# NMFS National Standing Working Group on Fishing Technology

## Report of First Meeting, March 6-7, 2002

**U.S. Department of Commerce**
**National Oceanic and Atmospheric Administration**
**National Marine Fisheries Service**

## Introduction

The first meeting of the NMFS Standing Working Group on Fishing Technology (FTWG) was held at the Northeast Fisheries Science Center, Woods Hole, on March 6-7, 2002. In attendance were:

| | |
|---|---|
| Christopher Boggs * | NMFS Southwest Science Center (F/SWC2) |
| Alan Blott * | NMFS Northeast Region (F/NER) |
| Val Chambers * | NMFS Headquarters (F/SF3) |
| Ned Cyr * | NMFS Headquarters (F/ST) |
| Henry Milliken * | NMFS Northeast Science Center (F/NED32) |
| Craig Rose * | NMFS Alaska Science Center (F/AKC2) |
| Waldo Wakefield * | NMFS Northwest Science Center (F/NWC42) |
| John Watson ** | NMFS Southeast Science Center (F/SEC4) |
| | |
| Arne Carr *** | Massachusetts Division of Marine Fisheries |
| Joe DeAlteris *** | University of Rhode Island |
| Cliff Goudey *** | MIT Sea Grant College Program |
| Chris Glass *** | Manomet |
| Pingguo He *** | University of New Hampshire Sea Grant |
| Mike Pol *** | Massachusetts Division of Marine Fisheries |
| Ron Smolowitz *** | Coonamessett Farm |

* working group member
** working group chair
*** invited presenters

Agenda items for the meeting were:

- Review of draft terms of reference
- Review of fishing technology research
    - Alaska Fisheries Science Center
    - Northwest Fisheries Science Center
    - Southwest Fisheries Science Center
    - Southeast Fisheries Science Center
    - Northeast Fisheries Science Center
- Review of national recommendations for addressing bycatch
- Review of budget and staffing needs by region
- Review of New England ground fish fishery bycatch issues

John Watson opened the meeting with a discussion of the need and purpose of the group as expressed by the NMFS Science Advisory Board. Mike Sissenwine welcomed the group to the Woods Hole Laboratory and gave a brief presentation on the New England fishery and the status of litigation concerning the New England groundfish fishery. Bill Hogarth addressed the group via teleconference. He briefly reviewed bycatch issues from the national perspective and charged the group to review the national recommendations on bycatch and provide recommendations on funding and personnel requirements to address bycatch issues. He indicated a budget initiative was being prepared for gear technology research in 2004 and requested input from the group on regional needs. Bill also asked the group to address the New England groundfish bycatch problem and provide recommendations.

**Terms of Reference**

Draft terms of reference for the working group were reviewed. The mission, composition, and responsibilities of the NFTWG were discussed in detail and changes to the draft agreed upon. The group discussed possible overlap between the fishing gear technology working group and the sampling technology working group and concluded that while there may be technologies that would be common to both endeavors, the missions were distinctly different. The two groups should, however, share information on new technologies that may be applicable to both group's research needs. The NFTWG members discussed the current status of research on fishing gear technology and the general consensus was that there is a critical shortage of personnel within NMFS to conduct fishing technology research. There are industry, state, university, and private organizations conducting fishing technology research and the group stressed the importance of coordination and communication between these organizations and the NMFS Fishing Technology Working Group. The Group recommended that NFTWG meetings be rotated between regions in order to facilitate coordination and communication with non-NMFS researchers in each region. The group also recommended that the NFTWG have an advisory role in management decisions concerning bycatch/gear technology priorities and research direction. It was recommended that a permanent representative from both the Science and Technology and Sustainable Fisheries Division be included in the NFTWG to facilitate better communication and coordination with NMFS managers. The revised NMFS Fishing Technology Working Group Terms of Reference are provided in Appendix I.

**Review of Fishing Gear Technology Research**

**Fishing Technology Research by the Alaska Fisheries Science Center**

Through a mix of cooperative and direct research, NMFS scientists have assumed a critical role in the improvement of fishing technology used in Alaska waters, and aided such developments in other regions. Our efforts have emphasized NMFS capabilities that complement the efforts of industry, including specialized observation equipment, behavior research, and experimental, testing and analysis abilities. There are a growing number of opportunities to reduce fishery problems through improvements in fishing technology and NMFS is positioned to serve a critical role in such efforts, limited by staff and funding.

Federal fishing technology research in this region includes work by the Seattle Exploratory Fishing and Gear Research Base in the 50's - 70's. Gear development to facilitate fisheries expansions was emphasized, including midwater trawls, traps and survey gear. Some devices to avoid bycatch were also developed. *In situ* observations were made by scuba divers.

In the late 70's, the work was halted on commercial gears and limited principally to gear used in resource assessment surveys. Accomplishments during this period included prototype development and application of trawl mensuration equipment to monitor the performance of survey trawls. Such equipment was added as a standard element of trawl surveys in the late 80's, accompanied by increased standardization of trawling procedures.

Beginning in the late 80's, cooperative research with industry and other agencies brought the Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering (RACE) Division into an increasing role in studying ways to reduce bycatch through the modification of fishing gear, resuming historical work on commercial gears. Recognizing that fish behavior is key to the selection process, video systems were developed and used to remotely observe fish behavior in trawls. Observation capabilities also sped the development of prototype devices and methods for bycatch reduction. Observation systems include a range of video systems using ambient, visible and infrared lighting that can be operated either through cables or remotely recording.

These observation systems have been used to understand variation in fish behavior between species and under different environmental conditions. Where needed, separation concepts are developed with these observations and further tested and improved by observations on modified fishing gears and comparisons of catch rates. Industry developed concepts are similarly developed. All testing is done on commercial fishing vessels starting with gear similar to that used in the fisheries. Separation systems with sufficient promise are subjected to testing under full fishery conditions, generally in an exempted fishery in cooperation with industry.

Some examples of the devices developed and/or tested in this program are:

- Reducing halibut, cod and pollock bycatch in sole fisheries through opening the top of a section of the net ahead of the codend (intermediate section)

- Reducing halibut bycatch in sole fisheries with an industry-developed excluder grate in the intermediate section.

- Development of separate devices to exclude large and small halibut from cod trawls

In addition to commercial gear development, these systems have been applied to improving understanding of survey gear performance. Video observations have supplemented studies of herding of fish ahead of trawls and escape under the footrope, increasing our ability to understand and interpret the population estimates derived from surveys and the variability of those estimates. Sensors were developed by the Fishing Technology group to continuously monitor the contact of trawls with the seabed. Observation systems have also been developed to further studies of fish habitat and the effects of fishing gear on it.

Another section of the RACE Division, the Fisheries Behavioral Ecology Program, based in Newport, Oregon, has performed a range of laboratory studies to develop basic fish behavior information for use in understanding the fish selection and incidental mortality associated with fishing gears. Important results include the effects of physical factors (light level, temperature, air exposure, sea conditions) on fish escape, injuries and mortality. Fish size controls mortality, with smaller fish being more sensitive to stress. Delayed mortality appears to be important and must be considered in field and laboratory experimental design. There is also a wide variety of sublethal behavioral effects resulting from bycatch stressors which decrease predator avoidance capabilities and increase the probability for mortality of escapees and discards.

A number of other agencies and institutions have conducted fishing technology projects in the region, nearly all of which have availed themselves of the opportunity to use the equipment and/or expertise of the NMFS program. These have included:

- A Saltonstall-Kennedy (NMFS) funded project by the Alaska Fisheries Development Foundation (AFDF), and the Universities of Washington and Alaska to study the size selectivity and escapee mortality of pollock in the Alaska fishery.

- A joint project of the International Pacific Halibut Commission and the trawl industry to begin development of halibut excluders for trawls

- A joint project of the longline industry and the University of Washington to develop and test devices to prevent seabird bycatch on longlines

- Projects by Oregon Department of Fish and Wildlife to test fish excluders for shrimp trawls and a selective flatfish trawl and to study behavior of fish around fish pots.

Through cooperation with industry and other research groups, RACE division scientists have greatly increased the effect of a very small (in both personnel and funding) fishing gear research program on many fishery issues that can be affected by better understanding and performance of fishing gear, including bycatch, protected species interactions, and protection of essential fish habitat.

**Recommendations from 'Managing Bycatch' 1998 - Accomplishments**

A review of the fishing gear-related recommendations for bycatch for the Alaska region from the 1998 'Managing Bycatch' document shows some progress on each, with substantial opportunities for continuing work.

- Conduct research on the survivability (acute and chronic mortality) and recovery of bycatch species from stresses imposed by capture - Work with the AFDF pollock survival project produced initial estimates of survival escapee mortalities and developed methods and equipment for use in future studies of this type. A study was completed on the injury rates of red king crab that encounter and escape bottom trawl footropes on the seafloor. The Fisheries Behavioral Ecology Group has clarified a number of the environmental and fishing factors that affect fish survival after encountering fishing gear. There a still an abundance of species that encounter and escape fishing gear for which mortality has not been assessed, as well as the need to estimate the variability due to the range of fishing situations in the fisheries. As new methods are developed for avoiding bycatch through gear modifications, assessment of escapee mortality and modification to improve survival will be necessary development steps. Progress in this area has been severely limited by the personnel and funding requirements of such research.

- Increase industry's involvement in the development and testing of methods to reduce bycatch mortality - Elements of the Alaska groundfish industry have been very active in the development of bycatch reduction devices, in many cases in spite of substantial individual costs in efforts where benefits of the work are dispersed through the entire fleet. NMFS gear researchers have facilitated these efforts through providing needed equipment and services as well as participating in the development and conduct of exempted fishing projects to allow testing by industry. There is a synergy between government research and developments by industry. The early stages of concept development often involve high costs and risks that are not compatible with normal fishery operations. Use of developing and experimental fishing gear and observation equipment produces delay and catch losses, while the need to test the effect on bycatch species requires increased encounters with those species at rates that would trigger regulatory consequences in the open fishery. Even additional catch opportunities provided under exempted fishery permits often do not compensate for losses to participating vessels. Therefore, government participation and funding is most useful and often critical during earlier stages. As bycatch reduction devices proceed to the point of feasibility in the commercial fishery, industry is much more able to complete the remaining development.

- Improve technology transfer of bycatch reduction methods through reports, videos and workshops - All three of the mentioned communication tools have been used to inform Alaska fishers (as well as fishery mangers and other scientists) of the results of bycatch reduction research, in addition to one-on-one contacts with gear manufacturers and fishermen. There is considerable room for increasing and improving communication with the fleet and with that opportunities for improving both the research and the fishery.

