NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Research Steering Committee

I. STATUS

A. Meetings: The Council's Research Steering Committee met on February 1, 2008 to further discuss its management review processes, but in particular to develop comments on the NMFS proposed rule to streamline and clarify the experimental fishery permit process (December 21, 2007); to develop research priorities for use in a 2008 Broad Agency Announcement (BAA)/Request for Proposals (RFP); and to begin mapping a process to develop a five-year plan for research priorities. The latter product will be referred to the SSC once it is completed.

The committee also conducted a management review of two final cooperative research reports:

- ***Testing of low profile, low cod bycatch gillnets: Phases I and II***; Michael Pol, MA Division of Marine Fisheries
- ***Survival of sub-legal cod in the Northwest Atlantic longline fishery***; J. Pappalardo, T. Rudolph, M. Sanderson (Cape Commercial Hook Fisherman's Association); H. Milliken (Northeast Fisheries Science Center) and M. Farrington (New England Aquarium).

II. COUNCIL ACTION

A. The Council should consider the recommendations of the RSC concerning the 2008 priorities for a possible BAA/RFP as well as the comments of the RSC concerning its review of the final reports.

II. INFORMATION

1. RSC meeting summary for February 1, 2008
2. Documents relating to priority-setting in previous years and CRPP- funded projects

2a. Council work priorities

3. NMFS proposed rule concerning the exempted fishing permit process
4. Research Steering Committee Policy for Incorporation of Research Results into the NEFMC Management Process
5. Final Report - *Testing of low profile, low cod bycatch gillnets: Phases I and II*
6. Final Report - *Survival of sub-legal cod in the Northwest Atlantic longline fishery*

#1

New England Fishery Management Council
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John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

Research Steering Committee
February 1, 2008
Waltham, MA
Meeting Summary

The Research Steering Committee (RSC), chaired by Council member David Goethel, met on February 1, 2008 at the Home Suites Inn, in Waltham, MA. Other Council members serving on the committee and in attendance were Doug Grout, David Preble and Dana Rice. Additional participating committee members included fishermen Richard Taylor and Curt Rice, Gib Brogan of *Oceana*, Michael Pol and Dr. Mike Armstrong of the MA Division of Marine Fisheries, Dr. John Hoey of the National Marine Fisheries Service's Cooperative Research Partners Program (CRPP) and Dr. Fred Serchuk from the Northeast Fisheries Science Center (NEFSC). New England Fishery Management Council (NEFMC) staff member Patricia Fiorelli also was present along with CRPP staff Dr. Earl Meredith.

Audience members included Carolyn Woodhead also from the CRPP, Paul Perra and Ryan Silva from NOAA Fisheries Regional Office (RO), Dr. John Annala from the Gulf of Maine Research Institute and Cape Cod MA gear technologist Ron Smolowitz.

Overview
The following agenda items were addressed during the meeting:

- Briefing on the status of NCRPP activities and 2008 funding for cooperative research
- Discussion about clarifying the RSC role in "steering research"
- Management review of two Northeast Consortium final reports:
  - ***Survival of sub-legal cod in the Northwest Atlantic longline fishery***; J. Pappalardo, T. Rudolph, M. Sanderson (Cape Commercial Hook Fisherman's Association); H. Milliken (Northeast Fisheries Science Center) and M. Farrington.
  - ***Testing of low profile, low cod bycatch gillnets: Phases I and II***; Michael Pol, MA Division of Marine Fisheries
- Development of comments on the NMFS proposed rule to streamline the experimental fishery permit application process
- Development of research priorities for use in a 2008 NMFS Broad Agency Announcement/Request for Proposals (RFP)
- Discussion of an approach to develop a five- year plan for fisheries research to support NEFMC management activities

Major points made during the RSC meeting are highlighted below.

Update on CRPP Activities
Dr Hoey briefed the committee on CRPP activities. He reported that the program is likely to be level-funded – that is, funding would be similar to last year's. Ongoing initiatives that been supported through CRPP have included the operations of the RSC, enhancement of the study fleet, the ME-NH Inshore Groundfish Trawl Survey, the NEAMAP (Northeast Area Monitoring and

Assessment Program) Survey (which, among other areas, covers a gap in the NEFSC bottom trawl survey between Montauk and Martha's Vineyard), cod-tagging (in order to make results available for the upcoming cod stock assessment) and the Marine Resource Education Program. While it maintains its status as a separate entity, funds for the Northeast Consortium (NEC) also are channeled through the CRPP. NEC funding was eliminated by Congress in 2008, a matter of great concern to the RSC given the level and quality of research it heretofore supported.

Additional NEFSC initiatives under consideration include a monkfish survey, a dogfish tagging initiative and workshop, a region-wide meeting of the parties involved in cod, haddock, yellowtail flounder and monkfish tagging, continued halibut tagging and squid mesh selectivity work. Given these possibilities, current needs and other aspects of the budget process, the possibility or level of funding for a competition (Broad Agency Announcement/RFP) is unknown at this time, according to Dr. Hoey.

Clarification of the RSC Role in "Steering Research" for RSA Programs

Following on the actions taken at the last Council meeting concerning the evaluation of proposals to be funded through its research set-aside programs (RSAs) and management reviews of RSA-associated final projects, the committee deliberated on the matter of the planned management review processes. Use of a workshop format with RSC involvement was suggested as an approach to address management reviews, but other remedies will be further discussed by the staff and committee. Any additional committee member comments on this issue will be coordinated by Patricia Fiorelli and the issue scheduled for further discussion at the next RSC meeting.

Final Project Reviews

The Research Steering Committee reviewed two final reports related to cooperative research. As outlined in the Council's Research Review Policy, the RSC is charged with reviewing final reports that are generated through cooperative and possibly other research activities in the Northeast Region and providing advice on whether results may be acceptable for consideration in the management process.

The reports reviewed at this meeting addressed two NEFMC research priorities --- for the first project, evaluate discard, bycatch and non-catch mortality rates; initiate special studies under experimental design protocols to calculate gear interaction or discard rates; and for the second, initiate gear research that enhances selectivity, targets healthy stocks, minimizes harvest losses and bycatch and improves fishing practices.

1). ***Survival of sub-legal cod in the Northwest Atlantic longline fishery***; J. Pappalardo, T. Rudolph, M. Sanderson (Cape Commercial Hook Fisherman's Association); H. Milliken (Northeast Fisheries Science Center), M. Farrington (New England Aquarium) and over 15 industry partners. Funded by the Northeast Consortium - $123,612. Two independent technical reviews were provided by the Consortium.

The PIs proposed to quantify the mortality of sub-legal sized cod on Georges Bank during various seasons and at various depths. Three to six vessels utilized hook and line to catch and then release sub-legal sized cod into cages that were monitored for 72 hours. The authors suggested that results could be used to develop a policy to minimize the bycatch mortality rate of sub-legal sized cod caught by bottom-set longlines.

Project Results
The committee concluded that it showed that mortality was not necessarily 100 percent (the underlying assumption), with mortality varying by temperature, depth and method of hook removal. Conclusions were somewhat complicated by discard mortality occurring in the control group in jig gear was used.

RSC Discussion
The committee agreed that project information did not lead to definitive results or a recommendation with respect to mortality rates for discards of hook caught fish. Further use in assessments, members suggested, must be determined by the appropriate scientific groups, perhaps accompanied by some feedback on its utility in this application.

There were added comments that the effort illustrates the difficulties in incorporating the results of this and any similar experiments into stock assessments. Even very controlled and perfectly orchestrated experiments in which handling techniques, time on deck, and duration of tow times, as well as depth and temperature are examined, document only the practices and circumstances of specific gear operating under the specific conditions, precluding fleet-wide extrapolations.

(As a technical matter it was further pointed out that results could *not* be definitive in terms of discard mortality because fish in this case were released in a cage, a scenario that provided protection not otherwise available to fish under normal harvesting conditions.)

Because of the technical difficulties associated with determining overall discards in most fisheries, such work may support "best practices" by prompting modifications to fishing activities to reduce either discards in general or discard mortality. An audience member pointed to another important issue identified by considering this project: that such studies may point to other types of research priorities; for example, more conservation engineering projects that focus on selectivity work in place of mortality studies.

The committee commended the PIs for their initiative in undertaking a follow-on experiment that corrected some deficiencies in earlier work and agreed to direct the report package to the Council's Groundfish Committees and its Plan Development Team for use as appropriate, as well as the NEFSC for consideration in the stock assessment process.

2) *Testing of low-profile, lowcod-bycatch gillnets: Phases I and II,* M. Pol (MA Division of Marine Fisheries), with industry partner R. MacKinnon. Funded by the Northeast Consortium - $71,710. In this case, three independent technical reviews were provided by the Consortium.

The PI and colleagues proposed using two experimental designs to reduce the vertical profile of flatfish gillnets and exploit a behavioral difference between cod and flatfish observed by fishermen and through video observations, which suggest cod do not often venture to the very bottom of the ocean, and flatfish do not often rise more than one foot above the bottom. The PIs suggested the ultimate use of the experimental nets, if proven, was to either allow fishing for flatfish in areas closed for cod, or to reduce the bycatch of cod in open areas.

Project Results
The RSC agreed the project was successful, demonstrating that the experimental nets reduced

catches of cod compared to standard flatfish gillnets by exploiting the behavioral differences between species, as anticipated by the investigators.

RSC Discussion

Despite the lengthy period of time it took to complete and move the project through the review process, members judged the work to be at least as relevant today as when the original award was made by the Consortium. What had been common practice in the fishery and information reported anecdotally was confirmed by the subjecting the hypothesis to experimental design and data analysis --- an approach that has been one of the underlying tenets of cooperative research.

RSC members agreed the experiment confirmed that reducing the vertical profile of gillnets has implications for protected species interactions as well as potential reductions in catches of groundfish stocks of concern without loss of targeted species.

In particular, the RSC wanted to highlight the second paragraph of PI Michael Pol's response to the technical reviews, noting that one reviewer may not have been familiar with the operations of the gillnet fishery for groundfish species in the Northeast. Overall, the committee agreed with the technical reviews, except where noted, and considered the work well done and successful. Members supported forwarding the package on to the Council's Groundfish Committee and its Plan Development Team (PDT) for their use as appropriate. Mr. Pol recused himself from this project evaluation.

Exempted Fishing Permit (EFP) Proposed Rule

The RSC discussed the National Marine Fisheries Service proposed rule concerning the experimental fishery permit application process. The intent of the rule is to revise regulations to be consistent with changes to the Magnuson-Stevens Act, clarify EFP regulations, and expedite the application process. The RSC review resulted in the following findings/recommendations:

1) The proposed rule's measures were difficult to understand, in particular the definition of "gear testing" as compared to "conservation engineering". The RSC would like the rule to explicitly clarify the term "gear testing with examples of how its definition, as proposed, would be applied versus the proposed rules defined "conservation engineering" activities in the Northeast.

2) The RSC also discussed at length what would be considered research activities under the proposed rule. Research activities can be conducted under a Letter of Acknowledgement (LOA) rather than an EFP, and the LOA has simpler and quicker processing requirements than an EFP. Therefore, bringing more activities under an LOA was viewed as desirable by the RSC. The proposed rule may allow for more "gear research activities" to be considered scientific research, a scenario that should reduce time and workload for applicants and NMFS to review and approve these activities.

3) The proposed rule notes that the public notice process (via the *Federal Register*) used by the Mid-Atlantic Council for its research set-aside (RSA) funded projects is incorporated into its annual FMP specifications process. Approved experiments are described and impacts analyzed in the specifications packages which are then subject to public review and comment periods, thereby streamlining the process to review and issue those EFPs. The proposed rule exempts Mid-Atlantic RSA project proponents from the need to apply for a separate EFP, as well as the associated *Federal*

Register notification procedure. This exemption does not apply to the NEFMC process. Further, the RSC members viewed its possible inclusion as unnecessary and confusing item because most NEFMC fisheries do not have annual FMP specifications. Also, they noted that including the EFP public review period in NEFMC FMP fishery management actions would further complicate the development of major fishery management actions and supported the continuance of current EFP notification process.

4) The proposed rule would allow for NMFS observers and biological technicians to sample fish on commercial vessels without an EFP, but would require university and other fish sampling programs to have an EFP. This distinction is an impediment to research and should be addressed to promote partnerships to accomplish cooperative research not create roadblocks.

5) The proposed rule maintains the NEPA review requirements for issuing EFPs, thus keeping the process administratively burdensome. The RSC does not have a specific substitute to recommend, but believes, again in keeping with the Congressional mandate to expedite the issuance of experimental fishing permits, that the NEPA process is not the model to use. Alternatives should be explored and substituted.

6) The proposed rule would allow NMFS to charge a fee for issuing EFPs. The RSC was not in favor of charging a fee for EFPs.

7) Because the proposed rule actions are extremely confusing, it is difficult to understand how they would affect EFP policies in the Northeast. The RSC strongly recommends a description (for example, a side-by-side comparison) of how the EFP application process is presently implemented in the Northeast Region compared to the changes outlined proposed rule.

Overall, the RSC judged the proposed rule to be unclear in many cases and in need of further work in general if it is to expedite cooperative research. Further it does little, as charged by Congress, to promote a regionally based process.

Research Priorities for Inclusion in a NMFS BAA/RFP or Use by Other Funders

The RSC agreed to forward the recommendations listed below to the Council to address cooperative research priorities for use in a 2008 NMFS Broad Agency Announcement/RFP (should one be issued) or by other institutions that fund cooperative research in the Northeast. In the area of conservation engineering:

1. Develop gear that would separate haddock from all other species in the Eastern U.S./Canada Area;
2. Develop species selective gears that will reduce the capture of dogfish and reduce the capture of skates (in particular thorny skates) in fisheries where these species are taken as bycatch; and
3. Develop and implement a data collection/monitoring program that would promote accurate fine-scale spatial accounting of all catch components of the multispecies fishery (to include landings, bycatch and discards).

Multi-Year Research Priorities for Approval by the SSC

The committee began work to develop research priorities for an initial five-year period, in keeping with the reauthorized Magnuson Act. The plan should address fisheries interactions, habitats, and other areas of research that are necessary for management purposes. The plan will be submitted to the Council's SSC for final approval.

#2

For Priorities Discussion
RSC Meeting 2/1/08
Groundfish and Skate PDT Recommendations
Not Listed in Order of Priority

Groundfish (A13) Priorities

1. Synthesis of available information/research results to improve utility to managers (in particular related to A13 priorities *5, *6, and *8).

2. Development of a management strategy evaluation program. (This is a specific approach to address scientific and management uncertainty — a hot topic in fisheries literature right now.

3 Investigations into stock definition, stock movements, mixing, and migration, such as through tagging studies, DNA markers, morphological characteristics, etc. Effect of assumptions on stock definition, movements, mixing, and migration on stock assessments.

4. Methods to improve sampling of commercial catch at age data, such as through cooperative NMFS/industry programs to supplement port agents.

*5. Investigations into relationships between stocks, including predator/prey relationships and evaluation of whether stock status of some species is slowing rebuilding of groundfish stocks.

*6. Comparative studies on the impacts (positive and negative) of gear on habitat, such as the different impacts between chain nets, roller gear, and rockhopper gear, etc. Studies on whether limiting roller or rockhopper gear, or specifying other aspects of trawl gear, results in areas of complex habitat that are not used by trawl fishermen.

7. Development of appropriate programs to collect information required for social and economic impact analysis.

*8. Research on extent and composition of discards and bycatch in the groundfish fishery, including research to estimate discard mortality rates by gear for groundfish.

9. Research fishing practices or gear modifications that may change the ratio of component catch species or improve selectivity of gear. As an example, research should consider ways to catch flatfish and not roundfish, or ways to target haddock and not cod.

10. Research on bycatch and discards of groundfish in other fisheries, including small mesh fisheries, and fishing practices or gear modifications that may reduce bycatch or improve selectivity of gear.

11. Quantify the impacts of closed areas, and evaluate the effectiveness timing closures to coincide with spawning activity (e.g. Gulf of Maine rolling closures).

12. Development of industry-based information collection systems to improve information used for groundfish management.

Skate Priorities

1) Discard mortality studies (e.g., tagging studies) on commercial vessels in various fisheries—determine rates by gear type, area, season, depth, and bottom type for all seven species with an emphasis on overfished species (thorny, winter, barndoor, and little skates).
2) Gear research on trawls, gillnets, and dredges to improve skate selectivity and skate discard survival, including designs that would reduce incidental catches of skates in non-directed fisheries (primarily trawl and gillnet), while maximizing the catch of target (non-skate) species.

3) Development of effective species identification methods for fishermen, dealers, and port samplers. This could include an inexpensive biochemical/genetic assay method, better training, and better morphological keys for juvenile skates.
4) Directed skate research trips to survey and study:
   a) species distribution (particularly in waters deeper than sampled by the NMFS survey),
   b) catch (species) composition,
   c) collect biological samples and fill in remaining gaps in age, growth, maturity, and fecundity of managed skates,
   d) predator/prey interactions and trophic interactions between skate species in the complex and between skates and other bottom species that occupy the same habitats, and
   e) electronic tagging and telemetry to address short- and long-term movements, migrations, stock structure, habitat use, and growth rates.
5) Investigate the influence of physical factors (including environmental changes) on shifts in range and distribution of species within the skate complex.

Shaded priorities added by the Groundfish PDT since the publication of Amendment 13 to the Northeast Multispcies FMP.

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April 17, 2007

Dr. Nancy Thompson
Science and Research Director
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543

Dear Dr. Thompson:

At its meeting last week, the New England Fishery Management Council discussed and approved priorities for 2007 cooperative research. Focusing its attention on a single priority, members voted to support the Research Steering Committee's (RSC) recommendation that the highest priority for 2007 consist of analyses of the cod and yellowtail flounder industry-based survey data so that as much relevant information as possible, as specified by the scientists conducting the benchmark assessments, is available for the August 2008 Groundfish Assessment Review Meeting.

The Research Steering Committee had the benefit of an excellent briefing by Dr. John Hoey of the Northeast Cooperative Research Partners Program (NCRPP), including information about the status of current funds and projects that have been identified by the Northeast Fisheries Science Center as its priorities, and a full discussion at the March 29, 2007 committee meeting.

While cod and yellowtail flounder data analyses are not cooperative research projects *per se*, the RSC, with Council concurrence, considers such an effort the final step in using information collected via several of the major cooperative research pilot programs supported by the Council over the last several years and funded through the NCRPP.

The Council appreciates the opportunity to provide input to the Center and your consideration of this request. As always, I am available to discuss the issue further if you have any questions.

Sincerely,

Paul J. Howard

Paul Howard
Executive Director

cc: Patricia Kurkul - NOAA/NMFS

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February 16, 2006

Ms. Patricia Kurkul
National Marine Fisheries Service
One Blackburn Drive
Gloucester, MA 01930

Dear Pat:

At its January/February Council meeting the New England Fishery Management Council approved by consensus a number of research priorities for 2006. These were based on recommendations forwarded by the Council's Research Steering Committee following a discussion of the information needs in the Northeast.

Based on their importance to management decision-making, the following were considered to be high priority projects for funding in 2006. The recommendations themselves are not listed in any order of priority.

1. A peer review of both the cod and yellowtail flounder industry-based survey (IBS) projects, given that they have been in operation for several years. The committee suggested that all east coast IBS surveys in general should be examined in a workshop format so that they might be better integrated into a coast-wide, coordinated effort.

2. Data analysis for the current cod and yellowtail flounder industry-based survey (IBS) and cod tagging programs, short-term bycatch-related projects that involve the study fleet program, fishing power experiments to address vessel calibration (if survey results are to be used to calculate indices of abundance) and other projects that might complement these long-term programs.

3. Along with the other industry-based survey projects, equal consideration of the ME-NH inshore groundfish survey as a funding priority. This recommendation was based on the high quality of the data collected in a unique area, size and age information obtained on of a range of species that is not available through other surveys and the belief that funding for this effort should not be dependent on a competitive grants process.

4. A critical review of all the recent conservation engineering projects (separator trawls, rope trawls, escape panels, sweepless nets, etc.). The suggestion was made to conduct this effort in a workshop format and include principal investigators and fishermen as participants.

5. The collection of economic and social information on the recreational sector of the groundfish fishery, particularly in relation to issues such as the impacts of potential requirements such as electronic monitoring and a national registration system for recreational fishermen.

6. Coastal pollution studies to better support ecosystem-based approaches to fisheries management.

We have made significant progress toward building partnerships through the hard work of the Regional Office and its staff, along with the Northeast Fisheries Science Center and the participation of the Research Steering Committee. As you know, the Council remains committed to supporting cooperative research and continuation of the long-term programs and appreciates the opportunity to provide input. Please feel free to contact the Council staff or me if you have any questions concerning the recommendations provided in this letter.

Sincerely,

Frank Blount

Frank Blount
Chairman

New England Fishery Management Council
Research Priorities
2005

Northeast Multispecies (Groundfish)

Investigations into stock definition, stock movements, mixing, and migration, such as through tagging studies, DNA markers, morphological characteristics, etc. Assess the effect of assumptions on stock definition, movements, mixing, and migration on stock assessments.

Investigations into relationships between stocks, including predator/prey relationships and evaluation of whether the stock status of some species is slowing the rebuilding of groundfish stocks.

Research on the extent and composition of discards and bycatch in the groundfish fishery.

Research on fishing practices or gear modifications that may change the ratio of component catch species or improve selectivity of gear. As an example, research should consider ways to catch flatfish and not roundfish, or ways to target haddock and not cod.

Research on bycatch and discards of groundfish in other fisheries, including small mesh fisheries, and fishing practices or gear modifications that may reduce bycatch or improve selectivity of gear.

Sea Scallops

Projects should address the current area rotation management program, as well as protected species interactions. Examples include:

- Discard reduction
- Estimation of factors affecting fishing power
- Ways to control predation on scallops
- Quantification of fishing costs related to fishing in specific areas (e.g. fishing gear modification, steaming time, and opportunity costs)
- Research to actively manage spat collection and seeding
- Identification of scallop habitat and ecological relationships, including those enhanced/impeded by area closures
- Social and economic impacts and consequences of closing areas to enhance scallop productivity
- Sea turtle interactions and gear research
- Affected habitat research

Herring

Continue to develop and utilize the inshore and offshore hydroacoustic and trawl surveys to provide an independent means of estimating stock sizes. Collaborative work between the National Marine Fisheries Service, the Canadian Department of

Fisheries and Oceans, state agencies, and the herring industry concerning acoustic surveys for herring should continue to be encouraged.

Develop tagging and morphometric studies to explore uncertainties in stock structure and the impacts of harvest mortality on different components of the stock. Although tagging studies may be problematic for assessing survivorship for a species like herring, they may be helpful in identifying the stock components and the proportion of these components taken in the fishery on a seasonal basis.
Investigate bycatch/discards in the directed herring fishery through at-sea and portside sampling.

Synthesize predator/prey information and conduct investigations to address information gaps; investigate the role of herring in the Northwest Atlantic ecosystem and the importance of herring as a forage species for other commercial fish stocks; assess the importance of herring as forage relative to other forage species in the region.

Continue commercial catch sampling of Atlantic herring fishery (there is a potential lack of funding after the 2004-2005 season) according to ACCSP/Maine Department of Marine Resources protocols.

Habitat

Provide high-resolution benthic/sediment mapping of mid-Atlantic and New England areas to assist in better identification and descriptions of biogenic structure and biological communities associated with different physical habitat types.

Develop a mechanism for fishing industry-supported, high-resolution sediment mapping in the Gulf of Maine and Georges Bank, using the Canadian sea scallop industry mapping effort as an example to establish a process for similar mapping efforts in U.S. waters.

Monkfish

Research to minimize bycatch, specifically, bycatch of monkfish and other species in directed monkfish fisheries, including sea turtles and other protected species.

Research to minimize impacts of the fishery on EFH or other sensitive habitats.

Research on monkfish biology or population structure, specifically:

(1) a program, such as a reward program, to collect samples of large (>120 cm total length) monkfish from commercial fishing vessels to improve reliability of age and growth estimates and natural mortality assumptions; and
(2) additional tagging studies as a basis for evaluating adult movement across depth strata, spatial segregation by sex, and rates of growth.

Red Crab

Port Sampling of Landed Crabs (Size Structure)

The Red Crab Fishery Management Plan (FMP) does not regulate a minimum allowable size for red crab landed in either the controlled access directed fishery or the open access incidental catch fishery. A downward trend in the size of the crabs landed could have significant implications for the sustainability of the resource. The FMP suggested several ways to collect information on the size structure of landed crabs:

- A voluntary sub-sampling program in which participating controlled access vessels will report the size of a sample of all crabs harvested
- An observer program for this fishery
- A port sampling program that reports the size structure of landed crabs

Handling Mortality

"Handling mortality" is the rate of mortality to red crabs that results from being brought to the surface, handled, and returned to the seafloor. There are no precise estimates of the magnitude of handling mortality, but high handling mortality would indicate a large percentage of the discarded females and small males would die even though they are returned to the sea and not landed.

- Mark/recapture studies performed under typical fishing conditions should be designed and implemented in order to better estimate handling mortality.
- Other approaches could include a cage being sent to the bottom and hauled back to assess survivability.

Stock Assessment

The current status of the red crab resource is unknown. This information is critical not only to assess the status of the resource and determine whether or not the species is overfished, but also to better understand and monitor the effectiveness of the FMP. Funding should continue for ongoing projects that address this need.

Skates

Discard mortality studies (e.g., tagging studies) on commercial vessels in various fisheries: determine rates by gear type, area, season, depth, and bottom type for all seven species with an emphasis on overfished species (thorny and barndoor skates).

Collect information on and determine skate survivability where possible (e.g., tagging programs).

Develop estimates of skate bycatch rates in other fisheries (e.g., multispecies, scallop and monkfish fisheries). In addition, undertake gear selectivity experiments to reduce regulatory discards of skates in other directed fisheries (possibly to expand on gear work being performed in the monkfish and scallop fisheries).

CRPP Funded Projects: Categories & Council Priorities 2000-2006

Project Name	Research Category	Year Funded	Level of Funding ($)	Council Priority # 1	Council Priority # 2	Council Priority # 3
Strategic Planning to Design a Collaborative Cod Tagging Program	Strategic Planning/Scoping	2000	$110,786	improve stock id and delineation, esp. for GOM and Georges Bank cod	improve the exchange of info between f/men and scientists	
Near term observations of the effects of smooth bottom net trawl fishing gear on seabed	Habitat	2000	$150,990	measure effects of gear on habitat & reduce negative impacts	effects of mobile gear on newly settled or near-zero year classes of managed species	
The Effects of Mesh Size and Shape on Size of Selectivity in the Multispecies Fishery	Conservation Engineering	2000	$122,700	improve mesh size selectivity & escapement info	develop methods to reduce bycatch	monitor discards
Testing Bycatch in an Observer-Based Experimental Shrimp Fishery Conducted in an Area of Higher Groundfish Concentration	Conservation Engineering	2000	$152,334	document bycatch mortality	develop methods to reduce bycatch	
Design a Whiting fishery in the GOM that meets conservation goals for size selectivity and bycatch	Conservation Engineering	2000	$201,732	develop methods to reduce bycatch	improve mesh size selectivity & escapement info	monitor discards, including regulatory
To Organize Seven One Day Workshops On Industry-Based Surveys And Study Fleets	Strategic Planning/Scoping	2000	$24,690	improve stock asess. through industry-conducted resource surveys	improve exchange of info between f/men and scientists	ask f/men how to improve the quality of fisheries data
Correlation of Silver Hake abundance with bottom water temps/stock ID using Microsat DNA	Stock ID / Genetic	2000	$79,916	develop methods to collect & integrate ecosystems info into fisheries mgmt	improve stock id and delineation	map habitat and integrate info with landings data
A Proposal To Conduct A Series of Scoping Meetings To Discuss Bycatch Reduction Techniques With Fisherman And The Fishing Industry	Strategic Planning/Scoping	2000	$76,743	improve the exchange of info between f/men and scientists	develop effective and efficient methods to reduce impacts of unwanted bycatch	ask f/men how to improve the quality of fisheries data
A High-Resolution Industry-Conducted Fishery Resource Survey	Industry Based Survey/ Fishery Independent	2000	$570,088	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info. on resources in inshore-areas	improve exchange of info between f/men and scientists
Gulf of Maine Inshore Trawl Survey	Industry Based Survey/ Fishery Independent	2000	$503,301	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info. on resources in inshore-areas	enhanced port and sea sampling including quality & comp. of discards
A collaborative Program to Assess Possible Temporal Access to Closed Area II: Targeting Yellowtail Flounder Without Significant Bycatch of Cod and Haddock	Special Access Programs	2001	$500,000	develop methods to reduce bycatch	monitor discard, including regulatory	improve exchange of info between f/men & scientists
Expanding the Use of the Sweepless Raised Footrope Trawl in Small-Mesh Whiting Fisheries	Conservation Engineering	2001	$60,113	develop methods to reduce bycatch	monitor discards	evaluate discard, bycatch, and non-catch mortality
Development of a Fishermen-Designed Electronic Logbook System for the Northeast Multispecies Fishery	Study Fleet/ Fishery Dependent	2001	$67,658	ask f/men how to improve quality of fisheries data	improve exchange of info between f/men & scientists	studies focusing on improving effectiveness of regs
Ongoing Study Expansion - Smooth Bottom Net Trawl Fishing Gear Effect on the Seabed: Investigation of Temporal and Cumulative Effects	Habitat	2001	$212,785	measure effects of gear on habitat & reduce negative impacts	integrate ecosystem info into mgmt	obtain better fine-scale info on resource status in inshore areas
Soft Species Seperation System for the New England Multispecies Fishery	Conservation Engineering	2001	$297,874	develop methods to reduce bycatch	monitor discards, including regulatory	enhance collection of bio. info through industry participants
Gulf of Maine Inshore Trawl Survey	Industry Based Survey/ Fishery Independent	2001	$332,455	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info. on resources in inshore-areas	enhanced port and sea sampling including quality & comp. of discards

Characterization of Bycatch Reduction from Codend Mesh Size Increases in the Directed Scup Bottom Trawl Fishery	Conservation Engineering	2002	$48,898	develop methods to reduce bycatch	improve mesh size selectivity & escapement info	evaluate discard, bycatch, and non-catch mortality
Improving the Selective Efficiency of Trawl Gear with Escape Windows and Visual Stimuli	Conservation Engineering	2002	$174,956	increase fishing gear selectivity	evaluate discard, bycatch, and non-catch mortality	obtain detailed info on fishing power
Development of Video Techniques for Bycatch Reduction Study	Conservation Engineering	2002	$67,060	to document & mitigate bycatch mortality	obtain detailed info on fishing power	develop methods to reduce bycatch
Codend Mesh Selectivity in the Gulf of Maine Multispecies Trawl Fishery	Conservation Engineering	2002	$246,341	increase fishing gear selectivity	document & mitigate bycatch mortality	obtain detailed info on fishing power
Gloucester MA Trawl Selection Study	Conservation Engineering	2002	$135,027	increase fishing gear selectivity	evaluate discard, bycatch, and non-catch moratality rates	improve exchange of info between f/men and scientists
A Collaborative Program to Test the Use of a Cod/Haddock Separator Panel in Trawl Nets	Conservation Engineering	2002	$273,000	increase fishing gear selectivity	evaluate discard, bycatch, and non-catch moratality rates	improve exchange of info between f/men and scientists
Assessing the By-catch of Groundfish in the Monkfish Fishery	Conservation Engineering	2002	$147,920	document bycatch mortality	enhance collection of bio. info through industry	improve exchange of info between f/men and scientists
Development of a GIS for the Atlantic cod IBS	Industry Based Survey/ Fishery Independent	2002	$100,000	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Industry-Based Survey for GOM Atlantic cod distribution	Industry Based Survey/ Fishery Independent	2002	$850,980	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Industry-Based Survey for Southern New England yellowtail flounder distribution	Industry Based Survey/ Fishery Independent	2002	$739,189	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Phase 1: Implementation of a Pilot Study Fleet- Working with CCFHA, Manomet, GMRI	Study Fleet/ Fishery Dependent	2002	$1,915,947	improve stock assessments through use of study fleets	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Tagging Cape's Cod	Cod Tagging	2002	$932,750	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Cod Tagging - George's Bank	Cod Tagging	2002	$259,180	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Tagging Study of Atlantic Cod in the Gulf of Maine: Cashes & Fippenies Ledge, and Mount Desert Island out to Brown's Bank	Cod Tagging	2002	$412,684	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Building the Infrastructure for a Successful Cod Tagging Program in the Gulf of Maine, Georges Bank, and Southern New England.	Cod Tagging	2002	$945,103	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	implement cod tagging program on a local or regional level, with an entity to coordinate tagging, outreach & tag return and data management
Eastern Gulf of Maine Inshore Community Based Tagging of Atlantic Cod	Cod Tagging	2002	$35,475	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Video Examination of the continuous change in the habitats of closed areas of George's Bank	Habitat	2003	$99,910	projects related to marine habitat research	evaluate effectiveness of area closures as tool to protect and rebuild stocks	integrate ecosystem info into mgmt
Development of Species Specific Essential Habitat Indices Using Biological and Habitat Data Collected Using Remote Sensing	Habitat	2003	$296,025	projects related to marine habitat research & EFH	conduct industry-supported sediment mapping & id bio communities assoc with mapped areas	projects related to marine habitat research

