-end.

Continuous records of fish behaviour within the trawl with small UW-TV-cameras fixed under the upper panel helped to understand the efficacy of the different cod-end designs.

Fishing effort of gillnets

This research program trying to elucidate the decreasing efficiency of gillnets left in the sea over longer periods makes slow progress. The projects still fights with the adaptation of an adequate methodology.

Technical investigations:

A new definition of Fishing Effort

A new attempt was made to quantify fishing effort by combining fishing power and fishing effort in a new theoretical index "catch efficiency". The model is presently published at national level for comments and discussion.

Hydraulic beamtrawl – final assessment

Experiments carried out in the frame of the EU- Project "Reduce" with a beamtrawl fitted out with water jets instead of heavy chains were conclusively evaluated. The final assessment led to the decision not to continue this development in account of the observed catch losses and the high technical effort necessary to make the gear operational.

Development of a precise baiter for longlines

The development into a simple precision baiter for pieces of fish and whole fish were continued. Tests at sea brought encouraging results though some technical bugs still have to be removed.

A new calibration program for hydroacoustical sounders

A new program developed in the institute allowing for the calibration of the echosounder used in hydroacoustic investigation was tested successfully. With the new program the calibration of the split beam sounder can be done without having to position the standard target exactly into the middle of the sound beam

Continued development of a cableless video observation system

A cableless video observation system transmitting the video signals to the ship from a buoy at the water surface is in use in shallow water investigations since 1998. Recent applications include video observations in cod-ends with improved selectivity for cod and flounder. A second camera was built into a towed body fastened by a crowfoot at the cod-end selvedges. A switch allows for pictures either from the camera fixed inside the cod-end or, alternatively, to get the full view of the cod-end in operation from a position 2 m above.

Digital video based measuring system for shrimps

A digital video based measuring system for shrimps was used to quantify the length distributions of shrimp in the EU-project DISCRAN. A recent update of the software allows for a better recognition of very small shrimp or of those extremely flexed.

B Rostock University

Theoretical and experimental studies concerning the selection of Baltic flatfish cod-ends were continued at the Institute for Maritime Systems and Fluid Mechanics in collaboration with the Institute for Fishing Technology and Fish Quality at the Federal Research Centre for Fisheries.

Three cod-ends were tested with regard to their selective properties using the cover technique on FRV " Clupea". In general, these were two panel cod-ends featuring some innovative technical details. Tested were changes in the selectivity by shortening the lestridges by attached ropes as well as the use of an escape window filled with netting turned through 90 degrees in the lower panel. The third modification tested was the so-called BACOMA- cod-end with a complete upper panel made of square mesh ULTRACROSS netting. The assessment of the selection characteristics of the three test cod-ends was carried out under commercial fishing conditions and in comparison to a cod-end corresponding to the present EU regulations. The swimming and escape behaviour of Flounder (*Platichthys flesus*) during the towing and hauling periods could be analysed by means of UW-TV equipment. Further, the real towing velocity inside the cod-end was measured by means of a SCANMAR speed meter.

Experiments to assess pressure and speed distributions inside a cod-end and at its outside were begun in the big wind canal of the Rostock University. These investigations shall serve to the qualitatively assess the swimming and escape behaviour of the flatfish. First results were obtained with regard to the design modifications chosen. The experiments are backed by calculations of the shape and the stress within the cod-end using the analytical software "Rope-Net-Calculator".

Further fishery related activities at the Institute are

- Wind canal investigations for a Norwegian customer (Dr Winkel)
- Calculation of super-size pelagic trawls (Dr Niedzwiedz)
- Education of students and tuition of candidates for a doctors degree (Dr Niedzwiedz)

NORWAY, National Report 2000

In 2000, the following work has been carried out in Norway:

Institute of Marine Research:

Biological sounds from fish used to develop selective fishing methods

A project is run in order to study the possibility of using biological sounds produced by fish as a tool to develop selective fishing methods. Sounds made of several marine vocal fish species are recorded in field, analysed and species-specific sound characteristics determined. These sounds are subsequently replayed to the same species and/or predatory and prey species to study the effect on fish behaviour. Observed attractive and repulsive behavioural responses of fish will then be utilised to improve selectivity in existing passive fishing methods.

Searching behaviour of fish

A stationary positioning system is used to study the searching behaviour of cod and ling, in particular their food-search strategy in relation to baited fishing gear. The fish are tracked both under natural conditions and when stimulated by bait odours. Detailed analyses of their search pattern will be conducted.

The response of fish to water currents in trawls

In the Norwegian shrimp fishery we use grids to sort out unwanted fish such as cod, haddock and redfish. Separating fish and shrimp within the trawl itself has largely been successful, but we still find excessively high proportions of 0-group fish in shrimp trawls, because the fish fry are about the same size as the shrimp.

Preliminary studies indicate that a vertical water current force or stimulate fish to exit the trawl through the escape window during towing. Small scale experiments have been carried out on 0-group cod and haddock with a new selection device, based on the new knowledge gained in the preliminary studies.

Reduction in by-catch of king crab in the cod and haddock fisheries in the Varanger Fjord

Further trials on reducing the by-catch of king crab in the pot and longline fishery for cod and haddock in the Varanger Fjord has been carried out. The behaviour of king crab towards pots and gillnets has been observed by means of an underwater video camera. Comparative fishing trials with floated cod pots and longlines to bottom longlines has been carried out. There was no catch of king crabs in the floated pots, but also the catch rates of the target species were reduced. There was no difference in catch rates between the bottom and floated longlines.

Selection in trawl and Danish seine

The work on the development of the Eurogrid, an EU funded programme to develop a selection grid suitable for the North Sea demerasl trawl fisheries, was continued with flume tank experiments, handling trials at sea and selectivity experiments for saithe. The flume tank experiments and later sea trials showed that the operation of the grid critically depends on the proper installation of the grid. The handling of the grid during fishing operations onboard commercial vessels did not present any problems, but the grid may not be strong enough to sustain extreme forces when wound unfavourably onto a net. The data on selectivity have not yet been analysed.

Work on species selection in Danish seine has continued. Experiments with a horizontal separating panel in the extension was carried out in order to separate cod and haddock in the seine. Underwater video observations showed that there is room for improvement. The work will continue in 2001.

Survival in the Barents Sea bottom trawl fisheries

During 1990–1995, several experiments were conducted at the Institute of Marine Research to study survival of cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and saithe (*Pollachius* virens) escapees in the northern bottom trawl fisheries. No mortality was found among cod and saithe, and only a low mortality (about 5%) among haddock. However, after sorting grids were made mandatory in the bottom trawl fisheries in the Barents Sea north of 62^{o}N, the trawler fleet suspected that grids increases escapee mortality in comparison to conventional cod-ends. They also claimed that the former experiments were not representative of commercial conditions. In particular, doubts were raised

on the fate of fish after repeated encounters with sorting grids. Therefore, new survival experiments were started summer 2000 in order to improve the confidence in the survival figures for gadoid species. Methodological problems during the first experimental period gave a too high mortality in all the experiment groups (grid selection, mesh selection and control groups), but indicated a lower mortality after grid sorting than mesh selection. Due to the methodological problems faced, the experiments will be repeated this summer.

Unintended effects of fishing with bottom trawl in the Barents Sea

A study aiming at quantifying the unintended effects of fishing was started inside the Marine Protected Area (MPA) around Bear Island in the Barents Sea in May 2000, and will continue for 3 years. Experimental trawling with otter trawl and rockhopper gear was conducted to simulate commercial fishing and its impact on the bottom substrate and fauna. Fauna samples were collected using an epibenthic sledge both before and after trawling. Mapping of sediment characteristics by several observational techniques was also made. In October 2000 new samples of fauna and habitat characteristics were obtained. Due to labour and time consuming post processing in the laboratory, the biological results from this project are currently under examination, although no immediate impact from trawling activity was found on the epifauna (no visible damages on larger epifauna).