**Outlook for Fishing Technology Research in the Region**

**Needs**

The Alaska fisheries are unique in the nation in having very intensive on-board observer coverage of the vast majority of the groundfish fishing effort. Thus, discarded bycatch can be estimated and accounted for in assessment and management. In most cases, however, no survival information is available to do more than make the conservative assumption that all discarded fish die.

There is no shortage of gear-related issues that could be addressed with enhanced fishing technology research in the prosecution and management of Alaska groundfish fisheries. These include bycatch reduction and mortality assessment, effects of fishing gear on seafloor communities and their reduction where needed, down to collecting basic information on specifics of current fishing technology in the fishery. A listing of potential projects follows.

Bycatch Reduction Developments

- salmon bycatch in pollock trawl fisheries
- crab bycatch in bottom trawl fisheries
- better size selection in sole fisheries (reduce discards)
- halibut bycatch in longline fisheries for cod
- shark bycatch in pollock fisheries
- skate bycatch in bottom trawl fisheries
- crab injuries (mortalities) from trawl bridle (sweep) encounters

Survival studies

- pollock, sole and cod escaping through meshes or excluders
- halibut escaping through excluders
- estimation of discard survival for all discarded species
- measurements of environmental factors (light levels, temperature, air time, sea state) in gear, through water column and on board ship during landing and sorting of catch to link results with laboratory studies and better understand the range of conditions that bycatch are exposed to in fisheries.
- measurements of fish size and body core temperatures of discarded bycatch to evaluate thermal history and relate this to environmental factors for making predictions of discarded bycatch stress and mortality.

Fishing gear surveys - Key specifics of gear used by fisheries

Effects of Fishing on Habitat

- Fishing intensity and distribution analysis
- Passive Gears - measurement of area affected while hauling gear - effects on habitat
- Reduction opportunities -
    - Off-bottom doors
    - harvest of pollock from very near the seafloor, while limiting seafloor contact
    - pot modifications to prevent seafloor effects

Improved communication with industry, management and other stakeholders

Improved technology for fish behavior observation

Most of the fishing effort in Alaska waters occurs in waters dark enough to A) prevent observation with even the most sensitive cameras without artificial light and B) alter fish behavior from that which can be observed at higher light levels. Thus, there is a serious disconnect between our ability to observe fish behavior relative to fishing gear and the conditions that those fish encounter in the fisheries. The AFSC program has pioneered the use of infrared illumination to provide some observational capabilities, but this is limited to very short ranges. New sonar systems have recently been developed that allow fish observations without light at an update rate and resolution sufficient to observe fish behavior. These systems are currently beyond the budget of existing FT programs to procure ($ 90,000), but would provide a breakthrough in relevant fish behavior studies.

**Outlook with current resources**

Current budgets allow continuation of work on this subject, but limit it to either pilot level studies on several of these areas or full studies on only one at a time over several years. We have taken the former approach and will work this year on salmon bycatch, crab injuries and effects of passive gears on seafloor habitats.

**Needs for fuller implementation**

Funds to procure $90,000 sonar video in 2002
One additional research biologist in 2003, one in 2004
Gear technologist in one of those years
Funding base increase of $200,000 in 2003, additional $400,000 in 2004

**Fishing Technology Research by the Northwest Fisheries Science Center**

**NO REPORT AVAILABLE**

**Fishing Technology Research by the Southwest Fisheries Science Center**

Fishing technology research at the Southwest Fisheries Science Center (SWFSC) since the 1970's was limited by a policy discouraging "fishery development" research. However the SWFSC has been active in developing gear modifications to reduce bycatch and especially to reduce interactions with protected species. Historically, the gravest issues have been those surrounded the taking of marine mammals, especially dolphins in tuna purse seine operations. Most recently the primary issues have been the take of albatross and sea turtles in longline fishing operations.

Purse seine fishing that targeted yellowfin tuna associated with porpoise in the eastern tropical Pacific was the focus of concerted fishing gear research at the SWFSC for over 3 decades. Porpoise tended to get stuck by the rostrum in the meshes of the seine as it was pursed and drowned when they could no longer get to the surface. With the expansion of purse seine fishing porpoise populations declined. An early solution to the problem was engineered by the U.S. purse seine fishery. This solution involved use of the "Medina panel" at the edge of the seine in a position that leaves the panel farthest from the fishing vessel as the net is pursed. This panel has smaller mesh than the rest of the seine to prevent snaring dolphins, and is used to create a sort of ramp from the vertical side of the seine to the upper edge of the seine. When used properly this technology was very successful at reducing porpoise kills, and widespread use helped lead to a recovery of porpoise populations. However, national mandates for marine mammal protection called for reducing porpoise catches to as close to zero as possible. The low level of dolphin mortalities that continued to occur in the U.S. fishery contributed to pressure on that fishery to depart from the eastern Pacific, while less regulated Latin purse seiners continued to set on porpoise.

The U.S. industry voluntarily adopted "dolphin safe" standards for tuna accepted for canning, while the U.S. government pursued treaties and trade sanctions to discourage the Latin American nations from setting on dolphins. The SWFSC continued to address the problem by conducting a wide variety of research efforts to develop "dolphin safe" purse seine fishing technology such as improved spotting technology for free-swimming tuna schools (e.g. radar, sonar, lidar) and use of fish aggregating devices (FADs). Purse seine setting on floating objects, including FADs, has a very low rate of interaction with porpoises but tends to catch smaller, less valuable tuna and has a much higher rate of fish and sea turtle bycatch than setting on porpoise. A steady increase in "dolphin safe" purse seine sets on floating objects led to problems with bycatch in the 1990s and eventually to international quotas for this fishing method to limit bycatch of juvenile bigeye tuna in the eastern Pacific.

One lesson learned from the tuna-porpoise fishing technology saga is that progressive and successful development of improved fishing technologies by U.S. fisheries may not help when national goals call for minimization of protected species interactions at any cost. Setting on dolphins with improved technology could have been sustained if the nation's policy had been to achieve a recovery of the porpoise populations. An amendment to Murphy's law also states that any technological solution to one problem (e.g. dolphin mortality) will simply lead to another (fish bycatch around floating objects).

The tuna-porpoise issue was one of several issues in which policy aspects of international bycatch problems plagued SWFSC efforts at technological solutions. A decade ago an international effort was launched by NMFS with Japan, Korea, and Taiwan to scientifically monitor bycatch in the high-seas drift gillnet fisheries, assess the impact of this bycatch, and develop bycatch mitigation strategies. Participation by the Honolulu Laboratory included placing observers on foreign vessels and measuring bycatch and persistence of "ghost" fishing by derelict drift gillnets. Midway into this international collaboration the U.S. spearheaded a United Nations ban on all such fishing on the high seas, alienating our research partners and terminating the research. Meanwhile the same fishing method continued to be used within the U.S. EEZ. The SWFSC continued working to develop gear modifications and sonic pingers to reduce bycatch of marine mammals in the coastal drift gillnet fishery for swordfish and sharks.

Work on insular fisheries technology for the central and western Pacific at the Honolulu laboratory focused mainly on fisheries for crustaceans and bottomfish. Deepwater shrimp trapping was developed to assess a newly exploited stock in a very short-lived fishery. Escape vents were developed for the lobster trap fishery in the Northwestern Hawaiian Islands. Bottom longline gear including hook timers invented by Honolulu Laboratory scientists was developed to gauge gear-saturation effects on CPUE surveys. These hook timers were later modified for research on pelagic longline fishing gear selectivity and hooked longevity of longline caught fish. Hook timer research showed that marlin, spearfish, and mahimahi caught on "deep" longline hooks were most often caught while those hooks "troll" through the mixed layer during longline retrieval and that such fish are seldom captured on hooks in or below the thermocline during daylight hours.

The recent focus of fishing technology research has been on mitigating longline gear interactions with albatrosses and sea turtles. Prior to the northward expansion of the Hawaii-based longline fishery in1989-92, interactions with seabirds were probably very rare, and turtle bycatch was probably less than 10% of what it became in the 1990s. In the last decade virtually all seabird interactions with the longline fishery were Laysan and black-footed albatrosses whose range and nesting colonies were north of the traditional tuna longline fishing grounds. From 1994 to 2000 the fleet was estimated to catch several thousand of each species of albatross each year. The short-tailed albatross is the only endangered bird that may possibly interact with the fishery. During this same period longline bycatch of about 400 sea turtles annually was predominantly loggerheads and leatherbacks, also caught mostly north of the traditional tuna longline fishing grounds. Area closures, an observer program, and a limited entry program were established in the 1990s to limit and monitor endangered sea turtle bycatch, with ancillary reductions of interactions with protected albatrosses.

Seabird deterrent research began at the NMFS Honolulu Laboratory in 1997 with limited testing of bird-deterring streamer lines aboard the NOAA ship *Townsend*

*Cromwell*. In 1999 the *Townsend Cromwell* tested the effectiveness of blue dyed bait, added weights, and towed streamer lines in reducing contacts between albatrosses and mock fishing gear (gear without real hooks). This study indicated that streamer lines reduced albatross contacts with fishing gear by about 70%, and that blue dyed bait or added weights reduced seabird contacts by about 90% for both albatross species. Commercial fishery testing of seabird deterrents was begun on regular commercial fishing trips in1998, under contract to the WPRFMC. This study documented the effectiveness of strategic offal discards, night setting, blue dyed bait, and towed streamer-lines for reducing interactions with albatrosses. Reduction of interaction rates with these deterrent measures for black-footed albatross ranged from 83% reduction (strategic offal discards) to 95% (blue dyed bait), and for Laysan albatross reductions ranged from 40% (night setting) to 91% (strategic offal discards).

Mandated seabird interaction mitigation measures proposed by the WPRFMC in 1999 focused primarily on modifications to fishing gear and operations, and required fishermen to select among 6 seabird deterrent measures (see albatross mitigation measures, below) when setting and hauling longline gear. However, a subsequent USFWS Biological Opinion of the Effects of the Hawaii-based Longline Fishery on the Short-tailed Albatross called for all longliners to use strategic offal discards and thawed, blue dyed bait. Longliners targeting tuna were also required to use a line setting machine and weighted branch lines. And those targeting swordfish were also required to set at night. The objective of the November 2000 opinion was to prevent taking more than 2.2 endangered short-tailed albatross per year (no takes have ever been observed). These mitigation measures became mandatory in March 2001, except that the specific provisions for swordfish longliners became moot because that style of fishing was banned to reduce sea turtle bycatch.