Assessment of Benthic Community Recovery in the Western Gulf of Maine Closed Area	Habitat	2003	$155,565	determine relationships between sediment & bio communities	investigate the benthos and conditions that contribute to post-settlement groundfish survivability	evaluate effectiveness of area closures as tool to protect and rebuild stocks
A Quantitative Assessment of Substrate Changes Due to Scallop Dredging in the New York Bight and Associated Recovery Rates	Habitat	2003	$73,345	projects related to marine habitat research	measure effects of gear on habitat & reduce negative impacts	projects related to conservation engineering and environmental impacts
Reproductive Life History and Essential Fish Habitat Mapping of Western Georges Bank Cod: GIS mapping of eggs, larvae and juvenile cod	Habitat	2003	$257,167	projects related to marine habitat research and EFH	identify life history & time and areas of spawning as determined by industry	identify major nursery areas and characteristics
Define Monkfish Trawl Exemption Areas & Monkfish Trawl Gear That Will Reduce Groundfish Bycatch & the Frequency Of Deployment On Groundfish Habitat	Conservation Engineering	2003	$374,409	develop effective & efficient methods to reduce bycatch	measure effects of gear on habitat and reduce negative impacts	investigate marine habitat; essential fish habitat; & anthropogenic influences affecting the abundance or distribution of the NE multispecies fishery
Habitat - Dependent Catch Composition and Food Web Dynamics with Respect to long-term and Rolling Closures in Stellwagen Bank	Resource Dynamics	2003	$250,000	improve understanding of predator/prey interactions and food habits	compare impacts of trawling to a variety of habitat types	evaluate effectiveness of area closures as tool to protect and rebuild stocks
An Industry-Based Characterization of Essential Fish Habitat in the Western Gulf of Maine	Habitat	2003	$193,700	investigate marine habitat and essential fish habitat	investigate conditions & benthos that contribute to post-settlement survivability	integrate ecosystem info into mgmt
Identifying Habitat Association of Early Juvenile Cod in Nearshore Gulf of Maine Waters	Habitat	2003	$180,000	investigate marine habitat and essential fish habitat	id nursery areas and their characteristics	obtain better fine-scale info on resource status in inshore areas
Identification of Juvenile Groundfish Habitat within Nearshore Waters of GOM	Habitat	2003	$257,607	investigate marine habitat and essential fish habitat	id nursery areas and their characteristics	obtain better fine-scale info on resource status in inshore areas
Industry-Based Survey for GOM Atlantic cod distribution	Industry Based Survey/ Fishery Independent	2003	$688,371	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Industry-Based Survey for Southern New England yellowtail flounder distribution	Industry Based Survey/ Fishery Independent	2003	$606,326	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Cod Tagging - George's Bank	Cod Tagging	2003	$311,664	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Tagging Study of Atlantic Cod in the Gulf of Maine: Cashes & Fippenies Ledge, and Mount Desert Island out to Brown's Bank	Cod Tagging	2003	$476,684	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Eastern Gulf of Maine Inshore Community Based Tagging of Atlantic Cod	Cod Tagging	2003	$35,000	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	enhanced collection of bio. data through industry participants
Testing the Selectivity of Gillnets to Target Haddock in the Gulf of Maine	Special Access Programs/ Conservation Engineering	2004	$77,917	increase fishing gear selectivity	develop methods to reduce bycatch	obtain detailed info on fishing power
Cooperative, industry-based and scientifically controlled at-sea experiment to test the performance of a haddock-separator trawl in GB Closed Area I	Special Access Programs/ Conservation Engineering	2004	$297,614	development of B DAS programs	improving fishing gear selectivity	evaluate discard, bycatch, and non-catch mortality rates
A Rope Separator Trawl for Haddock and Pollack using "B" Days-at-Sea in the Inshore Western Gulf of Maine	Special Access Programs/ Conservation Engineering	2004	$214,585	development of B DAS programs	improving fishing gear selectivity	evaluate discard, bycatch, and non-catch mortality rates
Examining the Efficacy of the Haddock Separator Trawl in Eliminating Cod Bycatch in Limited Areas within Closed Area I and Closed Area II	Special Access Programs/ Conservation Engineering	2004	$440,000	development of B DAS programs	improving fishing gear selectivity	evaluate discard, bycatch, and non-catch mortality rates

Using Hook and Line to minimize cod bycatch in a directed haddock fishery on Georges Bank and in the GOM	Special Access Programs / Conservation Engineering	2004	$300,000	development of B DAS programs	improving fishing gear selectivity	evaluate discard, bycatch, and non-catch mortality rates
Bycatch Reduction in the Directed Haddock Bottom Trawl Fishery	Special Access Programs	2004	$422,000	development of B DAS programs	improving fishing gear selectivity	evaluate discard, bycatch, and non-catch mortality rates
Feasibility of Successful "B Regular Day" Programs: Social, Enforcement, and Data Factors	Special Access Programs	2004	$33,100	development of B DAS programs	conduct studies focusing on mgmt & enforcement issues	methods to integrate f/men's knowledge into mgmt
Development of a GIS for the Atlantic cod IBS	Industry Based & Survey/ Fishery Independent	2004	$39,000	improve stock asess through industry conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Industry-Based Survey for GOM Atlantic cod distribution	Industry Based Survey/ Fishery Independent	2004	$210,000	improve stock asess through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Industry-Based Survey for Southern New England yellowtail flounder distribution	Industry Based Survey/ Fishery Independent	2004	$210,000	improve stock asess through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Phase II: Implementation of a Pilot Study Fleet- Working with CCFHA, Manomet, GMRI	Study Fleet/ Fishery Dependent	2004	$906,248	improve stock assessments through use of study fleets	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Gulf of Maine Inshore Trawl Survey	Industry Based Survey/ Fishery Independent	2004	$249,999	improve stock asess through industry-conducted resource surveys	obtain better fine-scale info. on resources in inshore areas	enhanced port and sea sampling including quality & comp. of discards
A Fisherman-led Fishing Gear Workshop for Non-fishermen	Outreach	2005	$27,724	improve the exchange of info between f/men & scientists	methods to integrate f/men's knowledge into mgmt	develop an understanding of f/men's views of future of fishing
Design and Test of a Topless Shrimp Trawl to Reduce Finfish Bycatch in the Pink Shrimp Fishery	Conservation Engineering	2005	$131,237	develop methods to reduce bycatch	conduct research on fishing practices and gear that improves selectivity, analysis of bycatch and discards.	obtain detailed info on fishing power
An Assessment of Escape Vent Selectivity, Bycatch & Discard Survivability in the NE Fishery for Deep Water Red Crab	Conservation Engineering	2005	$100,198	address handling mortality of discarded red crabs	conduct research on fishing practices and gear that improves selectivity, analysis of bycatch and discards	provide enhanced port and sea sampling info through industry, including discard info
A Social Study of the Gulf of Maine Lobster Industry	Socioeconomic	2005	$98,491	develop databases to better evaluate socioeconomic impacts of mgmt measures	Identify socioeconomic issues of fishing households & communities, working conditions, community dependence on fishing, safety & views of the future, & social relations linked to fishing;	conduct surveys that investigate the expenditure impacts of the fishing industry in New England, locations of expenditures, localized input/output analyses
Effects of the Western Gulf of Maine Closure on Boulder and Deep Mud Habitats	Habitat	2005	$85,000	monitor & evaluate effectiveness of area closures as a tool to protect & rebuild stocks	provide identification and descriptions of biogenic structure and communities assoc. with different habitat types	projects related to marine habitat research & anthropogenic influences affecting abundance/distribution of groundfish
"Staying Alive: Promoting a Culture of Safety at Sea in the New England Fishing Industry	Outreach/Safety	2005	$124,440	identify socioeconomic issues of fishing households & communities, working conditions, community dependence on fishing, safety & social relations linked to fishing	develop understanding of f/men's views of future of fishing	improve the exchange of information between f/men & scientists
A Cooperative Research Project to Develop Gear Modifications for the Herring Midwater Trawl Fishery to Minimize Haddock Bycatch	Conservation Engineering	2005	$143,302	investigate bycatch/discards in directed herring fishery at-sea and portside	increase fishing gear selectivity	obtain detailed info on fishing power
Evaluation of Hook Size and Shape In the Catch of Sublegal Cod and Haddock in the Recreatoinal Fishery	Conservation Engineering	2005	$82,200	conduct research on fishing practices and gear that improves selectivity, analysis of bycatch and discards	develop methods to reduce bycatch	obtain detailed info on fishing power
Deploy and Host the Industry Based Survey Website	Outreach	2005	$10,000	improve the exchange of information between fishermen & scientists		

Industry-Based Survey for GOM Atlantic cod distribution	Industry Based Survey/ Fishery Independent	2005	$193,000	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Building the Infrastructure for a Successful Cod Tagging Program in the Gulf of Maine, Georges Bank, and Southern New England.	Cod Tagging	2005	$193,000	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	implement cod tagging program on a local or regional level, with an entity to coordinate tagging, outreach & tag return and data management
Gulf of Maine Inshore Trawl Survey	Industry Based Survey/ Fishery Independent	2005	$169,905	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced port and sea sampling including quality & comp. of discards
Improving the Accuracy of Length and Weight Information for the Angling Category Atlantic Bluefin Tuna Fishery	Resource Dynamics	2006	$62,855	investigate fisheries stock structure, movements, and relationships, including predator/prey relationships	obtain life history information	improve the exchange of info between f/men & scientists
Haddock Harvesting Technologies: Workshop and Conference	Outreach	2006	$29,456	review Cons. Engineering projects in a wkshop format	conduct research on fishing practices and gear that improves selectivity, analysis of bycatch and discards	improve the exchange of info between f/men & scientists
Biological Sampling, Behavior and Migration Study of Atlantic Halibut in the Gulf of Maine	Resource Dynamics	2006	$152,111	investigate fisheries stock structure, movements, and relationships	obtain life history info	enhanced collection of bio data through industry participants
Demonstrating A Risk-Based Approach To Rapid Vulnerability Assessments In New England Fishery Communities	Socioeconomic	2006	$131,902	develop databases to better evaluate socioeconomic impacts of mgmt measures	identify socioeconomic issues of fishing households & communities, working conditions, community dependence on fishing, safety & views of the future, & social relations linked to fishing	conduct surveys that investigate the expenditure impacts of the fishing industry in New England, locations of expenditures, localized input/output analyses
Marine Resource Education Program: Serving the Needs of the Marine Community and Documenting Case Studies of Program's Impact	Outreach/ Education	2006	$97,741	improve the exchange of info between f/men & scientists	conduct studies that focus on mgmt and enforcement, compliance, & improving effectiveness of regulations	enhanced collection of bio data through industry participants
Industry-Based Survey for GOM Atlantic cod distribution	Industry Based Survey/ Fishery Independent	2006	$851,221	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced collection of bio. data through industry participants
Building the Infrastructure for a Successful Cod Tagging Program in the Gulf of Maine, Georges Bank, and Southern New England.	Cod Tagging	2006	$180,226	improve stock id and delineation, esp. for GOM and Georges Bank cod ; continue data analysis for current program, and id. related short-term projects	investigate fisheries stock structure, movements, and relationships, as well as bycatch and discards	implement cod tagging program on a local or regional level, with an entity to coordinate tagging, outreach & tag return and data management
Gulf of Maine Inshore Trawl Survey	Industry Based Survey/ Fishery Independent	2006	$319,451	improve stock asess. through industry-conducted resource surveys	obtain better fine-scale info on resource status in inshore areas	enhanced port and sea sampling including quality & comp. of discards

$22,445,371

Count of Level of Funding ($)	Year Funded							
Research Category	2000	2001	2002	2003	2004	2005	2006	Grand Total
Conservation Engineering	3	2	7	1		4		17
Industry Based Survey/ Fishery Independent	2	1	3	2	4	2		14
Habitat	1	1		8		1		11
Cod Tagging			5	3		1		9
Special Access Programs/ Conservation Engineering					5			5
Outreach						2	1	3
Resource Dynamics				1			2	3
Special Access Programs		1			2			3
Strategic Planning/Scoping	3							3
Study Fleet/ Fishery Dependent		1	1		1			3
Socioeconomic						1	1	2
Stock ID / Genetic	1							1
Outreach/Safety						1		1
Outreach/ Education							1	1
Grand Total	10	6	16	15	12	12	5	76

#2A

Council Work Priorities

2008 Actions Approved

The Council approved the following actions for completion in 2008.

- Groundfish Fishery Management Plan (FMP) - Amendment 16; includes a process to establish annual catch limits and accountability measures (ACLs and AMs)

- Herring FMP – Amendment 2; to address monitoring of catch as well as ACLS and AMs and sectors or some other form of limited access privilege program

- Scallop FMP – Amendment 15; includes ACLs and AMs, a revision to the overfishing definition and days-at-sea leasing/transferability, as well as sectors or some other form of limited access privilege program for the limited access fleet

- Monkfish FMP – Framework Adjustment 6; to address a revision to the backstop measure, put in place when the stock was determined to be overfished and when overfishing was occurring, that calls for a fishery closure in 2009 when landings exceed a specified amount within the 2007 fishing year

- Skate FMP - Amendment 3; includes measures to cap or reduce skate catches in order to rebuild thorny and winter skates, as well as ACLs and AMs

- Habitat Omnibus Amendment 2 – continuation of the current action which includes completion of Phase 2, a gear effects evaluation and a determination of adverse impacts on EFH

The Council delayed a whiting amendment and included herring as a 2008 priority based on the amount of fishery information that is still lacking --- principally catch and bycatch versus landings and the associated need for better monitoring through more comprehensive observer coverage.

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lease in million barrels of oil equivalent (MMBOE):

Water depth	Minimum royalty suspension volume (MMBOE)
(1) 200 to less than 400 meters	17.5
(2) 400 to less than 800 meters	52.5
(3) 800 meters or more	87.5

8. Section 260.117 is removed.

9. The title of § 260.124 and the introductory language of paragraph (b) are revised to read as follows:

§ 260.124 How will royalty suspension apply if MMS assigns a lease issued in a sale held after November 2000 to a field that has a pre-Act lease?

* * * * *

(b) If we establish a royalty suspension volume for a field as a result of an approved application for royalty relief submitted for a pre-Act lease under part 203 of this chapter, then:

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[FR Doc. 07–6161 Filed 12–20–07; 8:45 am]

BILLING CODE 4310–MR–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 600

[Docket No. 071121736–7619–01]

RIN 0648–AR78

Magnuson-Stevens Act Provisions; Experimental Permitting Process, Exempted Fishing Permits, and Scientific Research Activity

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Proposed rule; request for comments.

SUMMARY: NMFS proposes new and revised definitions for certain regulatory terms, and procedural and technical changes to the regulations addressing scientific research activities, exempted fishing, and exempted educational activities under the Magnuson-Stevens Fishery Conservation and Management Act. This action is necessary to provide better administration of these activities and to revise the regulations consistent with the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA). NMFS intends to clarify the regulations, ensure necessary information to complete required analyses is requested and made available, and provide for expedited review of permit applications where possible.

DATES: Comments must be received by March 20, 2008.

ADDRESSES: You may submit comments, identified by RIN 0648–AR78, by any one of the following methods:

- Electronic Submissions: Submit all electronic public comments via the Federal eRulemaking Portal *http://www.regulations.gov*
- Fax: 301–713–1193, Attn: Jason Blackburn
- Mail: Alan Risenhoover, Director, Office of Sustainable Fisheries, 1315 East-West Highway, SSMC3, Silver Spring, MD 20910, Attn: EFP Comments

Instructions: All comments received are a part of the public record and will generally be posted to *http://www.regulations.gov* without change. All Personal Identifying Information (for example, name, address, etc.) voluntarily submitted by the commenter may be publicly accessible. Do not submit Confidential Business Information or otherwise sensitive or protected information.

NMFS will accept anonymous comments. Attachments to electronic comments will be accepted in Microsoft Word, Excel, WordPerfect, or Adobe PDF file formats only.

Send comments on collection-of-information requirements to the same address and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503 (Attn: NOAA Desk Officer), or email to *David_Rostker@omb.eop.gov*, or fax to (202) 395–7285.

Copies of the categorical exclusion (CE) prepared for this action are available from NMFS at the above address or by calling the Office of Sustainable Fisheries, NMFS, at 301–713–2341.

FOR FURTHER INFORMATION CONTACT: Jason Blackburn at 301–713–2341, or by e-mail at *jason.blackburn@noaa.gov*.

SUPPLEMENTARY INFORMATION:

Background and Need for Action

On May 28, 1996, NMFS established procedures pertaining to scientific research, exempted fishing, and exempted educational activities (61 FR 26435). These procedures were established to provide minimum standards for dealing with scientific research, exempted fishing and exempted educational activities under the Magnuson-Stevens Act. These standards clarified the requirements for those managing and enforcing the fishery regulations, and for the public. These regulations were subsequently codified in 50 CFR part 600 (61 FR 32538, June 24, 1996). Shortly thereafter, the Magnuson-Stevens Act was amended by the Sustainable Fisheries Act, which included important provisions dealing with essential fish habitat (EFH), rebuilding of overfished fisheries, and the requirement to minimize bycatch and bycatch mortality to the extent practicable. These new requirements resulted in an increased interest in fisheries research.

On January 12, 2007, the MSRA was enacted. Section 204 of the MSRA added a new Cooperative Research and Management Program section (Section 318) to the MSA. Section 318(d) of the revised MSA requires that the Secretary, through NMFS, "promulgate regulations that create an expedited, uniform, and regionally-based process to promote issuance, where practicable, of experimental fishing permits."

A major reason for the expansion in fisheries research has been the need to minimize bycatch and the mortality of bycatch as required under National Standard 9 of the Magnuson-Stevens Act. Much of this effort has been concentrated on studies investigating fish behavior and the development and testing of new gear technology and fishing techniques to minimize bycatch and promote the efficient harvest of target species.

Over the years, many questions have arisen regarding the differences between a scientific research activity and fishing and how NMFS interprets each type of activity under the implementing regulations. The existing regulations

contain three authorizations for catching fish outside prescribed fishing regulations: Scientific research from a scientific research vessel, exempted fishing under NMFS-issued exempted fishing permits (EFPs), and exempted educational activities. As these types of activities have increased in both volume and variety, NMFS and the affected public have identified several aspects of the regulations that could be improved in order to streamline the permitting of exempted fishing and exempted educational activities, and the acknowledgment of scientific research.

Proposed Changes from the Current Regulations

NMFS is proposing substantive and administrative changes to the current regulations, including revising and adding definitions; clarifying the differences among scientific research, exempted fishing, and exempted educational activities; clarifying the difference between conservation engineering and gear testing; clarifying the need for and extent of data required to be collected in conjunction with exempted fishing and exempted educational activities; clarifying the application process for obtaining an EFP; exempting research projects funded by quota set-asides from the requirement to publish separate notices; and defining whether and to what extent the NMFS Observer Program requires EFPs. These topics are discussed in more detail below.

Changes to Existing Definitions

In § 600.10 Definitions, three definitions would be added and several others revised. As part of the Sustainable Fisheries Act, Congress authorized the Secretary of Commerce (Secretary) to use private sector vessels, equipment, and services to conduct fisheries resource surveys. The Secretary is authorized to structure competitive solicitations to compensate a contractor for a fishery resources survey (i.e., "compensation fishing") by allowing the contractor to retain for sale fish harvested during the survey. If, however, the contractor is not expected to harvest during the survey the quantity or quality of fish that would allow for adequate compensation for the survey, the Secretary is authorized to structure the solicitation so as to provide that compensation by allowing the contractor to harvest on a subsequent voyage, and retain for sale, a portion of the allowable catch of the fishery as specified in a contract or EFP. Foreign vessels would not be allowed to engage in compensation fishing outside the scope of the applicable scientific research plan, or outside the time frame in which the actual scientific research activity is being conducted.

This proposed rule would define "compensation fishing" and authorize, as appropriate, this activity as a reason for issuing an EFP. Compensation fishing as described under section 402(e)(2)(B) of the Magnuson-Stevens Act would be authorized through an EFP. It is proposed that in cases where exemptions are not needed, compensation fishing could be conducted without an EFP. An example of this is the Mid-Atlantic Research Set-aside (RSA) program, where research projects are funded through compensation fishing. In the RSA program, vessels are either issued a Letter of Acknowledgment (LOA) or an EFP. Vessels receive an LOA if they will be conducting research. Vessels receive an EFP if they will be compensation fishing and need an exemption from the regulations. For example, an EFP would be needed for a participating vessel to harvest and land their quota during a fishery closure. The compensation fishing provisions within the NMFS general regulations dealing with scientific research and exempted fishing (§ 600.745), would apply unless fishery-specific compensation fishing regulations are in place, such as those in the West Coast Groundfish regulations (§ 660.350).

A new definition would also be added for "conservation engineering." Section 404(c)(2) of the Magnuson-Stevens Act describes conservation engineering as an area of research that includes the study of fish behavior and the development and testing of new gear technology and fishing techniques to minimize bycatch, promote efficient harvest of target species, and minimize adverse effects on EFH. Because a significant number of fishery stocks are either overfished or experiencing overfishing, NMFS is concerned that bycatch of these species will make it more difficult to control mortality. Conservation engineering has become an important field of research and has led to cooperative research ventures involving NMFS, researchers, and fishermen.

For the same reasons that conservation engineering has become important, NMFS is concerned about its potential impacts on fishery resources. Conservation engineering activities often take commercial quantities of fish. In the past, these projects have been considered fishing and not scientific research because the Magnuson-Stevens Act definition of scientific research, as interpreted at § 600.10, excludes "the testing of fishing gear." NMFS believes the mortality associated with conservation engineering work needs to be properly accounted for. In addition, NMFS wants to ensure that conservation engineering activities do not adversely affect fisheries resources. To best protect fisheries resources while allowing conservation engineering activities, NMFS proposes to define conservation engineering based on section 404(c)(2) of the Magnuson-Stevens Act in a manner that best protects fisheries resources while allowing conservation engineering activities. NMFS also proposes to define "gear testing" to differentiate it from conservation engineering. Gear testing would be defined as an at-sea activity with its sole purpose being the testing of the functionality of fishing gear. When a vessel is performing gear testing, it may not retain fish, and it must meet the specific requirements of any regulation that pertains to fishing and/or gear testing in the applicable fishery. For example, the Alaska management measures require that trawl gear testing must be performed within specified trawl gear test areas.

Some conservation engineering activities would not qualify as a scientific research activity, and would more appropriately require an EFP. To be classified as scientific research:

- At-sea research must meet the criteria for scientific research activity laid out in the regulations, and occur aboard a scientific research vessel;
- A research activity must address a testable hypothesis;
- A research activity must follow a scientific plan that includes sufficient observations and appropriate experimental design to test the hypothesis;
- A research activity must address a fishery management problem or issue;
- All fish captured for research must be necessary to meet the objectives of the experimental design, i.e. the sample size needed to prove or disprove the hypothesis. (This does not include fish captured for compensation fishing).

For example, in the development of a bycatch reduction device, research could be conducted to assess the behavior of target and bycatch species to detect exploitable differences, to determine whether prototype gear modifications achieve the desired stimuli and escape opportunities, to test whether fish respond to those stimuli as expected, or to examine whether a prototype device achieves the expected species separation. If these activities are conducted on a scientific research vessel then an LOA would be sufficient, whereas if these activities are conducted on a vessel not meeting the definition of

a scientific research vessel, then an EFP would be required. However, an opportunity for vessels to conduct sea trials of the resulting devices as proof of concept to determine their practicality and effectiveness with their gear and procedures in actual fishing conditions might qualify for an EFP, but would not be scientific research.

Technical Revisions to Definitions

Several technical revisions are proposed to be made to the Definitions section. In the definitions for "exempted educational activity" and "exempted or experimental fishing," the words "part 635 or" would be removed as redundant, since part 635 is a part of chapter VI of title 50. In the definitions for "region," "Regional Administrator," and "Science and Research Director," the word "five" would be changed to "six" to reflect the creation of the new NMFS Pacific Islands Region and NMFS Pacific Islands Fisheries Science Center. In the definition of "scientific research activity," in the second sentence, the words "or to test a hypothesis" would be revised to read "and to test a hypothesis," making this definition consistent with the new definition of conservation engineering. In the third sentence, the word "issues" would be revised to read "topics" to better describe the object of the research, and the words "or other collateral fishing effects" would be added following the word "bycatch" to encompass the range of potential impacts of fishing on the environment. In the fourth sentence, the words "unless it meets the definition of conservation engineering" would be added following "or the testing of fishing gear" to clarify that conservation engineering may be permissible. In addition, an example is provided to clarify what is meant by "the testing of fishing gear."

In § 600.512(a), for foreign fishing, and § 600.745(a), for domestic fishing, the procedures for acknowledging scientific research activity would be revised by adding "aboard scientific research vessels" to clarify that these sections apply only to scientific research activities aboard scientific research vessels in the Exclusive Economic Zone (EEZ).

To clarify who the designee could be for the Regional Administrator or Director, §§ 600.512(a) and 600.745(a) would be revised so that the Regional Administrator having responsibility for the fishery or the Director of the Office of Sustainable Fisheries (for Atlantic highly migratory species) would be primarily responsible for the issuance of LOAs, but that this responsibility may be delegated to an appropriate NMFS Science and Research Director, or the Assistant Regional Administrator for Sustainable Fisheries.

The current regulations note that the LOA "is separate and distinct from any permit required under any other applicable law." For laws administered by NMFS, this reference applies to incidental take permits under the Marine Mammal Protection Act (MMPA) or section 10 permits or consultations under the Endangered Species Act (ESA). There may be additional permits required (e.g., from the Corps of Engineers) that are not under the jurisdiction of NMFS. Since the MMPA and ESA are administered by NMFS by the same officials who issue LOAs, it is appropriate for NMFS to consider the effect of the research under the provisions of these laws when the request for the LOA is being reviewed. Therefore, §§ 600.512(a) and 600.745(a) would be modified to indicate that the MMPA and ESA are two laws that may require an additional permit or consultation. NMFS would undertake an initial review of a request for an LOA to determine if any additional permit or consultation is needed. If, after an initial review, the Regional Administrator or Director believes that such a permit or consultation is required and none has been completed, the Regional Administrator or Director would not issue an LOA until required permits are issued and consultations completed. A research vessel that conducts operations without these authorizations may potentially be found in violation of the applicable law.

In addition to the foregoing changes, §§ 600.512(a) and 600.745(a) are proposed to have additional clarifying language added regarding revisions to the scientific research plan and to the rebuttable presumption that a vessel is a scientific research vessel conducting scientific research.

In § 600.745(b)(1), as previously discussed, compensation fishing is proposed to be added as a reason for an EFP. Similarly, although conservation engineering potentially could be described under several other reasons for requesting an EFP, it is proposed to be added as a specific reason for an EFP because of its increasing use in determining ways of avoiding bycatch and the extent of conservation engineering activities.

It has not always been clear to authorized officers or the exempted fishing permittee which regulations they have been exempted from. To provide a clear record of what regulatory exemptions apply to a particular EFP, § 600.745(b)(1) is also proposed to be revised to clearly indicate that a vessel with an EFP is only exempt from those regulations specified in the EFP.

Changes to Application and Permit Process

In § 600.745(b)(2)(v), NMFS proposes that an applicant for an EFP provide any anticipated impacts of the proposed activity on the environment, including impacts on fisheries, marine mammals, threatened or endangered species, and EFH, as part of an EFP application. Under the National Environmental Policy Act (NEPA), NMFS must make a determination regarding the environmental impact of any permitted activity. This NEPA determination is usually in the form of a CE (i.e., a category of actions which do not individually or cumulatively have a significant effect on the environment and which have been found to have no such effect and for which neither an environmental assessment (EA) or environmental impact statement (EIS) is required), which includes reference to any relevant previous NEPA analysis. Under some circumstances, an activity might require an EA or what may be even more rare, an EIS. Similarly, under § 600.920, NMFS must make a determination of the impact on EFH of any permitted activity and, therefore, needs to be provided with any available information on the activity that has a potential effect on EFH. NMFS recognizes that applicants have routinely provided this type of information as part of their application. This proposed change would document the current practice and clarify the reasons for collecting the information.

A series of changes are proposed in the application process to speed public notification and allow for timely review of an application.

The current regulations state, "... notification of receipt of the application will be published in the **Federal Register** with a brief description of the proposal, and the intent of NMFS to issue an EFP. Interested persons will be given a 15- to 45-day opportunity to comment and/or comments will be requested during public testimony at a Council meeting." NMFS proposes to revise this language to remove "and the intent of NMFS to issue an EFP." The decision to issue an EFP should come after the public notice and comment process. NMFS also proposes to revise the language allowing public discussion of EFP applications at Council meetings, to clarify that Council meeting notices are not a substitute for publishing **Federal Register** notices for EFP applications, but are instead supplemental to that process. If the Council intends to take comments on

EFP applications at a Council meeting, it must include a statement to this effect in the Council meeting notice and meeting agenda. Multiple applications for EFPs may be published in the same **Federal Register** document and may be discussed under a single Council agenda item.

MSA section 318(f) specifically exempts research projects funded by quota set-asides from any new procedures established under section 318. There are existing procedures in place for processing EFP applications associated with these projects, which are necessary for NMFS to properly evaluate and analyze each project's compliance with NEPA, ESA, and MMPA requirements. NMFS believes the current procedures are beneficial to our process and help streamline the review and issuance of EFPs for quota set-aside programs. Therefore, these procedures will be retained. To further expedite the review of EFP applications for such projects, research projects funded through quota set-asides, such as those that participate in the Mid-Atlantic RSA program, will be exempted from the requirement to publish a separate **Federal Register** notice for each EFP application. Notice of selected Mid-Atlantic RSA projects is provided in the RSA section of the annual specifications notice that is published for each fishery management plan with an RSA program. An EA is normally prepared and analyzes the potential impacts of the selected RSA projects as part of each annual specifications process. The majority of the current quota set-aside funded projects are conducted in Northeast fisheries that are managed by the Mid-Atlantic Council. Examples of Mid-Atlantic RSA programs include: summer flounder, scup, black sea bass, squid, and monkfish. In addition, the New England Council has an RSA program for Atlantic sea scallops. RSA projects go through two concurrent processes before they receive their EFPs. There is a grant process, and an EFP process. Since 2003, the NMFS Northeast regional office has streamlined the RSA processes, particularly the EFP application and issuance process. The existing process accommodates variability, as not all fisheries or projects operate in the same manner.

NMFS proposes that § 600.745(b)(3)(i)(C) be revised to include impacts on fisheries and EFH.

In § 600.745(b)(3)(ii), current language states, "The Council(s) or the Administrator or the Regional Administrator shall notify the applicant in advance of any meeting at which the application will be considered, and offer the applicant the opportunity to appear in support of the application." The language is proposed to be revised to clarify that the applicant has a right to be present and make comments only at public meetings.

In § 600.745(b)(3)(iii), new language is proposed to be inserted that would clarify that NMFS would issue EFPs only after all required analyses and consultations (e.g., NEPA, EFH, ESA and MMPA) have been completed. This is in effect what currently occurs. In § 600.745(b)(3)(iii)(B), confusing language is proposed to be removed and in § 600.745(b)(3)(iii)(C) the language is clarified to indicate that while purely economic allocations could be grounds for a denial, compensation fishing should not be a reason to deny an EFP.

NMFS is proposing language to clarify what terms and conditions should be included in an EFP. As previously discussed, a new paragraph (C) would be added to § 600.745(b)(3)(v) to require that the EFP cite the specific regulations exempted. The subsequent paragraphs would be renumbered accordingly, and the renumbered paragraph (F) would be revised to indicate that observers and electronic monitoring devices may be required. Renumbered paragraph (G) would be revised to specify acceptable records for data reporting and to indicate that incidental catch and bycatch must be reported in all EFPs.

A new paragraph (4) would be added to § 600.745(b) to require that EFP holders must date and sign the permit, and return a copy of the original to the NMFS Regional Administrator or Director, to acknowledge the terms and conditions of the permit. The permit is not valid until signed by the holder. The subsequent paragraphs would be renumbered accordingly.

In § 600.745(b)(5), language relating to revocation, suspension or modification of permits would be removed, as these activities are described in § 600.745(b)(9).

In § 600.745(c)(1), clarifying language is proposed to indicate that NMFS is requesting the research information, and to clarify that the request is made for research exempted from the Magnuson-Stevens Act (research activity conducted from a scientific research vessel).

Section 600.745(c)(2) would be revised to specify that persons operating under EFPs must report their catch at the end of the EFP activity, or at specified intervals during the course of the exempted fishing activity, as determined by the Regional Administrator or Director. This supports the previous discussion and proposed changes concerning the importance of documenting all catch and bycatch related to EFPs.

Exempted educational activities are a subset of EFPs issued exclusively for educational purposes, i.e., the instruction of an individual or group, and allowing the capture of enough fish to demonstrate the lesson. Section 600.725(n) specifies that the trade, barter, or sale of any fish taken under an exempted educational activity is prohibited. This language is proposed to be repeated in § 600.745(d)(1) for clarity and ease of reference.

Consistent with the discussion regarding EFP applications in § 600.745(b)(2)(v), it is proposed that an applicant for an exempted educational activity provide any anticipated impacts of the proposed activity on the environment; including the fishery, marine mammals, threatened or endangered species, and EFH; as part of an exempted educational activity application.

Section 600.745(d)(3)(ii) would be revised to indicate that terms and conditions are mandatory for exempted educational activities in order to regulate and track catches, consistent with the proposed requirements of § 600.745(b)(3)(v).