Physical changes of sediment properties were readily observed by side-scan sonar. The trawl doors and rockhopper gear penetrated the seabed, making the surface rougher with bottom material lining up in parallel bands in the towing direction. This change could also be seen from changed acoustical properties as observed by RoxAnn bottom classification system and underwater video observations. Due to natural variation in sediment movement, the alteration of habitat visible in May had disappeared in October. This suggests that resilience time (time needed to get back to the long term trend) was less than six months for this area.

The bottom conditions in the area consisted of sand, gravel and shell fragments but also areas with rougher material with large stones and rocks were common. This made sampling difficult and a lot of the time during the cruises was spent collecting quantitative samples of the epifauna from the sledge. This is to our knowledge also the first investigation of possible effects of trawling in the Barents Sea and much time was allocated to develop the method.

Further work on the EU-financed project FANTARED on lost gillnets – "ghost fishing", has been carried out. Deliberately lost gillnets have been inspected by ROV and during hauling, and the results suggest that the catch rates of the nets decreases with time.

University of Tromsø:

Several experiments have been undertaken with plastic (HDPE) separator grates in the deep-sea shrimp fishery in Norwegian waters/Spitzbergen. Bar spacing of 19.0 mm seems suitable for most conditions, but may cause some shrimp loss when the shrimp size gets larger than 100 per kg. By-catches of juvenile fish are too high with 22.0 mm bar spacing. Several advantages with plastic grates compared to steel grates are seen. The use of 19.0 mm Nordmöre plastic grates is included in Norwegian legislation.

Recent experiments with the 2.5 m long stainless steel separator grate at theoretical 48^{o} angle of attack gave acceptable sorting effects (selection characteristics), but underwater observations revealed more clogging compared to the grid operated at 30 ^{o} angle of attack.

Recent experiments with a new type of double trawl/"twin body trawl" (Ω2x342# by 155 mm) gave encouraging results in developing further methods for full scale and direct comparisons between selectivity devices in the cod-end of large trawl.

SINTEF: Activities in gear and gear design at SINTEF Fisheries and Aquaculture (SFH)

The Institute has since 1 August 2000 had activities at the flume tank in Hirtshals. Four employees have started working for SINTEF and is now operating the tank after DIFTA closed down.

Selection in trawl

Flexible sorting grid has been further developed and has been tested with good results. The flexible grids have got a lot of international interest and we have discussions with Argentina, Iceland and USA for developing grids for their

fisheries. The Institute has further developed its international contacts and has made a co-operation agreement with Danish Institute of Marine Research.

As a part of a Strategic Institute Research program (SIP) governed by IMR, Bergen, SFH has done a series of tests with different types of net sections in order to establish flow patterns inside and around leading panels used in trawls. The tests have been done in the SFH (former DIFTA) flume tank in Hirtshals, Denmark, at the end of October 2000 and at the beginning of February in 2001.

The tested net sections have all been in scale 1:1, with different shapes (taper ratios) and solidity (mesh size/twine diameter). Measurements of water speed distribution, horizontally and vertically, have been performed with the sections mounted inside an 8-meter long ("extension") part of a coastal shrimp trawl, as well as (outside) in the free water flow. The test results are currently being analysed and will be reported within the next months.

Active trawl control

The Norwegian Company Scanmar AS in co-operation with SINTEF Fisheries and Aquaculture are developing an active trawl control system

Bottom trawling can be questioned with respect to environmental impact, the development aims at improving the qualities of the trawl with respect to see floor impact, energy consumption, selectivity and safety in operation. The active trawl system will contain a mathematical model for control combined with sensors and control elements or actuators on the trawl doors and the trawl net. The aim is to precisely control the motion of the trawl in order to catch the desired fish species without disturbing the sea floor or hooking obstructions on the seabed.

Progress report from Danish Institute for Fisheries Research

Selected projects

Development and testing of a grid system to reduce by-catches in Norway pout trawls (EU study project). Contact person: Ole Ritzau Eigaard (ore@dfu.min.dk).

Fishing power and selectivity of net and vessel types trawls (EU study project). Contact person: Thomas Moth-Poulsen (tmp@dfu.min.dk).

Improving and estimating the selectivity of cod-ends for the pelagic Baltic cod fishery (EU study project). Contact person: Niels Madsen (nm@dfu.min.dk).

Selectivity of square mesh top and side panels in the North Sea whitefish fisheries fishery (EU study project). Contact person: Karl-Johan Stæhr (kjs@dfu.min.dk).

Technical Measures – Development of evaluation model and application in Danish fisheries (National project). Contact person: Niels Madsen (nm@dfu.min.dk).

Experiments with acoustic alarms and reflecting gill nets to reduce by-catch of harbour porpoises. Contact person: Finn Larsen (fl@dfu.min.dk).

Gear related research in 2000. National Report. Sweden

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Vesa Tschernij (iconex@co.inet.fi), Iconex, Pargas, Finland

Håkan Westerberg (hakan.westerberg@fiskeriverket.se) National Board of Fisheries, Göteborg, Sweden

1) Improving Technical Management in Baltic Cod Fishery (BACOMA). EU-project. Contact person: P-O Larsson or Vesa Tschernij.
2) Size Selectivity and Relative Fishing Power of Baltic Cod Gill Nets. EU-project. Contact person: P-O Larsson or Vesa Tschernij.
3) Selective whitefish grid system for demersal towed gear fisheries in the North Sea and adjacent waters. EU-project. Contact person: P-O Larsson or Vesa Tschernij.
4) Selectivity Database (SELDAT). EU-project. Contact person: P-O Larsson or Vesa Tschernij.
5) Evaluation of mesh measurement methodologies for fisheries inspection and research (MESH). EU-project. Contact person: P-O Larsson or Vesa Tschernij.
6) Development and testing of grids for the Skagerrak and North Sea shrimp fishery. EU-project. Contact person: P-O Larsson or Mats Ulmestrand.
7) A study of roundfish and Nephrops survival after escape from commercial fishing gears. EU-project. Contact person: Mats Ulmestrand.
8) Experimental study of the selectivity of eel-pots in a population with a known size distribution and under semi natural conditions. Contact person: Håkan Westerberg.
9) Behaviour studies of fish in relation to fixed gears in the Baltic Sea. Studies on non-visual net detection in salmonids and the dependence of environmental variables on detection distance. Contact person: Håkan Westerberg.
10) Studies of acoustic attraction and herding of whitefish (Coregonids) and perch in the Baltic Sea. Contact person: Håkan Westerberg.
11) A Fishing Technology Center, directed at coastal fishery at the Skagerrak coast, has started some R&D projects on gear development, e.g. to improve selectivity in crab and *Nephrops* pots, to improve selectivity and seal protection in eel pots and to develop a totally new type of ”otter board”, aimed at reducing fuel demand and harmful effects on the sea bed. Contact person: Christian Almström (ftc@tmbl.gu.se), FTC, Strömstad, Sweden.

ICES FISHING TECHNOLOGY AND FISH BEHAVIOUR WORKING GROUP

SEATTLE, USA, 23–27 APRIL 2001

UK (Scotland) - Report of Activities in 2000

FISH BEHAVIOUR EFFECTS ON SELECTIVITY

The relationship between sea state induced vessel motion and cod-end selection was investigated. This investigation, carried out over a number of years, comprised a cruise on FRV Clupea to study the response of trawl cod-ends to vessel motion; flume tank trials to study the hydrodynamics and catch dynamics of a longitudinally pulsing cod-end; and an analysis of recorded observations of pulsing cod-ends and the associated fish escape behaviour. It was found that fish were more likely to escape during a particular part of the cod-end cycle, and that at this part of the cod-end cycle a number of hydrodynamic and behavioural factors, favourable to the active and passive escape of fish, are coincident.