**Albatross mitigation measures**

Strategic Offal Discards are defined as discards of bird-attracting spent bait, offal, or other waste fish parts on the opposite side of a fishing vessel from where the fishing operation is being conducted. A very effective method developed by fishermen involves splitting and trimming fat-laden swordfish heads so that they remain afloat at some distance behind the fishing operations, drawing birds away from where baited hooks are being deployed or retrieved. The strategy is to discard at times when birds might be particularly vulnerable, such as when lines stray farther from the vessel's hull or are brought nearer to the surface while boating fish or removing tangles. Researchers originally expected to see a reduction in interactions when spent bait and offal was withheld. Instead they discovered that withholding increased the rate of interactions because birds attention remained focused on baited hooks.

Night setting was routine for Hawaii-based longline fishing operations that targeted swordfish, but when part of a set occurred around sunset or in twilight birds could still see and interact with baited hooks. Night setting is defined as waiting to start a set until at least an hour after sunset, and to finish it by sunrise. This measure is least effective for Laysan albatross, which seem more able to detect food in low light, including light produced by a fishing vessel. Longliners that target tuna usually set in daylight but tend to have very low rates of interaction with albatross due to their more tropical fishing grounds and the fact that they set slack main lines that submerge more quickly than the taught main lines set by longliners that target swordfish.

Blue dyed bait has only been effectively field tested in operations targeting swordfish using squid as bait. The normally white squid is much more difficult for birds to see when dyed blue with food coloring because it blends with the background sea color. Dying involves soaking the bait in food coloring which has the added advantage that the bait is thawed prior to use which causes faster sinking and makes it harder for albatross to reach. Dying bait a variety of colors was a practice developed by fishermen to increase the attractiveness of bait to target fish species. Fishermen noted a reduction in seabird interactions when using blue dye. Target fish catch rates seem to be at least as good as when undyed bait is used, and the food coloring is inexpensive. After hearing of its effectiveness in the Hawaii fishery the Japanese fleet began trying blue dyed bait as a seabird deterrent.

Towed streamer lines, also called "tori"(bird) lines were first developed by Japanese fishermen to reduce loss of bait to scavenging seabirds. They are the most widely applied mitigation measure in world longline fisheries. Streamer lines act as either a "scarecrow" or as an obstacle to the flight path of birds seeking to reach baited hooks trailing out behind a fishing vessel. Birds can avoid streamer lines when the vessel changes course or the wind shifts, drawing the streamer off of the immediate area of the baited hooks. Streamers can also become tangled in the fishing gear and broken. The suite of bird mitigation measures required in the Hawaii-based fishery is unusual in that streamer lines are optional, but this is because the other mandatory mitigation measures are so highly effective.

Weighted branch lines were common practice in the Hawaii-based fishery prior to any requirement for seabird mitigation measures. The formal definition calls for a standard weight located close to the hook on each branch line. This location may be somewhat more dangerous than the traditional weight location because it places the weight close to the hook where it may spring directly at fishermen when fish throw the hook.

Line setting machines are used to pull the main line off of the longline reel at a speed that is faster than the speed of the fishing vessel through the water. This produces slack in the main line so that it goes directly into the water. Without a shooter the main line is pulled off the reel by the drag of the water as the boat moves, and the main line is suspended in air for some distance behind the vessel. An even more effective mitigation device may be the underwater line setting machine. The Audubon Society and NMFS began testing an underwater line setting machine in cooperation with the Hawaii-based longline fishery in February 2002. Results indicate 100% success in eliminating albatross mortality and 98.8% success in eliminating albatross interactions with longline fishing gear.

Annual workshops on protected species interactions were initiated by the WPRFMC in 1996 with the first Albatross Workshop for Hawaiian Longline Fishers, which reviewed albatross biology, laws protecting seabirds, and mitigation techniques. The Australian book "Catch Fish Not Birds"was translated into Korean and Vietnamese and disseminated to Hawaiian longline fishers along with laminated cards with photographs of the three albatross species detailing mitigation techniques. A second Fishers' Workshop was convened in 1997 and a Black-footed Albatross Population Biology Workshop in1998. NMFS Pacific Islands Area Office (PIAO) began conducting annual Protected Species Workshops for fishermen in 2000 to provide fishermen with technical training in how to reduce the severity of protected species fishery interactions and mortality of albatrosses, sea turtles and marine mammals. Attendance at the workshops became mandatory for limited entry license-holders in 2001.

**Sea turtle longline bycatch mitigation measures**

The goal of this research is to develop methods to reduce longline bycatch and mortality of sea turtles resulting in 'sea turtle safe' longline fishing. Objectives are 1) to reopen the swordfish segment of Hawaii longline fishery and 2) to develop methods of 'sea turtle safe' longline fishing for transfer to foreign longline fisheries. Categories of research underway are: 1) Fishing experiments with Hawaii longline industry; 2) Sensory and behavioral research using captive sea turtles; 3) Tracking sea turtles with pop-up satellite tags; and 4) Sea turtle population simulation modeling.

Fishing experiments being conducted with the Hawaii-based longline fishery starting in 2002 were designed to test various gear modifications over 3 years. The largest effort was intended to test whether minor, economically viable alterations to fishing gear and operations would reduce turtle bycatch. This effort is not yet underway due to permit restrictions. Bycatch reduction testing requires substantial takes of sea turtles to detect significant effects. Other, major changes in fishing gear and operations are being tested to see if they are economically viable prior to testing for turtle bycatch reduction. The largest element of the fishing experiments would have involved about 12 swordfish longline vessels per year testing the use of blue dyed squid bait and branch lines arranged >40 fathoms away from float lines on half of 1,040 research sets per year, with the other half serving as the control. Support for this approach comes from experiments with captive turtles showing avoidance of blue-dyed bait and analysis of Hawaii longline fishery observer data showing that branch lines attached <40 fathoms from float lines catch the most turtles and have only average success in capturing target fish species.

An Endangered Species Act Section 10 Research Permit obtained by the Honolulu Laboratory in January 2002 allows several smaller experiments to be conducted, but the main experiment awaits evaluation of a similar experiment in the Atlantic. However, the Atlantic experiment was designed to test a more moderate gear change than the Hawaii-based experiment. Moreover, separate Pacific experiments are required because pelagic longline fishing strategies and tactics differ between the Atlantic and North Pacific Oceans. These differences in fishing strategies and tactics are related to fundamental differences in oceanic structure between the two oceans. The Atlantic fishery operates primarily at edges of the Gulf Stream in ecosystem influenced by relatively near shore environments and comparatively shallow habitats, whereas the North Pacific operates in two mid-ocean ecosystems that are markedly different from the Atlantic. The tuna segment of the Pacific fishery operates near the edge of a mid-ocean gyre ecosystem influenced by the North Equatorial Current, and the swordfish segment operates in the mid-ocean Subtropical Convergence Frontal system marking the boundary between the tropical and subtropical North Pacific.

The portions of the research that are underway in Hawaii are the testing of stealth (camouflaged) swordfish longline gear and deep daytime swordfish fishing to see if these modifications retain viable economic performance. Stealth gear will also be tested on tuna longline gear. Research is underway using hook timers and time depth recorders to document when and where turtle bycatch occurs most frequently in the sequence of longline deployment and retrieval. A piggyback project is also testing large (18/0) circle hooks for catching swordfish. Smaller circle hooks were tested by other researchers in 2000-01, but were found to be less effective in catching swordfish that the traditional J-hooks. Circle hooks may reduce the degree of injury to captured turtles.

As of May 31, 2002, five Hawaii longline fishing vessels on contract to NMFS have conducted about 140 research sets (33 deep daytime sets, 33 stealth swordfish sets, 33 normal swordfish sets conducted alongside the previous sets to serve as a control group, and about 40 sets with hook timers and circle hooks). Two additional vessels will conduct tests of stealth gear in tuna fishing operations this summer, bringing the total fishing effort to at most about 250 research sets this season. The first permit year will end July 31, 2002 or sooner depending on the mortality of sea turtles in the experiments. As required by special conditions of the permit, the experiments will cease if there is an observed or projected estimated post-hooking lethal take of 1.0 leatherback or 4.0 loggerhead sea turtles. These special conditions drastically reduce the research effort and the directed take of sea turtles far below the take totals included in the permit. The annual report on the research is due Sept 31, 2002. Start of the fishing experiments next season will be Dec 1, 2002..

There have been 2 loggerhead turtles captured and released alive so far in the experiments. Both turtles were taken by unmodified swordfish fishing methods (one by the control vessel operating alongside the stealth and deep daytime vessels, and one by a hook timer vessel). The vessels using modified fishing methods have not yet caught any sea turtles. All results to date are preliminary, but we can say that it was more difficult than anticipated to fish deep during the daytime. The deep daytime swordfish fishing method, as constrained by the capabilities of the vessel used, was not successful in achieving viable catch rates of the target species (swordfish). Preliminary results indicate that the initial stealth swordfish fishing gear was not as economically viable as normal (control) gear, but with some modifications, the stealth gear shows great promise of viable catch rates for target species. No results are available yet from hook timers. Preliminary results from testing large (18/0) circle hook versus J hooks shows increased catch rates for bigeye tuna using circle hooks, but substantially decreased catch rates for swordfish.

Experiments on captive sea turtles are being conducted to define physiological and behavioral differences between sea turtle and target species that may be used to develop new fishing gear and tactics to reduce sea turtle bycatch and mortality. Captive turtle work is being conducted in collaboration with academic experts and by NMFS scientists at the Hawaii Kewalo Research Facility and the Galveston, TX laboratory. Tests on captive sea turtles are being conducted to determine types of bait, and other components of fishing gear and tactics that may reduce bycatch of sea turtles but will not reduce catch of targeted species. Experiments are underway to evaluate the color and odor of natural and artificial baits that sea turtles may not be able to detect or which are repulsive to turtles. Experiments are also being conducted to evaluate various colors of light sticks (conventional and electronic) and the intensity of light sticks that may be undetectable by sea turtles. So far the research has shown that sea turtles are attracted to natural colored squid bait and to red-dyed baits. Tests also show that Kemp's ridley, green and loggerhead sea turtles clearly avoid blue-dyed bait. Captive turtle studies to evaluate potential deterrent effects of baits soaked in squid ink, urea, garlic, bitters, and Jabanero chili extract have been unsuccessful – turtles ate all of these baits. However, studies with empty and baited containers confirm that turtles are attracted to (and potentially repulsed by) odor emitting substances. Behavior experiments indicate that juvenile loggerhead sea turtles are attracted to conventional green light sticks but not pure yellow light sticks. Electronic light sticks generate pure yellow light and are part of the stealth fishing gear being tested by Hawaii longline fishermen.