As with EFPs, several clarifications are proposed to specify what may be included in the terms and conditions for exempted educational activities. In § 600.745(d)(3)(ii), a new paragraph (B) would be added to require that the exempted educational activity authorization cite the specific regulations exempted. The subsequent paragraphs would be renumbered accordingly, and renumbered paragraph (E) would be revised to specify acceptable records for data reporting.

In § 600.745(d)(3)(iii) and § 600.745(d)(7), NMFS proposes adding language that would require the exempted educational activity authorization specify the person(s) who will be in charge and present for the exempted educational activity to proceed. This would emphasize the educational nature of the activity and provide more assurance that the activity would be carried out as specified in the exempted educational activity authorization.

EFP Requirements for NMFS Observer Program

There have been questions regarding when, or if, observer programs are required to obtain EFPs in order for those observers to conduct catch sampling, biological studies, and retain fish for further analysis when doing so would be in violation of the applicable fishing regulations. In addition, the

fisheries use several types of NMFS-sanctioned observers, including NMFS employees, NMFS contracted observers, and third party contractors who are permitted by NMFS to provide observers in the fishery. There are also various other programs that provide "sea samplers" on fishing vessels: Universities, states, and industry groups. In § 600.745, a new paragraph (e) would exempt observers in the NMFS-sanctioned observer programs described above from the requirement to obtain an EFP. Other programs could continue to provide sea samplers, but would need an EFP to retain prohibited species or otherwise act in contravention of the published regulations.

Classification

Pursuant to section 304 (b)(1)(A) of the Magnuson-Stevens Act, the NMFS Assistant Administrator has determined that this proposed rule is consistent with the provisions of section 318(d) and 305(d) of the Magnuson-Stevens Act, and other applicable law, subject to further consideration after public comment.

This proposed rule has been determined to be not significant for purposes of Executive Order 12866.

The Chief Counsel for Regulation of the Department of Commerce certified to the Chief Counsel for Advocacy of the Small Business Administration that this proposed rule, if adopted, would not have a significant economic impact on a substantial number of small entities.

This proposed rule would provide clarifications of current regulations and information requirements, as well as other administrative requirements regarding scientific research, exempted fishing, and exempted educational activities. The proposed rule would serve only to define terms, clarify distinctions among scientific research activity, exempted fishing, and exempted educational activities, and standardize procedures for applying for and issuing EFPs and authorizations for exempted educational activities as allowed under EFPs.

As a result, an initial regulatory flexibility analysis is not required and none has been prepared.

This proposed rule contains a collection-of-information requirement subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB. The public reporting burden for this collection of information is estimated: (1) To average 6 hours per response to send NMFS a copy of a scientific research plan and average 1 hour per response to provide a copy of the cruise report or research publication; (2) to average 1 hour per response to complete an application for an EFP and average 0.5 hours per response or authorization for an exempted educational activity; and (3) to average 2 hours per response to provide a report at the conclusion of exempted fishing and average 0.5 hours per response to provide a report at the conclusion of exempted educational activities, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection information.

Public comment is sought regarding: Whether this proposed collection of information is necessary for the proper performance of the functions of the agency, including whether the information shall have practical utility; the accuracy of the burden estimate; ways to enhance the quality, utility, and clarity of the information to be collected; and ways to minimize the burden of the collection of information, including through the use of automated collection techniques or other forms of information technology. Send comments on these or any other aspects of the collection of information to the Office of Sustainable Fisheries at the **ADDRESSES** above, and email to *David_Rostker@omb.eop.gov*, or fax to (202) 395–7285.

Notwithstanding any other provision of the law, no person is required to respond to, and no person shall be subject to penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB control number.

List of Subjects in 50 CFR Part 600

Fisheries, Fishing.

Dated: December 18, 2007.

William T. Hogarth,

Assistant Administrator for Fisheries, National Marine Fisheries Service.

For the reasons stated in the preamble, NMFS proposes to amend 50 CFR part 600 as follows:

PART 600 MAGNUSON—STEVENS ACT PROVISIONS

1. The authority citation for part 600 continues to read as follows:

Authority: 16 U.S.C. 971 *et seq.* & 1801 *et seq.*

2. In § 600.10, definitions for "Exempted educational activity", "Exempted or experimental fishing", "Region", "Regional Administrator", "Science and Research Director", and "Scientific research activity" are revised, and definitions for "Compensation fishing", "Conservation engineering", and "Gear testing" are added, in alphabetical order, to read as follows:

§ 600.10 Definitions.

* * * * *

Compensation fishing means fishing conducted for the purpose of recovering costs associated with resource surveys and scientific studies that support the management of a fishery, or to provide incentive for participation in such studies. Compensation fishing may include fishing prior to, during, or following such surveys or studies. Foreign vessels that qualify as scientific research vessels and which are engaged in a scientific research activity may only engage in compensation fishing during the scientific research cruise and in accordance with the applicable scientific research plan. Compensation fishing must be conducted under an EFP if the activity would otherwise be prohibited by regulations under this part.

* * * * *

Conservation engineering means the study of fish behavior and the development and testing of new gear technology and fishing techniques that reduce collateral effects, such as minimizing bycatch and any adverse effects on EFH, and promote efficient harvest of target species. Conservation engineering is considered to be scientific research if it would otherwise meet the definition of a scientific research activity and is conducted by a scientific research vessel. Otherwise, conservation engineering is considered to be fishing, and must be conducted under an EFP if the activity would otherwise be prohibited by regulations under this part.

* * * * *

Exempted educational activity means an activity, conducted by an educational institution accredited by a recognized national or international accreditation body, of limited scope and duration, that is otherwise prohibited by this chapter VI, but that is authorized by the appropriate Regional Administrator or Director for educational purposes.

Exempted or experimental fishing means fishing from a vessel of the United States that involves activities otherwise prohibited by this chapter VI, but that are authorized under an EFP. The regulations in § 600.745 refer exclusively to exempted fishing. References elsewhere in this chapter to experimental fishing mean exempted fishing under this part.

* * * * *

Gear testing means at-sea activity for the purpose of testing the functionality

of fishing gear. During this type of activity, no fish may be retained aboard the vessel. Regional fishery regulations may specify additional requirements that would apply to this activity, such as using designated gear testing areas, testing trawl nets with the codend(s) open, or testing during closed seasons.

* * * * *

Region means one of six NMFS Regional Offices responsible for administering the management and development of marine resources in the United States in their respective geographical areas of responsibility.

Regional Administrator means the Director of one of the six NMFS Regions.

* * * * *

Science and Research Director means the Director of one of the six NMFS Fisheries Science Centers described in Table 1 of § 600.502 of this part, or a designee, also known as a Center Director.

* * * * *

Scientific research activity is, for the purposes of this part, an activity in furtherance of a scientific fishery investigation or study that would meet the definition of fishing under the Magnuson-Stevens Act, but for the exemption applicable to scientific research activity conducted from a scientific research vessel. Scientific research activity includes, but is not limited to, sampling, collecting, observing, or surveying the fish or fishery resources within the EEZ, at sea, on board scientific research vessels, to increase scientific knowledge of the fishery resources or their environment, and to test a hypothesis as part of a planned, directed investigation or study conducted according to methodologies generally accepted as appropriate for scientific research. At-sea scientific fishery investigations address one or more topics involving taxonomy, biology, physiology, behavior, disease, aging, growth, mortality, migration, recruitment, distribution, abundance, ecology, stock structure, bycatch or other collateral fishing effects, conservation engineering, and catch estimation of finfish and shellfish (invertebrate) species considered to be a component of the fishery resources within the EEZ. Scientific research activity does not include the collection and retention of fish outside the scope of the applicable research plan or the testing of fishing gear, unless it meets the definition of conservation engineering. For example, the testing of fishing gear to examine fish behavior in response to a bycatch reduction device would be conservation engineering and a scientific research activity, and would therefore not require an EFP. On the other hand, the testing of fishing gear to examine the gear's ability to catch more fish would not be conservation engineering or a scientific research activity, and would therefore be fishing and might require an EFP. Data collection designed to capture and land quantities of fish for product development, market research, and/or public display are not scientific research activities and must be permitted under exempted fishing procedures. For foreign vessels, such data collection activities are considered scientific research if they are carried out in full cooperation with the United States.

* * * * *

3. In § 600.512, paragraph (a) is revised to read as follows:

§ 600.512 Scientific research.

(a) *Scientific research activity.* Persons planning to conduct scientific research activities aboard a scientific research vessel in the EEZ that may be confused with fishing are encouraged to submit to the appropriate Regional Administrator or Director, 60 days or as soon as practicable prior to its start, a scientific research plan for each scientific cruise. The Regional Administrator or Director will acknowledge notification of scientific research activity by issuing to the operator or master of that vessel, or to the sponsoring institution, a letter of acknowledgment (LOA). This LOA is separate and distinct from any permit or consultation required under the Marine Mammal Protection Act, the Endangered Species Act, or any other applicable law. If the Regional Administrator or Director believes that such a permit or consultation is required, the Regional Administrator or Director will not issue the LOA until the vessel obtains such a permit or the consultation is completed. If the Regional Administrator or Director, after review of a research plan, determines that it does not constitute scientific research activity but rather fishing, the Regional Administrator or Director will inform the applicant as soon as practicable and in writing. The Regional Administrator or Director may designate a Science and Research Director, or the Assistant Regional Administrator for Sustainable Fisheries, to receive scientific research plans and issue LOAs. The Regional Administrator, Director, or designee may also make recommendations to revise the research plan to ensure the cruise will be considered to be a scientific research activity. In order to facilitate identification of the activity as scientific research, persons conducting scientific research activities are advised to carry a copy of the scientific research plan and the LOA on board the scientific research vessel. Activities conducted in accordance with a scientific research plan acknowledged by such a letter are presumed to be scientific research activities. An authorized officer may overcome this presumption by showing that an activity does not fit the definition of scientific research activity or is outside the scope of the scientific research plan.

* * * * *

4. In § 600.745:

A. Redesignate paragraphs (b)(3)(v)(C) through (H) as paragraphs (b)(3)(v)(D) through (I), respectively.

B. Redesignate paragraphs (b)(4) through (8) as paragraphs (b)(5) through (9), respectively.

C. Redesignate paragraphs (d)(3)(ii)(B) through (F) as paragraphs (d)(3)(ii)(C) through (G), respectively.

D. Add paragraphs (b)(3)(v)(C), (b)(4), (d)(3)(ii)(B), and (e).

E. Revise paragraphs (a), (b)(1), (b)(2)(v), (b)(3)(i) introductory text, (b)(3)(i)(C), (b)(3)(ii), (b)(3)(iii) introductory text, (b)(3)(iii)(B), (b)(3)(iii)(C), (b)(3)(v) introductory text, (b)(3)(v)(F), (b)(3)(v)(G), (b)(5), (c), (d)(1), (d)(2)(vii), (d)(3)(ii) introductory text, (d)(3)(ii)(E), (d)(3)(iii), and (d)(7).

The revisions and additions read as follows:

§ 600.745 Scientific research activity, exempted fishing, and exempted educational activity.

(a) *Scientific research activity.* Nothing in this part is intended to inhibit or prevent any scientific research activity conducted by a scientific research vessel. Persons planning to conduct scientific research activities aboard a scientific research vessel in the EEZ are encouraged to submit to the appropriate Regional Administrator or Director, 60 days or as soon as practicable prior to its start, a scientific research plan for each scientific cruise. The Regional Administrator or Director will acknowledge notification of scientific research activity by issuing to the operator or master of that vessel, or to the sponsoring institution, a letter of acknowledgment (LOA). This LOA is separate and distinct from any permit or consultation required by the Marine Mammal Protection Act, the Endangered Species Act, or any other applicable law. If the Regional Administrator or Director believes that such a permit or consultation is required, the Regional Administrator or Director will not issue the LOA until the vessel obtains such a permit or the consultation is completed. If the Regional Administrator or

Director, after review of a research plan, determines that it does not constitute scientific research but rather fishing, the Regional Administrator or Director will inform the applicant as soon as practicable and in writing. The Regional Administrator or Director may designate a Science and Research Director, or the Assistant Regional Administrator for Sustainable Fisheries, to receive scientific research plans and issue LOAs. The Regional Administrator, Director, or designee may also make recommendations to revise the research plan to ensure the cruise will be considered to be scientific research activity or recommend the applicant request an EFP. In order to facilitate identification of the activity as scientific research, persons conducting scientific research activities are advised to carry a copy of the scientific research plan and the LOA on board the scientific research vessel. Activities conducted in accordance with a scientific research plan acknowledged by such a letter are presumed to be scientific research activity. An authorized officer may overcome this presumption by showing that an activity does not fit the definition of scientific research activity or is outside the scope of the scientific research plan.

(b) * * *

(1) *General.* A NMFS Regional Administrator or Director may authorize, for limited testing, public display, data collection, exploratory fishing, compensation fishing, conservation engineering, health and safety surveys, environmental cleanup, and/or hazard removal purposes, the target or incidental harvest of species managed under an FMP or fishery regulations that would otherwise be prohibited. Exempted fishing may not be conducted unless authorized by an EFP issued by a Regional Administrator or Director in accordance with the criteria and procedures specified in this section. An EFP exempts a vessel only from those regulations specified in the EFP. All other applicable regulations remain in effect. The Regional Administrator or Director may charge a fee to recover the administrative expenses of issuing an EFP. The amount of the fee will be calculated, at least annually, in accordance with procedures of the NOAA Handbook for determining administrative costs of each special product or service; the fee may not exceed such costs. Persons may contact the appropriate Regional Administrator or Director to determine the applicable fee.

(2) * * *

(v) The species (target and incidental) expected to be harvested under the EFP, the amount(s) of such harvest necessary to conduct the exempted fishing, the arrangements for disposition of all regulated species harvested under the EFP, and any anticipated impacts on the environment, including impacts on fisheries, marine mammals, threatened or endangered species, and essential fish habitat.

* * * * *

(3) * * *

(i) The Regional Administrator or Director, as appropriate, will review each application and will make a preliminary determination whether the application contains all of the required information and constitutes an activity appropriate for further consideration. If the Regional Administrator or Director finds that any application does not warrant further consideration, both the applicant and the affected Council(s) will be notified in writing of the reasons for the decision. If the Regional Administrator or Director determines that any application warrants further consideration, notification of receipt of the application will be published in the **Federal Register** with a brief description of the proposal. Research projects funded by quota set-asides, such as those that participate in the Mid-Atlantic RSA program, are exempt from the requirement to publish such a notice. Interested persons will be given a 15- to 45-day opportunity to comment on the notice of receipt of the EFP application. In addition comments may be requested during public testimony at a Council meeting. If the Council intends to take comments on EFP applications at a Council meeting, it must include a statement to this effect in the Council meeting notice and meeting agenda. Multiple applications for EFPs may be published in the same **Federal Register** document and may be discussed under a single Council agenda item. The notification may establish a cut-off date for receipt of additional applications to participate in the same, or a similar, exempted fishing activity. The Regional Administrator or Director also will forward copies of the application to the Council(s), the U.S. Coast Guard, and the appropriate fishery management agencies of affected states, accompanied by the following information:

* * * * *

(C) Biological information relevant to the proposal, including appropriate statements of environmental impacts, including impacts on fisheries, marine mammals, threatened or endangered species, and EFH.

(ii) If the application is complete and warrants additional consultation, the Regional Administrator or Director may consult with the appropriate Council(s) concerning the permit application during the period in which comments have been requested. The Council(s) or the Regional Administrator or Director shall notify the applicant in advance of any public meeting at which the application will be considered, and offer the applicant the opportunity to appear in support of the application.

(iii) As soon as practicable after receiving a complete application, including all required analyses and consultations (e.g., NEPA, EFH, ESA and MMPA), and having received responses from the public, the agencies identified in paragraph (b)(3)(i) of this section, and/or after the consultation, if any, described in paragraph (b)(3)(ii) of this section, the Regional Administrator or Director shall issue the EFP or notify the applicant in writing of the decision to deny the EFP, and, if denied, the reasons for the denial. Grounds for denial of an EFP include, but are not limited to, the following:

* * * * *

(B) According to the best scientific information available, the harvest to be conducted under the permit would detrimentally affect the well-being of the stock of any regulated species of fish, marine mammal, threatened or endangered species or essential fish habitat; or

(C) Issuance of the EFP would have economic allocation as its sole purpose (other than compensation fishing); or

* * * * *

(v) The Regional Administrator or Director may attach terms and conditions to the EFP consistent with the purpose of the exempted fishing and as otherwise necessary for the conservation and management of the fishery resources and the marine environment, including, but not limited to:

* * * * *

(C) A citation of the regulations from which the vessel is exempted.

* * * * *

(F) Whether observers, a vessel monitoring system, or other electronic equipment must be carried on board vessels operated under the EFP, and any necessary conditions, such as predeployment notification requirements.

(G) Data reporting requirements necessary to document the activities and to determine compliance with the terms and conditions of the EFP and established time frames and formats for submission of the data to NMFS.

* * * * *

(4) *Acknowledging permit conditions.* Upon receipt of an EFP, the holder must date and sign the permit, and return a copy of the original to the NMFS Regional Administrator or Director. The permit is not valid until signed by the holder. In signing the permit, the holder:

(i) Agrees to abide by all terms and conditions set forth in the permit, and all restrictions and relevant regulations under this subpart; and

(ii) Acknowledges that the authority to conduct certain activities specified in the permit is conditional and subject to authorization and revocation by the Regional Administrator or Director.

(5) *Duration.* Unless otherwise specified in the EFP or a superseding notice or regulation, an EFP is valid for no longer than 1 year. EFPs may be renewed following the application procedures in this section.

* * * * *

(c) *Reports.* (1) NMFS requests persons conducting scientific research activities from scientific research vessels submit a copy of any cruise report or other publication created as a result of the cruise, including the amount, composition, and disposition of their catch, to the appropriate Science and Research Director.

(2) Upon completion of the activities of the EFP, or periodically as required by the terms and conditions of the EFP, persons fishing under an EFP must submit a report of their catches and any other information required, to the appropriate Regional Administrator or Director, in the manner and within the time frame specified in the EFP. The report must be submitted to the Regional Administrator or Director no later than 6 months after concluding the exempted fishing activity. Persons conducting EFP activities are also requested to submit a copy of any publication prepared as a result of the EFP activity.

(d) * * *

(1) *General.* A NMFS Regional Administrator or Director may authorize, for educational purposes, the target or incidental harvest of species managed under an FMP or fishery regulations that would otherwise be prohibited. The trade, barter or sale of fish taken under this authorization is prohibited. The decision of a Regional Administrator or Director to grant or deny an exempted educational activity authorization is the final action of NMFS. Exempted educational activities may not be conducted unless authorized in writing by a Regional Administrator or Director in accordance with the criteria and procedures specified in this section. Such authorization will be issued without charge.

(2) * * *

(vii) The species and amounts expected to be caught during the exempted educational activity, and any anticipated impacts on the environment, including impacts on fisheries, marine mammals, threatened or endangered species, and EFH.

* * * * *

(3) * * *

(ii) The Regional Administrator or Director may attach terms and conditions to the authorization, consistent with the purpose of the exempted educational activity and as otherwise necessary for the conservation and management of the fishery resources and the marine environment, including, but not limited to:

* * * * *

(B) A citation of the regulations from which the vessel is being exempted.

* * * * *

(E) Data reporting requirements necessary to document the activities and to determine compliance with the terms and conditions of the exempted educational activity.

* * * * *

(iii) The authorization will specify the scope of the authorized activity and will include, at a minimum, the duration, vessel(s), persons, species, and gear involved in the activity, as well as any additional terms and conditions specified under paragraph (d)(3)(ii) of this section.

* * * * *

(7) *Inspection.* Any authorization issued under this paragraph (d) must be carried on board the vessel(s) for which it was issued or be in the possession of at least one of the persons identified in the authorization, who must be present while the exempted educational activity is being conducted. The authorization must be presented for inspection upon request of any authorized officer. Activities that meet the definition of "fishing," despite an educational purpose, are fishing. An authorization may allow covered fishing activities; however, fishing activities conducted outside the scope of an authorization for exempted educational activities are illegal.

(e) *Observers.* NMFS-sanctioned observers or biological technicians conducting activities within NMFS-approved observer protocols are exempt from the requirement to obtain an EFP. For purposes of this section, NMFS-sanctioned observers or biological technicians include NMFS employees, NMFS observers, observers who are employees of NMFS-contracted observer providers, and observers who are employees of NMFS-permitted observer providers.

[FR Doc. E7–24866 Filed 12–20–07; 8:45 am]

BILLING CODE 3510–22–S

#4

New England Fishery Management Council
Approved in May 2004
Revised in September 2004
Revised in June 2005

Research Steering Committee
Policy for Incorporation of Research Results into the NEFMC Management Process

Introduction

The Research Steering Committee (RSC), at the request of the New England Fishery Management Council's Executive Committee, developed a policy for the review and incorporation of new research results into the management arena. The Executive Committee's request was based on concerns that various cooperative research programs have funded a large number of projects that have relevance to management. Additionally, other types of external reports may also lack sufficient technical review prior to use in the management process. If results are to be used by managers in decision-making, the Executive Committee determined there should be some mechanism to evaluate the efficacy of the results and direct final reports to appropriate end users.

The Council reviewed and approved an initial draft of this document at its September 2003 meeting, but asked the RSC to provide more detail about the process as well as criteria for channeling projects to end users. They also asked the RSC to expand its discussions to include *all* new research projects that are to be used in making management decisions, not only those generated through cooperative research programs. This iteration of the policy includes those details.

In developing this process, it was the stated intent of the Research Steering Committee to be as constructive as possible in its review of research results and the preparation of advice to the Council as well as researchers. The RSC also proposes to implement the steps below as a pilot effort in order to address any unforeseen considerations or to further refine the process if necessary.

General

- The Council's Research Steering Committee will review final reports for projects funded through the National Marine Fisheries Service's Northeast Cooperative Research Partners Program (NCRPP), the Total Allowable Catch research set-aside programs provided for in the Council's Fishery Management Plans, and the Northeast Consortium, as well as other new research outside of the cooperative programs that may become available to the Council and its Plan Development Teams.

- The RSC will provide a review of final reports prior to the use of results in the Council decision-making process. The RSC will identify the applicability of results to management and the appropriate end user of the information in the report. As part of its review, the committee will comment on whether a project has had an adequate technical review, and if not, recommend that one be undertaken. Technical reviews from other institutions may be acceptable.

- Technical and contractual reviews of final project reports funded through the CRPI will remain the responsibility of NOAA Fisheries as required by its grants program. Both NOAA Fisheries and the RSC, however, will communicate the RSC protocols outlined below to potential applicants for CRPI funding and to other institutions that fund cooperative and other types of research. This will create an awareness of the Council's need for the RSC management review, as well as a technical review of project results.

- A potentially critical element in the management process, the RSC will ensure that an appropriate review of new research results is undertaken before those results and associated conclusions are used in a management action. This could involve several different pathways, depending on the nature of the project. All completed will be required to go through a sufficient technical review before results are used in the New England Council's management process.

Project Completed/ Final Report Submitted

It is expected that most projects are likely to fall within this category. In these cases, the RSC will review a package consisting of the project abstract (or possibly the full proposal) along with the final report, and either a summary of the technical reviews or the actual text of the review(s). Based on the committee's discussion and a review of these materials, the RSC will develop comments and/or recommendations on whether the technical review is adequate, project results are applicable to management, whether further work needs to be undertaken to validate results and the likely end user(s). Comments could include recommendations for immediate or future use by the Council and its committees, PDTs, SSC or SSAC, suggestions for further investigations, broader field-testing in the form of an experimental fishery, or other course of action.

The RSC also could advise that the information is not appropriate for use in a management context based on the summary of technical reviews, comments by RSC members, or other rationale related to the efficacy or appropriateness of the project. The committee could elect to forgo the development of comments if it did not feel they are warranted or because of time constraints.

If a project does not have a technical review, or the RSC determines the technical review is not sufficiently rigorous, the RSC will recommend that a technical review take place or channel the completed report to its SSC, SSAC or other technical group for the review. The RSC will consider projects that have received technical reviews completed by other groups.
A package (including the summary of technical reviews, the RSC comments and a final report) will be prepared by the Council staff and forwarded to the Council and its appropriate oversight committees for use in the management process. The Council and its oversight committees will coordinate any further use of project information. This would include, but is not limited to forwarding a report to its Advisory Panels, Plan Development Teams or other groups.

> **Example** - Typical projects would be the University of New Hampshire's cod end mesh selectivity study in the Gulf of Maine multispecies trawl fishery or the F/V Kathleen A. Mirarchi's observations of the effects of trawl gear on soft bottom habitats.

SARC/Peer Review: Projects that fall within this category are generally long-term or unique and would be integrated into the databases used for management. This would include the results of long-term projects such as industry-based resource surveys, study fleet initiatives, the cod tagging program and possibly other projects.

Example – The Northeast Fisheries Science Center Science, the Massachusetts Division of Marine Fisheries, the School of Marine Science and Technology and Rhode Island Fish and Wildlife, along with fishermen throughout New England are engaged in a project to tag yellowtail flounder in an on-going collaboration to better understand yellowtail movements, mortality and aging. Data will augment Center assessments of this species.

Responsibilities of Principal Investigators

- To ensure the use of the research results for management purposes, PIs will be required to identify project objectives, expected impact on or use in the management process and the end users of their results. Typically this should be stated at the proposal stage, but minimally should be detailed in a final report.

- Recognizing that researchers have a proprietary interest in protecting data until publication, at some point yet to be established, all PIs will be asked to provide the data on which their research conclusions are based. If these data are intended to be used in a publication, data access should be provided following the publication of research papers. Agreements can be reached to ensure data will be used only in the development of a fishery management plan and not by Council staff or its PDT members for publication purposes.

- In all cases if research is to be used by the Council for management purposes, data must be accessible to the Council staff and its Plan Development Teams in a readily usable format and accompanied by the relevant analyses and results prior to use in the development of a management action.

Technical Review Criteria
Approved by the NEFMC, September 2004

The following document was developed by the Council's Research Steering Committee concerning criteria for the technical review of cooperative and other research results that are to be considered in management decision-making. Based on discussion of the issue at the September 14-16, 2004 Council meeting, this list will append this document to its final policy to incorporate research results into fisheries management decision-making.

Levels of technical review that could be deemed sufficient for Council decision-making purposes:

- Publication in a peer-review journal
- Publication in a Federal/State Agency or academic technical report series in which papers are subject to internal peer review
- Review by a peer-review forum such as a SARC, TRAC, SEDAR (Southeast Data, Assessment and Review - SEFSC' stock assessment review process), SSC, SSAC, NRC, etc
- Expedited review by NMFS and/or other appropriately qualified scientists
- Review of the research paper by two or more independent experts, unaffiliated with the PIs (with proof that any review comments provided by the reviewers were subsequently addressed by the PIs). This might pertain to the Center reviews of final reports of
-

state/federal grants and contracts, or to reviews specifically solicited by the PIs themselves from independent scientists.

- Academic dissertations and theses (presuming that the research in these reports have been reviewed for technical sufficiency and rigor by faculty members).
- A peer-review forum (perhaps a workshop) developed specifically to review/vet draft research reports (this might be something that could be convened under the auspices of the Cooperative Partners Research Initiative or the Northeast Consortium).
- Review by scientists familiar with the research topic area (this is the PDT model in which PDT members assess the technical merits of unvetted research results). The PDT may also recommend an outside review by additional scientists.

Some approaches that would NOT qualify as sufficient to consider a research document as having had a valid technical review might include:
Oral presentation of the research results at a scientific meeting (AFS, ICES, etc).
Publication of an Abstract

Preparation/submission of a Working Paper/Research Document to a Meeting/Working Group at which peer review is not the main objective of the Group (e.g., ICES Working Papers; NAFO Research Documents, ICES ASC Documents; etc) or in which the review is likely to be perfunctory

Additional Comments
There are still grey areas concerning whether analyses generated at PDT and Monitoring Committee meetings or reviews undertaken by those groups receive adequate vetting. Pending experience with this process and further discussion, the committee may modify this document.

Management Review Checklist

The RSC policy concerning the committee's review of final reports for applicability to the management process states that it will develop comments and/or recommendations on whether a technical review is adequate, project results are applicable to management, whether further work needs to be undertaken to validate results and the likely end user(s). Comments could include recommendations for immediate or future use by the Council and its committees, PDTs, SSC or SSAC, suggestions for further investigations, broader field-testing in the form of an experimental fishery, or other course of action.

The RSC may advise that the information contained in a given final report is not appropriate for use in a management context based on the summary of technical reviews, comments by RSC members, or other rationale related to the efficacy or appropriateness of the project. The committee also could elect to forgo the development of comments if it does not feel they are warranted or because of time constraints.

If a project does not have a technical review, or the RSC determines the technical review is not sufficiently rigorous, the RSC will recommend that a technical review take place or channel the completed report to its SSC, SSAC or other technical group for the review. The RSC will consider projects that have received technical reviews completed by other groups and subsequently

undertake its own review. The RSC review may include a presentation by the principal investigators.

Following the RSC review, a package (including the summary of technical reviews, the RSC comments and a final report) will be prepared by the Council staff and forwarded to the Council and its appropriate oversight committees for use in the management process. The Council and its oversight committees will coordinate any further use of project information. This would include but is not limited to forwarding a report to its Advisory Panels, Plan Development Teams or other groups.

Suggestions for Specific Comments

1. Has there been a sufficient technical review of the project results and, if so, is that information available to the Research Steering Committee?
2. Did the project accomplish all of its stated goals and objectives?
3. Are project deliverables available and formatted for use by the Council and its technical committees?
4. Does the project address an immediate management need or contribute to a long-term strategy to rebuild and sustain stocks?
5. Does the project support past work and/or provide new information?
6. Does it point to a management action not in place now, or offer an innovative solution to a problem?
7. Did the project elucidate other information not specifically stated in the goals and objectives?
8. Is there a need for further work or follow-on research such as wider field-testing?
8. Who is the appropriate end-user and are there recommendations/caveats about how this information should be used?
9. Overall rating based on the above criteria: excellent, very good, good, fair, or poor.
11. Additional comments.

#5

Northeast Consortium

University of New Hampshire • Massachusetts Institute of Technology
University of Maine • Woods Hole Oceanographic Institution

November 27, 2007

Capt. Paul Howard
Executive Director
New England Fishery Management Council
50 Water St.
Newburyport, MA 01950

Dear Capt. Howard,

The Northeast Consortium has facilitated an independent technical evaluation of the cooperative research project,

"Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II."

This project received funding in FY2000 ($78,810) and FY2001 ($71,710) to examine the reduction of height in a flounder gillnet for its potential to lower the catch of cod. Mr. Mike Pol of the Massachusetts Division of Marine Fisheries lead the project in partnership with four commercial fishermen from Massachusetts and scientific collaborators at the Division and at Manomet Center for Conservation Sciences.

I am pleased to submit the evaluation documents to the New England Fishery Management Council. This includes the final report, two evaluation reports, and a response to the review written by Mr. Pol.

The Review:
The evaluation served as a formal assessment of the project. Two independent scientists each conducted a mail review of the project, providing comments and suggestions, which while occasionally critical, were made with the intent to improve the research, applications of the data, and future research. The reviewers were asked to focus on the final report, but supporting documents were included in the review package to give further perspectives on the project.

Evaluation Criteria:
The evaluation criteria are listed in the enclosed document that describes the Northeast Consortium general review process. Reviewers were asked to focus on the second criteria, certification of results, i.e. whether the experimental design was appropriate and if the conclusions are well supported by the data.

Project Data:
The project investigators have submitted raw data to the Northeast Consortium's Fisheries and Oceans Data Management System: http://www.northeastconsortium.org/data.shtml, and much of it is available on-line. Please let me know if you need assistance accessing the data.

Conflict of Interest and Confidentiality:
Each reviewer signed the Northeast Consortium's conflict of interest and confidentiality policy for the technical evaluation of projects. The evaluation reports submitted do not necessarily reflect views of the Northeast Consortium, the reviewers' employers, or governments. As requested by the NEFMC Research Steering Committee, the review comments are being submitted to the Council anonymously. However, I am always willing to act as a liaison for questions of the reviewers regarding any aspect of the evaluations.

The Northeast Consortium values this cooperative research project and the contributions that it can make to fisheries management and our collective knowledge of the Gulf of Maine and Georges Bank ecosystem. Thank you in advance for your consideration and assistance in ensuring the appropriate use of the study and the evaluation reports in the management arena. Do not hesitate to contact me with any questions you may have.

Sincerely,

Rachel Feeney

Rachel Feeney
Fisheries Specialist
(603) 862-2276
rachel.feeney@unh.edu

CC:
Pat Fiorelli, NEFMC
Chris Glass, Northeast Consortium

Enclosures:

- The Northeast Consortium's guidelines for the final technical evaluation for cooperative research projects, including evaluation criteria.
- Pol, M. *"Testing of low-profile, low cod bycatch gillnets: Phases I and II."* Final report submitted to the Northeast Consortium, June 22, 2006.
- "*Technical evaluation report*," submitted to the Northeast Consortium July 2, 2007.
- "*Technical evaluation report*," submitted to the Northeast Consortium July 18, 2007.
- Response to the technical evaluation written by M. Pol, November 27, 2007.