WHOLE GEAR SELECTIVITY

A short cruise was carried out on FRV Scotia to develop and assess methods to evaluate the whole gear selectivity of the GOV survey trawl. The Seabat sonar was mounted on the remote controlled television vehicle (RCTV) to obtain information of fish populations in and ahead of the trawl and to obtain simultaneous video footage using the SIT camera; the performance of the ROS Navigator 20/20 camera was assessed both on the RCTV and on a frame ahead of the cod-end; a newly designed small mesh cod-end cover was also tested.

COD-END SELECTIVITY

The Marine Laboratory investigated technical gear measures to improve whitefish conservation, which the UK introduced unilaterally to reduce discarding of the good 1999 haddock year class. Two cruises were carried out on twin rig trawlers to examine the effect of the position of a 90mm square mesh panel on the selectivity of a 100mm diamond mesh cod-end.

An EU project to measure the effect of a 90mm square mesh panel on the discards and landings of a demersal trawler was carried out by the North Atlantic Fisheries College, Shetland and the Marine Laboratory, Aberdeen. Trials continued throughout 2000 for one week per month and the final report is being prepared for submission to the Commission.

NEPHROPS GRID SELECTIVITY

In collaboration with several other institutes FRS Marine Laboratory completed the EU shared cost **Netrasel** project. Two cruises, one on grid selectivity, the other a catch comparison trial, were carried out on chartered Scottish vessels in the northern North Sea. Assistance was also given on grid species separation trials in the Adriatic. The data are currently being analysed and a report will shortly be presented to the Commission.

FINFISH GRID SELECTIVITY

Two cruises on demersal pair trawlers were carried out for EU shared cost project **Eurogrid** using whitefish grids with 25mm, 30mm and 35mm bar spacings. Target species were cod, haddock, whiting, and saithe in ICES Subarea IVa. Grid and cod-end selectivity data will be pooled together with that obtained by other participants in the project and a predictive model of the selectivity characteristics of Eurogrids will be developed to establish relationships between bar spacing, L50 and selection range for each species.

FISHING EFFORT

A study of the inshore under 10m fleet was carried out to investigate growth in numbers of “super under 10’s”. This showed over half of Scottish vessels in 8–10m range had engines over 150 horsepower.

OIL INSTALLATION / FISHING GEAR INTERACTION

A video film scrapbook of underwater towed gear shots was produced for distribution to the oil industry.

DEVELOPMENT OF TECHNIQUES FOR ASSESSMENT OF SURVIVAL OF FISH ESCAPING FROM COD-ENDS

Recent work has been further developing techniques used to assess escape mortality, in particular the sampling and collection of fish escaping from the trawl cod-end. Using flume tank models and full scale sea trials aboard FRV Clupea, the effect of capture, within a cod-end cover, upon the sampled population has been studied in terms of: a description of water flow within the cover, the behaviour of the captive fish and demonstrating the effect of sampling time upon observed mortality (from analysis of a historic dataset). Moreover, these observations have been used to produce an improved sampling protocol using a new cod-end cover design which reduces the influence of the cover on water flow around the cod-end and minimises flow in the main body of the cover, where the sampled fish collect.

PHYSICAL AND MATHEMATICAL MODELLING

Approximate analytical solutions to the equations governing the bending of twines and fibres under tension were found and shown to be accurate for problems of interest to the fishing industry. A similar analysis is being applied to study the influence of twine bending stiffness on mesh measurement

ICES FTFB Working Group meeting, Seattle

Progress report from Seafish UK

Philip MacMullen

Nephrops trawl development: This work is based upon a complete re-design of *Nephrops* trawls so as to avoid round fish by catches. The major features of this are a headline that is c. 25% longer than the groundgear and the use of large mesh throughout the upper panels. Two designs have now each been through engineering performance trials and some limited commercial fishing trials. One net has been evaluated in a *Nephrops* fishery off the West Coast of Scotland and the other off the NE coast of England.

In summary, both designs have achieved a high level of success from the point of view of avoiding the unwanted by catches. However the new nets have not yet proved themselves commercially for the target species. Despite a number of rigging changes, the prawn catches with these nets have been disappointing. Further trials are now being carried out to try and establish if the poor prawn catching performance is attributable to the lack of cover and cutaway section.

Ecodredge: This project is studying three main aspects of scallop dredging – improving selectivity, reducing incidental mortality, and reducing any undesirable environmental effects associated with dredging. The ultimate intention is to develop dredge designs and management strategies with reduced environmental impacts. EC funding covers 50% of full costs. Sea trials have been conducted to investigate the effect of belly ring size on selectivity for king scallops, Pecten maximus. Three ring sizes were compared against a standard 'population' ring size of 59mm: 'normal' (10mm wire) commercial rings of 75mm and 85mm internal diameter, and also 81mm rings made from 12mm bar. The number of whole rings that could be fitted across the dredge bellies dictated these sizes. 75mm corresponds to 8 rings across and the 85 and 81mm rings correspond to 7 rings across. The trials were successfully conducted off the West Coast of Scotland and preliminary analysis of the results indicate that the 85mm ring size resulted in a very sharp selectivity curve with no loss of scallops of marketable size. The next trials will investigate the effects of wear on the size selection of dredge bellies. This will be assessed at regular intervals by comparison with bellies made from 59mm rings. An investigation has already been carried out into wear patterns on dredge bellies and the combined data will be used to assess the durability of the larger ring sizes. This information will be used to design dredge bellies with possible improved durability and selectivity.

Queen scallop (Acquipecten) swimming behaviour and selectivity has been investigated in detail using a 'covered dredge' system. This deploys a trawl-type net above the array of dredges to capture animals swimming over them. This arrangement has been deployed 4 times at intervals of approximately 6–8 weeks. The results show that swimming queen scallops were encountered predominantly during September and that the majority of swimming queen scallops was of the smaller size groups. Information on types of dredge used in the fishery is being assembled with a view to designing and testing a dredge, which will select queen, scallops from king scallops.

Physical impact studies took place in August 2000 and the data have now been processed. We are working with a Consultant who will create a model of the interaction between the seabed and the scallop dredge teeth. This will form the basis for considering possible changes in tooth design intended to reduce undesirable environmental impact. Further trials are expected this summer when the model based on the first trials has been created and discussed fully.

Lost static gear: this project addresses the combined problems of resource wastage through lost gear 'ghost fishing' and the vulnerability of the catching sector to criticism about lost gear. It will determine the extent to which gear is lost, review possible mitigating actions, their costs and benefits, and produce an information package describing the lost gear phenomenon in objective terms. There are six other research partners.

Our experiences so far are leading us to the conclusion that 'ghost fishing' problems in European waters are limited to fisheries operating under quite well defined circumstances. These relate almost entirely to the levels of gear conflict and the level of water movement/energy at the site of the loss.

The UK National Advisory Group (NAG) met in January to review our work so far and to look at our forward plans. A major step forward with our NAG is that we have been able to attract representatives from the Wales and West Coast PO based in Milford and La Coruña as well as fishermen and others from the SW and from Grimsby/Denmark. This is important because the Anglo-Spanish boats prosecute fisheries in much deeper water than those, which are purely UK owned. Despite some initial apprehension the meeting went extremely well. There was no tension; in fact there was solidarity because of the experience that the various groups shared in their dealings with the towed gear sector. For the next meeting we hope also to have representatives from the Anglo-Spanish PO in Fleetwood.