**Recommendations from 'Managing Bycatch' 1998 – Accomplishments**

Pacific Pelagic & Insular Fisheries Recommendations

- <u>Increase research on immediate and post- release mortalities of animals encountering fishing gear</u>. Satellite tracking of sea turtles is revealing significant new information on sea turtle habitat, movement patterns, and post-hooking survival. Approximately 50 turtles have been tracked with conventional ARGOS transmitters. About 20 turtles have been tracked with 'pop-up' satellite tags. Argos transmitters indicate that post hooking survival predominates for many months after release and the pop-up tags will indicate whether post-release survival extends to 6 months or longer. Post hooking survival is being correlated with the condition of released turtles. New work with "pop-up" tags has also been initiated to measure post-release survival of longline-caught sharks and sportfishing released marlins.

- <u>Work closely with the Western Pacific Fishery Management Council to develop solutions to bycatch problems including transfer of knowledge and techniques to reduce bycatch of seabirds in the longline fishery</u>. As indicated above we have made very substantial progress on this and in similar work on sea turtles. The WPRFMC has been a major supporter and collaborator in this research.

- Develop mitigation techniques to reduce mortality of lobster bycatch. A successful study was published in 2002 which measured handling mortality associated with the Northwestern Hawaiian Islands lobster trap fishery. The study found means of minimizing mortality induced by handling on board the fishing vessel, but also concluded that discarded lobsters are subject to high predation from giant trevally which aggregate around the fishing vessels, and that total discard mortality might approach 100%. No feasible method has been developed to allow commercial fishers to discard lobster bycatch with a substantial survival rate. But the issue has become moot due to changes in harvest strategy.

- Develop and evaluate modifications to existing fishing gear to allow a reduction in the retention of the legal bycatch of small size classes of lobster. Aside from the effective lobster trap escape vents developed in the 1980s there has been no progress on this issue, largely because of a change in the harvest strategy which is now to allow retention of all lobsters (100% mortality) and reduce the quota to prevent excessive risk to the population. The previous management regimes assumed some survival of discarded lobsters but the new strategy does not. Meanwhile the issue is moot because the Northwestern Hawaiian Islands lobster trap fishery is now closed.

**Outlook for Fishing Technology Research in the Region**

The crucial problems relate to the closure of fisheries or fishery sectors to minimize impacts to protected species. To revive these fisheries will require technological innovations to fishing gear and tactics. Aside from the problems of policy which tend to make any level of endangered species interaction unacceptable, there will be a need for sustained funding to meet this challenge. Many of the fisheries that have not yet been closed are poorly monitored with respect to bycatch and interactions with protected species. Funding for more observer programs and continued funding for the existing observer program will be needed by the new Central and Western Pacific Region. Existing funding for sea turtle bycatch reduction of $3,000,000 annually has been provided by congressional add-on and will expire after FY 2003 (perhaps sooner). To meet responsibilities for reduction of bycatch and endangered species interactions will require a similar level of permanent base funding for the new Central and Western Pacific Science Center. Additional funding for albatross and lobster work is being acquired through funding for cooperative research with industry.

**Fishing Technology Research by the Southeast Fisheries Science Center**

The Southeast Fisheries Science Center has maintained a fishing technology capability since the inception of the Pascagoula Exploratory Laboratory in the early 1950's. This capability has been expanded over the years to include capabilities in observation equipment (Scuba, cameras, ROVs, sonars, etc), behavioral research, and staff specialist in fishing gear design, operation and construction. Research in the 1950s and 1960s was aimed at improving fishing gear and sampling gear technology. In the 1970's the fishing gear research unit began a program to address finfish bycatch in the penaied shrimp fishery. In the 1970s legislation was enacted to protect endangered and threatened sea turtle species and in the 1980s management plans to recover over fished stocks had direct impact on the commercial peneaid shrimp trawl fishery in the Southeastern United States. The shrimp trawl fishery was identified as a significant source of sea turtle mortality and discards of unwanted fish bycatch which impacts sustainability of managed fish stocks. To address these problems, intensive programs were undertaken to develop and implement sustainable fishing technologies. Research conducted by federal, state, and industry gear technologist between 1978 and 1988 resulted in the development and refinement of grid devices and webbing panels to allow escapement of sea turtles, and other bycatch from shrimp trawls. These devices collectively called turtle excluder devices (TEDs) were implemented by mandatory regulations into the shrimp industry in 1989. Although there was initially a significant resistance to the mandatory requirement of this technology, the industry has successfully implemented and perfected this technology.

The grid and panel devices reduce a significant portion of shrimp trawl bycatch but do not significantly reduce juvenile fish bycatch of important commercial fish species, which are under management regimes including red snapper (*Lutjanus campechanus Poey*), Spanish mackerel (*Scomberomorus maculates Mitchell*), and weakfish (*Cynoscion regalis Baloch, Schneider).* These species have been over fished and are under both state and federal management plans, which include regulations mandating reduction of shrimp, trawl bycatch mortality. In 1992 a cooperative research plan was implemented which included the identification, development, and evaluation of gear options for reducing fish bycatch in the Gulf of Mexico and Southeastern Atlantic shrimp fisheries. Between 1990 and 1996 one hundred and forty five bycatch reduction conceptual gear designs contributed by fishers, net shops, gear technicians, and biologist were evaluated. Sixteen of these designs were operationally evaluated on commercial shrimp vessels. Four designs have demonstrated potential to significantly reduce bycatch of managed fish species in the Gulf of Mexico and Southeastern Atlantic fisheries. The fisheye and extended funnel bycatch reduction devices have been implemented in the Southeastern Atlantic and the Gulf fisheye and Jones/Davis bycatch reduction devices have been implemented in the Gulf of Mexico. In 1999, NOAA Fisheries gear specialist from the SEFSC and Norwegian gear specialist collaborated on a research project investigating the responses of juvenile fish to water flow patterns in and around bycatch reduction device designs. This research has resulted in the documentation of a behavioral response to inclined water flow and horizontal grids, which has the potential to significantly improve the performance of bycatch reduction devices for juvenile fish. Research is ongoing to improve the efficiency of bycatch reduction technology in the Southeastern penaied shrimp fishery. This technology is also being transferred to other countries including Australia and Mexico which have similar fisheries.

In 2001, the NMFS Southeast Fisheries Science Center in cooperation with the U.S. Pelagic longline fishing industry, the Southwest Fisheries Science Center, the Northeast Fisheries Science Center, and the University of Florida began a research effort to investigate the feasibility of gear modifications and/or fishing practices to reduce the incidental capture of endangered and threatened sea turtles by pelagic longline fishing gears. NOAA Fisheries gear specialist are working with fishers, NOAA researchers from other NMFS regions, and state and university researchers to gain insight into fishing gear and fishing practices to develop mitigation measures to reduce turtle interactions with pelagic longline fishing gear. Prototype mitigation techniques are being developed using captive reared turtles in controlled experiments and evaluated on commercial fishing vessels in the Atlantic pelagic fishing grounds. Studies include evaluation of de-hooker and line cutter prototypes to allow removal of fishing gear from turtles, bait types and hook designs developed to reduce hooking of sea turtles, satellite tags to determine survival, distribution and behavior of sea turtles and operational changes in fishing practice to reduce turtle interactions.

**Recommendations from 'Managing Bycatch' 1998 – Accomplishments**

**Southeast Fisheries Recommendations**

- <u>Provide stable funding for research and development capabilities in gear technology</u>. Funding for research and development is dependant on year to year funding through research proposals from various sources. Long term base funding is needed to provide stable personnel capability and long term commitment to gear technology research.

**Atlantic & Gulf Pelagic Fisheries Recommendations**

- <u>Improve gear-handling techniques to reduce discard mortality</u> The U.S. pelagic fishing industry has implemented gear changes and operating procedures to reduce discard mortality, but there is no formal program to document the efficiency or improve the technology.

- <u>Conduct research on gear</u> Research is being conducted by the SEFSC on gear modifications and fishing tactics to reduce the interaction with and mortality of sea turtles by pelagic longline gear. More research effort is needed to address other bycatch species in the pelagic longline fishery.

- <u>Deployment methods that will reduce interactions between and mortality of protected species</u> This research is currently being successfully conducted by the SEFSC under a three year research program which was initiated in 2001.

- Work cooperatively with the fishing industry to transfer new knowledge and techniques between fishermen and researchers Significant progress has been made recently in this area through the cooperative efforts in developing mitigation measures for reducing sea turtle interaction with pelagic longline gear. Efforts are currently under way to develop a format for sharing new technologies and information internationally.

- Reduce bycatch and bycatch mortality of undersized swordfish and tunas Efforts are underway in this area through time and area closures, but there is a need for additional research into fishing techniques to reduce the bycatch of undersized swordfish and tunas, as well other bycatch species.

**Outlook for Fishing Technology Research in the Region**

There is an increasing need for fishing gear technology research in the Southeast Fisheries Center and for transfer of existing technology and expertise to other regions and internationally. The Southeast Fisheries Science Center has an active fishing gear technology transfer program to assist domestic and foreign fishers in implementing selective fishing gears and in developing gear improvements. There has also been an increased demand for assistance from other regions and agencies to address fishing gear related problems. Most recently the gear specialist in the Southeast Fisheries Science Center have assisted the U.S. Navy, the U.S. Corps of Engineers, the U.S. State Dept., the Australian fishing industry, the Canadian fishing industry, the domestic catfish aquaculture industry, and the Northeast Fisheries Science Center in conducting fishing gear research and development. The Southeast Fisheries Science Center is currently involved in a cooperative research program with the pelagic longline fishing industry, the Southwest Fisheries Science Center, the Northeast Fisheries Science Center, and the University of Florida to develop mitigation measures to reduce the interaction and mortality of sea turtle with pelagic longline gear. Work is ongoing in the Southeast Fisheries Science Center to further improve turtle excluder device efficiency and to improve bycatch reduction device efficiency for red snapper in the penaied shrimp trawl fishery. Gear technologist from the SEFSC are also working with other researchers on TRT's (take reduction teams) to address marine mammal interactions with fishing gear.

Critical fishing gear technology R&D issues currently not being addressed or need additional research are:

- Undersized swordfish and bluefin, tuna, sharks, and billfish (blue and white marlin, spearfish, and sailfish bycatch by the pelagic longline fishery
- Sea turtle interactions with scallop dredges
- Sea turtle interactions with pot gear
- Sea turtle interactions with fish trawling gear
- Discarding and survival of fish in the recreational fisheries

- Effect of fishing gear on critical habitat
- Marine mammal interaction with commercial fishing gears
- Improvement in bycatch reduction in the shrimp trawl fishery
- Bycatch in fish trawl fisheries

**Needs**

Long term funding for sustained capability in fishing technology research is needed. Only 40% of salaries and 20% of operations are base funded. Sixty percent of salaries and 80% of operations are funded through various sources of funding from annual project proposals. To meet the expected long term needs in fishing gear technology research, an annual funding increase of between $600,000 and $1,000,000 is needed.