Northeast Consortium

Final Technical Evaluation for Northeast Consortium Cooperative Research Projects

The Northeast Consortium administers a final technical evaluation of all appropriate aspects of funded cooperative research projects once they are complete, including methods, data, data analysis and management, results and conclusions, deliverables, application for ocean and fisheries management, socio-economic impacts, and other impacts on end-users. The technical evaluation of a project is an essential step in the successful transfer of project results and products to appropriate end-users. Following evaluation, Northeast Consortium staff work to ensure that the data, information, and other deliverables are effectively used and integrated into fisheries and ocean management, further research, commercial fishing practices and products, and other practical applications, as appropriate.

The Final Technical Evaluation Process

The final technical evaluation of each project is unique, since the Northeast Consortium funds research that varies greatly in project topic area, size, and duration. The extent to which research outcomes may impact fisheries management is also likely to be unique. Therefore, the Northeast Consortium facilitates independent evaluations that are appropriate to both the nature of the research and the expected applications of the project outcomes. An internal review is conducted for each project and the vast majority of projects also receive an external review. In each case, a Northeast Consortium staff member is designated to provide programmatic and logistical support to the evaluation process.

Internal review. The Northeast Consortium staff reviews each project to ensure that project reporting requirements are met and that project funds were spent appropriately as determined by the approved project budget. There is also an analysis of the potential impact of project results to fisheries management or other end-users to determine if an external independent review is appropriate. Staff seek input of end-user communities in this determination.

External review. For projects which have results and outcomes that may have an impact on fisheries management or on an end-user community, an external review is facilitated by the Northeast Consortium. This evaluation takes the form of a mail and/or panel review. Project final reports and supporting materials are sent to technical reviewers. The projects are reviewed according to the Northeast Consortium's general criteria for the technical evaluation of completed projects, and possibly project-specific terms of reference. Reviewers submit technical evaluation reports to the Northeast Consortium. The Northeast Consortium staff member may compile a summary of the evaluation reports in the case of multiple reviews.

In the case of panel reviews, a technical expert in an appropriate discipline is selected by the Northeast Consortium Representatives to chair the evaluation panel. The Northeast Consortium staff works with the Representatives and the Chair to select 2-3 additional panel members. The Chair, in consultation with other panel members and the Northeast Consortium, decides how to

proceed with the evaluation, which may include meetings, video conferencing, project visits, interviews with project participants and end-users, and consultations with outside experts on related topics. The Chair may request mail review by additional independent experts. One evaluation report is written by the panel, though reviewers may submit individual comments.

Information Available to Reviewers

The Northeast Consortium staff member provides reviewers with copies of all relevant project documents, including the project proposal, final report, all data sets, publications, press coverage, descriptions and photos of new fishing gear or oceanographic instrumentation, lists of all deliverables and impacts, and names and contact information of all end-users and others who have direct knowledge of the project's real-world impacts and products. Any panel member may request additional information at any time during the evaluation. For mail reviews, the Northeast Consortium staff member can liaison questions about the project between the reviewers and project participants.

Evaluation Criteria

The following are the general criteria that reviewers use in evaluating projects. In addition, project-specific terms of reference are commonly used.

1. **Project success:** Did the project accomplish its stated goals and objectives?

2. **Certification of results:** Is there adequate description of the approaches to experimental design, methods, and data analysis? Were these approaches appropriate? Are there other approaches that the participants could have considered or used? Are the data accurate, precise, and believable? Are the results and conclusions well supported by the data and statistically valid? Can the results and conclusions contribute to a sound basis for management decisions and policies? If not, can anything be done to allow this?

3. **Data accessibility and dissemination of results:** Are the data available through the Northeast Consortium Fisheries and Ocean Data Management System? Are the data being served via another internet-accessible database? If so, are the data formatted suitably for data integration by the Northeast Consortium database? Are the project deliverables (publications, reports, and communications materials) of high quality? Have they been distributed appropriately? Is the final report complete, sufficient, and understandable to end-users?

4. **Project partnerships:** Consider the degree to which the project was of mutual interest to participants and whether partners were key participants throughout the course of the project, including project design, data collection and analysis, and application of the results or products. What were the most and least successful aspects of the partnership? Were all parties equally interested and engaged in the project?

5. **Project impacts:** What impacts has the project had or could it have? What are the potential effects on fishing practices; socio-economics; and fisheries, coastal, and ocean management?

6. **End-Users:** Being as specific as possible, who could benefit from knowing about the research? How can a fishing sector incorporate any new information from the project? Which fishery management organization, working group, or plan development team could use the data?

7. **Overall rating.** Rate the overall project according to the criteria listed above as excellent, very good, good, fair, or poor. Explain the reasoning behind the rating.

8. **Future research.** Is additional research needed to answer the original questions posed by the project? Are there obvious avenues of further research that should or must be pursued? Given the investment to date, should this future research be a high priority for the Northeast Consortium?

9. **Additional comments and guidance.** Provide any additional comments that will assist the Northeast Consortium in evaluating this project.

The Final Technical Evaluation Report

The reviewers, whether collectively as a panel or individually, prepare written reports, providing detailed comments on each of the evaluation criteria and terms of reference, noting specific strengths and weaknesses of the project. Reports of approximately five pages in length are anticipated, but longer reports are acceptable. Technical evaluation reports should be submitted by reviewers to the Northeast Consortium within six weeks of receiving project documentation. In the case of a panel review, the report is a "consensus" document written by all panelists. Panelists may provide additional/personal comments in individual reports.

Distribution of a Technical Evaluation Report

Final technical evaluation reports are not posted on the Northeast Consortium's website, but are available upon request on a case by case basis to representatives of end-user communities and organizations. This includes the National Marine Fisheries Service; New England Fishery Management Council; Atlantic States Marine Fisheries Commission; commercial fishing industry organizations and individuals; Coastal Zone Management program; Office of State Planning; the Advisory Committee of the Northeast Consortium; and/or other appropriate local, state, or federal agencies or programs. The Northeast Consortium staff member may prepare a summary of the report targeted for a specific end-user.

External Reviewers

Reviewer selection. Those selected as external reviewers include Northeast Consortium Advisory Committee members and others as needed to ensure appropriate expertise for each project and may come from outside the New England region. The Chair of a panel review may veto the selection of any panelist. The Northeast Consortium may offer honoraria for review panel service to each panel member. Expenses for travel and other incidentals will be reimbursed upon request.

Confidentiality and conflict of interest. The evaluation process is intended to be as fair and objective as possible. Project mail reviews are anonymous. Members of panel reviews are not identified to end-users without their prior permission. The Northeast Consortium seeks such permission only as necessary to provide evidence of authority and expertise; names of review panel members are not otherwise be made public. Panel members may not copy, quote, discuss or otherwise use materials about projects without the consent of the Northeast Consortium and project participants. Conflicts of interest are scrutinized when selecting panel reviewers and it is the responsibility of each panel member to inform the Northeast Consortium of any potential conflicts of interest. Each reviewer must read and sign the Northeast Consortium's conflict of interest and confidentiality policy prior to participating in a review. All materials used in the project evaluation process are returned to the Northeast Consortium or destroyed.

For More Information

Additional information about the Northeast Consortium can be found on its website (www.northestconsortium.org). The Northeast Consortium welcomes comment on policies and procedures at any time. For matters relating to the technical evaluation of cooperative research, please contact Rachel Gallant, Fisheries Specialist.

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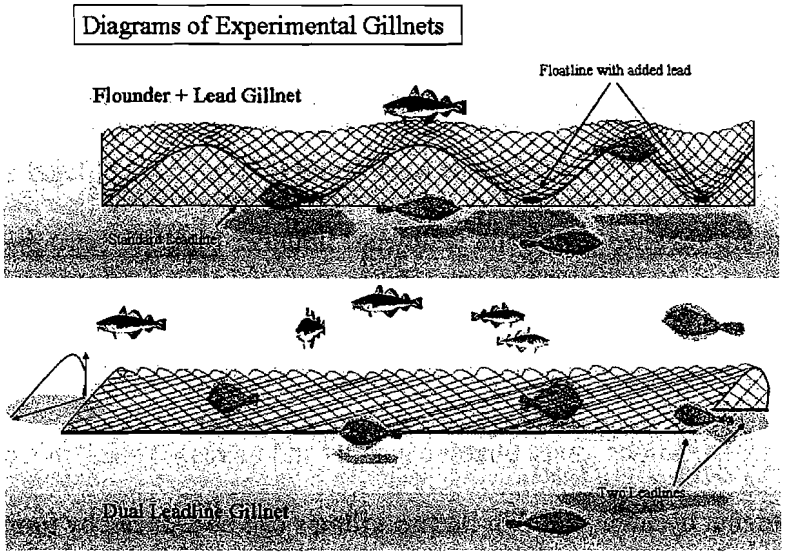
Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II

Award ZZ-487: 7/1/2000-12/31/2001

Award ZZ-569: 7/1/01-6/30/2003 (Extended to 5/31/2004)



Submitted: 22 June 2006

Michael V. Pol

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Abstract

Reduction of gillnet height through the addition of spaced weights on a foamcore floatline and replacement of the floatline with another leadline was effective in maintaining flatfish catch amounts and sizes while reducing bycatch of Atlantic cod by 49% and 58%, compared to standard commercial flatfish gillnets in the Gulf of Maine. Thirty-five sets of experimental gillnets, developed collaboratively between a commercial fisherman and Division of Marine Fisheries biologists, and standard gillnets demonstrated reductions in catch rates of retained and discarded Atlantic cod Gadus morhua between designs. No differences were found in catch rates of legal-sized winter flounder Pleuronectes americanus and yellowtail flounder Limanda ferruginea among flatfish gillnet designs. Undersized winter flounder catch rates were reduced by experimental designs by 88%. Underwater examination of nets verified that the experimental modifications lower floatline heights and increased slack in webbing. These results indicate that bycatch of cod in flatfish gillnets can be reduced by limiting floatation in the floatline.

Introduction

Gillnets can be an excellent way to target a particular-sized fish if the appropriate mesh size is used (Lagler 1978, Blady et al. 2002). Theoretically, mesh size is closely linked to fish girth (or its proxy, fish length) by the mechanism of wedging or gilling (Hamley 1975; Reis and Pawson 1999). In practice, gillnets catch fish several ways that are not directly linked to mesh size, such as entanglement by jaws or lips (Mentjes and Panten 2000). Also, stiffness of fish bodies can make the size-to-mesh relationship less

clear (Lucena et al. 2000). Despite these sources of variability, gillnets usually select a certain size fish better than other gears, including longlines (Santos et al. 2002, Erzini et al. 2003) and trawls (Nedreaas et al. 1996; Halliday 2002; Olin and Malinen 2003).

Narrow selectivity for fish size, when correctly matched to minimum landing size, can avoid discards of sublegal fish and contribute to a sustainable fishery. However, gillnets can catch a wide range of species (Järv et al. 2000). Recent reported unwanted catches of concern in gillnets include pipe clay (Williamson 1998), seabirds (Melvin et al. 1999; Simeone et al. 1999; Österblom et al. 2002), turtles (Santora 2003), seals (Baraff and Loughlin 2000), whales and dolphins (Trippel et al. 1999; Culik et al. 2001; Amir et al. 2002; Borodino et al. 2002), rare marine species (Stein et al. 2004), marine species in a weak condition (Godøy et al. 2000) and under strict management controls (Spingle 2002a).

Reduction of unwanted bycatch by altering where a gillnet fishes in the water column was tested by Samaranayaka et al. (1997). In that study, gillnets were hung below the surface at 1, 6, and 8 m the species composition of the catches was compared. Godøy et al. (2003) floated gillnets 0.5 m above the sea floor using norsels. This small relative height difference resulted in a 58% reduction in unwanted catches of red king crab Paralithodes camtschaticus. Brothers (2002) tested a similar design to avoid snow crab Chionoecetes opilio that resulted in excessive losses of the target.

The latter two projects exploit small-scale differences in habitat use by different species. In both, lifting the webbing of the gillnet 0.5 m off-bottom decreased crab bycatch substantially, taking advantage of the demersal orientation of crabs. Our project

similarly attempted to use small differences in habitat use by decreasing the vertical height of bottom-set gillnets.

The concept of altering vertical height of gillnets to separately target flatfish is not new. Within multispecies fisheries, flatfish are traditionally targeted by altering the vertical profile of gillnets. Floatlines constructed of foamcore (which contains its own flotation), polyethylene with no added flotation (Carr and Blott 1991, Ulrik Jes Hansen, SINTEF, personal communication), or tie-downs (tying the floatline of a full-size net to the leadline) (Spingle 2002a), have been used, in contrast to cod gillnets (or "stand-up gear") that maximize floatline height with deepwater floats.

Industry gear modifications, especially if unquantified, are often less-preferred in designing management measures. Effort controls such as time and area closures, limits on the amount of gear, and vessel size limits are more popular (for example, see Kelly and Griffin 2004). In New England, the species selectivity of gillnets designed to target flatfish is not well quantified, including the bycatch of Atlantic cod. Extensive management measures triggered to control cod bycatch in flatfish fisheries do not distinguish flatfish gillnets from cod gillnets. As a result of these measures, exploitable flatfish populations at times cannot be fished due to fears of bycatch of cod. Therefore, the potential benefit of gillnets that can be demonstrated to catch flatfish and not catch cod is large both by economic and ecological measures.

We lowered the vertical profile of gillnets in two ways: replacement of the floatline with another leadline ("dual leadline"); and by adding lead weight at intervals along a foamcore floatline ("lead-added"). Similar work on dual leadline gillnets to avoid cod bycatch in an American plaice Hippoglossoides platessoides fishery was also

developed by local fishermen in Cape Breton, Canada (Spingle 2002b). Also, based partly on this research, gillnets with lower floatlines resulting from a reduction in the mesh depth were tested in the Gulf of Maine by He (2006).

This project fulfilled the goals of its primary funder, the Northeast Consortium, by developing partnerships between commercial fishermen and scientists, enabling commercial fishermen and commercial fishing vessels to participate in cooperative research and the development of selective gear technologies, bringing fishermen's information, experience, and expertise into the scientific framework needed for fisheries management, and by using commercial fishing vessels as research and monitoring platforms.

Project Objectives and Scientific Hypotheses

The goal of this project was to test gillnet modifications that reduced the bycatch of Atlantic cod in flatfish gillnets, cooperatively with gillnet fishermen. We constructed the following hypotheses:

1) Cod catch:

H_A: The experimental designs (dual leadline; lead-added) each catch cod at lower rates than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch cod at the same rates as a standard flatfish design.

2) Cod length:

H_A: The experimental designs (dual leadline; lead-added) catch cod of different lengths than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch cod of similar lengths compared to a standard flatfish design.

3) Flatfish catch:

H_A: The experimental designs (dual leadline; lead-added) each catch individual species of flatfish at lower rates than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch individual species of flatfish at the same rates as a standard flatfish design.

4) Flatfish size:

H_A: The experimental designs (dual leadline; lead-added) catch flatfish of different lengths than a standard flatfish design.

H_0: The experimental designs (dual leadline; lead-added) catch flatfish of similar lengths compared to a standard flatfish design.

Our intent was to catch less cod than standard flatfish gillnets while catching flatfish of similar size at similar rates. The ultimate use of the experimental nets, if proven, was to either allow fishing for flatfish in areas closed for cod, or to reduce the bycatch of cod in open areas.

Key Participants

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Monument Beach, MA 02553

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Marshfield, MA 02050

Participating Vessels

F/V Lady Irene, Scituate, MA
Capt. Scott MacKinnon, Capt. John Welch

F/V Sasquatch III, Gloucester, MA
Capt. Paul Cohan

F/V Michael Brandon, Scituate, MA
Capt. Thomas Bell

Others

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Methods

Four types of gillnets were constructed for this study (Table 1). Each gillnet was 91 m (300 ft) long. Two complete sets of nets (48 nets) were constructed. All reported gillnet characteristics are nominal.

The standard flatfish, lead-added, and dual leadline nets were identically designed except for the construction of the floatline. Each type was constructed of light green (mesh size: 178 mm (7 in)), monofilament mesh webbing with a diameter of 0.47 mm, twenty-five meshes deep. The leadline was 91 m (50 fm) of 23 kg/183 m (50 lb/100 fm) leadline.

The floatline of the standard flatfish net consisted of 91 m (50 fm) of 13 mm (0.5 in) diameter foamcore float line with built-in floatation (1.7 oz./yd (52.5 g/m)). The lead-added design was made with a floatline the same as the standard flatfish net, but with flat

pieces of lead weight wrapped around the floatline every 9 m (5 fm). The dual leadline net was made with the floatline and leadline consisting of 91 m (50 fm) of 23 kg/ 183 m (50 lb/100 fm) leadline. This net had no floatline as it is normally defined.

The standard cod net was used to determine if cod were present in the study area. It was designed following industry practice, and differed from the other three nets in color, twine diameter, leadline weight, and hanging ratio. It was constructed of light green monofilament mesh webbing (mesh size: 178 mm (7 in)) with a diameter of 0.57 mm, twenty-five meshes deep. The floatline was 91 m (50 fm) of 9.5 mm (0.375 in) twisted polyethylene (PE) floatline with one deepwater gillnet float every fathom, or fifty floats per net. Each float provided approx. 3 oz. (85 g) of flotation. The leadline was 91 m (50 fm) of 29 kg/ 183 m (65 lb/100 fm) leadline.

Eight nets of the same design were tied into a string; one string of each design was set in the same general location. The geographical arrangement of the strings was changed each time the nets were hauled, based on a modified Latin square design to reduce bias. In general, strings were set and hauled following normal commercial fishing practice. However, soak times were limited to overnight (~24 h), shorter than standard when targeting flatfish. This shorter soak time was selected to allow more rapid testing and to increase survival of discarded fish. A "set" was defined as each instance of a net being hauled and its catch quantified.

Strings were fished on consecutive days whenever possible. Testing was halted for safety reasons and scientific validity when weather conditions were poor. Bottom temperatures were collected by probes attached to nets during the May 2001 and February 2002 testing periods.

Soak durations were defined as the difference between the time when the setting of the nets began until the end of the hauling of the nets. On trips where the gear was set and not hauled, set times were recorded by the vessel captain. When only the time that setting ended was recorded, an estimate of the begin time was made by using other set durations for that vessel. When no set time was recorded, soak times were estimated using water temperatures collected by sensors attached to three of the four nets, if available. Durations were used to normalize catches to lb/hr.

Modified box-and-whisker plots were constructed for catch rates (lb/hr) of cod and yellowtail flounder separately above and below minimum landing size (MLS) and for winter flounder above MLS. Box-and-whisker plots give a visual representation of the distribution of the catch rates for each net by set. The box ends are defined as the first and third quartile of all observed catch rates for that net. The median is a solid line through the box. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots.

Box-and-whisker plots typically cannot be used for hypothesis testing. To determine the appropriate statistical test, Bartlett's test for homogeneity of variance (Sokal and Rohlf 1995) was first employed; catch rates (lb/hr) were found to be heteroscedastic, making use of ANOVA or t-tests for catch comparisons inadvisable unless transformed. As an alternative to transforming data, the non-parametric randomization test (Sokal and Rohlf 1995, Rago 2004) was chosen to compare the catch of several species and size groups in each experimental net (lead-added and dual leadline) against the control, the standard flatfish net.

Using this method, mean differences in catch rates were compared set-by-set for cod, yellowtail and winter flounders above and below MLS. Sets that had zero catches in all four designs were excluded from analysis. The observed mean difference between the catch rate in each experimental string and the standard flatfish string for each set was compared to a distribution of 1000 or more differences determined from random assortments of the pool of catch data. The p-value was defined as the percentage of the mean differences more extreme than the observed difference.

Length-frequencies of target species were pooled and compared between the standard net and each of the control nets using the Kolmogorov-Smirnov test (Sprent 1989). Sample sizes were adjusted for cluster effects following the methods of Pennington et al. (2001).

One day of filming was conducted with an underwater remotely-operated vehicle (ROV) to examine the underwater profile of individual nets.

Data

Operational and environmental data were recorded by Manomet Center for Conservation Sciences (Manomet) or DMF observers for each set following NMFS Northeast Fisheries Science Center (NEFSC) protocols and forms. Species composition and weights of catch was recorded. Lengths of cod and flatfish species were recorded to the nearest centimeter. Set locations and durations, along with weather and additional data, were also recorded. Where the level of identification of catch was inconsistent, catches were combined during analysis to the broadest common taxa. For example, some skates were identified as "All Skates".

All data were submitted to the Northeast Consortium Fisheries & Ocean database on 5 January 2005.

Results and Conclusions

Thirty-five overnight sets of all four nets were completed between 12 December 2000 and 23 February 2002 in three phases: December 2000 – January 2001; May 2001; February 2002 (Table 2). Nets were set off the coast of Massachusetts, USA in the vicinity of Cape Ann and Provincetown (Figure 1). Some of the testing occurred in areas closed to general fishing, under an experimental fishing permit issued by the National Marine Fisheries Service (NMFS). Timing and location of sets were determined by fishermen's experience, catches and regulatory limits. Nets were set overnight, with durations of soak time ranging from 16.9 to 76.4 hours. The longest set was due to engine difficulties which required the vessel to return to port for repair without hauling all gear.

Approximately 17,081 kg (37,578 lb) of vertebrate and invertebrate marine organisms were caught during the thirty-five overnight sets completed for this study. 68% of this catch was categorized as "kept", and were landed for sale or consumption, representing 18 taxa (Table 3). The remaining 32% of the catch was discarded for a variety of reasons, including size limits, lack of quota, poor condition, or lack of market. Organisms representing thirty-five taxa were caught and discarded (Table 4). Table 6 includes the common and scientific names for species mentioned in this study.

Cod made up the majority of kept species, contributing 39% of the kept catch (4528 kg, 9961 lb). Yellowtail flounder (28%, 3187 kg, 7011 lb) and skates Rajidae

(16%) were the other major landed species. All other kept species contributed less than 9% each to the total kept catch.

Skates (42% of all discards), crabs Infraorder Brachyura (11%), and spiny dogfish Squalus acanthias (10%) were the primary discard taxa. Discarded cod represented 12% (685 kg, 1507 lb) of overall discard; all other taxa contributed less than 7% each of the total discard.

Overall, catch rates during the experiment were typical of commercial operations with short soak durations (R. MacKinnon, pers. communication). Catch rates of cod above MLS (19 in (48.3 cm) at the time of the experiment) per string were highest in the cod gillnet (6.1 lb/hr (2.77 kg/hr), Table 5, Figure 2). The two experimental flatfish gillnets caught less cod per hour than the standard flatfish design (3.27 lb/hr (1.48 kg/hr), Table 5, Figure 2). The gillnet with lead added to the floatline caught an average of 1.91 lb/hr (0.86 kg/hr; 58%) less than the standard design ($p=0.00$); the dual leadline flatfish gillnet caught 1.59 lb/hr (0.72 kg/hr; 49%) less ($p=0.01$).

Catch rates of cod below MLS were lowest in the cod gillnet (0.05 lb/hr (0.02 kg/hr), Table 5, Figure 2). The three flatfish nets averaged 0.77 lb/hr (0.35 kg/hr) (standard flatfish), 0.38 lb/hr (0.17 kg/hr) (lead-added), and 0.48 lb/hr (0.22 kg/hr) (dual leadline). The differences among the flatfish nets were not significant when all data were included. However, catch data for undersized cod were widely dispersed, with one set having a large influence (Figure 2). Reanalysis with this set removed as an outlier showed much lower cod catches with approximately 41% less small cod in the experimental nets (standard: 0.37 lb/hr (0.17 kg/hr); lead-added: 0.22 lb/hr (0.10 kg/hr); dual leadline: 0.23 lb/hr (0.10 kg/hr)). These differences approached the 0.05 level of

significance between both experimental flatfish nets and the standard control flatfish net (Table 5).

Average catch rates of yellowtail flounder above MLS (13 in (33.0 cm)) per string were highest in both experimental nets (lead added: 3.56 lb/hr (1.62 kg/hr); dual leadline: 3.57 lb/hr (1.62 kg/hr) but were not significantly different from the standard flatfish gillnet (2.50 lb/hr (1.14 kg/hr)) (Table 5, Figure 3). The cod gillnet caught only an average of 0.15 lb/hr (0.07 kg/hr) of yellowtail flounder. Catch rates of undersized yellowtail flounder were also not significantly different among the flatfish nets (range of means: 0.36-0.45 lb/hr (0.16-0.20 kg/hr). The cod gillnet averaged 0.02 lb/hr (0.009 kg/hr).

Catch rates of winter flounder above MLS (12 in (30.5 cm)) were low among all flatfish nets (0.75-0.84 lb/hr (0.34-0.38 kg/hr) and not significantly different (Table 5, Figure 4). The cod gillnet averaged 0.22 lb/hr (0.10 kg/hr). Catches below MLS in all nets were significantly lower in the experimental nets (0.01 lb/hr (0.007 kg/hr) for both, a reduction of 88% from the standard flatfish net (0.16 lb/hr (0.07 kg/hr)). The cod net caught undersized winter flounder at the lowest rate (<0.01 lb/hr (0.003 kg/hr); Table 5, Figure 4).

Catch weights are an important measure of comparative net performance. Additionally, comparison of pooled length-frequency distributions were necessary to determine whether gillnets caught similar sizes of fish. No significant differences ($p = 1.00$) were found among any of the three flatfish net designs for the three species examined: cod, yellowtail, and winter flounders (Figures 5, 6, 7). A curious non-significant anomaly was observed in the pooled flatfish flounder catches: the standard

flatfish gillnet caught more winter flounder at the most common size, as illustrated by the differences in the peaks in Figure 7, while the relationship was inverted in catches of yellowtail flounder (Figure 6).

The cod gillnet caught a different size range of fish than the three flatfish gillnets for all three species. In general, the cod gillnet caught fewer flatfish over the same size range as the flatfish nets. Its catch was more selective for larger cod, >63 cm (25 in), than all three flatfish nets. The flatfish nets appeared to catch far more cod below MLS.

Pooling of length frequencies for all sets ignores variation between sets, often masking important information. For example, a very large majority of the small cod (32-59 cm (13-23 in)) were caught by the flatfish nets in one set. Otherwise, catches of cod were evenly distributed across a size range similar to the cod gillnets, which caught similar sizes of cod during the entire experiment.

Bottom temperatures were retrieved for one string in May 2001 and varied little between sets, with mean temperatures ranging from 4.1-4.2 °C (39–40 °F). Temperatures were retrieved from three strings during the February 2002 testing. Temperatures between sets and among strings ranged from 4.9-5.4 °C (41-42 °F).

A remotely operated vehicle (ROV) was used to view the nets underwater. Deployment of an ROV near the gillnets led to frequent tangling. Low water clarity and rough seas contributed to the difficulty of seeing the nets and measuring heights. These conditions also required the ROV to approach the nets closely. Sufficient video was collected to characterize but not quantify the vertical profile of the nets. The cod gillnet with floats attached stood up to the maximum height of its endlines (14.6 ft (4.5 m)) with no slack in the webbing and was even across its length. The foamcore-only floatline

maintained an even low height with visible slack in the webbing. Carr and Blott (1991) found that gillnets with no floatation had heights only 15% of maximum height. Using this relationship translates to a minimum estimated height of the standard design of 2.1 m (6.9 ft). The effect of the lead added to the foamcore floatline created a series of quaternary arcs in the floatline. The maximum height of the arcs appeared to be equal to the height of the unmodified foamcore floatline. Wherever lead was added, that part of the floatline was in contact with the bottom, with a steep-sided arc leading to the next piece of added lead. The dual leadlines of the dual leadline net were seen to rest very close together on the sea floor, at times touching. This configuration resulted in a cloud of nearly invisible webbing that drifted back and forth with local current.

Several important conclusions can be drawn from these results. First, we confirm that the traditional industry-developed cod and flatfish gillnets are each effective at targeting cod and flatfish; the cod gillnet was especially selective for legal-sized cod, with a small bycatch of spiny dogfish. The relatively small bycatch of spiny dogfish differs from He's (2006) similar study, although this difference may be due to densities of dogfish rather than gear design. Secondly, the experimental designs reduced cod catches in the flatfish gillnet by 49% and 58%, demonstrating that the floatline modifications were effective in avoiding cod. Catches of cod below MLS, following removal of one anomalous set, were reduced at levels approaching the 0.05 significance level. Catches of legal-sized yellowtail and winter flounder in experimental nets were not different from catches in the standard flatfish gillnet. Further, catches of undersized winter flounder were also significantly lower in the experimental designs. These results

indicate that adoption, mandated or voluntary, of the modified gillnet designs would lead to reductions in cod bycatch compared to standard flatfish gillnets.

The lengths of flatfish caught in the experimental gillnets, as reflected in length-frequency distributions, were not different from the standard flatfish gillnet. This result indicates that adoption of these designs would not lead to any reduction in the landed value of flatfish catches due to size differences. In short, evidence was found to reject the first null hypothesis and, with the caveats of one anomalous set and p-values close to 0.05 in the case of sublegal cod, that the experimental designs do catch cod (above and below MLS) at a lower rate than the standard flatfish net (Hypothesis 1). No evidence was found to refute the null hypothesis for cod length that all flatfish designs would catch cod of similar lengths (Hypothesis 2). No evidence was found to refute Hypothesis 3 (All flatfish designs, experimental and standard, would catch flatfish at similar rates) for yellowtail above and below MLS, and winter flounder above MLS. It was rejected for winter flounder below MLS. Lastly, no evidence was found to reject Hypothesis 4. All flatfish nets caught similar lengths of flatfish. The experimental nets therefore performed as hoped, improving the standard flatfish design by reducing cod bycatch, while also reducing winter flounder below MLS, too.

The ROV work provided evidence to determine why the experimental nets worked as hoped. The underwater footage indicated that modifications to the floatline resulted in a reduction in overall vertical profiles and an increase in the vertical slack of the net webbing. The footage showed that the floatation on the cod gillnet caused that net to assume a maximum vertical profile that created a certain amount of stiffness in the webbing panel, in contrast to the standard flatfish net, whose vertical profile was much

lower and resulted in loose webbing. The degree of stiffness in the webbing resulting from the buoyancy of the floatline has an impact on the mechanics of meshing or wedging of fish into the net opening (Wan et al. 2004). Loose slack webbing probably contributed to the catch of undersized cod in all flatfish designs. Also, extra netting on the seabed was found by He (2006) to be a factor in increased flatfish catches.

ROV observations of decreased net height in gillnets and the catch differences found in this study support the conclusion that cod and flatfish have differences in their use of the ocean space just above the bottom, apparently with flatfish lower and cod higher. While it would be simplistic to assert that a clear line of separation between species exists, other studies support the existence of near-bottom species separation. He (2003), using video, found that winter flounder were limited in activity to no more than 0.6 m off bottom, a result in line with fishermen's experience. The raised-footrope trawl, fishing approximately 0.5 m (1.5 ft) off-bottom, reduces catch of flatfish by over 80% (DMF, unpubl. data). Using gillnets, He (2006) found decreases in cod bycatch by use of 8 mesh deep gillnets with low floatation and a maximum height of 1.2 m (3.9 ft). The actual fishing height was certainly lower. The occupation of near-bottom space may be species- or size-specific. In contrast to winter flounder, yellowtail flounder have distinct off-bottom behavior, with periodic movements averaging 15 m (49 ft) to a maximum off-bottom height of 56 m (184 ft) (Cadrin and Westwood 2004). In this study, catch rates of sublegal winter flounder were much lower in the lower gillnets while legal-sized winter flounder were caught at similar rates. Detailed examination of bottom-orientation and species-specific behavior appear to provide a potential pathway toward improved species selectivity of gillnets, and requires further investigation.

Measurement of gillnet height is necessary to determine if separation zones between species exist. However, use of ROVs or divers to obtain these heights is complicated, expensive, and unreliable, and usually results in single data points. The use of small sensors attached to the floatline and leadline and capable of measuring depth at less than 0.5 m resolution over long time periods has recently been pioneered by DMF (Ed Lyman, DMF, unpubl. data) using data storage tags. This tool should be examined for monitoring of gillnet height during fluctuations of tide and current as an aid to understanding gillnet and species behavior.

We presented results with one outlier representing a single day's high catch of cod below MLS in the experimental and standard flatfish nets removed. One can reasonably argue from a scientific viewpoint that this removal is legitimate: the catches of small cod occurred on one single set (8 Dec 2000) in a location known by our industry partners to be suboptimal for flatfish. Typically, flatfish gillnets are not deployed by industry where small cod are present, or are removed if small cod are present (R. MacKinnon, personal communication). Although the experimental nets caught less cod than the standard flatfish nets, these guidelines should be considered when deploying these experimental nets as well. Further, while ignoring a rare event may be scientifically defendable, risks of rare events may need to be considered by managers when contemplating implementation.

The development and mandated use of species-specific gear has become useful as a way to maintain fishing opportunity where some stocks are in a weakened condition. However, this form of management runs counter to a historical multispecies approach to commercial fishing. While gillnetters have developed separate flatfish and cod gillnets,

lack of species-specificity may be in fact be desirable to allow some valuable bycatch; for example, cod in flatfish gillnets. It is more of a management imperative to refine gillnets to catch exclusively one species. It should be recognized that, especially where bycatch quotas exist, decreasing bycatch of non-target species may lead to loss of expected and economically vital landings. This loss is one reason that highly species-selective fishing gear may not be embraced by industry.