Our NAG, along with those from Norway, Sweden, France Spain and Portugal, is very keen to hold an international workshop later this year. All agree that ghost fishing is, potentially, a very divisive issue. The workshop will aim to produce a consensus code of good operating practice for netters in order to minimise gear loss and to agree a management strategy, which will mitigate the effects of any gill nets that are lost. A funding application for this workshop has just been submitted to the Commission and, if accepted, it will be funded at 100% of costs.

Discard studies: These are looking at two aspects of discarding. One study is looking at how discard data can be made more useful to managers and to fishermen. It is doing this by reviewing users' needs and then designing sampling strategies, analyses and the presentation of data around those needs. It should lead to a better understanding of how technical measures can be introduced to complex fisheries and their use targeted to maximum effect. There are partners in four European countries and EC funding covers 50% of full costs.

The 15 months of field work for this first project is now complete except for one trip on an Anglo Spanish vessel planned for June 2001, which will complete the seasonal survey for this métier. A total of 27 trips have been undertaken by the Seafish discard team. These results, together with the results from the other partners should enable a comprehensive picture of the discarding practices in Western waters. These data will be analysed in order to gain improved understanding of the use of discard data in the assessment of stocks and possible technical measures.

Interestingly, the recent publicity, and proposals for an action plan to save the northern hake stock have added considerably to industry interest in possible further research. Seafish staff recently gave assistance to a short research trip underwritten by Cornish FPO, which looked at mesh size selectivity for hake in beam trawls.

The second project involves the feasibility of fisher self-sampling of catch. It is important for improved stock assessments that sustained sampling of discards is achieved and that the sampling takes place on as many vessels as possible. Fisher self-sampling is seen as a means for achieving this but the technique requires full scale testing. The objective of this work is to carry out and assess a sustained survey of discards using fisher self-sampling in commercial fisheries in ICES Area VII.

After a slow start due to the appalling weather conditions in Western Waters during the autumn this project is now well underway with up to eight vessels being commissioned to carry out self-sampling per month. The vessels work within a sampling strategy described as 'sampling with partial replacement'. In this a core group of vessels are sampled on a regular basis through the project and other vessels are sampled at random from the rest of the fleet in order to compare the core group with the fleet. The discard officer sampling will be continued in the same métiers in order to provide results for comparison with those obtained from self-sampling.

The project is fully funded by the UK Fisheries Ministry MAFF.

Ghost fishing preventors for shellfish traps: This study, which was fully funded under contract to MAFF has evaluated various devices that could be used to disable traps over time. The need for the work was identified by industry associations concerned that effort levels for shellfish traps have been increasing in recent years. With increasing amounts of gear being used, gear losses generally increase too. Losses of parlour pots led to the concern that ghost fishing could be occurring.

The provisional conclusions from this study were that:

1) the levels of trap loss are generally low and fishers' experiences are that lost traps are generally disabled fairly quickly by water movement or the activities of trawlers,
2) where trap loss is a cause for concern there is a case for fitting some device to limit any subsequent fishing activity. Drop-out panels are recommended because they can also incorporate escape gaps. It is recommended that further work should look at the design and fitting of panels incorporating escape gaps,
3) some attention should also be paid to the techniques for the retro-fitting of drop-out panels to parlour and inkwell traps.

Video production: This continues to be an important means of supporting industry. Releases of our video on twin rig trawling, including 50 that have been released to North America in NTSC format, now total around 500. Videos currently being produced include:

- fish catch self-sampling,

- a multi-lingual video documentary as part of the major EC fisheries project Fantared 2 on lost gillnets. Computer generated images will be used alongside digital video footage of project procedures and interviews with fishermen, to form a final documentary to be pitched at laypersons.

A library/resource base of footage describing problems with otter boards and how these can be corrected.

Progress Report to the ICES Fish Technology and Fish Behavior Working Group, April 2001.

UNITED STATES

NORTHEAST

Massachusetts Division of Marine Fisheries

Conservation Engineering Program

H. Arnold Carr and Michael Pol

Testing of Low-Profile, Low Cod By-catch Gillnets

Two experimental gillnets designed with low vertical profiles were tested against a standard cod gillnet and a standard flatfish gillnet. One experimental net replaces the floatline with another leadline; the second adds lead to the floatline every 30 ft. Fifteen overnight sets have been completed. Low catches of flatfish did not permit catch comparisons; catches rates of cod were significantly reduced by the added-lead design. The mean cod catch rate using the dual leadline was lower than the standard, but not significantly so. Further testing is planned.

Groundfish Trawlnets Designed to Reduce the By-catch of Cod

Two experimental trawl nets designed to allow cod to escape through the top of the net have been filmed and pairwise catch comparisons are planned. Underwater filming of the nets showed cod escaping through large (>8 in) square mesh on the top of one experimental net. This large mesh extends from the headrope aft to the cod-end. The second modified net shifts the headrope as far aft as possible by removing the top wings. Filming verified that cod escaped ahead of the headrope in this net; in a standard net, twine may have blocked the escape of these cod. Comparisons of catch rates are delayed pending Federal experimental fishing permits.

Improving the Selectivity and Utility of Demersal Hook Fishing

This long-term project with Susan Goldhor, Center for Applied Regional Studies, seeks to develop a selective, effective artificial bait for use in the demersal longline fishery. A variety of artificial bait formulas is being offered to cod in raceways; responses are filmed and analyzed. Some positive reactions to bait formulas have been observed. Baits for flatfish and field testing of successful baits will be conducted in later phases.

Scup By-catch Reduction in Squid Fishery

Behavioral observations of squid and scup in response to trawl nets continue. Development of nets that exploit these differences to reduce by-catch (especially scup), in collaboration with Chris Glass, Manomet Center for Conservation Sciences, compared the effect individually of a raised footrope trawl, a large mesh band, and a dark tunnel. Extreme variability in scup catch obscured possible effects. Data did indicate that raised footrope trawls are effective in reducing catches of dispersed scup.

Juvenile Mortality Reduction in Demersal Longline Cod Fishery

MaDMF, in collaboration with Marianne Farrington, New England Aquarium, has supported the modification by fishermen of hauling gear to decrease injury to juvenile cod. Testing of comparative survival rates between traditional practice and an experimental flip technique was hindered by the absence of cod. Development of instructional materials to disseminate the technique is underway.

Development of an Acoustic Scallop Dredge

In situ observations suggest that bay scallops react to the sound of outboard engines. Bay scallops held in aquaculture facilities and in the field were subjected to recordings of outboard engine noise with mixed results. Output frequencies of several models of engines were analyzed in the range 50-6000 Hz. Higher quality equipment to reproduce sound underwater at high volumes is being acquired for further testing.

Manomet Center for Conservation Sciences

Marine Division

Dr. Chris Glass

By-catch Reduction Program: *Loligo* Squid Fisheries

Inshore

Studies on the behavioral reactions of *Loligo* squid and scup to trawl gears continued during 2000. Discard levels in the fishery consistently remained at approximately 40% by weight when using a standard net. When a raised footrope configuration was employed, discard fell to <5% by weight while maintaining target catch. By adding escape windows and tunnels, as well as other modifications to induce escape behavior of fish, squid may be retained while allowing other fish species to escape. Research will continue during 2001 to further refine selectivity of small mesh squid fisheries.

Offshore

Research continued during 2000/2001 on by-catch reduction and improved selectivity in Atlantic longfin squid fisheries in the Mid-Atlantic region. By-catch and discard of non-target species is a problem in these fisheries but of more significant concern is the discard of small squid for which no market exists. Studies demonstrated that L_{50} for squid could be increased from 9 cm in the standard 1 7/8" cod-end to 13 cm in an experimental 2 ½" cod-end without loss of larger marketable squid. Use of larger mesh netting has the added benefit of reducing fuel costs. Research continues into developing methods and strategies to reduce by-catch and discard of scup in small mesh squid fisheries.