**Fishing Technology Research by the Northeast Fisheries Science Center and the Northeast Regional Office**

Fishing technology research has a long history in the northeast. It began with exploratory fishing and gear research aimed at increasing catch levels. In the 70's the emphasis changed to conservation engineering and studies to support management decisions. Some of the research included investigations of sub-legal escape vents and degradable links for lobster pots, habitat impacts of hydraulic clam dredges, and the effects of ghost gill nets. In the early 90's a major project of the Northeast Regional Office (NERO) was the development and demonstration of the Nordmore grate for the northern shrimp fishery. The successful completion of this project significantly reduced the bycatch of juvenile groundfish in the small mesh trawls.

Fishing technology research in the groundfish fisheries that is directly conducted by the Northeast Fisheries Science Center (NEFSC) has been limited in recent years to research related to enhancing stock assessment data. The NEFSC has performed several studies to assist in gaining a better understanding of stocks of monkfish, loligo, ilex and scallops. These studies have been performed in cooperation with the commercial industry and have been conducted on commercial vessels.

Recent gear research in the regional office has mainly been aimed at solving the problem of the entanglement of whales and porpoises in fishing gear.

**Recommendations from 'Managing Bycatch' 1998 - Accomplishments**

- <u>Increase the level and broaden the scope of the fishery observer program sufficiently to allow qualitative estimates of discards of fishery resources and incidental catch of protected species, with acceptable levels of precision and accuracy for inclusion in stock assessments</u>. Previously the days at sea in the groundfish fishery were reduced due to cuts in funding for this program. Presently there is an initiative, tied to the amendment 33 lawsuit that may increase the amount of observer coverage this year to 5% and next year 10% of the groundfish trips in the Northeast. This initiative is dependent on increased funding for the observer program, which has not been approved.

- <u>At the discretion of the Regional Administrator, allocate additional observer sea-days to evaluate new or existing technologies or to certify modifications to existing gear to allow fisheries to proceed under the bycatch constraints or potential biological removal limits</u>. This has not occurred. Previously other agencies have hired their own observers or used their own staff to evaluate gear modifications.

- <u>Increase the ability to assess the population, ecosystem, social, and economic effects of discards, and the impacts of management alternatives developed to reduce them through integrated data collection and analysis systems</u>. Recently the NEFSC has solicited to hire an economist to assist with this work. This effort has not received much attention in the past.

- Increase research on acute and long-term mortalities of animals encountering fishing gears, but not retained. Specifically, evaluate the fate of animals that escape through net meshes, the hook-and-release mortality of recreational fishes, and the effects of bottom-tending mobile fishing gears on benthic communities. This effort is being accomplished with funding to researchers outside of the NEFSC in the form of grants. There are several programs that provide money to researchers for conservation engineering work. Personnel from the NEFSC have minimal involvement in this work. There has been no effort to assess the fate of animals that escape through net meshes in the Northeast and only minimal effort at assessing the mortality of recreationally caught fish.

- Increase regional conservation engineering programs to develop, test, and certify species- and size-selective fishing gears to address critical conservation programs in the region (e.g., groundfish, scallops, protected species). This program should make maximum use of existing expertise in states, universities and the industry. This effort is being accomplished with funding to researchers outside of the NEFSC in the form of grants.

- Develop effective information exchange and distribution programs to communicate with the industry, regulators, and general public concerning the magnitude of bycatch and efforts to reduce it. There are no dedicated staff who work on conservation engineering as it relates to the groundfish fishery. We do have staff that work on conservation engineering issues that are related to protected species.

**Outlook for Fishing Technology Research in the Region**

The NERO realizes the need for investigation of sea turtle bycatch in many fisheries in the region. The problems are being worked on cooperatively with the southeast region and with various states. More research effort is needed for this and other protected resource problems.

The NEFSC has no dedicated personnel who work on conservation engineering issues in the groundfish fisheries. Presently all the research is being conducted by State agencies or private organizations. A recognized problem in the Northeast is the lack of direction of the research. There appears to be a haphazard approach to funding conservation-engineering projects. With the addition of conservation engineering staff dedicated to conservation engineering issues in the Northeast, the NEFSC could have better control and focus in the funding priorities related to gear research.

## Needs

Presently the NMFS in the Northeast Region has no personnel dedicated to bycatch research, fishing technology research, or selectivity research with the exception of research being conducted to reduce the bycatch of marine mammals. The Northeast region is an area where other researchers outside of NMFS have traditionally conducted studies that address these topics, yet with little direction from NMFS. The Northeast region should look at developing a group of NMFS employees that direct and oversee gear research in this region. This group would be tasked with establishing research priorities, reviewing the credibility of the research being conducted, and bringing the research to fisheries managers. With adequate funding, this group could also perform cooperative research with the fishing industry that addresses research needs in the region.

## Review of New England groundfish fishery bycatch issues

## Introduction

The NFTWG invited researchers from state, university, and private organizations working on gear related projects in the Northeast region to present the results of their research and to provide comments and recommendations to the group on the New England groundfish bycatch problem. John Watson discussed the purpose, organization, and objectives of the NFTWG and explained the objectives of the meeting to the invited scientist. A general discussion followed which included clarification of the purpose and intent of the NFTWG. Discussion followed on the definition of bycatch and Ron Smolowitz suggested that NMFS clearly define bycatch in terms of fisheries interactions. Some definitions are inclusive of interactions with fishing gear that does not result in capture. Henry Milliken then gave a brief review of the New England groundfish fishery to the group and invited scientist.

Arne Carr, Massachusetts Division of Marine Fisheries gave a presentation on two experimental trawls designed to reduce the bycatch of cod in the yellowtail and winter flounder fishery and experimental designs to reduce bycatch of scup in the loligo fishery. He also presented results of evaluations of low cod bycatch gillnet designs. The results of these evaluations are presented in Appendix II.

Cliff Goudey, MIT Sea Grant College Program, gave a presentation on novel methods of reducing trawl bycatch (Appendix II). Cliff presented information on traditional techniques for reducing bycatch including exploiting size and shape differences and behavioral differences in target and bycatch species. He discussed re-defining bycatch (zero discard fisheries) and using the concept of dynamic management to direct effort in areas of high target/bycatch ratios. He presented information on the use of kites and fabric panels to manipulate and control trawl webbing configurations and the application of these techniques in developing gear modification techniques for reducing bycatch. Cliff also discussed the possibility of using stretch mesh sections with the trawl extension to improve selectivity of trawls, soft door designs, the application of groundfish pots, and bycatch problem areas for the Northeast groundfish fishery.

Joe DeAlteris, University of Rhode Island, gave a presentation on size selection in bottom trawls (Appendix II). The purpose of his presentation was to address what we know about size selection in bottom trawls for flatfish and what information is needed. He presented an excellent summary of size selectivity theory and presented data from several past and recent size selectivity studies. Analysis of data from these studies indicate that the selection factor (S.F.) appears to vary with fish size due to morphological changes in the ratio of fish girth to length. S.F also appears to vary with region due to differences in fish morphology based on feeding and spawning condition. He recommends that, scientist should determine S.F. with an error estimate so that they can statistically compare S.F.s from experiments with different mesh sizes and different regions.

Pingguo He, University of New Hampshire Sea Grant, gave a presentation on the development of a double grid system to reduce cod catch in flatfish trawls, research on a semi pelagic shrimp trawl, cod and flatfish separators using horizontal panels, and shallow gillnets.

Chris Glass, Manomet, gave a presentation on research being conducted on square mesh windows, behaviour of cod, selection curves by season, composite codends for reduction of bycatch and regulatory discards of cod, a grid system for reduction of cod bycatch and evaluations of hexagonal mesh for bycatch reduction.

Ron Smolowitz, Coonamessett Farm, presented the results of research on reducing the bycatch of groundfish in the scallop dredge fishery. (Appendix II).

Following the presentations by invited scientist the New England groundfish bycatch problem was discussed by the attendees and recommendations proffered. Attendees felt that significant progress is being made to address the New England bycatch problem, but that there are significant obstacles that are inhibiting the development of effective gear related solutions. Among the most significant obstacles expressed by all the participants in the workshop was the administrative burden involved in conducting required research. The permitting requirements for conducting fishing gear experiments was the single most restrictive burden identified. The participants made a very strong recommendation that the Sustainable Fisheries Act (SFA) be changed to ease the issuance of experimental permits. Legitimate research needs to be exempted from guidelines of SFA. One possible solution would be to allow commercial vessels to qualify as research platforms. Participants also expressed frustration with inconsistencies in the permitting process between applications.

There is also a problem in using commercial vessels for gear development research that are under regulatory restrictions limiting days at sea (DAS). Days at sea conducting experimental gear research should not be counted against the vessel quotas. DAS have been reduced to the point that no time is available for research from commercial vessels. Some participants stated that research in state waters is being held hostage by the National Marine Fisheries Service regional offices and that the responsibility for research in state waters should be placed with the state.

The participants expressed frustration over the subject of enforceability of regulations involving gear modifications to reduce bycatch. Fishery managers are using inability to enforce regulations as an "excuse" not to implement gear based techniques to reduce bycatch.

Participants also identified the problem of research results not being conveyed to management. There is an apparent disconnect between the researchers and the councils. It was felt that the NMFS Fishing Technology Working Group was a good start at addressing the national problem, but that there should also be a mechanism in each region to convey the results of research to the fishery management councils. The participants suggested that regional conservation engineering organizations should be formed to convey scientific findings to the councils. Another suggestion offered was the councils form gear technology committees. Plan development teams need to include personnel with gear expertise.

The participants also expressed concern that NMFS is not publicising the success of fishing technology research in addressing bycatch problems.

Other recommendations from the participants included:

- More industry bycatch data collection initiatives
- More "port meetings" to canvas industry on research needs
- More observer coverage
- Non catch mortality should not be included as bycatch
- More communication between regions to share expertise
- More personnel with gear expertise on committees
- NMFS needs to make a sustained commitment to gear technology research
- More support for responsible fishing programs (examples; FAO and DFO programs)

## APPENDIX I.   National Fishing Technology Working Group Terms of Reference

# NMFS National Working Group on Fishing Technology

## Agency Needs

Effective management and conservation of U.S. fishery resources requires protection of critical habitat and development of selective harvesting gear. Increasing demands on fishery resources and interaction of fishing gear with protected species requires the development of new innovative harvesting technology which minimizes environmental impacts and associated bycatch. Within NMFS, fishing technology research has been successful in developing innovative gear designs to mitigate impacts of fishing gear and maintain viable commercial and recreational fisheries. This research has generally been specific to different regions within the United States and in most cases has involved cooperative research with other agencies, countries, universities, and industry. The NMFS Science Advisory Board recognizes a need to promote better communication between the different science centers and regions within the NMFS and to focus fishing technology research on a national level. To meet this need the NMFS Science Advisory Board has recommended the establishment of the Fishing Technology Working Group.