It was theorized that the experimental nets would be less vulnerable to harbor porpoise Phocoena phocoena due to lower vertical profiles. The use of acoustic warning devices was mandated during part of the study. No harbor porpoises were caught. The avoidance of porpoises is highly desirable, but many obstacles impede testing of this avoidance, not least of which is the rarity of capture.

A further by-product of this study is the documentation of catch rates for standard cod and flatfish gillnet designs. Information on these catch rates is scarce, and the results may provide valuable information for management and assessment. The combined impact of all of these results allows managers or fishermen to reduce bycatch of cod when targeting flatfish with gillnets by lowering or restricting gillnet height by using either the addition of spaced weight to the floatline or replacement of the floatline with leadline. If cod catch rates are low enough based on stock assessments, consideration should be given to allowing access by fishermen to healthy flatfish populations where cod bycatch is a concern.

Time and resources often limit gear testing to certain areas and seasons. Generalization from this study to the broader Gulf of Maine and at all times of year, however, is supported by the results of He (2006) who also found reduced bycatch of cod

by using gillnets of shorter height. Further research, jointly led by He and Pol on shorter gillnets, has been funded by the Northeast Consortium and is currently underway.

Literature cited

Amir, O.A., Berggren, P., Jiddawi, N.S. 2002. The incidental catch of dolphins in the gillnet fisheries in Zanzibar, Tanzania. Western Indian Ocean J. Mar. Sci. 1(2):155-162.

Baraff, L. S., Loughlin, T. R. 2000. Trends and potential interactions between pinnipeds and fisheries of New England and the U.S. West Coast. Mar. Fish. Rev. 62(4): 1-39.

Blady, W., Netzel, J., Zaucha, J. 2002. The impact of material and mesh size on the selectivity of deep-sea cod gillnets. Bull. Sea Fish. Inst. 2(156):3-14.

Borodino, P., Kraus, S., Albareda, D., Fazio, A., Palmeiro, A., Mendez, M., Botta, S. 2002. Reducing incidental mortality of Franciscana dolphin Pontoporeia blainvillei with acoustic warning devices attached to fishing nets. Mar. Mamm. Sci. 18(4):833-842.

Brothers, G. 2002. Reducing snow crab bycatch in turbot gillnets. Project Summary: EACT-10.2002.DFO (FDP 299) Fisheries and Oceans Canada.

Cadrin, S.X., Westwood, A. D. 2004. The use of electronic tags to study fish movement: a case study with yellowtail flounder off New England. ICES CM 2004/K:81.

Carr, H.A., Blott, A. 1991. A study of ghost gillnets in the inshore waters of southern New England. in J. T. DeAlteris, M. Grady (eds.) Proceedings of the Fisheries Conservation Workshop, Narragansett, RI, 4-5 April 1990.

Culik, B. M., Koschinski, S., Tregenza, N., Ellis, G. M. 2001. Reactions of harbor porpoises Phocoena phocoena and herring Clupea harengus to acoustic alarms. Mar. Ecol. Prog. Ser. 211:255-260.

Erzini, K., Gonçalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J., Stergiou, K.I. 2003. Quantifying the roles of competing static gears: comparative selectivity of longlines and monofilament gill nets in a multi-species fishery of the Algarve (southern Portugal). Sci. Mar. 67(3):341-352.

Godøy, H., Furevik, D. M., Løkkeborg, S. 2000. Reduced by-catch of red king crab (Paralithodes camtschatica) in the cod gillnet fisheries in northern Norway. ICES CM 2000/J:05.

Halliday, R.G. 2002. A comparison of size selection of Atlantic cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) by bottom longlines and trawls. Fish. Res. 57:63-73.

Hamley, J.M. 1975. Review of gillnet selectivity. J. Fish. Res. Bd. Can. 32: 1943–1969.

He, P. 2006. Effect of the headline height of gillnets on species selectivity in the Gulf of Maine. Fish. Res. 78: 252-256.

He, P. 2003. Swimming behaviour of winter flounder (Pleuronectes americanus) in natural fishing grounds as observed by an underwater video camera. Fish. Res. 60:507-514.

Järv, L., Dreves, T., Järvik, A. 2000. Size-species selectivity of gillnets in Estonian coastal zone: regulation efficiency. ICES CM 2000/J:16.

Kelly, B., Griffin, M. 2004. Marine Fisheries Regulation Summaries. http://www.mass.gov/dfwele/dmf/commercialfishing/2004regssummary.pdf

Lagler, K. F. 1978. Capture, sampling, and examination of fishes. In: Bagenal, T. (Ed.) Methods for Assessment of Fish Production in Fresh Waters. Blackwell Scientific, pp. 7-47.

Lucena, F.M., O'Brien, C.M., Reis, E.G. 2000. The effect of fish morphology and behaviour on the efficiency of gill nets, their selectivity and by-catch: two examples from southern Brazil. ICES CM 2000/J:11.

Melvin, E. F., Parrish, J. K., Conquest, L. L. 1999. Novel tools to reduce seabird bycatch in coastal gillnet fisheries. Cons. Biol. 13(6):1386-1397.

Mentjes, T., Panten, K. 2000. Relative size and girth selectivity of cod gillnets in the western Baltic. ICES CM 2000/J:12.

Nedreaas, K. H., Soldal, A. V., Bjordal, Å. 1996. Performance and biological implications of a multi-gear fishery for Greenland halibut (Reinhardtius hippoglossoides). J. Northw. Fish. Sci. 19:59-72.

Olin, M., Malinen, T. 2003. Comparison of gillnet and trawl in diurnal fish community sampling. Hydrobiologica 506-509:443-449.

Österblom, H., Fransson, T., Olsson, O. 2002. Bycatches of common guillemot (Uria aalge) in the Baltic Sea gillnet fishery. Biol. Cons. 105:309-319.

Pennington, M., Burmeister, L., Hjellvik, V. 2001. Assessing the precision of frequency distributions estimated from trawl-survey samples. Fish. Bull. 100:74-80.

Reis, E.G., Pawson, M.G. 1999. Fish morphology and estimating selectivity by gillnets. Fish. Res. 39:263-273.

Rago, P. 2004. Parametric and non-parametric tests. Catch Comparison Workshop, University of Rhode Island, Dec 8-9, 2004.

Samaranayaka, A., Engäs, A., Jørgensen, T. 1997. Effects of hanging ratio and fishing depth on the catch rates of drifting tuna gillnets in Sri Lankan waters. Fish. Res. 29:1-12.

Santora, C. 2003. Management of turtle bycatch: can endangered species be protected while minimizing socioeconomic impacts? Coastal Management 31:423-434.

Santos, M.N., Gaspar, M.B., Monteiro, C.C., Vasconcelos, P. 2002. Gill net and long-line catch comparisons in a hake fishery: the case of southern Portugal. Sci. Mar. 66(4):433-441.

Simeone, A., Bernal, M., Meza, J. 1999. Incidental mortality of Humboldt penguins Spheniscus humboldti in gill nets, central Chile. Mar. Ornith. 27:157-161.

Sokal, R.R., Rohlf, F.J. 1995. Biometry. W.H. Freeman and Co., New York.

Sprent, P. 1989. Applied nonparametric statistical methods. Chapman and Hall, New York.

Spingle, J. 2002a. Reducing cod bycatch in the 4R gillnet fishery for American plaice. Project Report: EACT-2.2002.DFO (FDP 290). Fisheries and Oceans Canada.

Spingle, J. 2002b. Reducing cod bycatch in the 4R gillnet fishery for American plaice (II). Project Report: EACT-2.2002.DFO (FDP 290). Fisheries and Oceans Canada.

Stein, A. B., Friedland, K. D., Sutherland, M. 2004. Atlantic sturgeon marine bycatch and mortality on the continental shelf of the northeast United States. N. A. J. Fish Man. 24:171-183.

Trippel, E. A., Strong, M. B., Terhune, J. M., Conway, J.D. 1999. Mitigation of harbour porpoise (Phocoena phocoena) bycatch in the gillnet fishery in the lower Bay of Fundy. Can. J. Fish. Aquat. Sci. 56(1):113-123.

Wan, R., W.Q. Huang, X.F. Song, F.X. Hu, T.Tokai. 2004. Statics of a gillnet placed in a uniform current. Ocean Engineering 31:1725-1740.

Williamson, J. 1998. Gillnet fishing. In Dorsey, E.M., Pederson, J. Effects of fishing gear on the sea floor of New England. Conservation Law Foundation, Boston, MA. Pp. 87-90.

Table 1. Net characteristics of the four types of gillnets built and tested.

NET CHARACTERISTICS	Standard Cod	Standard Flatfish	Lead-Added	Dual Leadline
Mesh size (mm)	178 (7 in)	178 (7 in)	178 (7 in)	178 (7 in)
Material	Mono	Mono	Mono	Mono
Twine diameter (mm)	0.57	0.47	0.47	0.47
Color	Light blue	Light green	Light green	Light green
Mesh depth	25	25	25	25
Floatline	9.5 mm (3/8 in) poly with one gillnet float per 1.8 m (1 fm)	13 mm (1/2 in) foamcore, no floats	13 mm (1/2 in) foamcore floatline with lead wrapped every 9 m (30 ft).	23 kg/ 183 m (50 lb/600 fm) leadline
Leadline	29 kg/ 183 m (65 lb/600 fm)	50 lb/600 fm	50 lb/600 fm	50 lb/600 fm
Hanging Ratio	1/2	1/3	1/3	1/3
Net Length (m)	91 (300 ft)	91 (300 ft)	91 (300 ft)	91 (300 ft)

Table 2: Fishing log of experimental sets included in analysis. Trip ID is a unique identifier for each fishing trip.

Date	Trip ID	Vessel	Latitude (N)	Longitude (W)
12/03/00	GN002	Lady Irene	42.1315	-70.5307
12/04/00	GN003	Lady Irene	42.3596	-70.2432
12/08/00	GN004	Lady Irene	42.2278	-70.6916
12/09/00	GN005	Lady Irene	42.2557	-70.6230
12/10/00	GN006	M. Brandon	42.2543	-70.6228
12/11/00	GN007	Lady Irene	42.2523	-70.6286
01/12/01	GN015	Sasquatch	42.5722	-70.5091
01/13/01	GN008	Lady Irene	42.5375	-70.3869
01/13/01	GN016	Sasquatch	42.5394	-70.3756
01/14/01	GN009	Lady Irene	42.5471	-70.4011
01/14/01	GN010	Sasquatch	42.5307	-70.3784
01/17/01	GN011	Lady Irene	41.9384	-70.5144
01/18/01	GN012	Lady Irene	41.9436	-70.5156
01/23/01	GN013	Sasquatch	42.5834	-70.4245
01/26/01	GN014	Sasquatch	42.5281	-70.6348
05/08/01	GN00	Sasquatch	42.4797	-70.6696
05/09/01	GN01	Sasquatch	42.4893	-70.6772
05/10/01	GN02	Sasquatch	42.4886	-70.6793
05/11/01	GN03	Sasquatch	42.4937	-70.6912
05/12/01	GN04	Sasquatch	42.4872	-70.6834
05/18/01	GN04B	Sasquatch	42.4933	-70.6831
05/19/01	GN05	Sasquatch	42.4930	-70.6933
05/20/01	GN06	Sasquatch	42.4967	-70.6911
05/21/01	GN07	Sasquatch	42.4930	-70.6933
05/30/01	GN08	Sasquatch	42.4940	-70.6811
02/07/02	GN01	Lady Irene	42.3889	-70.3046
02/14/02	GN02	Lady Irene	42.3760	-70.3074
02/16/02	GN03	Lady Irene	42.3832	-70.3134
02/17/02	GN04	Lady Irene	42.3808	-70.3114
02/19/02	GN05	Lady Irene	42.3933	-70.2811
02/20/02	GN06	Lady Irene	42.3925	-70.3320
02/21/02	GN07	Lady Irene	42.3932	-70.3489
02/22/02	GN08	Lady Irene	42.3808	-70.3114
02/23/02	GN09	Lady Irene	42.3856	-70.3154
02/23/02	GN10	Lady Irene	42.3872	-70.3005

Table 3: Summary of species caught and total kilograms kept. Some taxa were grouped at levels higher than species. K = retained by vessel; D = discarded at sea.

	Disp.	Total	Standard Cod	Standard Flatfish	Lead-Added	Dual Leadline
Atl. Cod	K	4527.7	2275.5	1193.2	481.4	577.7
Yellowtail Fl.	K	3187.0	50.9	909.1	1133.4	1093.6
All Skates	D	2331.3	45.0	803.9	811.0	671.4
All Skates	K	1841.4	47.7	580.9	883.6	329.1
Winter Fl.	K	906.0	78.9	322.0	261.5	243.6
Atl. Cod	D	685.1	18.2	330.0	146.9	190.0
All Crabs	D	590.1	29.7	154.8	222.3	183.4
Spiny Dogfish	D	533.6	325.0	119.1	49.1	40.5
Yellowtail Fl.	D	343.1	5.8	98.6	118.9	119.8
Haddock	K	303.2	231.8	42.3	13.6	15.5
Monkfish	K	296.8	65.9	155.0	58.6	17.3
Sea Raven	D	291.6	45.5	90.5	94.8	60.9
Lobster	D	205.0	1.4	74.5	78.2	50.9
Am. Plaice	K	170.8	15.8	55.2	58.0	41.8
Lobster	K	151.0	10.0	50.4	54.8	35.9
Am. Plaice	D	115.8	3.3	37.3	41.4	33.9
Atl. Sturgeon	D	85.0	37.3	22.7	25.0	
Atl. Mackeral	K	75.0	68.2	3.6	0.9	2.3
All Others		441.6	100.5	166.3	92.0	82.8
	Total	17081.3	3456.2	5209.5	4625.3	3790.3

Table 4: Species present at 1% or less of total catch in different net types. K = retained by vessel; D = discarded at sea.

			Net Type			
Species	**Disp.**	**Total**	**Standard Cod**	**Standard Flatfish**	**Lead-Added**	**Dual Leadline**
Am. Shad	D	X	X	X		
Atl. Mackeral	D	X	X	X		X
Atl. Wolffish	K	X	X	X	X	
Cunner	D	X		X	X	X
Cusk	K	X		X		
Cusk	D	X		X	X	X
Fourspot Fl.	D	X	X	X	X	X
Gray Sole	K	X	X	X	X	X
Gray Sole	D	X			X	
Guillemot	D	X	X			
Haddock	D	X	X	X		X
Harbor Seal	D	X	X			
Lumpfish	D	X		X		X
Monkfish	D	X	X	X	X	X
Ocean Pout	D	X	X			
Pollock	K	X	X	X		
Pollock	D	X	X		X	X
Red Hake	D	X		X	X	X
Redfish	K	X	X	X	X	X
Redfish	D	X	X	X	X	
Sculpin	D	X	X	X	X	X
Sea Robin	D	X			X	X
Sea Scallop	K	X		X		X
Sea Stars	D	X	X	X	X	X
Sea Urchin	D	X		X	X	X
Seaweed	D	X	X			
Striped Bass	K	X				X
Striped Bass	D	X	X	X		
Summer Fl.	D	X		X		
Tautog	K	X		X		
Whelks	D	X		X	X	
Whiting	K	X	X	X		X
Whiting	D	X	X	X		X
Windowpane Fl.	D	X	X	X		X
Winter Fl.	D	X	X	X	X	X

Table 5: Mean catch for four different gillnet designs. MLS = minimum landing size. N = number of sets. Asterisk indicates one outlier set was deleted. P-values are bolded where significant or marginally significant.

			Mean Catch (lb/hr)				Mean Difference			
		N	Standard Cod	Standard Flatfish	Lead-Added	Dual Leadline	Lead-Added v. Std Flat	p-value	Dual Lead v. Std Flat	p-value
Atl. Cod	>MLS	33	6.10	3.27	1.36	1.68	-1.91	**0.00**	-1.59	**0.01**
	<MLS	35	0.05	0.77	0.38	0.48	-0.39	0.28	-0.29	0.29
	<MLS*	34	0.04	0.37	0.22	0.23	-0.15	**0.07**	-0.14	**0.09**
Yellowtail Fl.	>MLS	30	0.15	2.50	3.56	3.57	1.06	0.17	1.07	0.11
	<MLS	26	0.02	0.36	0.45	0.45	0.08	0.25	0.09	0.24
Winter Fl.	>MLS	32	0.22	0.84	0.75	0.78	-0.09	0.65	-0.07	0.63
	<MLS	33	0.01	0.16	0.01	0.01	-0.14	**0.00**	-0.14	**0.00**

Table 6. Common and scientific names of organisms mentioned in this study.

Common name	Scientific name
All Clams	Order Bivalvia
All Crabs	Infraorder Brachyura
All Sculpins	Family Myoxocephalidae
All Skates	Family Rajidae
American Plaice	Hippoglossoides platessoides
Atlantic Cod	Gadus morhua
Atlantic Halibut	Hippoglossus hippoglossus
Atlantic Wolffish	Anarhichas lupus
Black Sea Bass	Centropristis striata
Fourspot Flounder	Paralichthys oblongus
Gray Sole	Glyptocephalus cynoglossus
Haddock	Melanogrammus aeglefinus
Lobster	Homarus americanus
Monkfish	Lophius americanus
Ocean Pout	Macrozoarces americanus
Sea Cucumber	Class Holothuroidea
Sea Raven	Hemitripterus americanus
Sea Scallop	Plactopecten magellanicus
Sea Star	Class Asteroidea
All Sea Urchins	Strongylocentrotus sp.
Spiny Dogfish	Squalus acanthias
Striped Sea Robin	Prionotus evolans
Striped Bass	Morone saxatilis
Summer Flounder	Paralichthys dentatus
Whiting	Merluccius bilinearis
Windowpane Flounder	Scophthalmus aquosus
Winter Flounder	Pleuronectes americanus
Yellowtail Flounder	Limanda ferrugineus
Pollock	Pollachius virens
Red Hake	Urophysis chuss
Redfish	Sebastes fasciatus
White Hake	Urophysis tenuis

Figure 1: Locations of testing of gillnets for this study and continued testing. The area shown is off the coast of Massachusetts, USA.

Figure 2: Modified box-and-whisker plots of Atlantic cod catches above (bottom) and below (top) MLS. The box ends represent the first and third quartile. The solid line through the box is the median. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots. Numbers in parentheses are values beyond the scale of the plot.

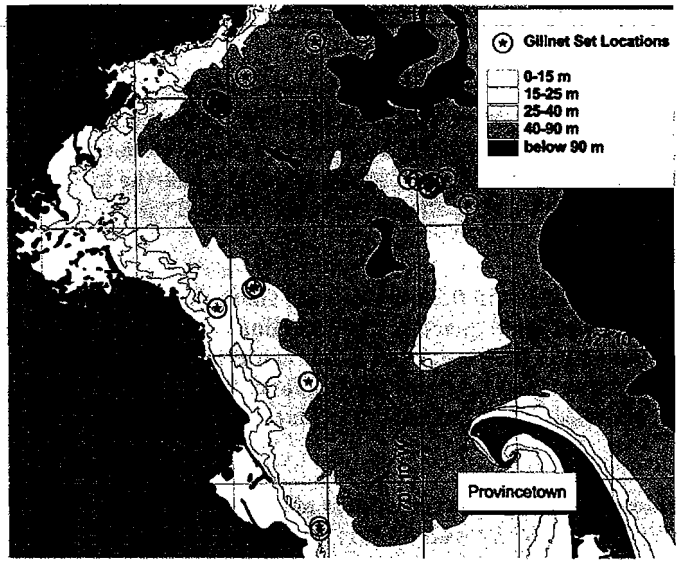
Figure 3: Modified box-and-whisker plots of yellowtail flounder catches above (bottom) and below (top) MLS. The box ends represent the first and third quartile. The solid line through the box is the median. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots. Numbers in parentheses are values beyond the scale of the plot.

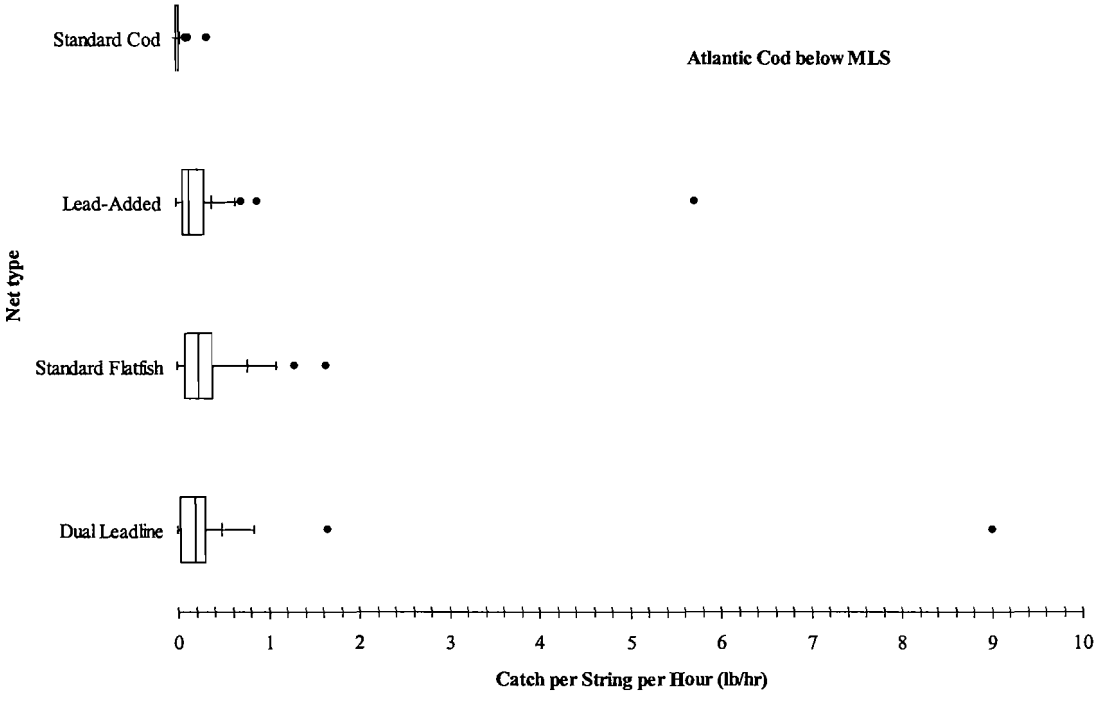
Figure 4: Modified box-and-whisker plots of winter flounder catches above MLS. The box ends represent the first and third quartile. The solid line through the box is the median. The mean is represented by a plus sign. The whiskers at either end extend to the most extreme data point, except where those points exceed 1.5 times the length of the quartile box. More extreme points are shown as solid dots. Numbers in parentheses are values beyond the scale of the plot.

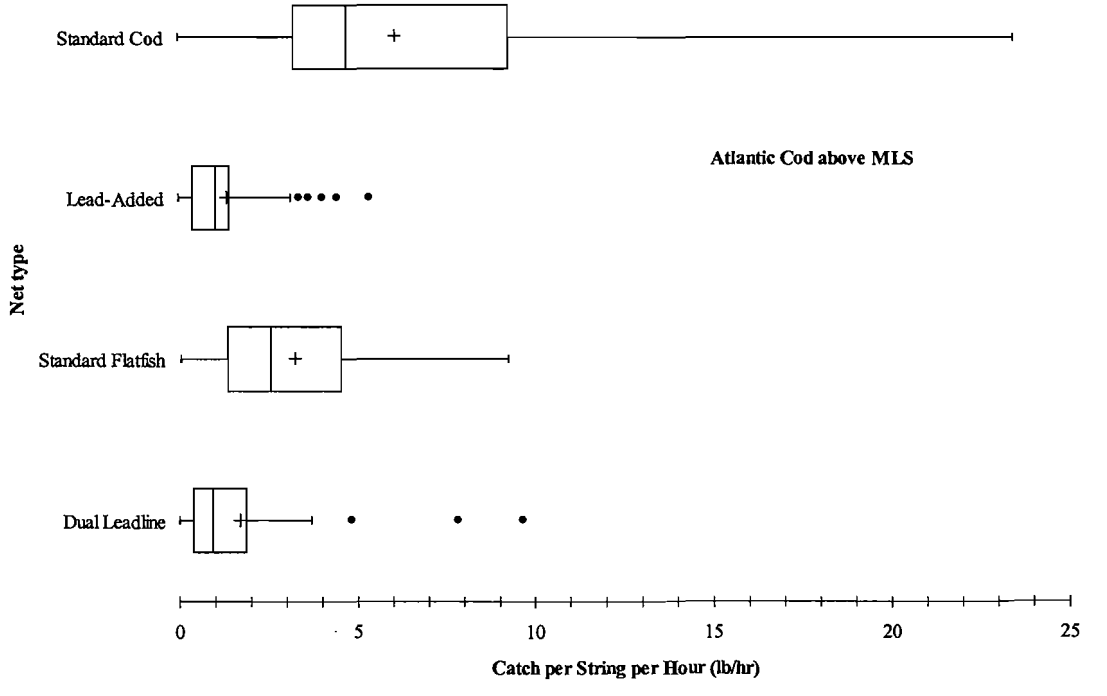
Figure 5: Pooled lengths of Atlantic cod by net type. Solid vertical line indicates minimum landing size. N = unadjusted sample size.

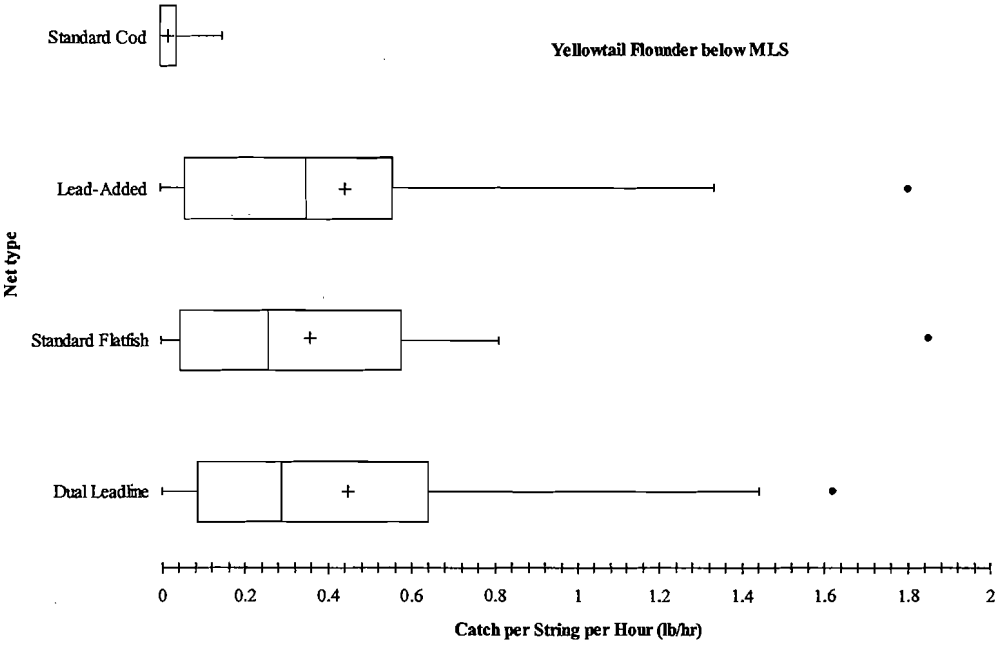
Figure 6: Pooled lengths of yellowtail flounder by net type. Solid vertical line indicates minimum landing size. N = unadjusted sample size.

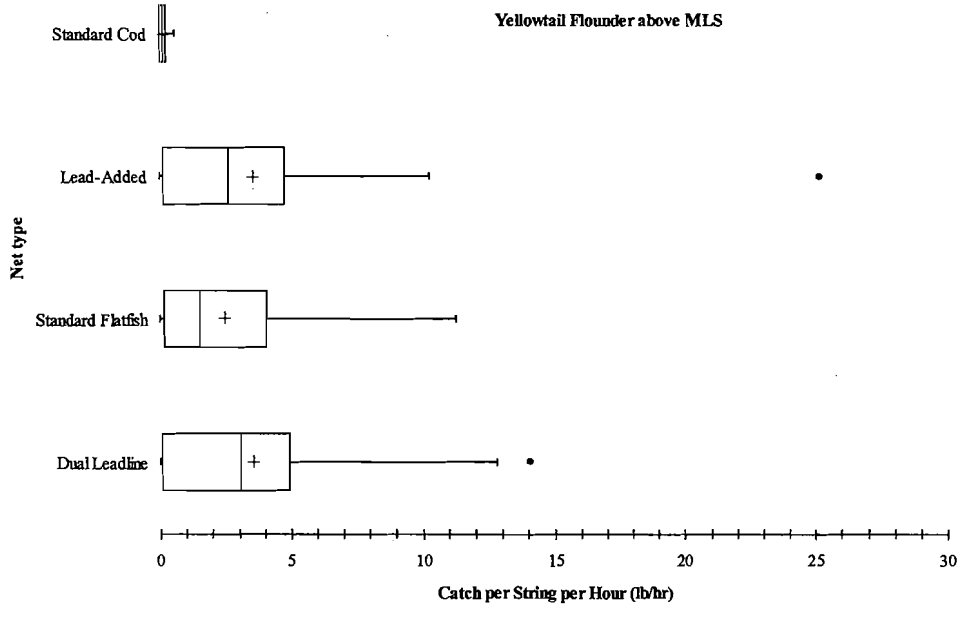
Figure 7: Pooled lengths of winter flounder by net type. Solid vertical line indicates minimum landing size. N = unadjusted sample size.