By-catch Reduction Program: Multispecies Groundfish Fisheries

Composite cod-ends

Experimental fishing trials were carried out on commercial boats in the Gulf of Maine during 2000/2001. Alternate haul, experimental trouser trawl and covered cod-end techniques were employed to assess the effectiveness of different cod-end configurations in reducing by-catch and discard of undersized yellowtail flounder and cod. Various composite mesh cod-ends have been compared with the standard 6.5" square mesh cod-end and 6" diamond mesh cod-end. This work will continue throughout 2001/2002. Results to date show significant reduction in undersized yellowtail flounder (and flatfish as a whole) when using a composite cod-end constructed with 6.5" square mesh on top and 6" diamond mesh on the bottom of the cod-end. There has been no significant reduction in catches of cod. Analyses and sea trials on the utility of composite cod-ends, and cod-end windows are continuing.

Ex-It Fish Excluder

Experiments are currently underway to assess the applicability of the Icelandic Ex-It cod excluder device in Gulf of Maine groundfish fisheries. This project is designed to test the effectiveness of the Ex-It by-catch reduction device in reducing the inadvertent catch of undersized fish in the Northwest Atlantic multi-species groundfish fishery. Sea trials on board chartered commercial fishing vessels are being conducted in the Gulf of Maine and in Canadian territorial waters. (Canadian trials conducted by DFO focus on redfish by-catch reduction). Selectivity parameters of trawl nets with and without the Ex-It device will be determined. Trials with 3 different grid spacings (50 mm, 60 mm, 70 mm) will be conducted to determine the most appropriate configuration for small cod exclusion. Video observations will be made on the behavior of fish near the by-catch reduction device and detailed behavioral descriptions and analysis will be conducted. Retaining bags will be placed over the Ex-It excluder and small mesh cod-end covers will be deployed in order to obtain selectivity curves from the catch data. Selective efficiency (L_{50}, the length of 50% retention) and selection range ($L_{25} - L_{75}$) will be determined for each experimental configuration and compared with standard (non-modified) fishing nets. Separate fishing trials will be conducted specifically to obtain video recordings of reaction behavior of fish. Detailed behavioral descriptions (ethograms) will be characterized for each key species. These data will be used to further develop the selective efficiency of the excluder device.

Fishing Industry By-catch/Discard Scoping Meetings

Manomet Center for Conservation Sciences in conjunction with MaDMF has recently conducted a series of by-catch/discard and conservation engineering meetings with industry throughout the New England region. Funding for this program was made available by NOAA/NMFS through the New England Fisheries Management Council Research

Steering Committee. Meetings were held in New York, Connecticut, Rhode Island, Massachusetts (Cape Cod, New Bedford, Scituate, Gloucester), New Hampshire, Maine (Portland, Port Clyde, Ellsworth). Each meeting provided a forum for local area fishermen to discuss and identify by-catch and discard issues particular to their own waters and fisheries. The meetings will be used to help set region-wide by-catch reduction strategies and priorities and to identify partners for future research programs.

National Marine Fisheries Service

Northeast Fisheries Science Center

Fisheries Independent Surveys Group

Tom Azarovitz, Linda Despres, Henry Milliken, John Galbraith
Holly McBride, Nancy McHugh, Victor Nordahl

Fisheries Scientific Computer System:

The National Marine Fisheries Service, Northeast Fisheries Science Center (NEFSC) implemented the Fisheries Scientific Computer System (FSCS) during the Spring 2001 Bottom Trawl Survey. The Office of Marine and Aviation Operations (OMAO) and the NEFSC have designed and developed this system over the past 2 years. It will completely replace data entry on paper logs and speed the time the data is available to end-users.

The hardware is ruggedized for extreme weather conditions and includes LCD touch screen displays with built in heaters, SCANTROL electronic measuring boards, Marel digital scales, label printers and barcode readers. The system is set up to run from a server through a network, but can be run from an individual workstation if the server ever goes down. The workstations and servers are backed up every time there is any information input to FSCS.

The software converts data to digital form; built-in audits are included to check the data as it is entered. Bar codes attached to age envelopes are utilized to link the pertinent information for each sampled specimen. The bar-coded envelope is permanently associated with that individual fish. Upon completion of a station the data can then be loaded into an Oracle table and audited. With some minor post processing, these files will be ready for archival to master data immediately upon returning to dockside.

Paired Study:

The Fisheries Independent Surveys Group has conducted several weeks of paired comparisons between the FRV Albatross IV and the FRV Delaware II. These paired studies are in preparation of a possible need to use the FRV Delaware II for future groundfish surveys as the FRV Albatross IV may not always be available for the groundfish survey work due to the increased age of the vessel. As well as catch comparisons, trawl mensuration (Simrad ITI) and bottom contact sensors (developed by the AFSC) are being deployed to ascertain any differences in the performance of the gear.

Monkfish Survey:

The Fisheries Independent Surveys Group has been assisting the Population Dynamics Branch with the implementation of a specialized monkfish (goosefish) survey. The aim of this work is to ascertain the relative catchability of the survey's trawl gear as compared to commercial trawl gear. Furthermore, the survey is sampling areas further offshore than sampled by the NEFSC's bottom trawl survey. All the work is being conducted aboard commercial fishing vessels with the cooperation of the fishing industry. Collaborators include the Massachusetts Division of Marine Fisheries and Rutgers University.

Scallop Research:

A scallop survey that has been conducted by the NEFSC since 1975 uses an eight-foot dredge. The dredge has not been equipped with rock chains, which results in several tows being disregarded due to the catch of rocks and boulders. Efforts are underway to assess the effects of adding rock chains on the dredge and what affect the addition of these chains will have on the catch. This study may lead to the addition of rock chains on the survey dredge to reduce the number of discarded survey tows and the possible addition of a conversion factor to manage any changes in the catch rates.

Website:

The Fisheries Independent Surveys Group has published a new website that contains the fishermen's reports, cruise reports, survey gear descriptions and other information about the NEFSC's survey program. The address is: http://www.nefsc.nmfs.gov/esb/index.htm.

Virginia Institute of Marine Science

School of Marine Science

College of William and Mary

David B. Rudders, William D. DuPaul, and J. David Lange Jr. and Kevin D. Goff

Survey Methodology For The Evaluation Of The Sea Scallop *Placopecten magellanicus* Population In The Mid-Atlantic Closed Areas

During June and September of 2000, two fishery-independent surveys of two mid-Atlantic sea scallop closed areas were conducted. The surveys represented a collaboration between the sea scallop industry, fisheries managers and academia with the common goal of obtaining the appropriate data to support an opening of the two closed areas. The objective of the surveys was to quantify the abundance and distribution of sea scallops and ultimately estimate sea scallop biomass within the two mid-Atlantic closed areas.

The survey data were gathered by the *F/V Alice Amanda*, a commercial sea scallop vessel towing standard New Bedford style dredges. Using this gear, 217 survey stations were sampled; inside, along the boundaries, and adjacent to the two closed areas. To complement the catch data, the surveys featured a differential global positioning system (DGPS) with integrated navigational software which recorded navigational parameters at short time intervals, and an inclinometer, attached directly to the scallop dredge, to accurately measure dredge attitude. These instruments and techniques resulted in improved estimates of the spatial orientation and towing time of the sampling gear during a survey tow. This information coupled with estimates of dredge efficiency derived from depletion based experiments formed the basis for estimates of swept area biomass.

Biomass estimates show that the Hudson Canyon South and Virginia Beach closed areas contain 20,393 and 1,389 metric tons of sea scallop meats, respectively. These results will support management decisions for a restricted commercial opening of the two closed areas in early 2001. The scheduled openings in the spring of 2001 represent the culmination of a developing rotational management strategy that attempts to increase the yield of sea scallops in a discrete area by realizing gains in biomass through growth. Results from these surveys indicate that significant gains in biomass were attained through the 36-month closure.