## Mission

Promote the development and use of innovative technologies and methodologies to reduce the impact of harvesting and recreational fishing gear on critical habitats and improve selectivity of fishing gear by reducing bycatch and interaction with protected species.

Foster communication and collaboration regarding fishing technology research and the development of new technologies and appropriate application of existing technologies within NMFS and between NMFS and its partners.

## Composition

- One or more scientist from each of the five NMFS Science Centers and/or regions.

- One representative from NMFS Headquarters.

- Other participants which may be nominated by the Science Board.

- Experts from other government offices, universities, and the private sector to be invited on an ad hoc basis.

- Subcommittees will be established as necessary to address specific areas of interest and report back to the working group.

## Responsibilities

1) **Identify critical needs for fishing technology research and provide research and development leadership by:**

    - Identifying and examining current and past research efforts including related efforts within other agencies, industry and international organizations.

    - Identifying and prioritizing fishing technology research needs through cooperation with fishery managers and other fishing technology scientist.

    - Monitoring NMFS research activities which involve fishing technology.

    - Identifying requirements of technical assistance and training related to application of new technologies.

    - Preparing recommendations on how fishing technologies can be modified, expanded, and/or improved to support agency stewardship responsibilities.

    - Sponsoring, encouraging, and participating in fishing technology research and development.

2) **Identify costs and funding opportunities for technological innovation by:**

    - Evaluating the costs and benefits of developing and/or applying new research technologies.

    - Developing appropriate budget initiatives

    - Assisting in the development of new funding opportunities in collaboration with other organizations.

3) **Improve awareness of agency needs for fishing technology research by:**

    - Preparing and delivering and annual briefing to the NMFS Science Board apprizing it of fishing technology developments and needs and opportunities for collaboration and/or budget initiative development.

    - Provide data and information for presentations, briefings, and talking points for agency management and Congress.

4) **Provide information and consultation on fishing technology issues.**

## APPENDIX II. Presentations on Gear Research Project in the Northeastern United States

**Reducing the bycatch of the sacred cod**
**Two Experimental Trawls**
**Arne Carr**

Massachusetts Division of Marine Fisheries

- Ribas trawl
- Topless Trawl

Catch rates and analysis of cod, yellowtail flounder, and winter flounder catches

| | **Average Pounds per Hour Caught** | | | | | |
|---|---|---|---|---|---|---|
| | net type---- | **Standard** | **Ribas** | %reduced | Sig. (2-tailed) | |
| *Cod* | | 162.19 | 38.61 | 76.19% | 0.04 | |
| *Yellowtail* | | | | | | |
| | **Kept** | 127.75 | 91.76 | 28.18% | 0.1 | |
| | **Discard** | 31.52 | 15.88 | 49.61% | 0.02 | |
| | | | | | | |
| | net type---- | **Standard** | **Topless** | %reduced | Sig. (2-tailed) | |
| *Cod* | | 236.99 | 15.65 | 93.39% | 0.1 | |
| *Yellowtail* | | | | | | |
| | **Kept** | 214.94 | 126.26 | 41.26% | 0.1 | |
| | **Discard** | 46.97 | 12.49 | 73.40% | 0.1 | |
| *Winter Flounder* | | | | | | |
| | **Kept** | 36.64 | 25.11 | 31.46% | 0.17 | |
| | **Discard** | 3.98 | 0.82 | 79.50% | 0.01 | |

Reducing the bycatch of Scup
2001 Trawl Design

- Raised footrope
- Fish eyes with separation panels

Issues...

- Bycatch in the squid fishery
- Access to closed areas
- Offshore / inshore vessels and gear

2002 Funding through scup/squid set-aside

## Summer 2001 Results

| | Mean Catches (lb) | | | | | | | | Lengths (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vee Excluder | | | | Ring Excluder | | | | Vee Excluder | | | | | | Ring Excluder | | | | | |
| | **N** | **Avg** | **Range** | | **N** | **Avg** | **Range** | | | **Avg** | **Range** | | **Modes** | | **N** | **Avg** | **Range** | | **Modes** | |
| *Summer 2001* | | | Min | Max | | | Min | Max | | | Min | Max | | | | | Min | Max | | |
| **Scup** | | | | | | | | | | | | | | | | | | | | |
| Main codend | 15 | 0.00 | 0 | 0 | 6 | 2.42 | 0 | 7.7 | 0 | | | | | | 65 | 17.4 | 5 | 20 | 18 | |
| Side codends | 15 | 222.93 | 30.8 | 1452 | 6 | 472.21 | 35.2 | 1427.8 | 3275 | 24.2 | 7 | 37 | 19 | 23 | 3719 | 24 | 11 | 36 | 19 | 24 |
| % Removed | 15 | 100% | 100% | 100% | 6 | 99% | 98% | 100% | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| **Squid** | | | | | | | | | | | | | | | | | | | | |
| Main codend | 18 | 2.65 | 0.01 | 8.8 | 8 | 3.93 | 1.1 | 6.6 | 1025 | 6.53 | 2 | 15 | 6 | | 426 | 9.04 | 2 | 21 | 9 | |
| Side codends | 18 | 2.76 | 0 | 6.6 | 8 | 0.37 | 0 | 2.21 | 575 | 8.45 | 2 | 18 | 7 | | 70 | 8.79 | 4 | 16 | 6 | 14 |
| % Removed | 18 | 53% | 0% | 100% | 8 | 7% | 0% | 29% | | | | | | | | | | | | |

## October 2001 Results

| | Mean Catches (lb) | | | | | | | | Lengths (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vee Excluder | | | | Ring Excluder | | | | Vee Excluder | | | | | | Ring Excluder | | | | | |
| | **N** | **Avg** | **Range** | | **N** | **Avg** | **Range** | | | **Avg** | **Range** | | **Modes** | | **N** | **Avg** | **Range** | | **Modes** | |
| | | | Min | Max | | | Min | Max | | | Min | Max | | | | | Min | Max | | |
| *October-2001* | | | | | | | | | | | | | | | | | | | | |
| **Scup** | | | | | | | | | | | | | | | | | | | | |
| Main codend | 10 | 25.08 | 4.4 | 70.4 | 6 | 9.09 | 3.3 | 18.7 | 2998 | 10.3 | 6 | 24 | 9 | 20 | 1311 | 9.49 | 6 | 23 | 9 | |
| Side codends | 8 | 229.75 | 63.8 | 1098.9 | 6 | 435.08 | 245.3 | 714 | 6143 | 16.3 | 6 | 31 | 9 | 20 | 6288 | 19.3 | 6 | 32 | 9 | 20 |
| % Removed | 8 | 86% | 82% | 96% | 6 | 97% | 93% | 100% | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| **Squid** | | | | | | | | | | | | | | | | | | | | |
| Main codend | 10 | 13.88 | 7.7 | 28.6 | 6 | 11.47 | 9.84 | 17.2 | 2653 | 7.66 | 2 | 22 | 7 | | 1100 | 8.45 | 4 | 17 | 9 | |
| Side codends | 8 | 29.82 | 9.9 | 45.1 | 6 | 17.55 | 5.52 | 28.6 | 3013 | 8.86 | 2 | 18 | 10 | | 1430 | 8.96 | 4 | 18 | 9 | |
| % Removed | 8 | 69% | 59% | 77% | 6 | 58% | 36% | 70% | | | | | | | | | | | | |

Testing of Low Cod-Bycatch Gillnets:
Two Experimental Nets

•Dual Leadline: Usual floatline is replaced by another leadline
•Foamcore plus lead: Foamcore floatline with lead added every 30 ft

Results so far...

| | Catch Rates (lb/24 hr/300 ft net) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cod | | | | Yellowtail Fl. | | Winter Fl. | |
| | Dec/Jan | | May | | May | | May | |
| | **Kept** | **Discard** | **Kept** | **Discard** | **Kept** | **Discard** | **Kept** | **Discard** |
| **Net** | | | | | | | | |
| A | 17.43 | 0.27 | 16.06 | 0.06 | 0.59 | 0.07 | 1.39 | 2.10 |
| B | 3.49 | 2.50 | 5.74 | 0.43 | 9.50 | 1.51 | 3.95 | 13.44 |
| C | 12.01 | 5.58 | 8.47 | 0.54 | 8.95 | 1.68 | 5.62 | 13.20 |
| D | 6.26 | 3.21 | 5.38 | 0.64 | 8.72 | 1.23 | 4.08 | 9.60 |
| | | | | | | | | |
| A | Standard Standup Cod gear w/ floats | | | | | | | |
| B | Experimental - Net C with lead added to floatline every | | | | | | | |
| C | Standard Flatfish Gear w/ Foamcore floatline | | | | | | | |
| D | Experimental- Net C with another leadline instead of headline | | | | | | | |
| Shading indicates sign.difference between A and the other three, | | | | | | | | |
| | with no other differences | | | | | | | |

Now what?

- Ten more hauls just completed.
- Exp. Nets provide advantages: lower harbor porpoise bycatch?
- No floats = fewer large cod

**Novel methods of reducing trawl bycatch**

**Clifford A. Goudey**

Center for Fisheries Engineering Research
MIT Sea Grant College Program

Traditional options using trawl gear design

- **Exploit size/shape differences**
  - **Mesh size**
  - **Grates**
- **Exploit behavioral differences**
  - **Large mesh panels**
  - **BRDs (bycatch reduction devices_)**
  - **Separator panels (dual codends)**

Other ways of controlling bycatch

•**Re-definition -** it's not bycatch if it is landed and sold - ***zero discard fisheries***.
•**Dynamic management -** direct fishing effort to areas with high target/bycatch ratio.

**These approaches require a major shift in assessment/management methods**

Controlling trawl position and shape using fabric panels

•First used in U.S. in 1987 where a headrope kite was used to gain headrope height and lift the footrope well clear of bottom. Result was a low-horsepower squid-butterfish net that fished effectively while reducing bycatch (Goudey, 1987).
•**Current research thrust -** Use of fabric panels to reduce habitat threats of trawl gear

Why fabric devices?

•Unlike netting, solid panels can generate lift.
•Forces are proportional to $V^2$, therefore shape is independent of speed.
•Distributed devices reduce the need for hard-spot reinforcements and abrupt shape changes.
•Lightweight, low cost.
•No depth restrictions.
•Can be rolled on net drum.