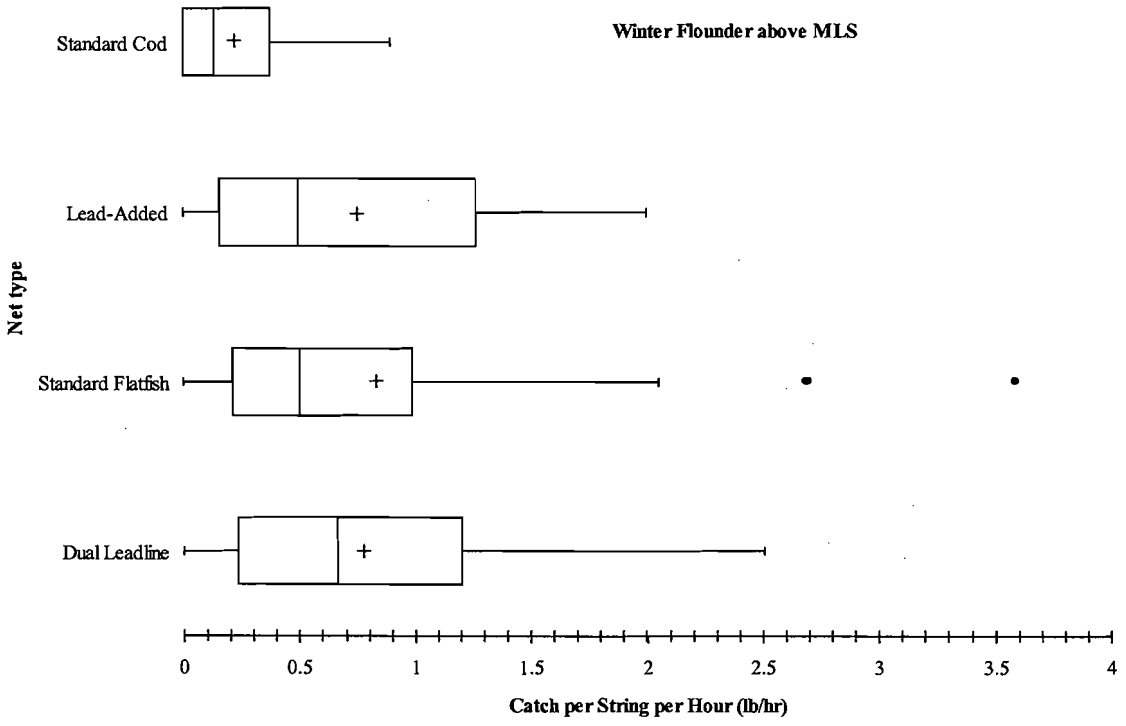

Gillnet Set Locations
0-15 m
15-25 m
25-40 m
40-90 m
below 90 m
Provincetown

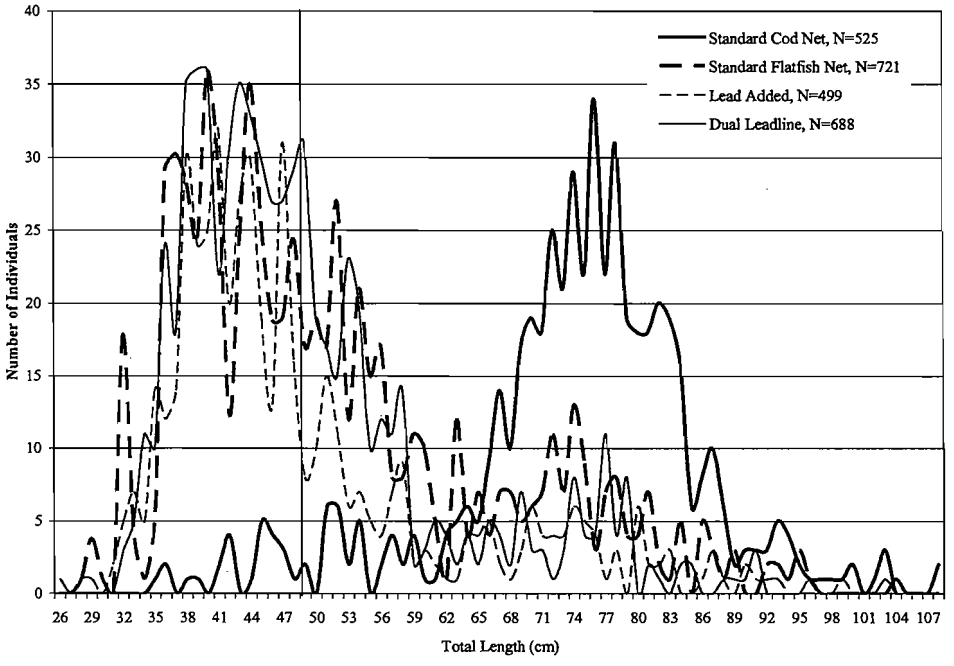

Standard Cod
Atlantic Cod below MLS
Lead-Added
Net type
Standard Flatfish
Dual Leadline
0
1
2
3
4
5
6
7
8
9
10
Catch per String per Hour (lb/hr)

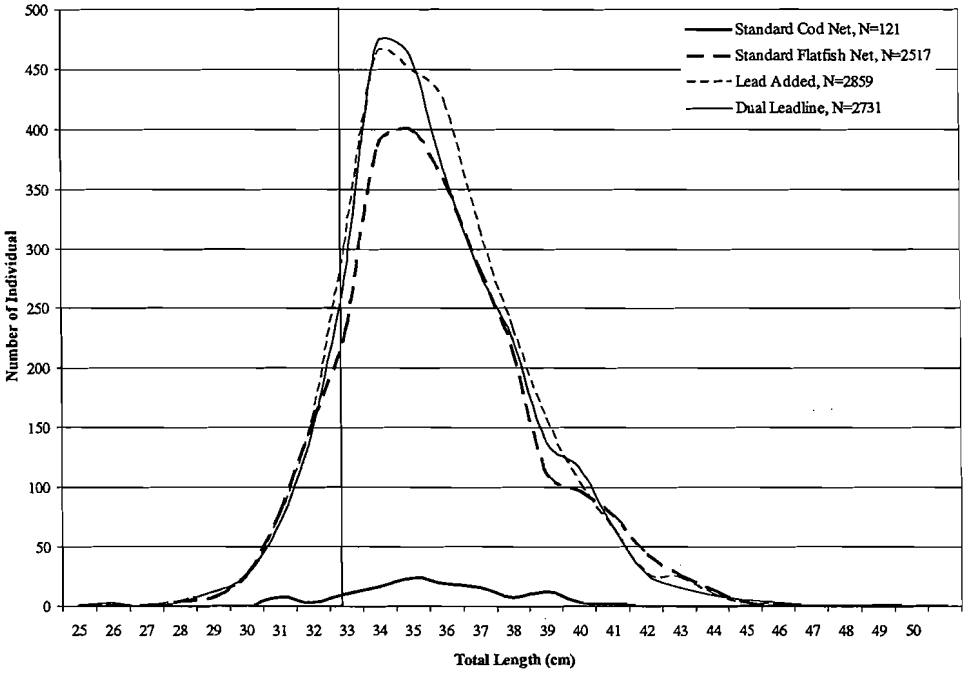

Standard Cod
Atlantic Cod above MLS
Lead-Added
Net type
Standard Flatfish
Dual Leadline
0
5
10
15
20
25
Catch per String per Hour (lb/hr)

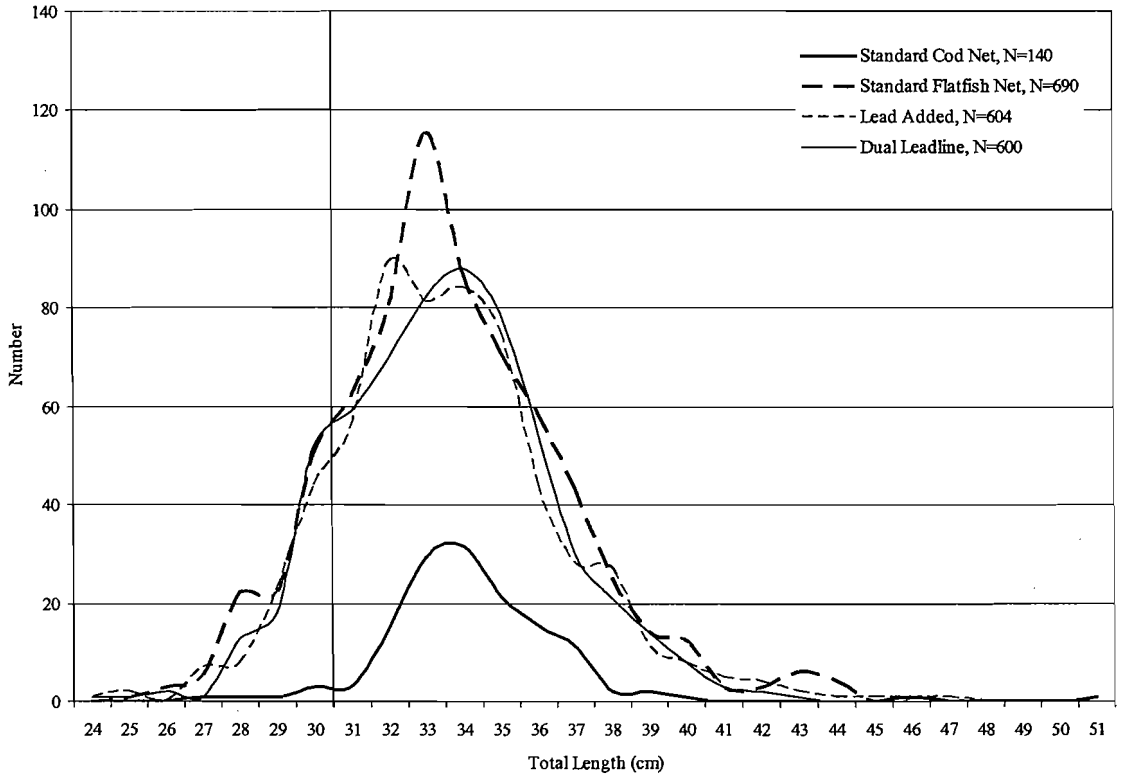

Yellowtail Flounder below MLS
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
Net type
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Catch per String per Hour (lb/hr)


Yellowtail Flounder above MLS
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
Net type
0
5
10
15
20
25
30
Catch per String per Hour (lb/hr)


Winter Flounder above MLS
Standard Cod
Lead-Added
Standard Flatfish
Dual Leadline
Net type
0
0.5
1
1.5
2
2.5
3
3.5
4
Catch per String per Hour (lb/hr)


Standard Cod Net, N=525
Standard Flatfish Net, N=721
Lead Added, N=499
Dual Leadline, N=688
Number of Individuals
0
5
10
15
20
25
30
35
40
26 29 32 35 38 41 44 47 50 53 56 59 62 65 68 71 74 77 80 83 86 89 92 95 98 101 104 107
Total Length (cm)


Standard Cod Net, N=121
Standard Flatfish Net, N=2517
Lead Added, N=2859
Dual Leadline, N=2731
Number of Individual
Total Length (cm)
0
50
100
150
200
250
300
350
400
450
500
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50


Standard Cod Net, N=140
Standard Flatfish Net, N=690
Lead Added, N=604
Dual Leadline, N=600
Number
Total Length (cm)
0
20
40
60
80
100
120
140
24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51

Partnerships

It has always been the goal of the Conservation Engineering Program to collaborate as fully as possible with fishermen. Fishermen identify the problems we seek to solve with gear modifications. We see fishermen as primary experts on the design, construction, and use of fishing gear. In addition, we rely on them to identify testing locations and times for testing purposes, and for many other reasons.

This project from its inception represented a full partnership between Bob MacKinnon and Arne Carr and Mike Pol. The idea for the gear alteration came from Bob, as did many other factors related to the project, including possible end uses for the gear design. The other participants, in the form of testing platforms, included fishing vessels, captains, and crews. They provided valuable guidance in terms of testing locations and times, rigging needs, regulatory problems and maintained safe conditions for scientists working onboard their vessels.

Manomet Center for Conservation Sciences, Inc. under the guidance of Dr. Chris Glass, acted as the funding recipient for this project prior to DMF developing the ability to receive funding from the Northeast Consortium. We are grateful for that support, and its success is testament to the already strong relationship between DMF and Manomet.

The project allowed the participants to understand each other's capabilities and motivations to a greater extent, and contributed to development of personal relationships across professions.

Related Projects

This report describes two separate projects funded by the Northeast Consortium. Phase II simply carried on the work begun in the first phase. Also, Bob MacKinnon and David Martins of the School for Marine Science and Technology (SMAST), University of Massachusetts-Dartmouth tagged cod caught during this study as part of the Cod Tagging Project developed through the Massachusetts Fisheries Recovery Commission (MFRC) and funded through the NOAA Fisheries Northeast Region Cooperative Research Partners Initiative (CRPI).

Impacts and Applications

Groundfish gillnets in New England are managed through a fishery management plan (FMP). The Groundfish FMP includes provisions for limiting gillnet effort with time and area restrictions, and gear limitations. These restrictions are primarily aimed a limiting cod bycatch, and are based on available information on cod bycatch in flatfish gillnets. This project was successful in quantifying bycatch and demonstrating the ability of experimental designs to limit cod bycatch while maintaining flatfish catches, and demonstrates that reducing gillnet height appears to reduce cod catch.

Two pathways are available for further development or implementation of these gear modifications. One avenue is to encourage voluntary industry adoption of these designs, which are legal for use anywhere flatfish gillnets may be used. Participating

fishermen in this study kept the gillnets built for this project, and one of them continued to fish them. However, no other efforts have been made to encourage industry to use them.

A second pathway for further implementation would be to allow additional opportunities for gillnetting for flatfish where the presence of cod limits it. The best judges of these opportunities sit on the Plan Development Team (PDT) of the Groundfish Oversight Committee (GOC); they can judge the validity of the research from the Council perspective. Following a technical review by the Northeast Consortium and management review by the Research Steering Committee, the PDT in turn can recommend management options to the GOC, which then presents recommendations to the NEFMC at large. Council approval is then reviewed by NMFS.

David Pierce, Deputy Director of DMF, Council designee, and chair of the GOC, has been briefed on the results of this research, primarily with the intent of understanding the bycatch of cod in flatfish nets and trying to understand how tie-downs might affect management options.

The potential implementation could take several forms. A Special Access Program (SAP) where flatfish levels are high offers the maximum reward to fishermen, but a broader requirement to use only these designs anywhere flatfish are targeted would, based on these results, result in less cod bycatch. It should be remembered, however, that some fisheries are only practical where a certain level of cod bycatch is allowed. In other words, reducing cod bycatch might benefit cod rebuilding, but may result in significant economic loss to fishermen due to the loss of cod landings.

Presentations

M. Pol. Testing of Low Cod-Bycatch Gillnets Phases I and II - An Update. Northeast Consortium Annual Meeting, 24 October, 2002, Portsmouth, NH.

M. Pol. Cooperative Design and Testing of Gillnets and Trawl Nets to Target Flatfish and avoid Atlantic Cod *Gadus morhua*. ICES Working Group on Fishing Technology and Fish Behaviour, 5-8 June 2002, Sete, France.

M. Pol. Testing of Low Cod-Bycatch Gillnets. NMFS National Standing Working Group on Fishing Technology, March 6-7, 2002, Woods Hole, MA.

M. Pol. Testing of Low Cod-Bycatch Gillnets. Northeast Consortium Annual Meeting, 3 October 2001, Portsmouth, NH.

H. A. Carr. Improving Selectivity of Various Gears in New England Waters (gillnets, longlines, and trawls). Second North Atlantic Responsible Fishing Conference, 7-9 November 2000, St John's, Newfoundland.

Student Participation

None

Published Reports and Papers

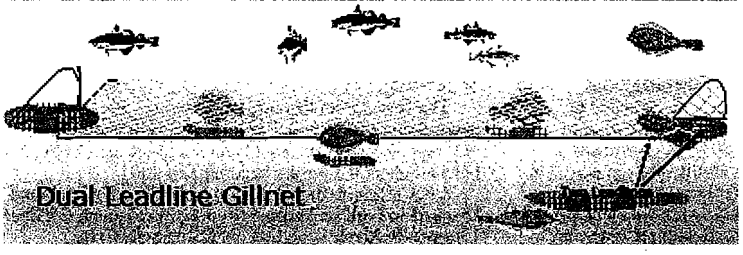
Poster presented at the 2006 Maine Fishermen's Forum

Low-Profile Flatfish Gillnets Catch Fewer Cod

Lowering the height of the floatline in flatfish gillnets reduced cod bycatch by 50%. Flatfish catches and sizes stayed the same.

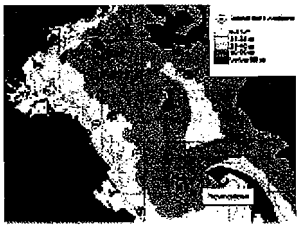
Foamcore + Lead Gillnet

We added lead to a Foamcore floatline in one net...



...and replaced the floatline with another leadline in another net.

Study Area



- Nets were compared to a standard flatfish gillnet.
- All were light blue, 8-gauge, 7-inch monofilament, hung on the half.
- Catch rates of cod: standard flatfish net - 60 lb/set; low-profile – 30 lb/set
- Catch rates of yellowtail: 70 lb/set (all nets)
- Catch rates of blackback: 17 lb/set (all nets)

Industry Partners
F/Vs *Lady Irene* & *Michael Brandon*, Scituate MA
F/V *Sasquatch III*, Gloucester MA

Net Designer and Industry Lead:
Robert MacKinnon
F/V *Antigonish*
Scituate MA

Scientific Lead:
Michael Pol
Conservation Engineering
Massachusetts Division of Marine Fisheries

Field and budget help from:

MANOMET

This project funded by:

Northeast Consortium

Conservation Engineering Program awarded $300,000 for gear research

Over $200,000 earmarked for cooperating fishermen

Arne Carr and Michael Pol of DMF's Conservation Engineering Program are continuing their cutting-edge fishing gear research. They've received three new grants from the Northeast Consortium to work with local fishermen to test innovations, and they are indirectly involved in a fourth.

The Northeast Consortium (www.northeastconsortium .org) is a coalition of the Maine, New Hampshire, MIT and Woods Hole Sea Grant Programs. It was given $2 million in federal funds to distribute for cooperative research between scientists and commercial fishermen. The goals of the funding included the development of selective fishing gear and programs to utilize commercial fishing vessels in oceanographic research. Following a competitive process where anyone could submit research ideas, ten research projects were funded. All of these research projects were developed in cooperation with commercial fishermen and use commercial vessels as research platforms. Approximately 70% of the funding will be paid to fishermen for sea-time, net building, and other activities. The following projects were also originally part of the Massachusetts Fisheries Recovery Commission's Fisheries Research Strategic Plan.

• Testing of Low-Profile Low Cod-Bycatch Gillnets

Robert MacKinnon, a commercial fisherman from Scituate, has developed two gillnets that are designed to target flatfish while avoiding cod. He, Michael Pol, and Arne Carr have been awarded $90,000 by the Northeast Consortium to test the cod-avoiding ability of these nets . On one net, the floatline is completely replaced by another leadline so that both the top and bottom of the net rest on the ocean bottom, with standard webbing floating in between. The dual leadline is the only difference between this net and standard gillnets. The second net to be tested has lead attached to the floatline every 30 feet to sink it to the bottom at set intervals. The catch from these two nets will be compared to a standard gillnet.

Both designs reduce the height of the nets underwater. Reducing the height of the nets may allow fishermen to catch flatfish, which stay very close to the bottom, and avoid cod, which tend to stay at least a short distance above the bottom. Also, lowering the height of the nets may reduce incidental takes of harbor porpoises.

Underwater cameras will be used to examine behavior of cod and flatfish near gillnets, in addition to gillnet sets that directly compare the catch of the two nets to the standard nets. Testing is planned for this winter aboard the *Lady Irene* off Scituate, and the *Sasquatch III* off Gloucester.

• Groundfish Trawlnets Designed to Reduce the Bycatch of Cod

Two trawl nets designed to catch flatfish and avoid cod will be tested. Luis Ribas, a leader among Provincetown commercial fisherman, has designed a trawl net with very large mesh openings all along the middle of the upper half of the net. The second net has been adapted by Arne Carr from a European net design that removes some of the webbing in the upper half of the net, moving the headrope as far back as practical. Both designs are based on the behavior of cod as they swim along in front of a trawl net. Underwater video shows that cod slowly rise as the net overtakes them. Placing large mesh on the top of the net, or removing some of the webbing on top of the net, should allow cod to rise and escape. This project, awarded to Capt. Ribas, Arne Carr and Michael Pol, is budgeted at about $100,000.

Sixteen days of gear testing are planned aboard the *Blue Skies* for this winter. Each net will be tested compared to a standard net, alternating nets every other tow.

The goal of this study and the gillnet study is to develop gear that allows fishermen to continue to trawl for flatfish without high discards of cod. Cod in the Gulf of Maine remains the most depleted of the commercially valuable groundfish species, and cod conservation is the driving force behind the restrictive closures.

• Improving the Selectivity and Utility of Demersal Hook Fishing

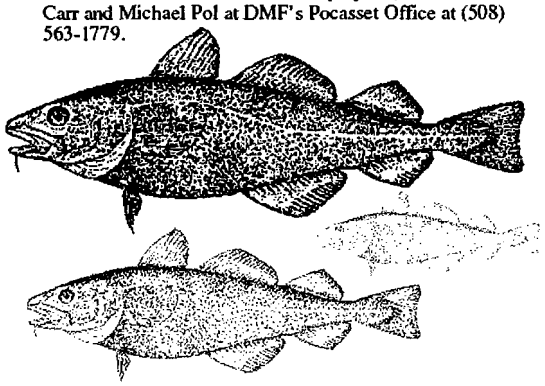
The Cape Cod Commercial Hook Fishermen's Association (www.ccchfa.org), working with Dr. Susan Goldhor of the Center for Applied Regional Studies (CARS), is participating with DMF to look at several aspects of bottom longlining. This project, funded for $111,000, has four goals: examining feeding and hooking responses of cod, haddock, and yellowtail flounder; find gear and artificial bait combinations that minimize bycatch: determine if certain flatfish species can be caught with longline gear in commercial quantities; and educate local fishermen about the results of the study.

The first step in this project, slated for this fall, is capture and holding of live cod, haddock, and yellowtail. These fish will be exposed to artificial baits. Field-testing of effective baits is scheduled for the beginning of 2001.

• A Collaborative Program to Reduce Bycatch and Discard in Gulf of Maine Otter Trawl Fisheries: Effect of Composite Mesh Codends on Trawl Selectivity

Proctor Wells, a fisherman from Maine, and two prominent Massachusetts fishermen, Frank Mirarchi and Russell Sherman, have teamed with Dr. Chris Glass of the Manomet Center for Conservation Sciences to continue testing codends composed of diamond and square mesh openings. Previous work has indicated that composite codends can be used to limit sizes of flatfish and roundfish by separately adjusting the mesh sizes. DMF has collaborated with Manomet on a similar project in the past, and will continue to do so with this funding.

For more information on these projects, contact Arne Carr and Michael Pol at DMF's Pocasset Office at (508) 563-1779.



http://www.mass.gov/dfwele/dmf/publications/dmfnq300.pdf

Work continues to improve commercial fishing gear

DMF's Conservation Engineering Program was awarded $300,000 in federal funding through the Northeast Consortium last year (see DMF NEWS, 4th Quarter 2000, page 5). Since last fall DMF personnel, Manomet Center for Conservation Sciences (MCCS) observers, participating fishermen, and scientists have spent many days at sea and on land conducting experiments and analyses. The following summaries describe progress for each project.

Improving Selectivity and Utility of Hook Fishing

This study has four objectives, and progress has been made on two of them. From February through April, live cod captured by Chatham hook fishermen were transported to Woods Hole Oceanographic Institution racewnys. Fish response to artificial baits developed by Dr. Susan Goldhor of the Center for Applied Regional Studies was filmed and evaluated by DMF personnel using underwater video cameras. The best recipes will be tested at sea. These artificial baits may allow fishermen to be more selective when targeting cod. This study also will determine if flatfish can be caught in commercial quantities using hook gear. The Cape Cod Commercial Hook Fishermen's Association has three boats testing some gear. Data on flatfish catch are being collected for analyses. Work continues on this project.

Trawl Nets Designed to Reduce Cod By-catch

Thirteen days of field testing (48 hauls) of two modified trawl nets were completed during May and June off Provincetown on the fishing vessel *Blue Skies*. Capt. Luis Ribas' design, replacing most of the twine on top of a groundfish net with large square mesh, and DMF's Arne Carr's design, removing the top wings and belly to shift the headrope back to the start of the extension, appear to be able to remove up to 90% of cod when compared to a standard net. DMF underwater video cameras revealed how fish behavior is key to project's success. In Luis Ribas's net, cod passed upwards through the large square mesh and escaped; in Arne Carr's design, cod rose ahead of the headrope and escaped.

Testing of Low-Profile Gillnets to Reduce Cod By-catch

Fifteen overnight sets of two experimental gillnets designed by Bob MacKinnon of Scituate were made in December 2000 and January 2001. F/V *Lady Irene* (Capt. Scott MacKinnon), F/V *Michael Brandon* (Capt. Tom Bell) of Scituate and F/V *Sasquatch III* (Capt. Paul Cohan) of Gloucester participated in the study, carrying DMF personnel and Manomet observers.

Bob MacKinnon's designs alter the floatline. In one net the floatline is replaced by a second leadline; in the other, lead is added to the floatline every 30 feet. The point of the modifications is to lower the profile of the net so cod swim over it while flatfish are caught.

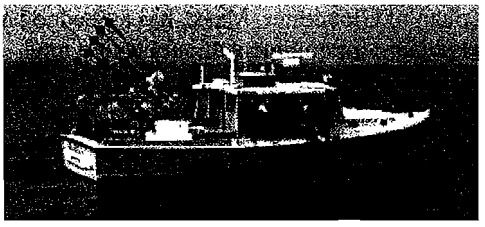
An ROV (remotely operated vehicle with a TV camera) was used to profile the nets underwater. We were surprised to see that the two leadlines from the dual leadline net ended up laying close together with a cloud of webbing drifting between them. Both this net and the added-lead net in fact stood lower than standard gillnets.

Catch data so far are encouraging. Modified nets catch fewer cod. However, data from some days were unusable due to small catches. Bad weather and area closures forced us to set nets in places where fish were scarce. We recently have been awarded further funding by the Northeast Consortium to continue this project.

Effect of Composite Mesh Cod-ends on Trawl Selectivity

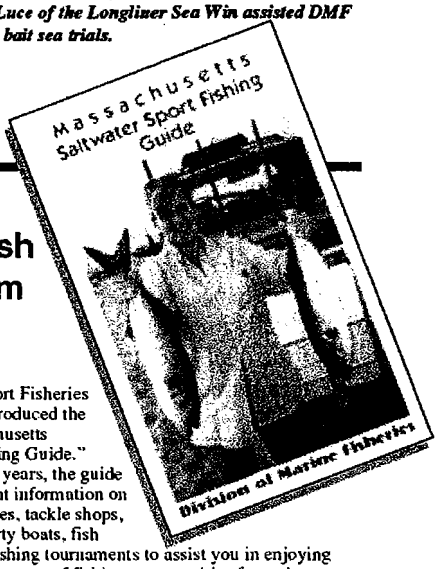
DMF is a collaborator with Dr. Chris Glass of MCCS, who leads this project. Composite mesh codends (a "cod-end" is the bag at the tail-end of a trawl net where fish are collected) were comprised of square mesh and diamond mesh panels. Diamond mesh is more efficient at letting small flounders escape and square mesh does a better job of letting small roundfish (e.g. cod, haddock) avoid capture. Manomet has collected data using Massachusetts and Maine fishing vessels and currently is analyzing results.

For more information contact Arne Carr or Mike Pol at DMF's Pocasset office @508-563-1779



Capt. Mark Leach of the longliner Sea Holly (pictured) and Capt.Thomas Luce of the Longliner Sea Win assisted DMF in the longline bait sea trials.

2001 Sportfish Program Guide



DMF's Sport Fisheries Program has produced the 2001 "Massachusetts Saltwater Fishing Guide." As in previous years, the guide contains current information on boat-launch sites, tackle shops, charter and party boats, fish profiles, and fishing tournaments to assist you in enjoying our spectacular array of fishing opportunities from shore or by boat.

A copy of the guide can be obtained at most bait and tackle shops, or at one of the field offices.

Experiments continue without inventor

Pol, Michael (Massachusetts DMF) and Robert MacKinnon (Mass. Bay Inshore Commercial Gear Fishermen's Assoc.

Project Title: ***Phase II: Testing of Low-Profile Low Cod-Bycatch Gillnets*** (\$71,710)

Although he designed them, Robert MacKinnon is no longer taking part in a collaborative research project that will continue fieldtesting two of his experimental gillnets.

The first phase of the project was funded by the Northeast Consortium in 2000, and the project received \$71,710 in funding thisyear.

MacKinnon, however, says he is now out of the business.

"I came up with all of the ideas and now I'm out of the box," MacKinnon said, citing increasing regulations as one of the reasons he gave up commercial fishing as part of the Massachusetts Bay Inshore Commercial Gear Fishermen's Association.

Paul Cohan of Gloucester, Mass., has agreed to help with the project in MacKinnon's absence, but he was unavailable for comment at publication time.

According to Michael Pol of the Massachusetts Division of Marine Fisheries, one of the experimental designs adds lead weight to an otherwise ordinary floatline; the second experimental design replaces the floatline of the gillnet with another leadline.

Both designs, Pol said, attempt to reduce the vertical profile of the nets and take advantage of a behavioral difference between cod and flatfish. Fishing experience and video observation suggest that cod do not often hang out on the very bottom of the ocean, and flatfish do not often rise more than one foot above the bottom. The potential use of the experimental nets, if proven, is to either allow fishing for flatfish in areas closed for cod, or to reduce the bycatch of cod in open areas, Pol wrote in his summary report.

Pol said he was able to get an experimental permit to go into Block 124 (Stellwagen), but was denied access to closed areas during the first phase of the project

"For consistency and simplicity, we're limiting all of the sets to 24 hours," he said.

Pol said uncooperative weather has slowed the project, but 10 sets were completed in May 2001 and another 10 sets should be completed soon.

Field testing was designed to allow comparisons of catch rates of cod and commercially valuable flatfish between experimental nets and standard nets. Results so far indicate that the designs are working; the net with added lead catches less cod than the standard cod and flatfish nets; the mean catch rate of the dual leadline net is lower than the standard nets, but not significantly so. Not enough flatfish were captured in the nets to allow comparisons of flatfish catch rates, Pol said.

http://www.namanet.org/collaborations/collab_mar_02.pdf

Images

Videotape footage was collected as part of the project by M. Pol. The footage is provided on the accompanying DVD, and archived by the Conservation Engineering Program of DMF using the following information. DMF logs of the footage are including in Appendix A.

ID Number	Title	Date	Medium
01MADMF567	NEC GILLNET STUDY TAPE 2	5/17/2001	MINIDV
00MADMF566	NEC GILLNET TAPE 1	12/2/2000	MINIDV

Photographs were collected on conventional 35 mm film; prints were scanned and are also included on an accompanying CD.

Captions for Gillnet Photographs

The first group of photos were all taken by M. Pol on 6 February 2002 on the Lady Irene.

Filename	Caption
Scan0001.jpg	Capt. Welch and crew prepare to remove gillnet from the bag.
Scan0002.jpg	A gillnet, visible on the spreading bar, is set as the boat move forward. The crewman watches to make sure the net does not tangle. Highflyers used to mark the ends of a string of nets are visible in the foreground.
Scan0003.jpg	Rough seas, difficult to convey through a photograph, complicate setting.
Scan0004.jpg	A crewman reaches for a coil of line being passed up from a hold.
Scan0005.jpg	Same as above.
Scan0006.jpg	Capt. Welch cuts open a net bag.
Scan 0007.jpg	Capt. John Welch is seen standing in the hold.
Scan0008.jpg	Crewman prepares endline for gillnet.
Scan0009.jpg	A gillnet, visible on the spreading bar, is set as the boat move forward. The crewman watches to make sure the net does not tangle.
Scan0012.jpg	Capt. Welch and crew prepare to remove gillnet from the bag.
Scan0013.jpg	A gillnet, visible on the spreading bar, is set as the boat move forward. The crewman watches to make sure the net does not tangle.
Scan0014.jpg	Gillnets are delivered in large plastic bags. This photo shows the name of the net maker.

The last two photographs were taken by Bill Campbell, ROV owner/operator, on 17 May 2001 on the Lady Irene.

Scan0010.jpg. Mike Pol looks at an ROV.
Scan0011.jpg Mike Pol (on right) watches Capt. Scott MacKinnon make an adjustment on the ROV.

Future Research

Additional research has already grown out of this project, primarily led by Dr. Pingguo He of the University of New Hampshire. The success of this project prompted him to conduct a project on half-height gillnets, building on the proposition that cod and flatfish can be caught separately with a small difference in height. His work had some success, leading to a joint project with Mike Pol of DMF to further investigate lower rigging of gillnets.

Further research is not planned on dual leadline or lead-added gillnets. This study effectively establishes their efficiency, and lack of expressed interest also has limited further efforts.

Appendix A: Logs for video footage

OOBIADMT 586

MDMF CAMERA LOG

12/8/2000, 1/11/01, 5/17/01

DATE:_____ SUBJECT: NEC GILLNET SPECIES:_____

BOAT: LADY IRENE WEATHER: OVERCAST SEAS: (calm) moderate rough

DEPTH: 17 M (Fa) CAMERA POSITION:_____ TAPE#: 1

SYSTEM: ROV TOW#:___ START TIME OF TOW:___ UNIQUEID#:_____ 620

BEGIN: LAT:_____ LONG:_____ END: LAT:_____ LONG:_____

off SCITUATE LOCATION: CAPE COD BAY COMMENTS: LOTS of SURGE

CLARITY OF FOOTAGE: (good) fair poor TAPE PROTECTED? (Yes) no

Tape Time	Event of Interest	Tape Time	Event of Interest
00:00:00	5.17.01 · TIME WRONG	~:48:00	END
: :	~800 LADY IRENE AT DOCK	: :	
:00:32	~~5.17.01~~ 12.00.00 ~2:30	: :	
: :	SETTING BOB MACKINNON	: :	
00 00:00	1.17.01 LADY IRENE	: :	
:51:04	DECK SHOTS	: :	
: :	HAULING - SCOTT MACKINNON	: :	
:2:24	DAVE MYRICK OBSERVER	: :	
: :	DAVE MARINS TAGGER - SMAST	: :	
: :	FROM HANDOUT	: :	
:3:57	VIEW of ~~DUAL LEADLINE~~ FOAM CORE ON HAULING TABLE	: :	
:4:34	MIKE DL PICKING	: :	
:6:41	VIEW of SETTING NET	: :	
:7:41	HAULING FOAMCORE + LEAD	: :	
10:58	DUAL LEADLINE	: :	
:11:30	FLOATS - COD END	: :	
RESET COUNTER :~~21:00~~	5/17 R.O.V.	: :	
:00:21		: :	
: :44	BILL CAMPBELL, 2 CREW	: :	
:1:10	OVER THE SIDE	: :	
:1:20	U/W VIEW	: :	
: :	FOLLOWING BUOYLINE	: :	
: :	LOOKING FOR NET	: :	
:24:13	FIND NET - FOLLOW to ANCHOR	: :	
: :	SEE NET · DUAL LEADLINE	: :	
:25:40	UNSPIN ROV	: :	
:27:00	WEBBING ROV TIME 18:27	: :	
* :37:01	VIEW of 2 LEADLINES	: :	
:38:19	& WEBBING	: :	
* :41:50	SPREAD LEADLINES	: :	

01MADMF567

MDMF CAMERA LOG

DATE: 5.17.01 SUBJECT: N.E.C GILLNET. SPECIES:

BOAT: LADY IRENE WEATHER: OVERCAST SEAS: (calm) moderate rough

DEPTH: 17 M (Fa) CAMERA POSITION: ROV / SURFACE TAPE#: 1

SYSTEM: ROV / DV TOW#: ___ START TIME OF TOW: : UNIQUEID#:

BEGIN: LAT: LONG: END: LAT: LONG:

LOCATION: CAPE COD BAY COMMENTS: off SCITUATE; LOTS of SURGE

CLARITY OF FOOTAGE: good fair poor TAPE PROTECTED? Yes no

Tape Time	Event of Interest	Tape Time	Event of Interest
:00:00	ROV HAULING	: :	JUST TO SEE VIS AT DEEPER DEPTH - TO CHECK IF WE SHOULD VIEW DEEPER SET of M NETS
: :	CAUGHT IN GILLNET	: :	
: :39	Dr. SCOTT MACKINNON	: :	
: :	BILL CAMPBELL (BLUE SHIRT)	: :	
: 2:04	U/W CUNNER	: :	
: :	LOADLINE IN VIEW	:45:57	HAULING BACK
: :	CUNNER SWIM THROUGH NET?	: :	
: :		: :	
* : 4:49	FLOATLINE CAUGHT ON ROV	: :	
: 6:20	CUNNER (LEAD ADDED)	: :	
* : 7:07		: :	
: 7:36	LOTS of SLACK IN WEBBING	: :	
: :		: :	
: 9:17	FLOATLINE	: :	
:10:58	NICE FISH - SP?	: :	
: :	SURGE	: :	
: 12 10	FLINE AT 47 FT	: :	
* :13:20	LEAD AT BOTTOM	: :	
:14:15	LEAD IN VIEW	: :	
GOOD VIEWS :15:40	FLOATLINE DRIFTING	: :	
* :18:32	LEAD ON BOTTOM	: :	
:22:26	SETTING GEAR	: :	
: :	COD NET - FLOATS	: :	
AT STAR :21:30	COD DRAG	: :	
:28:14	BEFORE POWER LOSS	: :	
:28:30	VIEW of FLOATLINE?	: :	
:30:00	LOBSTER POT WARP	: :	
:33:00	WARP OVER NET OVER BACK	: :	
* :35:27	NICE WEBBING VIEW	: :	
* :36:11	VIEW of FLOATLINE	: :	
:38:12	FLOATLINE VIEW	: :	
:42:50	DEEP WATER @ 98FT	: :	

Technical Evaluation Report

of the
Northeast Consortium cooperative research project,

"Testing of Low-Profile, Cod-Bycatch Gillnets: Phases I and II"

Anonymously reviewed

July 02, 2007

1. Introduction

This report documents an independent peer evaluation of the project, "Testing of low-profile, low cod-bycatch gillnets: Phases I and II." This cooperative research project received funding from the Northeast Consortium in FY2000 and FY2001 and was led by Mr. Mike Pol of the Massachusetts Division of Marine Fisheries (MDMF) in partnership with four commercial fishermen and scientific collaborators at the MDMF and at Manomet Center for Conservation Sciences. This mail review serves as a formal assessment of the completed project.