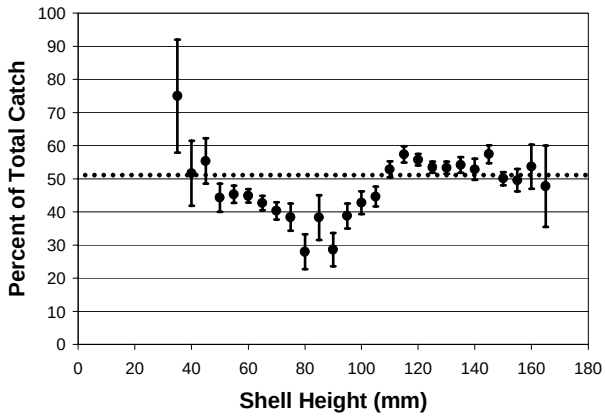

Figure 1. Percent catch per tow by a 4" ring dredge, when fished simultaneously with a 3.5" ring dredge. Points above 50% indicate greater retention; those below 50% indicate greater escapement. Error bars indicate standard error of the mean for tows in which those animals were present.

Results of sequential increases in sea scallop *Placopecten magellanicus* dredge ring size and the use of modified dredges specifically for area management strategies

Regulated changes on sea scallop dredge ring size since under Amendment 4 have resulted in significant changes in size selectivity patterns. Three regulated sequential increases in dredge ring size have shifted length frequency modes that reflect the differential selectivity of the gear to larger animals but not to an equal extent. Dredges with 88.9 and 100 mm rings inexplicably capture a greater number of animals >120 mm and >130 mm compared to smaller ring dredges (Figure 1). This phenomenon would be beneficial when attempting to increase yield per recruit, by selectively capturing larger animals. However, results from comparative gear experiments with incrementally increasing ring sizes show, the there is still much growth to be realized relative to the 100% retention points (Figure 2). The larger population of animals that would be created by closed area management may benefit from increased ring sizes to be selectively harvested under mixed age-class resource conditions.

Results of the comparison indicate that previous and present regulated ring size sizes are inadequate for optimizing the potential gains in growth and reproduction, and are not sufficient to take full advantage of gains resulting from temporary area closures.

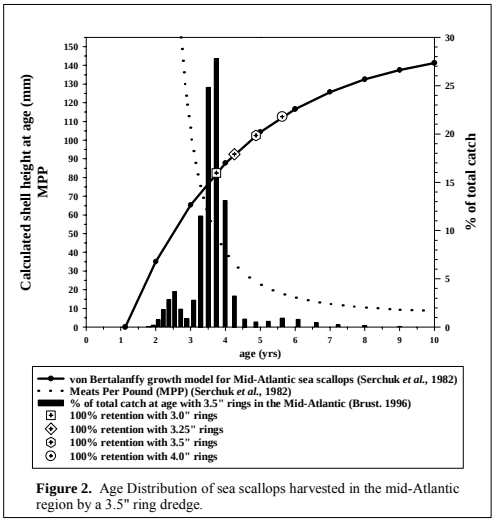

Figure 2. Age Distribution of sea scallops harvested in the mid-Atlantic region by a 3.5" ring dredge.

Significant gains in growth are not realized when the selectivity of the regulated gear captures sea scallops well before they reach maximum yield per recruit. We conclude that area management strategies should include the use of a more

size selective gear in order to maximize benefits related to increases in YPR. Recognizing the broad selectivity pattern and inherent inefficiencies of sea scallop harvesting gear, additional regulatory measures may be needed to maximize the biological potential of the resource.

SOUTHEAST

The Center for Marine Science

University of North Carolina at Wilmington

Teresa Thorpe and Ann Pabst

Assessment of modified gillnets as a means to reduce shark, sturgeon and marine mammal by-catch.

The Center for Marine Science, University of North Carolina at Wilmington, was awarded a grant to test the effectiveness of sinking gillnet modifications at reducing by-catch of sharks, sturgeon and marine mammals. The modified gillnets were constructed in the same way as commercial (unmodified) gillnets, except that the lead line was x4 weight and the floats were x2 the buoyancy. The idea was that this would reduce the number of specimens that were caught by wrapping in the webbing of the modified gillnet.

No sturgeons or marine mammals were caught in any net. Catch rates of sharks were lower in modified nets compared to unmodified nets, and significantly lower for Atlantic sharpnose and blacknose sharks. Catch rates of target fish were similar in modified and unmodified nets and did not vary significantly. Further analyses to detect differences in modes of entanglement of individual shark species in modified and unmodified gillnets, and gillnet selectivity are under-way. A final report to the funding agency is due at the end of April 2001.

NORTHWEST

Oregon Department of Fish and Wildlife

Robert W. Hannah, Stephen J. Parker, Keith Matteson

Tests of Bottom Escapement Panels in Trawls

We tested how large mesh escapement panels in the bottom of shrimp and bottom trawls altered the catch composition of the trawls. In both types of trawls, the escapement panels were installed just behind the fishing line of the nets. In the double-rigged shrimp trawls, there was some indication that lingcod and halibut utilized the escape panels readily. However, there was also some indication that differences in fishing line height above bottom between the two trawls were confounding the data. We are presently designing a device to remotely measure height of the fishing line above bottom to better control this variable in future studies. For the bottom trawl work, we used a capture bag and determined using video that while fish utilized the panels, the capture bag altered their behavior and they often re-entered the trawl. We removed the capture bag and switched to an alternate haul design. The small number of tows completed was inconclusive.

Sablefish Behavior Towards a Baited Pot (with Craig Rose of NMFS RACE Division)

This project used visible light and infrared light with video equipment to view the behavior of sablefish around and inside a baited sablefish pot. Video observations are hard to quantify, however it appeared that sablefish avoided the pot with the visible light source, but approached the pot with infra-red light quite readily. Sablefish were seen both entering and leaving the pot. Although sablefish can swim rapidly, their swimming behavior approaching a baited pot is a slow side to side swimming and looks like olfactory search behavior.

Projects Planned For 2001

In 2001 we hope to test how shrimp trawl footrope height influences shrimp catch and flatfish by-catch. We will also be testing two by-catch reduction devices (BRDs) based on modifications to existing soft-panel BRD designs and

modifications to the Nordmore grate. We also hope to begin work on tests of a trawl used in the Faroe Islands for local flatfish fishing. The trawl uses a low-rise design with a radically cutback headrope. Our hope is that this type of trawl can reduce rockfish by-catch in directed flatfish fisheries.

National Marine Fisheries Service

Alaska Fisheries Science Center

Ken Weinberg

The Effect of Trawl Speed on the Catch Efficiency of a Survey Bottom Trawl

The effect of speed through water on the footrope capture efficiency of an AFSC survey bottom trawl was experimentally investigated during 2000 by repetitively towing at three vessel speeds with an auxiliary net attached underneath the trawl footrope to capture fish escaping beneath the trawl. Length dependent capture efficiencies were then computed from the number of fish caught in both the trawl and the auxiliary net. Increases in trawl speed through water, such as those imposed by varying current conditions on survey tows, caused the center of the poly Noreastern survey trawl footrope to lose contact or lift off-bottom. Capture efficiencies for two gadoid species, Pacific cod and walleye pollock, did not vary by speed or with fish length, as was also the case for the large-sized Pacific halibut encountered. Capture efficiency for skates decreased with increasing trawl speed but remained unaffected by fish length. Capture efficiencies for flatfish species, arrowtooth flounder and flathead sole, increased with increasing fish length and decreased with increasing speed. These results indicate that variation in survey CPUE could be reduced for some species by standardizing towing speed to speed through water rather than speed over ground.