**Sweep kites** - reaching bottom without weight

Triangular mesh kites for local lift and spread
Can such devices influence fish behavior?

Ribbon foil kites provide height and width to trawl body. This may alter perception by fish regarding trawl narrowing and escape opportunities.

Circular ribbon foil kites add diameter without requiring a rigid hoop

Can prevent mesh collapse in codends and extensions

Soft Trawl Doors

May offer a practical method of spreading a net without the use of bridles and groundwires.

Potential application in Shrimp and other non- herding species.

Stretch mesh catch controls

•Project idea from Nino Randazzo of Gloucester who was tired of dumping large hauls of cod. He sought a method that would increase extension mesh size once a certain amount of fish was in the codend.
•NEC provided development funds to try a stretch mesh extension constructed of bungee twine.

Stretch-Mesh provides regulation mesh size at the beginning of the tow.

Stretch-Mesh expands to increase escapement under a specified load.

Controlling bycatch using gear modifications may be counterproductive under the SFA due concerns over habitat impacts. The development of trawls that are species selective, even if possible, will result in unacceptable habitat risks.
A preferred method may be to focus on mesh size while carefully controlling small-mesh fisheries through area controls and using simple gear restrictions

Groundfish pots

•Size and species selective.
• High survival of discards.
• Habitat friendly.

Bycatch problem areas for NE groundfish

•Certifying small-mesh fisheries as groundfish rebuild.
• Quantifying groundfish bycatch in midwater fisheries operating in closed areas.
• Understanding catch and bycatch implications of latent permits (we need a better understanding of fishing power).
• Appropriate gear for re-activating permits (understanding the bycatch implications of passive methods).

**Size Selection in Bottom Trawls**
**Harvesting Flatfish in Southern New England**

**Joseph T. DeAlteris and Laura Skrobe**

University of Rhode Island
Kingston, RI

Presentation Outline
Purpose
Theory, Application, and Goal of Size Selection
Previous Work
Recent Field Studies of Analyses
Conclusions and Need for Future Studies

Purpose of this Presentation
Address the question: given what we know about size selection in bottom trawls for flatfish what more do we need to know and why?

Theory of Fish Size Selection in Bottom Trawls
For a given codend mesh size and shape; and a particular fish species

Application of Fish Size Selection in Bottom Trawls
If $L_{50}$ of size selection curve matches minimum legal fish size

## Goal of Fish Size Selection in Bottom Trawls

A. To control fish age or size of entry into fishery, so as to maximize yield per recruit.
=

Goal of Fish Size Selection in Bottom Trawls
B. To control fish age or size of entry into fishery, so as to maximize spawning stock biomass per recruit

Additional Theory of Fish Size Selectivity in Bottom Trawls

A. Extrapolate the results of a given mesh size and shape selectivity study to other mesh sizes of the same shape using selection factor (*SF*)

Assume ratio of fish girth to fish length is constant

Additional Theory of Fish Size Selectivity in Bottom Trawls

- B. Logistic cumulative distribution function (LCDF) is the model used to fit observed probability of retention values from an experiment

$$PL_L = \left(1 + e^{(-\alpha 2 * (L - L_{50}))}\right)^{-1}$$

Where: $PL_L$ is the probability of retention at length ($L$)

$\alpha 2$ is the steepness of the curve, and

$L_{50}$ is the length at 50% selection.

Additional Theory of Fish Size Selectivity in Bottom Trawls

•Therefore, based on *SF* and *a*2 estimated from previous size selection experiments, can predict a family of selectivity curves for other mesh sizes.

Previous Work

DeAlteris, J.T. and Grogan, C. 1997. An analysis of harvesting gear size selectivity for eight demersal groundfish species in the Northwest Atlantic Ocean. URI Fisheries. Tech Report No.1

Winter Flounder Diamond Mesh

| Source Study | Mesh Size | SF | |
|---|---|---|---|
| Smolowitz (1983) | 10.3 cm | 1.97 | 0.46 |
| | 13.3 cm | 2.08 | 0.35 |
| | 13.3 cm | 2.27 | 0.58 |
| Simpson (1989) | 7.6 cm | 2.30 | 0.84 |
| | 10.2 cm | 2.21 | 0.62 |
| | 11.4 cm | 2.15 | 0.50 |
| | 12.7 cm | 2.23 | 0.47 |
| Reifsteck (1990) | 12.0 cm | 1.96 | 0.76 |
| | Average | 2.15 | 0.57 |

Summer Flounder Diamond Mesh

| Source Study | Mesh Size | SF | |
|---|---|---|---|
| Lange (1989) | 14.2 cm | 2.29 | 0.72 |
| | 5.8 cm | 4.40 | 0.74 |
| | 14.5 cm | 2.60 | 0.79 |
| | 6.4 cm | 4.48 | 0.84 |
| | 14.1 cm | 2.51 | 0.35 |
| | 6.4 cm | 4.58 | 0.36 |
| | Average | 3.48 | 0.63 |
| | Mod Ave. | 2.46 | 0.60 |

Yellowtail Flounder Diamond Mesh

| Source Study | Mesh Size | SF | |
|---|---|---|---|
| Smolowitz (1983) | 10.2 cm | 2.12 | 0.69 |
| | 13.3 cm | 2.10 | 0.38 |
| | 13.3 cm | 2.30 | 0.37 |
| Harris (1994) | 14.0 cm | 2.48 | 0.40 |
| | 15.2 cm | 2.51 | 0.68 |
| Lux (1968) | 12.9 cm | 2.25 | 0.42 |
| | 14.5 cm | 2.21 | 0.28 |
| DeAlteris (1991) | 15.5 cm | 2.06 | 0.43 |
| Carr (1990) | 14.0 cm | 2.36 | 0.80 |
| Testaverde et al. (1990) | 14.0 cm | 3.06 | 0.34 |
| | Average | 2.35 | 0.48 |

Winter Flounder Square Mesh

| Source Study | Mesh Size | SF | |
|---|---|---|---|
| Simpson (1989) | 10.2 cm | 2.10 | 0.58 |
| Reifsteck (1990) | 12.0 cm | 1.74 | 1.11 |
| | Average | 1.92 | 0.85 |

Yellowtail Flounder Square Mesh

Summary of Previous Studies

| Source Study | Mesh Size | SF | |
|---|---|---|---|
| Harris (1994) | 14.0 cm | 1.98 | 1.52 |
| | 15.2 cm | 2.07 | 0.40 |
| DeAlteris (1991) | 15.5 cm | 2.01 | 0.31 |
| Carr (1990) | 14.0cm | 2.02 | 0.63 |
| | Average | 2.02 | 0.72 |

| Mesh Shape | Species | SF | |
|---|---|---|---|
| Diamond | Winter Flounder | 2.15 | 0.57 |
| | Summer Flounder | 2.46 | 0.60 |
| | Yellowtail Flounder | 2.35 | 0.48 |
| Square | Winter Flounder | 1.92 | 0.85 |
| | Yellowtail Flounder | 2.02 | 0.72 |

Results of Recent Studies on Larger Mesh

| Mesh Shape | Species | SF | |
|---|---|---|---|
| Diamond | Winter Flounder | 2.51 | 0.68 |
| | Summer Flounder | 2.70 | 0.48 |

| | | | |
|---|---|---|---|
| Square | Winter Flounder | 2.22 | 0.40 |
| | Summer Flounder | 2.49 | 0.46 |

Results of Recent Studies on Larger Mesh

| Mesh Shape | Species | SF | |
|---|---|---|---|
| Diamond | Winter Flounder | 2.30 | 0.42 |
| | Yellowtail Flounder | 2.52 | 0.73 |
| Square | Winter Flounder | 2.22 | 0.40 |
| | Yellowtail Flounder | 2.13 | 0.98 |

Results of Recent Studies on Larger Mesh
Skrobe, Beutel, and DeAlteris (2001) –
RI: 15.2, 16.5, and 17.8 cm mesh

| Mesh Shape | Species | SF | |
|---|---|---|---|
| Diamond | Yellowtail Flounder | 2.42 | 0.40 |
| Square | Yellowtail Flounder | 2.08 | 0.42 |

Comparison of S.F. Results of Previous and Recent Studies

| Species | Shape | Previous | Recent |
|---|---|---|---|
| Yellowtail Flounder | Diamond | 2.35 | 2.42 |
| | Square | - | 2.08 |

Comparison of S.F. Results of Previous and Recent Studies

| Species | Shape | Previous | Recent (RI) | Recent (MA) |
|---|---|---|---|---|
| Winter Flounder | Diamond | 2.15 | 2.5 | 2.3 |
| | Square | 1.92 | 2.2 | 2.2 |

Comparison of S.F. Results of Previous and Recent Studies

| Species | Shape | Previous | Recent (RI) | Recent (MA) |
|---|---|---|---|---|
| Summer Flounder | Diamond | 2.46 | 2.7 | 2.5 |
| | Square | - | 2.5 | 2.1 |

Conclusions

- S.F. appears to vary with fish size due to morphological changes in the ratio of fish girth to length
- S.F. appears to vary with region due to differences in fish morphology based on feeding and spawning condition

- Therefore, we should determine S.F. with an error estimate so that we can statistically compare S.F.s from experiments with different mesh sizes and different regions

S.F. Error Analysis

Management Application of Fish Size Selection in Bottom Trawls

+/- 0.1 error in S.F. results in +/- 1.8 cm error in $L_{50}$

Small errors in S.F. can result in substantial losses of legal fish to fishermen, or discards and waste of resource

Therefore, should collect new data for each mesh size, so as to assure resource managers and fishermen of agreement between mesh selection characteristics and minimum legal fish size

## Double Grid System to Reduce Cod Catch in Flatfish Trawls
## Bycatch and Discard

**Pingguo He**

University of New Hampshire Sea Grant

Work in Progress:
Double Grid Device to Reduce Cod Bycatch in Flatfish Trawls

Exploiting differences in behaviour of flatfish and cod inside a trawl net, a double grid selectivity device was designed and refined through flume tank testing. A short sea trial was carried out in the fall of 2001 on board a commercial fishing vessel in the Gulf of Maine. Results are very preliminary. Further sea trials are being carried out in the spring of 2002, and more planned for the fall of 2002 and spring/summer of 2003. Other projects being carried out in the University of New Hampshire related to fisheries conservation engineering include modification of gear to reduce seabed contact, and shallower flatfish gillnets to reduce cod bycatch.