2. Reviewer

The following information about the reviewer is provided as evidence of the authority and expertise of the individual and to help authenticate the independent nature of the review process. The reviewer has signed the Northeast Consortium's "Conflict of Interest and Confidentiality Policies for the Technical Evaluation of Projects" agreement. The views expressed do not necessarily represent those of the Northeast Consortium.

The reviewer has led multi-agency selective fishing research projects for Pacific salmon stocks since 2002 and prior to this has conducted various fish behavior research for about ten years. Expertise areas include fish behavior, gear selection, survival analysis, and hatchery and wild interactions. Reviewer has published peer reviewed articles and technical reports.

3. Documentation

In advance of the evaluation, the reviewer was provided with the project's final report entitled, "Testing of low-profile, low cod-bycatch gillnets: Phases I and II." It was submitted to the Northeast Consortium on 22 June 2006. Along with the final report, the reviewer received the project's funding proposal and no manuscripts submitted for publication in peer reviewed literature.

Documentation received:

General:

- The Northeast Consortium's guidelines for the final technical evaluation for cooperative research projects, including evaluation criteria.
- The Northeast Consortium's conflict of interest and confidentiality policy for the technical evaluation of projects.
- The Northeast Consortium's final report writing instructions.
- Template for writing a technical evaluation report.

Project specific:

- Testing of low-profile, low cod-bycatch gillnets. FY2000 cooperative research funding proposal submitted to the Northeast Consortium.
- Testing of low-profile, low cod-bycatch gillnets. FY2001 cooperative research funding proposal submitted to the Northeast Consortium.

- Pol, M. Testing of low-profile, low cod-bycatch gillnets. Progress update submitted to the Northeast Consortium, February 2002.
- Pol, M. Testing of low-profile, low cod-bycatch gillnets. Progress update submitted to the Northeast Consortium, June 2006.
- He, P., R. Gauron, P. Iniss, M. Pol, T.M. Moth-Poulson, and S. Welch. Further tests on low-profile flounder gillnets to reduce cod catch in the Gulf of Maine. FY2004 cooperative research funding proposal submitted to the Northeast Consortium.
- In addition, project data was available through the Northeast Consortium's Fisheries and Ocean Data Management System, accessible at: www.northeastconsortium.org/data.shtml.

5. Comments and Recommendations of the Reviewer

The reviewer was asked by the Northeast Consortium to address the criteria developed for the evaluation of Northeast Consortium-funded projects that are complete, noting specific strengths and weaknesses of the project. All criteria were considered, but evaluation was focused on the second, "Certification of Results." The criteria were developed for the evaluation of all Northeast Consortium-funded projects that are complete.

5a. Project Evaluation

The project is good. More work is needed on the analysis and presentation of results.

Evaluation Criteria:

1. **Project success:** The project accomplished its stated goals and objectives.

2. **Certification of results:** The description of the approaches to experimental design, methods, and data analysis are not completely adequate. Despite that I have conducted many net experiments, I spent much time trying to understand how many nets were used and how many were built and how the test nets were fished in a modified Latin Squares design. I still am not sure that I understand, except that apparently 4 different nets were used and were fished in a similar location to each other. For example: if 4 nets were used and three boats fished, that should be 12 nets but the report states that 48 nets were built. I recommend further explanation, a diagram, and also a definition of "string." Further, with respect to study design, the "modified Latin Square" requires further explanation. How was this design modified? The approaches seem appropriate. I suggest a few other approaches –connecting the different nets together and changing their order could enable them to be more easily compared. Rather than the K-S test, a chi square test should work just as well and provide more statistical power. For statistical evaluation, rather than provide the number of fish captured in pounds, I recommend the data be provided in numbers, with a separation of those fish that are legal versus undersized. You note in the February 2002 Project Update that three of the nets captured smaller cod and appeared to tangle the cod as compared to the standard cod net. This information is very useful, because it indicates the

possibility for a fishery where cod could be captured and released with little harm and potentially high survival. I recommend a review of the literature on selective fishing and revival boxes to evaluate if these methods could be useful for the conservation of cod bycatch. The data appear accurate, precise, and believable and the results and conclusions are supported by the data. Based on the finding that smaller cod were captured and by tangling, I recommend further research be done to evaluate if cod captured in these gears can survive post-release. At this point, I do not believe the results are substantial enough for incorporation into management policies.

3. **Data accessibility and dissemination of results:** Data are available through the Northeast Consortium Fisheries and Ocean Data Management System but not all the data has been entered. The data that are present are for the most part suitably formatted. Throughout the text, a mixture of metric and non-metric units is used; this can be cleaned up by presenting all units in metric, with non-metric in parentheses. When the range of hours fished is provided, the average and standard error should also be presented. For ease of reading, I recommend incorporating all tables and figures into the document rather than placing them at the end. Table 3, the summary of species, should list the scientific names as well as the common names. The poster presentation states that the nets were "light blue" whereas in the report, the nets were reported as "light green" and in the latest proposal, they are described as "dark green." From my experience, the poster has too much text and not enough photos and figures. I doubt attendees read the entire poster. Typically ideas should be presented in bullet form. The poster may have worked as a handout that attendees could read at a later time.

4. **Project partnerships:** The project was clearly of mutual interest to participants and the participants suitably contributed to the project. Based on the continuation of the work, I assume that all parties were equally interested and engaged. I am always surprised when gears are tested, clear differences are shown, but management does not adopt new gear. It seems this is usually because commercial fishermen do not want to change their approach. Consequently, this work could be improved by addressing the socio-economic dimensions of changing to new gear. One clear problem with the study was receiving a permit to fish in an appropriate area. The reason that the permit could not be obtained was unclear.

5. **Project impacts:** It appears that this project has not had much impact to management. Were survival of released fish evaluated, the study gears have the potential to effect fishing practices, socio-economics, and fisheries. Unfortunately, it seems that most often, management must require new gears before fishermen are willing to adopt them.

6. **End-Users:** Fishermen and managers will benefit from knowing about the research. Further, the results are of interest not only to those people who work

with the cod and flatfish industries but could also benefit people evaluating selective gears for a variety of species.

7. **Overall rating.** I rate the overall project as good. The concept that using low-profile nets should make gears more selective for the target, flatfish, and less selective for bycatch where there is a conservation concern, cod, is excellent. Further, the decision to evaluate the gears in different locations is excellent. No work was done to compare the gears' effectiveness in each location, and this should have been done. The partnership with fishermen, where fishermen develop and fish the gears is excellent. The description of how the nets were fished and built is poor. The statistical evaluation is adequate and could have been better. For instance, no mention was made about temperature and in addition to poundage, providing the fish in numbers would have been helpful to assess the conservation effects of the gears. Also, diagrams or photos of how the nets fished would help. The diagram of the two experimental nets on the cover of the report is helpful but in addition, diagram(s) that show how each vessel fished with the four nets is needed. Survival differences (immediate or post-release) for cod would also improve the study. There were mistakes in grammar and spelling in the final report. Further, standard error should be provided when stating metrics such as "reduced bycatch by 49%."

8. **Future research.** Additional research is needed to answer the original questions posed by the project. This research is high priority but once gears are found that reduce cod catch, work needs to be done about how changes will be incorporated into the fisheries; a socio-economic issue.

5b. Summary/Other Recommendations

For incorporation of the work into fisheries, survival should be evaluated. Further, how the work will incorporate into management should be discussed and planned.

Technical Evaluation Report

of the
Northeast Consortium cooperative research project,

"Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II"

Anonymously reviewed

18 July 2007

1. Introduction

This report documents an independent peer evaluation of the project "Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II". This cooperative research project received funding from the Northeast Consortium in FY2000 and FY2001 and was led by Michael V. Pol of Massachusetts Division of Marine Fisheries in partnership with H. Arnold Carr and Capt. Robert MacKinnon. This mail review serves as a formal assessment of the completed project.

The project focused on reducing bycatch of Atlantic cod in the gillnet fishery for flatfish by developing and testing two variants of modified flatfish gillnets. One variant used a lead added floatline and the other used two leadlines. They were compared to a standard flatfish gillnet. A fourth net, a standard cod gillnet, was used as a control for the presence of cod during the tests. A total of 35 hauls were conducted each deploying all 4 types of nets in four separate strings. The trials were conducted during three cruises. Low number of flatfish in the initially planned trials motivated a second phase of the project, which essentially continued the work started in the first phase. Underwater filming of the nets was achieved during one day.

A set of four hypotheses concerning the catch rates (defined as catch weight per hour) and length distributions were posed. Data were analyzed by exploratory plots (box-whisker plots) and non-parametric test (randomization tests for the hypotheses concerning catch weight rates and Kolmogorov-Smirnov test for the hypotheses concerning length frequency distributions).

2. Main findings and conclusion of the evaluation

The report is very well written and documents that the work set out in the proposal has been achieved successfully. The project appears to have been well managed with collaboration between fishermen and scientists. However, I'm not fully convinced about some of the conclusions drawn from the data and suggest that these be reconsidered. It may also be worth having another look at the data, using different methods for the analysis; see comments below.

3. Reviewer

The following information about the reviewer is provided as evidence of the authority and expertise of the individual and to help authenticate the independent nature of the review process. The reviewer has signed the Northeast Consortium's "Conflict of interest and Confidentiality Policies for the Technical Evaluation of Projects" agreement. The views expressed do not necessarily represent those of the Northeast Consortium.

The reviewer has been engaged in fishing gear selectivity research during the past 13 years and has been involved in several international research projects (particularly European). The reviewer's main area of expertise is within the field of statistical planning, modeling and analysis.

4. Documentation

In advance of the evaluation, the reviewer was provided with the project's final report entitled "Testing of Low-Profile. Low Cod-Bycatch Gillnets: Phase I and II". It was submitted to the Northeast Consortium on 22 June 2006. Along with the final report, the reviewer received the funding proposals for both the initial project (Award ZZ-487) as well as for the extension of the project (Award ZZ-569).

In addition, project data was available through the Northeast Consortium's Fisheries and Ocean Data Management System, accessible at: www.northeastconsortium.org/data.shtml. The data were aggregated to total catch weight by species and gear design at haul level. There were no data on length frequencies or counts of fish.

The report was annexed with a (scaled) poster and three short communications.

5. Comments and Recommendations of the Reviewer

The reviewer was asked by the Northeast Consortium to address the criteria developed for the evaluation of Northeast Consortium-funded projects that are complete, noting specific strengths and weakness of the project. All criteria were considered, but evaluation focused on the second, "Certification of Results."

5a. Project Evaluation

The project addressed the very important issue of species selectivity in a mixed species fishery. By taking advantage of behavioral differences between Atlantic cod and target flatfish species (primarily yellowtail flounder and winter flounder), the project developed and tested novel gear, based on ideas provided by Capt. Robert MacKinnon. The aim was to develop gillnets which would ideally be avoided by the cod, but keep the same catch weight rates for flatfish (above MLS) as the standard flatfish gillnets. There is a considerable need for species selective solutions in mixed species fisheries with different regulations. It is thus a very important task that this project pursues.

5a1. Project Success:

The project was successful in achieving its main objective as set out in the proposals. The most important objective was testing of the two flatfish gillnets against a standard flatfish gillnet. This was achieved during 35 hauls, which also included deployment of a standard cod gillnet. Parts of the conclusions drawn from the data may however need to be reconsidered; see comments below.

It appears that fewer resources than planned (5 days) were employed (1 day) for the underwater video recording. This seems however to have been adequate in fulfilling the purpose of studying the "gear behavior" and the fish and gear interaction. The report lists valuable and interesting observations from the underwater filming, supporting the conclusions made from the quantitative data. It is noted that the video material supplied to the Northeast Consortium, was not made available for the evaluation. This is however not considered of any importance for the evaluation.

5a2. Certification of results:

Experimental design and scaling: The four types of nets were deployed separately in strings of 8 nets each, though in close proximity. Randomization of the observation was ensured by using a (modified) Latin square design. It is said in the report that this reduces bias. In my understanding, bias is a property of an estimator rather than of an experimental design. The Latin square design ensures optimal randomization of the observations, at the level to which the randomization is applied. I suspect the present design has inflated the between haul variation, and a more optimal design (smaller variances) could have been achieved by mixing the net types within the strings and rearranging the order of the nets between hauls. This would have remedied the correlation between nets of similar types within the hauls, due to being set at closer proximity than nets of different types.

The (first) proposal suggests that, "Five sets in two locations should provide the statistical power and geographical range to establish the effectiveness of the net designs in avoiding cod." The concern about statistical power is, in general, much neglected in the field of fishing gear research. It is therefore much appreciated that the proposal demonstrates an awareness of this important aspect of experimental research. Unfortunately, the proposal does not specify any requirements on the precision aimed for, other assumptions leading to the suggested scaling of the trials, or what method was used.

Analysis of catch rates: In accordance with the proposal, the analysis of catch rates focused on the weights. A traditional ANOVA approach was considered inappropriate as the observations were found to be heteroscedastic. The analysis resumed by a non-parametric approach. It might, however, have been worth considering using counts or counts-at-length as response instead. These are more basic measurements and are likely to be Poisson distributed, whereas normalized catch weight rates are aggregated statistics with less obvious distributions. First of all, the number of fish and their length frequency distribution is of relevance for the stock dynamics and stock conservation, whereas biomass can be considered an integration over length of weights-at-lengths. Secondly, it would facilitate a parametric modeling and analysis. Net-types could enter as fixed effects and thereby allow for direct comparisons by, say, likelihood ratio tests or Walds tests. The report states the awareness of neglecting the between haul variance, but gives no suggestions as how to incorporate this or its potential implications on the test results. Between-haul variation could be accommodated using a GLMM, and thereby provide more realistic variance estimates and more reliable tests. The unequal soak durations reflect varying efforts and could enter the model as offsets. Finally, mean catch weight rates can be derived from the fits.

The model outlined above should only be taken as a suggestion to improve the analysis. The report is sparse on technical details about the method being used (randomization test) and in particular it is unclear to what extent the variance component contributed by the hauls is accounted for. These considerations may affect the results and sharpen the conclusions.

It was not possible to show any significant differences in the catch rates of undersized cod between the test nets and the standard flatfish net using the full data set. The haul with the largest catch of cod was deemed an outlier and the data reanalyzed with this haul removed. The report states that the new p-values "approached the 0.05 level." Table 5 lists the p-values of 0.07 and 0.09 for the

lead-added and the dual lead nets, respectively. I would hesitate to put too much emphasis on p-values of these magnitudes as evidence against a null-hypothesis.

The exclusion of the haul with the largest catch of cod is only based on the magnitude of the catch. This seems insufficient justification for deeming it an outlier and it is of particular concern since it relates directly to the hypothesis being tested. The catch of undersized cod caught by this haul represents 56% of the total catch of undersized cod in all hauls. If this is a valid haul, meaning that such hauls do occur, though with a low frequency, it carries relevant and important information about the harvest pattern of the nets if used in a commercial fishery. They may well be more important than the more "normal sized" hauls. This is, by other words, also acknowledged in the report (p.18).

Although the results seem promising, the indications of heavy tailed distributions should not be ignored but calls for further considerations and perhaps for further experiments.

In conclusion, I'm not convinced that the problem of catching undersized cod in flatfish net has been solved by the modified flatfish nets.

Other comments:
p.3: The paper referenced "Godøy et al. (2003)" is not included in the reference list.
p. 5-6: I guess it is common practice to put the null-hypothesis before the alternative hypothesis. Furthermore, I suspect that $\mathbf{H_0}$ should be one-sided ("...catch cod at least at the same rates ...").
p.8: The description of the "geographical arrangement" and how it relates to the modified Latin square could be more clear.
p.9&11: The report gives the minimum and maximum durations, where the latter is due to extraordinary circumstance. What did the variation of the durations excluding this one?
p.10-11: I couldn't find recordings of length in the data base.
p.12: Change "p=0.00" to "p<0.01". Check other instances.
p.13: Change "p=1.00" to "p>0.99". Check other instances.
p.15: Change "experimental design" to, for example, "experimental net design," as experimental design is most commonly used in a statistical context, which I believe is not what is meant here.
p.18: One out of 35 does not qualify for an event to be called "rare".
p.19: Change "...may be in fact be desirable..." to ....
p.35: Why is there no plot for winter flounder below MLS?

5a3. Data accessibility and dissemination of results:
See 4 above on "Data accessibility". There appear to have been good efforts made to communicate the work and (intermediate) results both to the scientific community, by presentations at conferences, as well as to the industry. I encourage the project team to take this effort of rewriting the report into an article and submit it for publication in a peer reviewed journal. The report is well suited for this (taking the comments above into account), and I believe the content is of interest to a broader audience.

5a4. Project partnerships:
The project appears to have been a fruitful collaboration between scientist and fishermen.

5a5. Project impacts:
The results obtained in the project indicate that the new gear may have a potential as a more species selective alternative to the existing standard flatfish net. I believe, however, that further development and research is needed before more firm conclusions can be drawn.

5a6. End-users:
No comments.

5b. Summary/Other Recommendations
The report documents a clear and focused piece of scientific work. The project was successful in determining catch weight rates of cod and flatfish in all of the gillnets tested. Nevertheless, it appears that the project could have benefited from involving more statistical expertise, e.g. by engaging with a university department of applied statistics. The data and the analysis does not give conclusive and convincing evidence that the modified flatfish nets provide a better alternative than the standard flatfish net with respect to decreasing the catch rate of cod. Even though the standard flatfish net showed the highest catch rate in the vast majority of the hauls, the difference was not significant. The problem seems to be related to a small number of hauls with large catch rates. These hauls may potentially repeal the gain achieved by the more average sized hauls. Future work should address this issue and seek solutions which improve the species selectivity for the high catch rate scenario.

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27 November 2007

Rachel Feeney
Fisheries Specialist
Northeast Consortium
142 Morse Hall – Univ. of New Hampshire
39 College Rd
Durham NH 03824

Dear Rachel:

Thank you for the opportunity to respond to the two reviews conducted for "Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II." I'm pleased that both reviewers had so many positive comments to make. While most of their comments are in the nature of suggestions, rather than corrections, I would like to respond to some of them.

Both reviewers suggested that mixing strings of gillnets would have been preferable to maintaining strings of only one net type. I agree somewhat: certain gillnet experiments should only be done using strings (a series of individual gillnets tied together) that are mixed; that is, each string should include equal numbers of experimental and control nets. I've conducted gillnet studies using this type of arrangement. However, where physical characteristics of each type of individual gillnet could impact the adjoining gillnets, other arrangements are necessary. My choice of unmixed strings was based on two concerns. First, that neighboring nets with different floatation could influence one another. For example, if a dual leadline gillnet was tied to a Foamcore net, the dual leadline might partially pull down the Foamcore net. This effect can be mitigated by creating large gaps between gillnets, as in our later proposal. However, lengthy between-net lines are not standard industry practice. Further, the fundamental unit of gear in this study is not an individual net – it is a string of nets. This distinction is important. A gillnet string does not fish the same way as a bunch of individual gillnets would if fished separately. Gillnets can lead fish down the net, and this behavior impacts catch. Fishermen have long observed that gillnets at the ends of strings have a higher catch rate that those in the middle.

Consequently, single net type strings would provide data more comparable to commercial practice, while eliminating concerns over either neighboring nets influencing each other, or the use of atypical rigging arrangements. The results would be more acceptable to scientists, fishermen, and managers if I separated the net types in single strings. I attempted to adjust for the possibility that we were sampling from different populations by placing strings near each other. Experimental designs often involve this type of compromise.

Both reviewers suggest reworking the data using numbers (counts) instead of weights as reported. One points out that counts are more useful for stock dynamics and stock conservation. I see both sides of this point. Weights were chosen as being more useful to fishermen and the fleet in general. The analysis could be redone using numbers, and I will take that suggestion into consideration if a manuscript is produced. Reviewers additionally noted that length data were not available. These data were transmitted to the NEC data system prior to 5 January 2005, but do not appear to be on the data website.

Alternate analytic methods were suggested, using parametric methods or GLMMs that could be illuminating or useful. The suggestions were provided at least partly because the randomization testing was not well-described. To clarify, here is a more detailed description:

> Randomization testing is an exploration of the variability in the actual, observed data collected during the experiment. Comparisons were made between each experimental net and the control, separately. Catch data by species or species group were jumbled together without regard to the net type they were caught in. Thirty-five data points were randomly selected from this pool of data and assigned to each net type, control and experimental. The mean for each net using these "pseudo-values" was calculated, and the difference was recorded. This process was repeated 1000 times, creating a range of differences. The actual mean difference observed in the two nets was then compared to the differences from the randomly-assigned pseudo-values. The p-values that are reported indicate the percentage of the "pseudo-differences" were more extreme than the actual value. The process was then repeated for the data from the other experimental net and the control net.

One reviewer's comments on p-values really get to the heart of use of 0.05 as a threshold: the reviewer wrote, "I would hesitate to put too much emphasis on p-values of this magnitude." P-values represent the estimated probability that the conclusion reported could be wrong. For example, 0.05 represents a 1 in 20 chance that the conclusion made based on the test is wrong just by chance. This threshold is considered by some to be standard. I prefer to report the actual p-value and allow readers to make their own determination of the risk of accepting or rejecting the hypothesis. A value of 0.10 (1 in 10 chance of being wrong) may be acceptable in some situations, while a value of 0.01 (1 in 100) may not be acceptable in drug trials or military or space applications. Risk tolerance varies among individuals, so reporting the p-value allows individuals to determine if emphasis should be placed on the conclusions.

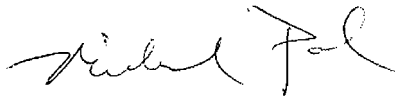
A few of the comments are difficult to react to. The reviewers differed in their understanding of the basic setup of the experiment and one recommended further explanation, diagrams, and a definition of string. These concerns will be taken into consideration in future versions of the document. One reviewer indicated that no mention was made about temperature, although bottom temperatures were presented on page 14. This reviewer also was critical of the amount of text and pictures on the poster; however, this poster has very little text, several pictures, and contains bulleted lists as this reviewer suggests. This reviewer did identify an error in the color description of the net twine on the poster; in reality, the visible difference between light green and light blue twine in gillnets is small.

One reviewer recommended investigation into or consideration of discard mortality (survival rates) of sub-legal Atlantic cod. I agree that further information on this topic might be useful for management or for addressing concerns over the implementation of the designs. However, I have reservations due to the variability in soak times in the general fleet and applicability of experimental survival rates to actual fishing.

In general, the reviewers identified alternative analyses and specific recommendations about reporting scientific names, reporting units, and other items. These recommendations will be considered in any future reporting of this work, if any. Or, if the Consortium or others request reanalysis or implementations of specific revisions, I will revise the report.

I hope I have satisfactorily responded to the concerns of the reviewers. I am happy to answer any additional questions regarding this study. My thanks again to you and the Northeast Consortium for the review, and the chance to respond.

Sincerely,



Michael Pol
Senior Marine Fisheries Biologist

#6

Northeast Consortium

University of New Hampshire • Massachusetts Institute of Technology
University of Maine • Woods Hole Oceanographic Institution

August 9, 2007

Capt. Paul Howard
Executive Director
New England Fishery Management Council
50 Water St.
Newburyport, MA 01950

Dear Capt. ~~Howard~~, Paul

The Northeast Consortium has facilitated an independent technical evaluation of the cooperative research project,

"Survival of sub-legal cod (Gadus morhua) in the northwest Atlantic longline fishery."

This project received funding in FY2003 ($123,612) to examine the survival rate for sub-legal cod using different handling techniques in the longline commercial fishery. Over 15 commercial fishermen from the Cape Cod Commercial Hook Fishermen's Association partnered with Henry Milliken from NOAA Fisheries Northeast Fisheries Science Centre and Marianne Farrington of the New England Aquarium on the project.

I am pleased to submit the evaluation documents to the New England Fishery Management Council. This includes the final report and three evaluation reports.

The Review:
The evaluation served as a formal assessment of the project. Two independent scientists each conducted a mail review of the project, providing comments and suggestions, which while occasionally critical, were made with the intent to improve the research, applications of the data, and future research. The reviewers were asked to focus on the final report, but supporting documents were included in the review package to give further perspectives on the project.

Evaluation Criteria:
The evaluation criteria are listed in the enclosed document that describes the Northeast Consortium general review process. Reviewers were asked to focus on the second criteria, certification of results, i.e. whether the experimental design was appropriate and if the conclusions are well supported by the data.

Feb 1 - Waltham MA

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Project Data:
The project investigators have *not* submitted raw data to the Northeast Consortium's Fisheries and Oceans Data Management System: http://www.northeastconsortium.org/data.shtml, but we encourage them to so soon.

Conflict of Interest and Confidentiality:
Each reviewer signed the Northeast Consortium's conflict of interest and confidentiality policy for the technical evaluation of projects. The evaluation reports submitted do not necessarily reflect views of the Northeast Consortium, the reviewers' employers, or governments. As requested by the NEFMC Research Steering Committee, the review comments are being submitted to the Council anonymously. However, I am always willing to act as a liaison for questions of the reviewers regarding any aspect of the evaluations.

Participants' Response:
Henry Milliken responded to the reviewers comments via email to me. The project participants intend to submit a manuscript on the project to a peer-reviewed journal and will incorporate suggestions made by the reviewers. He states, "Since the reviewers agreed with our statistical approach and the data were sufficient to infer a rate of mortality, regardless if our controls were true controls, there seems to be sufficient information in the previously submitted document [the final report] without elaborating further until we proceed with submission to a peer reviewed journal."

The Northeast Consortium values this cooperative research project and the contributions that it can make to fisheries management and our collective knowledge of the Gulf of Maine and Georges Bank ecosystem. Thank you in advance for your consideration and assistance in ensuring the appropriate use of the study and the evaluation reports in the management arena. Do not hesitate to contact me with any questions you may have.

Sincerely,

Rachel Gallant

Rachel Gallant
Fisheries Specialist
(603) 862-2276
rachel.gallant@unh.edu

CC:
Pat Fiorelli, NEFMC
Chris Glass, Northeast Consortium

Enclosures:

- The Northeast Consortium's guidelines for the final technical evaluation for cooperative research projects, including evaluation criteria.
- Pappalardo, J. et al. *"Survival of sub-legal cod (Gadus morhua) in the northwest Atlantic longline fishery."* Final report submitted to the Northeast Consortium, October 19, 2006.
- "*Technical evaluation report,*" submitted to the Northeast Consortium July 17, 2007.
- "*Technical evaluation report,*" submitted to the Northeast Consortium July 23, 2007.
- "*Technical evaluation report,*" submitted to the Northeast Consortium July 31, 2007.

Northeast Consortium

Final Technical Evaluation for Northeast Consortium Cooperative Research Projects

The Northeast Consortium administers a final technical evaluation of all appropriate aspects of funded cooperative research projects once they are complete, including methods, data, data analysis and management, results and conclusions, deliverables, application for ocean and fisheries management, socio-economic impacts, and other impacts on end-users. The technical evaluation of a project is an essential step in the successful transfer of project results and products to appropriate end-users. Following evaluation, Northeast Consortium staff work to ensure that the data, information, and other deliverables are effectively used and integrated into fisheries and ocean management, further research, commercial fishing practices and products, and other practical applications, as appropriate.

The Final Technical Evaluation Process

The final technical evaluation of each project is unique, since the Northeast Consortium funds research that varies greatly in project topic area, size, and duration. The extent to which research outcomes may impact fisheries management is also likely to be unique. Therefore, the Northeast Consortium facilitates independent evaluations that are appropriate to both the nature of the research and the expected applications of the project outcomes. An internal review is conducted for each project and the vast majority of projects also receive an external review. In each case, a Northeast Consortium staff member is designated to provide programmatic and logistical support to the evaluation process.

Internal review. The Northeast Consortium staff reviews each project to ensure that project reporting requirements are met and that project funds were spent appropriately as determined by the approved project budget. There is also an analysis of the potential impact of project results to fisheries management or other end-users to determine if an external independent review is appropriate. Staff seek input of end-user communities in this determination.

External review. For projects which have results and outcomes that may have an impact on fisheries management or on an end-user community, an external review is facilitated by the Northeast Consortium. This evaluation takes the form of a mail and/or panel review. Project final reports and supporting materials are sent to technical reviewers. The projects are reviewed according to the Northeast Consortium's general criteria for the technical evaluation of completed projects, and possibly project-specific terms of reference. Reviewers submit technical evaluation reports to the Northeast Consortium. The Northeast Consortium staff member may compile a summary of the evaluation reports in the case of multiple reviews.

In the case of panel reviews, a technical expert in an appropriate discipline is selected by the Northeast Consortium Representatives to chair the evaluation panel. The Northeast Consortium staff works with the Representatives and the Chair to select 2-3 additional panel members. The Chair, in consultation with other panel members and the Northeast Consortium, decides how to

proceed with the evaluation, which may include meetings, video conferencing, project visits, interviews with project participants and end-users, and consultations with outside experts on related topics. The Chair may request mail review by additional independent experts. One evaluation report is written by the panel, though reviewers may submit individual comments.

Information Available to Reviewers

The Northeast Consortium staff member provides reviewers with copies of all relevant project documents, including the project proposal, final report, all data sets, publications, press coverage, descriptions and photos of new fishing gear or oceanographic instrumentation, lists of all deliverables and impacts, and names and contact information of all end-users and others who have direct knowledge of the project's real-world impacts and products. Any panel member may request additional information at any time during the evaluation. For mail reviews, the Northeast Consortium staff member can liaison questions about the project between the reviewers and project participants.

Evaluation Criteria

The following are the general criteria that reviewers use in evaluating projects. In addition, project-specific terms of reference are commonly used.

1. **Project success:** Did the project accomplish its stated goals and objectives?

2. **Certification of results:** Is there adequate description of the approaches to experimental design, methods, and data analysis? Were these approaches appropriate? Are there other approaches that the participants could have considered or used? Are the data accurate, precise, and believable? Are the results and conclusions well supported by the data and statistically valid? Can the results and conclusions contribute to a sound basis for management decisions and policies? If not, can anything be done to allow this?

3. **Data accessibility and dissemination of results:** Are the data available through the Northeast Consortium Fisheries and Ocean Data Management System? Are the data being served via another internet-accessible database? If so, are the data formatted suitably for data integration by the Northeast Consortium database? Are the project deliverables (publications, reports, and communications materials) of high quality? Have they been distributed appropriately? Is the final report complete, sufficient, and understandable to end-users?

4. **Project partnerships:** Consider the degree to which the project was of mutual interest to participants and whether partners were key participants throughout the course of the project, including project design, data collection and analysis, and application of the results or products. What were the most and least successful aspects of the partnership? Were all parties equally interested and engaged in the project?

5. **Project impacts:** What impacts has the project had or could it have? What are the potential effects on fishing practices; socio-economics; and fisheries, coastal, and ocean management?

6. **End-Users:** Being as specific as possible, who could benefit from knowing about the research? How can a fishing sector incorporate any new information from the project? Which fishery management organization, working group, or plan development team could use the data?

7. **Overall rating.** Rate the overall project according to the criteria listed above as excellent, very good, good, fair, or poor. Explain the reasoning behind the rating.

8. **Future research.** Is additional research needed to answer the original questions posed by the project? Are there obvious avenues of further research that should or must be pursued? Given the investment to date, should this future research be a high priority for the Northeast Consortium?

9. **Additional comments and guidance.** Provide any additional comments that will assist the Northeast Consortium in evaluating this project.

The Final Technical Evaluation Report

The reviewers, whether collectively as a panel or individually, prepare written reports, providing detailed comments on each of the evaluation criteria and terms of reference, noting specific strengths and weaknesses of the project. Reports of approximately five pages in length are anticipated, but longer reports are acceptable. Technical evaluation reports should be submitted by reviewers to the Northeast Consortium within six weeks of receiving project documentation. In the case of a panel review, the report is a "consensus" document written by all panelists. Panelists may provide additional/personal comments in individual reports.