The Effect of Trawl Speed on Footrope Contact of the Bering Sea Survey Trawl

Another gear experiment is planned for summer 2001 aimed at studying the effect varying trawl speed through water has on footrope contact with the sea floor of the bottom trawl used in AFSC groundfish surveys of the Eastern Bering Sea. A bottom contact sensor will be attached to the footrope of the 83/112 Eastern trawl and changes in footrope distance off-bottom will be monitored as trawl speed through water is varied.

Estimating Trawl Capture Efficiency for Red King Crab Using Direct Observation Methodology

A year's recommended commercial harvest level for red king crab, *Paralithodes camtschaticus*, is based on a previous summer's estimates of relative abundance from the National Marine Fisheries Service (NMFS) Bering Sea bottom trawl survey. Abundance estimates from the survey are input into a length-based analysis (LBA) model. The LBA red king crab assessments assume 100 percent capture efficiency by the survey trawl. This assumption is likely untrue as evidenced by video footage taken in 2000 which revealed a number of adult crab passing underneath the trawl footrope. During the 2001 survey, low light cameras will be strategically mounted to the trawl such that the footrope will be in view and estimates of capture efficiency can be calculated. Descriptions of the spatial distribution and habitat of red king crab is also planned.

Alaska Fisheries Science Center

Conservation Engineering Project

Craig Rose

Halibut excluders, developed for sole fisheries, were redesigned and tested in 2000 for fisheries targeting Pacific cod. The excluders consist of panels across the intermediate with openings that accommodate passage of the target fish while blocking the larger halibut and directing them to an escape hole. The initial excluder for cod fisheries used panels of steel rings 22 cm in diameter. This effectively excluded halibut >85 cm in length. Unfortunately, many smaller halibut were taken in the cod tows. Large skates were also found to disable the excluders when they blocked the selection panels. Separate devices were added to remove skates before they reached the panels and to allow the small halibut to escape. A panel of 20 x 20 cm square mesh was installed ahead of the excluder to deflect skates downward to an opening in the bottom of the trawl.

Two vertical panels with horizontal slots 7 cm high were installed behind the ring grates to form a narrowing chute. The mesh was removed around this section to allow animals passing through the slots, including many of the small halibut, to escape. The slots were too narrow for all but the smallest cod to pass. After a series of adjustments, based on selectivity testing and video observations, this system achieved a halibut escape of 80% while only losing 15% of the cod catch.

ANNEX 1 – REPORT OF THE FTFB TOPIC GROUP ON EVALUATION OF SELECTION PROPERTIES FOR BALTIC COD TRAWLS USING DOUBLE NETTING MADE OF TWINE EXCEEDING CA 4 MM IN DIAMETER

TOR: Evaluate the selection properties for Baltic cod trawls using double netting made of twine exceeding ca 4mm in diameter

Justification: The request from IBSFC is to provide advise on possible alternatives to the practice used in the BACOMA project where a window in the trawl is suggested, with a special net material.

Introduction

It is often seen that the fishing industry changes the gear parameters in order to try to circumvent the effect of new technical measures. Frequently the intended effect of the measure will therefore not happen. A study carried out by Weber (1996) on the cod discards in the trawl fishery in the German Bight (southwestern North Sea) showed that in 1982–84 the discards in the fishery for cod tended to be zero for mesh sizes of 90 to 95 mm. A re-examination in 1992–93 revealed the existence of discards again for mesh sizes over 100 mm. In this period has neither the fishing effort decreased remarkably nor had the amount of recruits increased to any obvious extent. It is likely that gear changes such as the observed use of larger cod-end twine diameters or the use of double twines is the reason for this new discard problem.

For many years the fishing industry and gear scientists have been aware of that netting twine diameter and properties such as twine stiffness has an effect on cod-end selectivity. Recently, a systematic examination of the magnitude of these effects was carried out within the EU-project VARSEL (Study of factors affecting the variability of cod-end selectivity, Anon 1997; Lowry 1995, Lowry & Robertson 1994, 1996). Interpretation of the results proved to be somewhat troublesome because of the simultaneous effect of other factors influencing selectivity (e.g., catch size, sea-state). Evidence for the existence of this effect has also been observed by other investigations (Polet & Redant 1994, Ferro & O'Neill 1994).

Recently a joint German-Polish experiment has been conducted in which the effect a twine size and number of twines on cod-end selectivity was investigated for cod in the Baltic.

Results of German-Polish experiments with conventional diamond mesh cod-ends

Results of five selectivity experiments on Baltic cod carried out by the German Institute for Fishing Techniques and Fish Quality and the Polish Institute for Marine Research were presented during ICES FTFB Working Group in Seattle. Three single-twine cod-ends ranging from 4 to 8 mm and two double-twine of 4 and 6 mm respectively were tested. The trials were carried out in 1999–2001 on the same research vessel, on the similar operational conditions, at the same time of the year, same fishing ground and with identical trawls. Any differences observed, therefore, are likely to be caused predominantly by the changed twine diameters/netting twine configuration.

The five experiments (Table 1) showed a clear negative correlation between nominal twine diameter and cod-end selectivity for Baltic cod.

Table 1. Nominal twine size and numbers of twine.

Twine:	Single 4	Single 6	Single 8	Double 4	Double 6
L50:	37.7	31.7	26.8	33.0	24.9

At 4 mm single twine the mean selection length (L50) was 37.7 cm, at 6 mm single 31.7 cm and at 8 mm single 26.8 cm. With the same twine diameter the use of double twine increased the negative effect. Single 6 mm twine produced a L50 of 31.7 cm, double 6 mm a L50 of 24.9. By interpolation this means that an increase in twine diameter of one millimetre is able to produce a reduction of L50 with single twine of 2.7 cm, with double twine of ca 4 cm. Although the results originate from a research trawler and therefore can not directly be transferred to commercial ships, the results seems to indicate that increasing the number of twines is one of the most effective ways to reduce the selection of Baltic cod at a given legal mesh size.

Further, the study revealed that at present there are no suitable means to enforce twine diameter at sea particularly if the twine consists of a hollow-core braid. Dahm (1983) suggested a photographic- and Ferro (1989) an electronic

measuring method suitable to measure the actual twine diameter under given pre-tension. Both gave reproducible results in the inter-calibration tests, but only under laboratory conditions. The measuring principle of Ferro has recently been taken up in the development of a precise twine diameter measuring instrument, but again designed for laboratory use only.

Decision taken in Brussels in 13–14 March 2001 by IBSFC

Following discussions in Brussels at an Extraordinary Session on 13–14 March 2001 the following recommendation was issued by the International Baltic Sea Fishery Commission (as amendment to IBSFC fishing rule No. 9):

"It is prohibited to use trawls, Danish seines or gillnets having a mesh opening (measured when wet) smaller than that specified for the fisheries listed below:

a) Cod

Gillnets	105 mm
Trawls and Danish Seines with mesh size equal or larger than 105 mm applying BACOMA window with mesh size of and with specifications as laid down in Annex IV	120 mm
Trawls and Danish seines with mesh size equal or larger than made of polyamide in the extension and the cod-end and with single twine thickness of no more than 4.5 mm which may be used in own fishery zone.	125 mm
Trawls and Danish seines with mesh sizes equal or larger than made of all other materials with a single twine thickness of no more than 6 mm or with double twine thickness of no more than 4 mm.	130 mm

The above measures shall be implemented not later than 1.1.2002.

The Contracting Parties agree to re-examine the above technical measure during the Annual Meeting in 2004."