## Bycatch Reduction in Gulf of Maine Groundfish Fisheries

**Christopher Glass**

Manomet Center for Conservation Sciences
81 Stagepoint Road
Manomet MA 02345

Manomet Center for Conservation Sciences is currently conducting a number of studies aimed at understanding the nature and extent of discarding in Gulf of Maine groundfish fisheries, and exploring innovative and novel approaches to mitigate bycatch and discard. In particular, we are investigating the effect of mesh size, mesh type, composite mesh codends and articulating excluder grids. All of the research is based on the philosophy championed by Clem Wardle of The Marine Laboratory Aberdeen, that is, an understanding of the natural behavior patterns and reaction behaviors of fish is the only logical entry point into the study and development of more selective fishing gears. To that end all of the studies outlined below has a major component of underwater videography aimed at understanding the reaction behavior of target and non-target fish. The approach is to identify species or size specific behavior patterns and to attempt to use this information to target only those fish which we want to catch and release all other fish underwater.

### Square-mesh extension window

Scup is an important commercial and recreational species in Mid-Atlantic and southern New England waters. A recent study by Manomet Center for Conservation Sciences confirmed scup as one of the main constituents of the discard in small mesh fisheries targeting squid, by assessing its rate of discard in the 1997 fishing season at 5 % of total weight landed. Manomet Center for Conservation Sciences (MCCS) and The Massachusetts Division of Marine Fisheries (MAMF) has shown that *Loligo* squid demonstrate specific behavior patterns when herded into towed trawl gear in the shallow inshore waters of Nantucket Sound. These specific behavior patterns allow squid to be separated from other important bycatch species such as scup and flatfish. Here we focus on squid fisheries in the Mid-Atlantic region, where bycatch and discard of scup in directed small mesh fisheries, has been identified as a high priority by the Mid-Atlantic Fisheries Management Council. NMFS imposed Gear Restricted Areas to restrict small-mesh fisheries as a way of reducing discard mortality for small scup. Our aim here is to use conservation engineering techniques to identify means of reducing inadvertent capture of undersized scup in small fisheries as a means of providing alternative management strategies to GRA's.

The specific objectives of this program of research were:

1. To determine what gear modifications can be made to reduce the catch of scup in small mesh nets;
2. To test the effectiveness of novel codend configurations (designed with input from fishing industry groups), against standard codend arrangements;
3. To develop modified fishing gear and/or fishing practices that reduce levels of bycatch and discard of undersized scup;

Four different designs were tested;

1. 4 ½ " diamond mesh window
2. 5 ½" square mesh window
3. 5 ½" square mesh window with a black tunnel
4. 5" diamond mesh extension window

Experiments 1. and 4. showed no decrease in bycatch of undersized scup. Experiment 2. showed a decrease in discard of scup by nearly 60% while the inclusion of the black tunnel proved insignificant in improving the effectiveness of the 5 ½" square mesh window.

The most obvious conclusion from this research is that nets **can** be redesigned in a simple way to reduce the bycatch and discard of scup. Inclusion of a 5 ½" square mesh extension section shows significant reduction in capture of undersized scup. In addition, there was no significant reduction in squid catch.

## Composite and hexagonal mesh codends

Traditional codends comprised of either square or diamond mesh have increasingly been demonstrated to be ineffective in releasing all undersized individuals particularly in mixed or multi-species fisheries. Square mesh codends are more effective at releasing roundfish while diamond mesh codends are more effective at releasing flatfish. Other countries, notably Denmark, Sweden, The United Kingdom and Ireland have introduced composite mesh codends (that is codends composed of a combination of mesh sizes and or configurations) into their fisheries management regulations to improve the selective efficiency of the codend. Manomet, Center for Conservation Sciences, The Massachusetts Division of Marine Fisheries and The Department of Marine Resources, Maine, have conducted preliminary trials with composite codend configurations and hexagonal mesh codends in the Gulf of Maine during 1998/2001.

At time of writing these studies are not complete but preliminary analysis indicates that a composite codend constructed with 6 ½” square mesh on the top panel and 6 ½” diamond mesh on the bottom panel reduces capture of undersized cod by almost 70% while not reducing catch of legal sized cod or flatfish. This configuration is showing tremendous potential and is the subject of further detailed investigation.

Conclusions

- Codend modifications can help reduce bycatch and discard of undersized fish
- Composite mesh codends significantly reduce bycatch and discard of cod – mainly by increasing L50
- Seasonality is an issue. Selectivity of codends is different at different times of year. This could be a significant problem for management plans.
- 6 in. Hex mesh appears to be very effective in reducing cod bycatch and discard although results are as yet preliminary.

***Cod excluder device (Ex-It)***

During the period immediately following the collapse of cod stocks in Iceland, innovative solutions were sought to help reduce cod bycatch. A bycatch reduction device called Ex-It was developed by Icelandic industry, science and Governmental collaboration. This device is now utilized on over 60% of the fishing fleet in Icelandic waters and has been demonstrated to effectively reduce the bycatch of undersized fish in fisheries from Iceland to Namibia. Manomet Center for Conservation Sciences, MaDMF, Maine DMR and DFO Canada have conducted studies on the effectiveness of this cod excluder grid in the waters of the northwest Atlantic during 2000 – 2002. Studies were conducted initially with a bar spacing of 60 mm although future studies will focus on bar spacings of 50mm, 60mm and 70mm. Work is ongoing but preliminary analysis shows dramatic reduction in bycatch of cod with the 60mm grid. However, there is also a noticeable reduction in catch of legal sized flatfish.

Conclusions

- Ex-It grid significantly reduces bycatch and discard of cod
- Also reduces catch of flatfish which may prove unacceptable to industry
- Results are comparable to Icelandic studies
- A new design with a lower guiding panel may be more effective and will be tested in 2002

**Dredge Modifications to Reduce Incidental Groundfish Catches In the Northwest Atlantic Sea Scallop Fishery**

**Ron Smolowitz**

Coonamessett Farm

Background

- 1994: 50,000 scallop DAS
- 2001: 25,000 scallop DAS
- Bycatch quantities unknown
- Bycatch species primarily flatfish, skates, and monkfish
- Gadoids are seldom caught

The Gear

- Vessels tow two 15-foot wide dredges
- Dredge frames weigh about 2500 lbs
- Bag constructed of 3.5-inch rings
- Twine top used to lighten the bag
- In 1994 twine top was 6-inch mesh
- Dredges are rigged with chains

Bycatch Reduction Ideas

- Windows in the twine top (rope back)
- Tickler chains on the bale
- Block between cutting bar and depressor
- Reduce towing speed
- Stop before hauling
- Noise makers

Twine Top Experiments 1996-7

- 10-inch diamond to 6-inch diamond (50 Tows)
- 8-inch square to 6-inch diamond (80 Tows)

Results of Twine Top Tests

- Scallops
  - No reduction with 8-inch twine top
  - Significant reductions with 10-inch twine top
    - 35% reduction of scallops > 90 mm
    - 52% reduction of scallops < 90 mm

- YT Flounder 8.7-24.6 fish/hr
  - 31-38% reduction with 8-inch twine top
  - 37-67% reduction with 10-inch twine top

Results of Twine Top Tests

- Skate 37.6-184.2 skate/hr
  - 16-23% reduction with 10-inch twine top
  - 26-70% reduction with 8-inch twine top

- Monkfish
  - Indications of some reduction with 10-inch

Speed Trial July 1999

- 5 knots vs 3 knots covering same ground
- 16 tow pairs

- Scallops: 2991 vs 992
- Skates: 163 vs 43
- Monks: 28 vs 29
- Flatfish: 125 vs 27
- Others: 31 vs 1

Hanging Ratio July 1999

- 10-inch twine top hanging ratio 1:1 vs 2:1
- 8 tow pairs

- Scallops: 10232 vs 10702
- Skates: 268 vs 327 22% reduction
- Monks: 81 vs 82
- Flatfish: 171 vs 230 35% reduction
- Other: 51 vs 88

Raked Dredge Oct 1999

- Raked dredge w/10-inch excluder panel vs 10-inch twine top
- 5 tow pairs

  - Scallops: 23.5 bu vs 24 bu
  - YT flounder: 82 lbs vs 174 lbs
  - Skates: 6.5 bu vs 10 bu

Raked Dredge   May 2000

- Raked dredge w/8-inch excluder panel vs 10-inch twine top
- 12 tow pairs
  - Scallops: 95 vs 105 bu   10% reduction
  - YT flounder: 327 vs 530   39% reduction
  - Skates: 434 vs 578   25% reduction

Raked Dredge   May 2000

- Raked dredge w/extra blocking vs 10-inch twine top
- 21 tow pairs
  - Scallops: 135 vs 149 bu   9% reduction
  - YT flounder: 442 vs 770   43% reduction
  - Skates: 1236 vs 1769   30% reduction

Excluder Panel   May 2000

- 8-inch excluder panel vs 10-inch twine top
- 11 tow pairs
  - Scallops: 53 bu vs 56 bu
  - YT flounders: 236 vs 250
  - Skates: 993 vs 1252 22% reduction

Fish Sweep   May 2000

- Fish sweep w/8-inch excluder panel vs 10-inch twine top
- 14 tow pairs
  - Scallops: 35 vs 63 bu   42% reduction
  - YT flounder: 73 vs 348   79% reduction
  - Skates: 138 vs 202   30% reduction

New Dredge Design

- Bale extends straight out 18 inches before tapering to tow point
- Distance from cutting bar to tow point remains the same
- Dredge is lightened by removing gussets and other reinforcing components
  - About 500 lbs lighter (new frame is 1900 lbs)

New Dredge Dec 2000

- New dredge w/fish sweep vs standard dredge w/10-inch twine top
- 16 tow pairs NLSA

  - Scallops: 461 vs 414 bu 11% increase
  - YT flounder: 99 vs 160 37% reduction
  - Skates: 316 vs 440 29% reduction
  - Other flats: 101 vs 134 26% reduction
  - Monks: 33 vs 30

New Dredge January 2001

- New dredge w/fish sweep vs standard dredge w/10-inch twine top
- 25 tow pairs CAI

- Scallops: 680 vs 576 bu 22% increase
- YT flounder: 26 vs 44 41% reduction
- Skates: 772 vs 879 15% reduction
- Other flats: 90 vs 127 40% reduction
- Monks: 96 vs 60 58-80% increase

New Dredge October 2001

- New dredge w/fish sweep and excluder rings vs new dredge w/10-inch twine top
- 27 tow pairs CAI

- Scallops: 481 vs 495 bu
- YT flounder: 337 vs 551 40% reduction
- Skates: 2002 vs 3359 40% reduction
- Winter flounder: 206 vs 394 48% reduction
- Monks: 584 vs 605

Gear Research Needs

- 10-inch vs 6-inch twine tops on standard dredge frames in high scallop concentrations
- New dredge w/fish sweep and excluder rings vs standard dredge w/6-inch twine top