Conclusions

Proper attention should be paid to the twine- size and configuration in diamond mesh cod-ends. Twine sizes over 4mm has shown to cause a considerable decrease in selectivity. Same and even stronger effects are observed with the use of multiple twine. It should however be observed that for measurements of twine size at sea, no approved gauge exist at present.

Cod-end windows in square mesh knotted and knotless netting other than that used in the BACOMA cod-end∗ can produce the same selective properties as the BACOMA window. However, long-term use of knotted netting results in distortion of net configuration, which may reduce the selectivity of the window. Mesh distortion due to knot slippage in the BACOMA window netting after long-term use has not been observed and is not likely to occur because of the different construction of the netting.

Note∗: The netting used for the square mesh window in this cod-end is made of braided knotless netting, produced in a way that the production twine follows an unbroken line in the bar direction and not the conventional zigzag line. In a square mesh panel this gives unbroken longitudinal and transverse twines that runs straight through the joints ("knots") with a high mechanical strength and no knot slippage.

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ANNEX 2 – ADVISORY STATEMENT BY WGFTFB REGARDING TOPIC C: CONSIDER CURRENT STUDIES AIMED AT REDUCING BY-CATCH AND SEA BED IMPACT IN FISHERIES

(Lead author: Bob van Marlen)

The recent decline in the North Sea cod stocks and the associated area closures call for implementation of more selective gears in the demersal fleets. The presentations in topic b) selective Baltic cod trawls, and topic c) current studies aimed at reducing by-catch and sea bed impact showed considerable progress in improving selectivity through gear alterations. These contributions at the 2001 WGFTFB meeting are summarized below.

Escape windows can effectively improve the selection properties of Baltic cod trawls (Madsen, 2001; Tschernij and Suuronen, 2001). Model studies predict that stock size can be enhanced substantially when these techniques are introduced (BACOMA-project, Tschernij and Suuronen, 2001). However, cod-end twine thickness should be limited to avoid detrimenting such a measure (Dahm, 2001). Sorting grids are also effective. Kvamme (2001) documented the possibility of a long-term increase in the stock size of North East Atlantic cod as a result of introducing sorting grids in the Barents Sea bottom trawl fisheries. However, a short-term decrease has to be accepted. In the industrial fishery for Norway pout and blue whiting, the by-catch of juvenile round fish (cod and haddock) can be considerably reduced (70%-100%) by introducing sorting grids (Kvalsvik, 2001). Improved size selectivity can also be obtained in static gears. Farrington (2001) showed that the catch of sub-legal cod in the North West Atlantic longline fishery can be decreased by increasing hook sizes. In addition, the survival of discarded fish can be improved more gentle handling procedures.

Besides influencing the size distribution of target species, sorting devices are also effective at reducing by-catch. In the New England squid fishery, species-specific differences in behaviour were used to separate squid from the by-catch of demersal fish species. The change in gear rigging allowing this (i.e., a raised footrope) can, in addition, reduce bottom impact of the trawl (Glass, 2001). Rose (2000) described a suite of by-catch reduction devices enabling large reductions in Pacific halibut by-catch. In the North Sea *Crangon* fishery, use of sieve nets or sorting grids can eliminate much of the fish by-catch (plaice, dab, cod, and whiting; van Marlen, *et al.,* 2001).

By-catch reduction can also be extended to the reduction of trawl impacts on the non-target benthos. The direct mortality of benthic invertebrates in demersal beam trawling can be reduced by using drop-out windows or alternative stimulation (electric pulses) for the target fishes (van Marlen, *et al.,* 2001). A modified tow regime using shorter warps can be applied to decrease the forces that the trawl doors exert on the sea bed, and thereby reduce the negative affect of door contact with the sea bed (Benoit, 2001).

Effective management regimes show that industry participation can be improved to collect data as an input to stock assessment models and an aid to control the fisheries, provided that the industry sees direct benefits. Examples from Australia and New Zealand were presented by MacMullen, (2001). The transfer speed of vessel observer data can be enhanced greatly, enabling a more active fishery opening and closing regime to avoid excessive by-catches (Halfinger, 2001). The effectiveness of gear modifications was given a lower priority than other measures such as effort reduction and closed areas/zonation (Report ICES WGECO, ICES C/M.2000/ACME:02). The argument given is that fishermen will tend to compensate losses in target species by increasing effort, and that reduction of effort is therefore the best way to diminish adverse eco-system effects. However, where fisheries management ensured clear incentives industry responded by use of the proposed technical measure (e.g., sorting grids in the worldwide prawn fisheries).

The success of gear modifications to improve selectivity and reduce bottom contact was shown in the presentations given at this session, and their potential to contribute to enhancing fish stocks indicated. The WGFTFB believes that this should be communicated further within ICES, to ensure that this potential is fully appreciated.

ANNEX 3 – DRAFT RESOLUTION

The Working Group on Fishing Technology and Fish Behaviour [WGFTFB] (Chair: Dr David A. Somerton, USA) will meet in Sete, France, from 6–8 June 2002 to:

a) consider recent advances in the modelling of fishing gears, with particular emphasis on selectivity, sea bed impacts and applications to fisheries management;
b) review the use and impact of chafers, net strengtheners and other cod-end construction materials that impact species and size selectivity of trawls;
c) review the use of archival tags to elucidate the role of fish behaviour on catchability;
d) consider the affects of fish behaviour on the selectivity of mobile and static gear;
e) review the historical use of technical measures and evaluate their effectiveness, with special emphasis on North Sea gadoid fisheries.

Supporting Information:

Priority:	The current activities of this Group will lead ICES into issues related to the effectiveness of technical measures to change size selectivity and fishing mortality rates. Consequently these activities are considered to have a very high priority.
Scientific Justification:	**Term of Reference a)** Recent advances in the modelling of fishing gears and netting materials has permitted more efficient investigation of the fish capture process. A recent EU funded project (PREMECS) made use of this research to develop a predictive model of cod-end selection. Other current research areas include the study of sea bed impact of towed fishing gears, the evaluation of fishing effort and the design of survey trawls. **Term of Reference b)** The review of this subject at WGFTFB 2001 indicated that cod-end selectivity may be vastly improved with the reduction of chafers and associated attachments. In addition many FTFB members will conduct selectivity investigations in regard to these issues and will be prepared to report results in 2002. **Term of Reference c)** The use of archival tags to elucidate diurnal and seasonal fish movement has increased in recent years as the cost and size of such tags has declined. Since diurnal and seasonal movement patterns influences the catchability of fish to assessment surveys, knowledge of these behaviours could allow the design of more efficient surveys. **Term of Reference d)** Investigations on the affects of fish behaviour on selectivity are now being conducted by FTFB members. The most pertinent include: 1) trawl modifications to reduce the by-catch of non-target species, 2) grids and FDS in trawl gear, 3) artificial baits and larger hook sizes in longline fisheries and 4) modified gillnets that reduce by-catch. **Term of Reference e)** The recent North sea cod crisis has brought to the forefront the importance of technical measures in conservation of the resource. Focus will be on the effectiveness of species selective trawls, square mesh panels and any innovative trawl technical measures. Emphasis can also be extended to the Irish Sea.
Relation to Strategic Plan:	This Group directly addresses the remit of the Fisheries Technology Committee, and its terms of reference are embodied in the scientific objective 3h of the ICES Strategic Plan
Resource Requirements:	The research programmes, which provide the main input to this group, are already underway, and resources already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.

Participants:	The Group is normally attended by some 50 members and guests
Secretariat Facilities:	None
Financial:	No financial implications
Linkages To Advisory Committees:	There are no obvious direct linkages with the advisory committees
Linkages To other Committees or Groups:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It also is of close relevance to the Working Group on Ecosystem Effects of Fisheries.
Linkages to other Organisations	The work of this group is closely aligned with similar work in FAO.