Distribution of a Technical Evaluation Report

Final technical evaluation reports are not posted on the Northeast Consortium's website, but are available upon request on a case by case basis to representatives of end-user communities and organizations. This includes the National Marine Fisheries Service; New England Fishery Management Council; Atlantic States Marine Fisheries Commission; commercial fishing industry organizations and individuals; Coastal Zone Management program; Office of State Planning; the Advisory Committee of the Northeast Consortium; and/or other appropriate local, state, or federal agencies or programs. The Northeast Consortium staff member may prepare a summary of the report targeted for a specific end-user.

External Reviewers

Reviewer selection. Those selected as external reviewers include Northeast Consortium Advisory Committee members and others as needed to ensure appropriate expertise for each project and may come from outside the New England region. The Chair of a panel review may veto the selection of any panelist. The Northeast Consortium may offer honoraria for review panel service to each panel member. Expenses for travel and other incidentals will be reimbursed upon request.

Confidentiality and conflict of interest. The evaluation process is intended to be as fair and objective as possible. Project mail reviews are anonymous. Members of panel reviews are not identified to end-users without their prior permission. The Northeast Consortium seeks such permission only as necessary to provide evidence of authority and expertise; names of review panel members are not otherwise be made public. Panel members may not copy, quote, discuss or otherwise use materials about projects without the consent of the Northeast Consortium and project participants. Conflicts of interest are scrutinized when selecting panel reviewers and it is the responsibility of each panel member to inform the Northeast Consortium of any potential conflicts of interest. Each reviewer must read and sign the Northeast Consortium's conflict of interest and confidentiality policy prior to participating in a review. All materials used in the project evaluation process are returned to the Northeast Consortium or destroyed.

For More Information

Additional information about the Northeast Consortium can be found on its website (www.northestconsortium.org). The Northeast Consortium welcomes comment on policies and procedures at any time. For matters relating to the technical evaluation of cooperative research, please contact Rachel Gallant, Fisheries Specialist.

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Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery

NEC Grant #04-827
Period of performance:
July 1, 2003 through June 30, 2005 (extended to June 30, 2006)

NEC Service Provider Agreement #P6UZO126
Period of performance:
January 24, 2006 through June 30, 2006

Exempted Fishing Permits DA-316 and DA-0554

Submission Date: 10/19/2006

John Pappalardo
Policy Analyst, CCCHFA

Tom Rudolph
Research Director, CCCHA

Principle Investigators:

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Abstract

Federal fisheries regulations require that undersized individuals of commercially important species be returned to the sea and the National Marine Fisheries Service (NMFS) has listed investigations into discard mortality rates as a research priority. For demersal longline fisheries, survival of discarded bycatch is uncertain. Sub-legal sized fish can incur injuries in their mouth, gills, and eyes and sometimes in the gut from hooks, as well as undergo pressure and temperature changes as they are brought to the surface. This study built on previous work that investigated the survival of sub-legal cod. The results of the previous study were hard to assess because of the large numbers of control fish that died. Additionally, the results of the previous study were questioned because the study was not conducted using commercial vessels. This study, funded by the Northeast Consortium (NEC), was executed in collaboration with commercial vessels fishing their commercial hook and line gear. Two handling techniques were examined and compared to jigged fish that acted as the control to estimate cage induced mortality. Longline caught fish were either removed from the hook by hand (unsnubbed) or removed by allowing the hydraulic hauler to pull the fish against the parallel steel cylinders placed vertically on the gunwale, causing the hook to pull through the jaw (snubbed). At the extreme, this process can result in breaking the jaw. This study was a cooperative effort between fishermen and scientists using standard commercial fishing practices. 3,764 sub-legal cod were assessed for survival at three different depth ranges and four sea surface temperature ranges. Survival, assessed after holding the fish in cages for a minimum of 72 hours, ranged from 30.8% to 100%. Binomial logistical regression analysis indicated that depth, sea surface temperature, and de-hooking technique all affected survival. Depth and temperature affected survival more than the de-hooking technique. Survival improved as depth and sea surface temperatures decreased. Unsnubbed fish had less mortality compared to snubbed fish.

Introduction

Cape Cod Commercial Hook Fishermen's Association (CCCHFA) staff and members had pressing questions about sub-legal cod discard mortality; in particular, the assumption by some managers of 100% mortality on these discards. Several CCCHFA fishermen had participated in survival studies with Marianne Farrington (New England Aquarium) and Henry Milliken (NOAA Fisheries Northeast Fisheries Science Center). CCCHFA staff had concerns about the results of this study that were published in 1999 (Milliken et. al., 1999), specifically the sample size and handling time. The three groups agreed to collaborate on further research into hook and line discard mortality for sub-legal cod and secured funding from the Northeast Consortium in 2003.

Given that perfect selectivity can only be approximated, undersized or juvenile individuals are inadvertently taken as part of all commercially landed marine catches. As mandated by fisheries management law (Federal Register, 1989; NEFMC, 1985), this bycatch must be returned to the sea. Estimating bycatch survival has been the focus of many investigations. The actual survival of bycatch depends on complex interactions among a broad range of variables such as species type (Carr et al., 1995; Robinson and Carr, 1993; Poiner and Harris, 1996; Smith, 1996), individual injury levels (Milliken et al., 1999; Main and Sangster,1990), gear type (Carr et al., 1995; Rutecki and Meyers, 1992), fishing depth (Neilson et al., 1989), duration of set (Carr and Robinson, 1993), handling time (Neilson et al., 1989; Carr and Robinson, 1993), and fish length (Milliken et al., 1999; Neilson et al., 1989).

Bycatch survival in commercial fisheries is poorly understood. Developing quantitative methods to accurately assess discard mortality requires an understanding of the factors that contribute to this mortality, how mortality is defined within each context, and measuring these variables under commercial fishing conditions (Davis, 2002). Because bycatch survival affects the biomass of cod in the northwest Atlantic, including the Gulf of Maine, an undefined estimate of true survival negatively affects the successful management of fishery resources (Chopin et al. 1997; Mesnil 1996; Davis 2002; Ryer 2004). Unless the survival of bycatch is specifically quantified for a species, assessing the status of that stock, setting appropriate fishing levels and developing an optimum yield within a species population will remain problematic (Chopin et al. 1997; Mesnil 1996; Ryer 2004).

Fishermen in the bottom trawl and gillnet fishery are assessed 100% mortality for discarded cod. The assumption that 100% of the cod do not survive in the longline fishery is not supported by previous research of mortality estimates on cod in the longline fishery (Milliken, et al., 1999) and the mortality estimates for other species caught using longline gear (Neilson et al., 1989, Orsi et al., 1993). In fact, bycatch within the longline fishing industry has demonstrated high survivability as compared to other fishing methods. Soldal and Huse (1997) found no mortality of 18 sub-legal Haddock that had the hooks ripped from their mouths. The survival of Atlantic halibut (*Hippoglossus hippoglossus*) caught by longline was shown to be 77% compared to 35% in trawl caught fish (Neilson et al., 1989). The survival of juvenile sable fish (*Anoplopoma fimbria*) was much greater in fish that were captured by hand jigging (81%) versus traps (25%),

presumably because of the decreased incidence of secondary bacterial infection that resulted from skin abrasions obtained in the trap (Rutecki and Myers, 1992). A decrease in the survival of hook caught Chinook salmon (*Oncorhynchus tshawytscha*) was shown when using circle hooks instead of lures. This decreased the incidence of gut hooking and likely lead to decreased mortality due to the less abusive nature of the injuries (Orsi et al., 1993).

The only previous analyses of the survival of sub-legal cod in the northwest Atlantic demersal longline fishery (Milliken et al., 1999) assessed fish after 72 hours that had been placed in cages and returned to the depths at capture. Survival ranged from 22% to 47% for fish that were snubbed and 38% - 63% for fish that were carefully removed from the hooks (Milliken et. al. 1999). However, "control" fish that were individually captured by jigging (handgear, comprising handlines, manual rod and reel, and electric rod and reel) and carefully removed from the hooks also demonstrated significant mortality. The conclusions of this study necessitated the admission that the results may not have accurately estimated survival of sub-legal sized cod because the caging process and experimental techniques may have influenced the survivability of the fish (Milliken et. al. 1999). The need for better data as expressed by managers developing policy, ongoing concerns over the recruitment and survival of sub legal-sized discards in the hook fishery, and the concerns of hook fishermen about the previous study combined to necessitate additional work. An ambitious and rigorous research protocol that included input from the fishing community and that addressed variables like seasonality and depth was regarded as necessary.

Project objectives and scientific hypotheses

The explicit purpose of this project was to document the survival of sub legal-sized cod in the bottom-set (demersal) longline fishery in New England that included studying the effects of season (sea-surface temperature), depth, and unhooking technique.

Ho = Survival of sub-legal cod is not affected by different temperatures, depths, and unhooking technique.
Ha = Survival of sub-legal cod is affected by different temperatures, depths, and unhooking technique.

Ho = Mortality of sub-legal cod approaches 100%.
Ha = Mortality of sub-legal cod is significantly less than 100%.

Participants:

Program Management:		**Independent Consultants:**	
CCCHFA:		Industry Technicians:	Albert Nardini
Principle Investigator:	John Pappalardo		John Kenneway
Program Coordinator:	Tom Rudolph		Pete Schimmel
Program Coordinator:	Melissa Sanderson		Anne Magoon
Program Coordinator:	Lara Slifka		Connie Reid
Program Coordinator:	Eric Brazer		Charlie Pitts
Executive Director:	Paul Parker		Don Slifka
Finance Director:	Nat Mason		Mike Anderson
Comm. Coordinator:	Sarah Gallo		Jeremy Bicknell
New England Aquarium:			
Principle Investigator:	Marianne Farrington		
NOAA Fisheries Northeast Fisheries Science Center:			
Principle Investigator:	Henry Milliken		

Industry Participants (vessels)		**Industry Participants (crews)**	
Fishing Vessel	**Captain/Owner**		
FV Saga	Ben Bergquist	Dan Bergquist	Leo Maher
FV Rueby	Bill Chaprales	Jeff Daluz	Tyler Klaskow
FV Never Enough	Bruce Kaminski	Charlie Jones	Billy Trombi
FV Tenacious	Eric Hesse	Jerry Perry	Brian Blanchard
FV Miss Morgan	Glen Legeyt	Nick Chaprales	Pete Tamagini
FV Yellowbird	Jamie Eldredge	Jon Hesse	Jared Wilson
FV Time Bandit	Kurt Martin	Sean Leach	Roger Horne
FV Sea Holly	Mark Leach	Steve Young	Albert Nardini
FV Magic	Mike Abdow		
FV Seahound	Peter W. Taylor		
FV Wendy Jean	Terry Pickard		
FV Sea Win	Tom Luce		

Methods

For each sampling event, defined as a day on which actual fishing took place, two to four vessels utilized commercial bottom set longline gear and rod and reel to target cod. After capture, sub-legal cod (<22 inches) were evaluated and held in on-board live wells until 50 fish had been collected, constituting a replicate, and the vessel was prepared for caging. The fish were then lowered to the seafloor in cages that were retrieved and evaluated after at least 72 hours. Fishermen were responsible for determining suitable experimental fishing areas within each required season-depth strata.

Strata: In order to attain an adequate understanding of the survival of cod caught in the longline fishery, fish were collected during the winter, spring, summer and fall seasons. Seasons were described in the original statement of work by their simple names, which would presumably have translated to calendar dates for the purposes of planning fieldwork. In practice, the investigators recognized the main variable of concern from season to season was sea surface temperature and therefore aimed to sample in each of four temperature categories as follows:

Cold	(<= 43 F)
Cool	(44-48 F)
Warm	(49-58 F)
Hot	(> 58 F)

The study was also designed to assess survival across different capture depths, and to investigate the interplay between season and depth. The statement of work called for sampling to take place in 20, 30, and 40 fathoms. This range represents the depths where most regional longline fishing occurs (J. Pappalardo, P. Comm.). The only change to the protocol in this respect was to treat these categories as ranges as follows:

20 fathoms	15-25 fathoms
30 fathoms	25-35 fathoms
40 fathoms	35-45 fathoms

Treatments: As previously explained, within each unique combination of season and depth, three different treatments were conducted: snubbed, unsnubbed, and jigged. Snubbed and unsnubbed were both taken off the demersal longline gear and were intended to duplicate as closely as possible the release (discard) conditions for normal commercial fishing. As such, these treatments were comprised of the first 50 fish caught off a given string regardless of condition. While dead fish might not be tanked or caged to avoid attracting scavengers, they were still counted as mortality towards the sample size. The jigged fish were intended to act as a control, which would indicate cage-induced mortality. As such, only strong fish with no major injuries were selected towards the 50 fish sample; dead, weak or injured fish were not used or counted.

For each season, a minimum of 150 sub-legal fish were targeted for each of the three treatments at each of the three different depths.

Vessel Logistics and Deck Protocols: The research took place on commercial longline and handgear vessels. Each longline vessel fished their bottom set longline gear consisting of 1200 feet of mainline with 300 - 12/0 circle hooks spaced every four feet, constituting one bundle. 3-4 bundles were strung together to comprise a string, and 3-4 strings were set per fishing day to arrive at a total effort of approximately 3600 hooks per day. Strings of hooks were placed in close proximity to minimize any bias that could result from collecting fish from different areas (i.e. depths and temperatures), and bait type (squid vs. clams) was kept consistent across a given fishing event. The fishery studied does not soak the gear in the traditional sense- the fishing event is strictly tied to

the tidal cycle. The gear is set just before slack tide, and hauled as quickly as possible. As such, soak time is only as long as it takes to get the gear back, and is always brief, ranging from as little as an hour to a maximum of about 4 hours. Set time, set location, set depth, and soak time were all recorded.

Each vessel was equipped with live tanks sufficient to hold fifty fish. Live wells were aerated with circulated seawater or aeration pumps with air stones. When sea surface temperatures were hot (above 58F), live wells were chilled with saltwater ice to 50F or less to prevent live well induced mortality. Each of the longline vessels fished their gear at a predetermined depth. The first 50 sub-legal cod captured on each string were removed from the hook in one of two ways. Prior to fishing, a coin was tossed which determined which treatment would be followed for the first string, and then treatments were alternated on subsequent strings. Once assigned, a given treatment was followed until fifty fish were caught, or the end of the string was reached

The unsnubbed treatment group was unhooked by hand, without allowing the fish to contact the fair lead roller (a set of steel cylinders that guide the line and can be used to restrain the fish) and without allowing the force of the hydraulics to pull the hook out. The snubbed treatment group was de-hooked by allowing the fish to contact the fair lead roller, and then using the force of the hydraulics to pull the hook through the jaw. The result is that the hook often tears flesh, breaks the jaw, or causes other injury.

As a control, another subset of cod were caught by handgear and used as an indicator of potential cage-induced mortality. Handgear is defined as handlines, manual rod and reel or electric rod and reel equipped with terminal tackle consisting of 2-5 hooks with bait or artificial lures and a weighted jig. Vessels in this study used electric rod and reel almost exclusively, and the practice is often referred to in this report as jigging. These fish were caught in the same area and placed in cages in close proximity to those holding the longline fish, but instead of using the first 50 fish, the control cages selected for 50 strong and healthy fish. The study took advantage of the handling techniques developed by jig vessels contracted by the CCCHFA for the Northeast Regional Cod Tagging Program. These fish were handled carefully and were used as indicators of unanticipated mortality that might be attributed to the caging process.

The sub-legal fish were measured, assessed for condition and placed in live tanks, with an emphasis on limiting handling time. Information on the fish including the handling technique, depth of capture, air, surface and bottom temperature, size of fish, time of capture, and behavior upon placement in the live well were recorded. In addition, the stamina of the fish was rated into one of four categories (Vigorous, Moderate, Limp, or Dead). The location of the hook wound was recorded (Mouth, Eyes, Gills, Gut, or Body), as was the severity (None, Slight, Moderate, Serious, Severe). Finally, any apparent pressure effects were noted (Eyes, Stomach, Vent etc.) The fish were kept in the live wells until a sufficient number were collected or haul-back was completed. In order to minimize tanking time in instances when the sample was achieved early in the haul, participating fishermen would also consider buoying off the gear mid-haul to sink the cage.

Fish were transferred by dip net from the live well to cages tethered alongside the vessel, and no more than 50 fish were placed in each cage. Transfer time was recorded, dead fish were noted and discarded, and a final count of the number going into the cage was taken. Each cage was closed and secured, and immediately placed back on the bottom in depths similar to where they were captured. Cages were tied off and carefully lowered at a controlled rate (typically 1 to 2 minutes depending on depth).

In summary, 1-2 longline vessels were accompanied to the fishing grounds for a given depth by 1-2 jig vessels that caught the control fish. All fish were placed in the holding tanks, caged and sunk using the same techniques. Each longliner and jig vessel had a captain, crew and technician/scientific data collector (tech/SDC) on board. This tech/SDC was either a scientist or a technician recruited from the local fishing industry and trained by Dr. Farrington. No less than 72 hours later, a vessel returned to haul all the cages. Survival of the fish in the cages was assessed and recorded. This protocol was based on work by Sangster et. al. (1996), who showed that the majority of the mortality attributable to the capture process occurs in the first 72 hours. Following retrieval, the cages were brought back to port until the next sampling event.

This arrangement was a departure from the original plan, which called for the same vessels to jig and longline on the same trip, and called for these same vessels to haul previously set cages for evaluation on the same trip on which they fished. The investigators quickly determined that tidal restrictions made jigging and longlining on the same trip practically impossible. Therefore, separate vessels were sent. It was also determined that vessels equipped for hook and line were not capable of hauling the cages and storing them on deck prior to fishing. Therefore the plan was altered to a "fleet style" strategy in which sufficient longline and jig vessels were sent to the grounds to allow a given season-depth strata to be completely finished. Three days later a lobster vessel with a davit and an open stern would return to haul and evaluate all the cages before returning them to port. The research fleet would then move on to the next depth strata within that season and repeat the process.

Even with this new arrangement, it was discovered that the vessel time in the budget was insufficient to achieve the number of fish by treatment that was originally proposed. As such, the award was enhanced by NEC in early 2006 through a Service Provider Award, which allowed nine additional trips. Another change from the original project plan was that fish were not tagged prior to caging. This change was made because tags were not available, and because of the possibility that the tagging procedure could cause additional mortality.

Equipment: Industry input was especially critical in the design of the cage and associated equipment. Another minor concern of the CCCHFA membership with the previous cod study (Milliken et. al.) concerned the high center of gravity of the cage used. The waters in which these investigations took place are considered highly tidal, with significant current velocities generated, and the investigators sought to avoid any

possibility that the cages would move or be disturbed. As such, a rigid low-rise cage with a cylindrical shape and integrated bottom weights was designed and tested in local waters and showed great promise. Because of this requirement for low height and because of the small boats used in the study required a small diameter cage, the overall volume of the round cages was small (two feet high by four feet in diameter).

There were differing opinions on the number of fish that could be comfortably placed in this cage. Most of the fishermen felt it could hold up to 100 sub-legal cod, based on observations of tight schooling in live wells. Scientists thought space was critical, and suggested this cage was suitable for less than 10 fish. As such, and having an ambitious target for sample size, a density test was preformed in which 8 cages were filled and sunk, 2 each with 15, 30, 45 and 60 fish respectively. No differences in mortality were observed and it was decided that 50 fish was an appropriate density.

Cages were set as singles, with one anchor, one buoy line, one buoy and one high-flyer per cage. Anchors were 80-pound sections of steel railroad track with bridles constructed of a steel shackle, 12 inches of chain, and 4 feet of polypropylene rope. Buoy lines were 11/32" or 5/16" line, varied in length depending on the depth. Buoys were large, low drag poly-balls. High-flyers were 12 feet long and were equipped with radar reflectors. All gear was fully compliant with the requirements of the Atlantic Large Whale Take Reduction Plan, including commercially purchased swivel-style weak links incorporated into the buoy lines.

Data was collected on Palm Pilots purchased for the study and equipped with Smartlist to Go software. This offered the efficiency and accuracy of a date-time stamp for each entry, and eliminated the need for keypunching and any associated errors. Paper datasheets were provided as a backup.

Exempted Fishing Permits (EFP): The project took place under two different permits. EFP DA-316 was originally issued in December 2003, and expired in November 2004. EFP DA-0554 was issued in May 2005 and expired in April 2006. Both permits allowed the temporary retention of sub-legal cod in on-board live wells and seafloor cages, as well as the setting of the seafloor cages. In all other respects, the fishing was identical to actual commercial operations, and no other exemptions were needed or requested.

The original project budget used a standard daily rate for small vessels of $1560, but neglected to include funds for the substantial fixed daily expenses of bait and baiting incurred by the longline vessels. While the approved rate was sufficient to contract the jig and retrieval vessels, it was not viable for the longliners. As such, revenues from the sale of legal and marketable fish were used for this purpose.

Project Timeline:

April 2003	Proposal submitted
August 2003	Award notification received
September 2003	EFP application #1 submitted
December 2003	1st project planning meeting;
	EFP DA-316 issued
April 2004	NEC-CCCHFA contract executed
	CCCHFA-NEAq subcontract executed
May 2004	Cages purchased
May-June 2004	Field work commences
	1st field season
July 2004	EFP DA-316 amended
	Annual report submitted
February 2005	EFP application #2 submitted
	CCCHFA-NEC contract extended
March 2005	CCCHFA-NEAq contract extended
May 2005-June2005	EFP DA-0554 issued
	2nd field season
July 2005	Annual report submitted
August 2005	3rd field season
November 2005-January 2006	4th field season
May 2006-July 2006	Auditing and analysis
July 2006-September 2006	Reporting

Data:

Project data are briefly summarized in Table 1. As of this writing, project data have not been submitted to the NEC Fisheries and Oceans Database. The investigators expect to submit the data shortly, following submission of this report, and preparation of a journal article for publication. Please see next section (Results and Conclusions) for additional data tables and figures.

			Jigged		Snubbed		Unsnubbed	
Date caught	Temperature category	Water depth (Fath.)	Alive	Dead	Alive	Dead	Alive	Dead
12/28/2005	Temp 1 (<44 F)	20	147	11	32	10	87	15
1/6/2006	Temp 1 (<44 F)	30	129	29	69	37	35	19
1/24/2006	Temp 1 (<44 F)	40	152	14	87	35	50	10
6/9/2004	Temp 2 (44-48 F)	20	49	5	42	17	73	8
11/26/2005	Temp 2 (44-48 F)	20	37	8	14	7	61	23
5/17/2005	Temp 2 (44-48 F)	30	65	0	66	30	67	8
1/11/2006	Temp 2 (44-48 F)	40	146	14	45	10	94	26
12/5/2005	Temp 2 (44-48 F)	40	35	8	25	11	50	18
6/21/2004	Temp 3 (49-58F)	30 *	38	38	13	3	22	3
6/9/2005	Temp 3 (49-58F)	40	48	25	24	32	63	31
6/30/2004	Temp 3 (49-58F)	40	13	15	85	54	98	27
8/10/2005	Temp 4 (>58F)	20	111	16	34	19	84	22
8/6/2005	Temp 4 (>58F)	30	67	38	73	83	105	41
8/2/2005	Temp 4 (>58F)	40	61	47	45	101	51	104

Table 1: Number of alive and dead cod upon retrieval and evaluation by date, temperature, depth and treatment.

Results and conclusions

On fourteen different days, two to three vessels fished and caught 3764 sub-legal cod that were assessed for survival[1] at three different depths and four temperature categories (Table 1). When the data are compared, we attained rates that ranged from 100% to 30.8% survival (Table 2) not accounting for mortality associated with the handling and caging process. Survival was greatest at the lower temperatures and shallower depths.

[1] This does not include fish used to test cage density, or fish that were tagged and assessed.

	Depth	Jigged	Unsnubbed	Snubbed
Cold	20 Fath.	93%	85%	76%
	30 Fath.	82%	65%	65%
	40 Fath.	92%	83%	71%
Cool	20 Fath.	87%	81%	70%
	30 Fath.	100%	89%	69%
	40 Fath.	89%	77%	77%
Warm	20 Fath.		NO DATA	
	30 Fath.	50%	88%	81%
	40 Fath.	60%	74%	56%
Hot	20 Fath.	87%	79%	64%
	30 Fath.	64%	72%	47%
	40 Fath.	56%	33%	31%

Table 2: Percent survival for the three treatments by depth and by temperature.

A logistic binomial analysis was run on the data using survival as the dependent variable and temperature, depth, and treatment and a 2 cross (e.g. depth x temperature) and 3 cross (e.g. temp x depth x treatment) as the independent variables. The odds ratio generated from the model for temperature (3.567-6.823) and depth (2.398-5.038) as compared to the odds ratio for treatment (0.525 - 1.886) shows that differences in survival can be explained better by temperature and depth than by treatment. The graphs of the mean and 95% confidence intervals (Figures 4 – 8) show the greater differences in survival when temperature and depth are compared as opposed to treatment.

To reduce the 'noise' in the data that can likely be attributed to different handling procedures between treatments, the data was grouped by cold (<49F (9.4C)) and warm (>48F (8.9C)) (Table 3, Figure 2 and 7) and analyzed by adding the mortality of the jigged fish to the treatments (Table 4, Figure 3). Additionally, the middle point was added to the data that might be considered more representative of the actual survival. This was presented to show the possible range of mortality for the different treatments.

In general, the shallower depths and colder sea surface temperatures resulted in higher survival. The plots of the 95% confidence intervals show that survival when the sea surface temperatures were the highest (>58F (14.4C)) was lower when compared to temperatures below 44F (6.7C) and between 44F (6.7C) and 48F (8.9C).

Temperature	Cold combined (<49 F)			Warm combined (> 48 F)		
Depth	20 Fath.	30 Fath.	40 Fath.	20 Fath.	30 Fath.	40 Fath.
Treatment	% Survival					
Jigged	90.7%	87.0%	90.2%	87.4%	58.0%	58.4%
Unsnubbed	82.8%	79.1%	78.2%	79.2%	74.3%	56.7%
Snubbed	72.1%	66.8%	73.7%	64.2%	50.0%	45.2%

Table 3: Survival by treatment of sub-legal cod when data are grouped by cold (<49F [9.4C]) and warm (>48F [8.9C]) sea surface temperatures.

Treatment	Unsnubbed					
Temperature	Cold combined (<49F/9.4C)			Warm combined (> 48F/8.9C)		
Depth →	20 Fath	30 Fath	40 Fath	20 Fath	30 Fath	40 Fath
	% Survival					
Survival + jigged cage mortality	92.1%	92.1%	88.0%	91.8%	100.0%	98.3%
Observed survival	82.8%	79.1%	78.2%	79.2%	74.3%	56.7%
Middle point	87.4%	85.6%	83.1%	85.5%	87.1%	77.5%
Treatment →	Snubbed					
Temperature →	Cold combined (<49F/9.4C)			Warm combined (> 48F/8.9C)		
Depth →	20 Fath	30 Fath	40 Fath	20 Fath	30 Fath	40 Fath
	% Survival					
Survival + jigged cage mortality	81.5%	79.8%	83.5%	76.7%	92.0%	86.8%
Observed survival	72.1%	66.8%	73.7%	64.2%	50.0%	45.2%
Middle point	76.8%	73.3%	78.6%	70.5%	71.0%	66.0%

Table 4. Survival for snubbed and unsnubbed sub-legal cod when data are grouped by cold (<49F [9.4C]) and warm (>48F [8.9C]) sea surface temperatures and the mortality experienced by the jigged fish is added to the survival. A midpoint is also provided.

Conclusions:

The data collected during this study provide strong evidence concerning factors that can reduce mortality of sub-legal cod in the demersal longline fishery. Additionally the mortality estimates generated from this work are significantly lower than those attained in a previous survival study (Milliken, et. al., 1999).

The information collected shows that depth, temperature and handling technique all affect survival. Although handling technique did not show as much influence on survival compared to depth and sea surface temperature, if the snubbed fish had been assessed past 72 hours, the mortality may have increased due to the resultant jaw injury that may have prevented efficient feeding.

There is variability between survival among treatments when the data are compared for each of the temperatures and depths that were studied. To reduce the 'noise' in the data that is likely attributed to different handling procedures between treatments, the data was grouped by cold (<49F (9.4C)) and warm (>48F (8.9C)) and also analyzed by adding the mortality of the jigged fish to the treatments. Additionally, the middle point was added to the data that might be considered more representative of the actual survival. This was presented to represent what might be considered caging mortality and an estimate of what might be considered a good indication of actual short-term survival.

An important finding from this work is the increased survival rate as compared to that found in the previous study in New England (Milliken et. al. 1999). The work reported here was performed on commercial vessels using commercial fishing gear and utilized an improved cage design. Richards and Hendrickson (2006) noted a 35% difference in the effectiveness of a Nordmore grate when commercial data was analyzed and compared to the original controlled experiments. Although this work is still an experiment, the methodology assured that the procedures mimicked commercial fishing operations as closely as possible. The vessels were fishing commercially when the sub-legal cod were collected. Although it is difficult to ascertain why there is a discrepancy between the two survival rates for the separate survival studies, the larger sample size, reduced handling time and improved caging techniques suggest that the survival rates attained during this study are a closer representation of fishing mortality on sub-legal cod when compared to the previous study (Milliken, et. al. 1999). Additionally, there is more confidence in the results work because it has been tested in the fishery under actual fishing conditions.

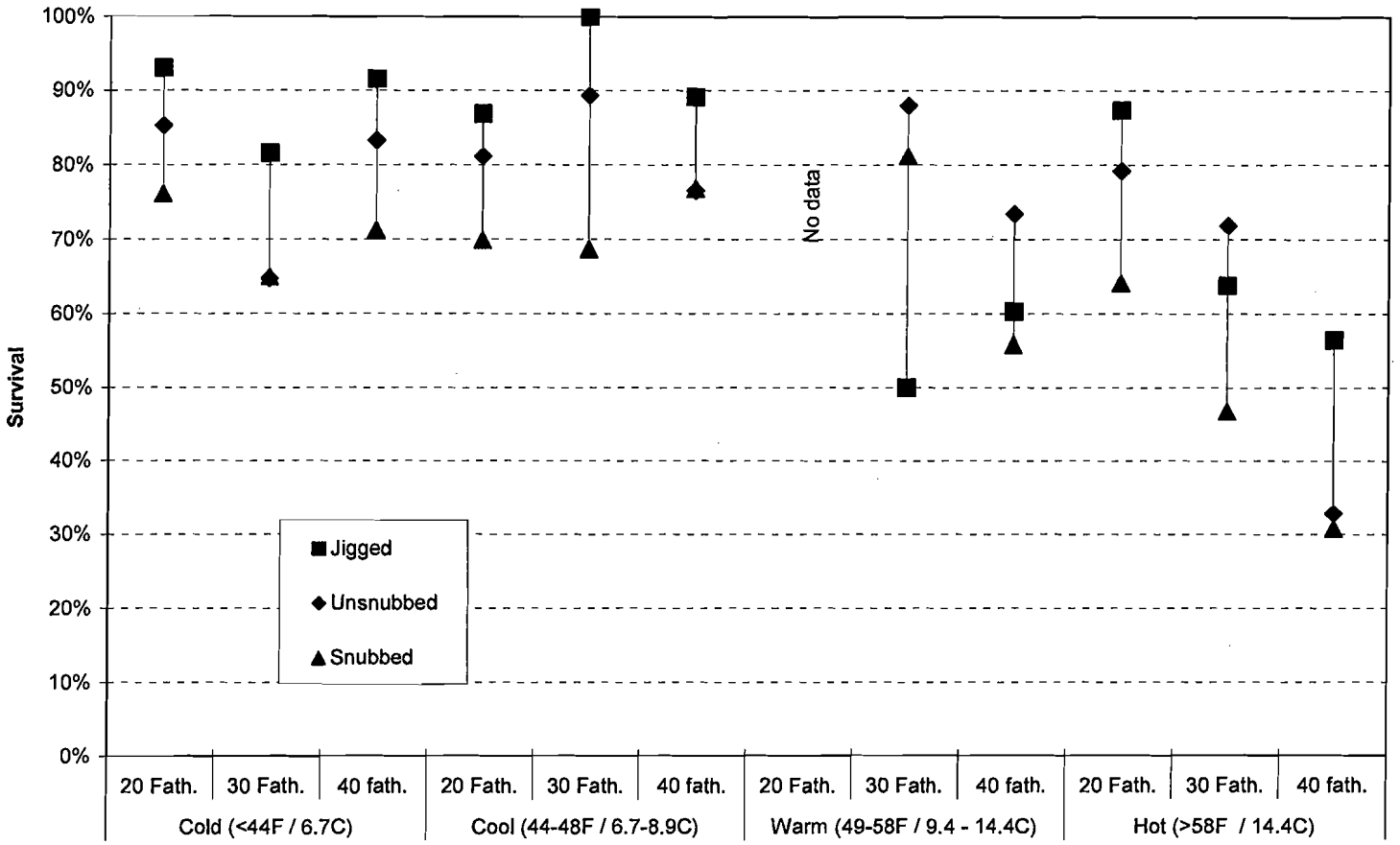

Figure 1: Data grouped by depth and sea surface temperatures. No fish were collected at 20 fathoms in warm water.

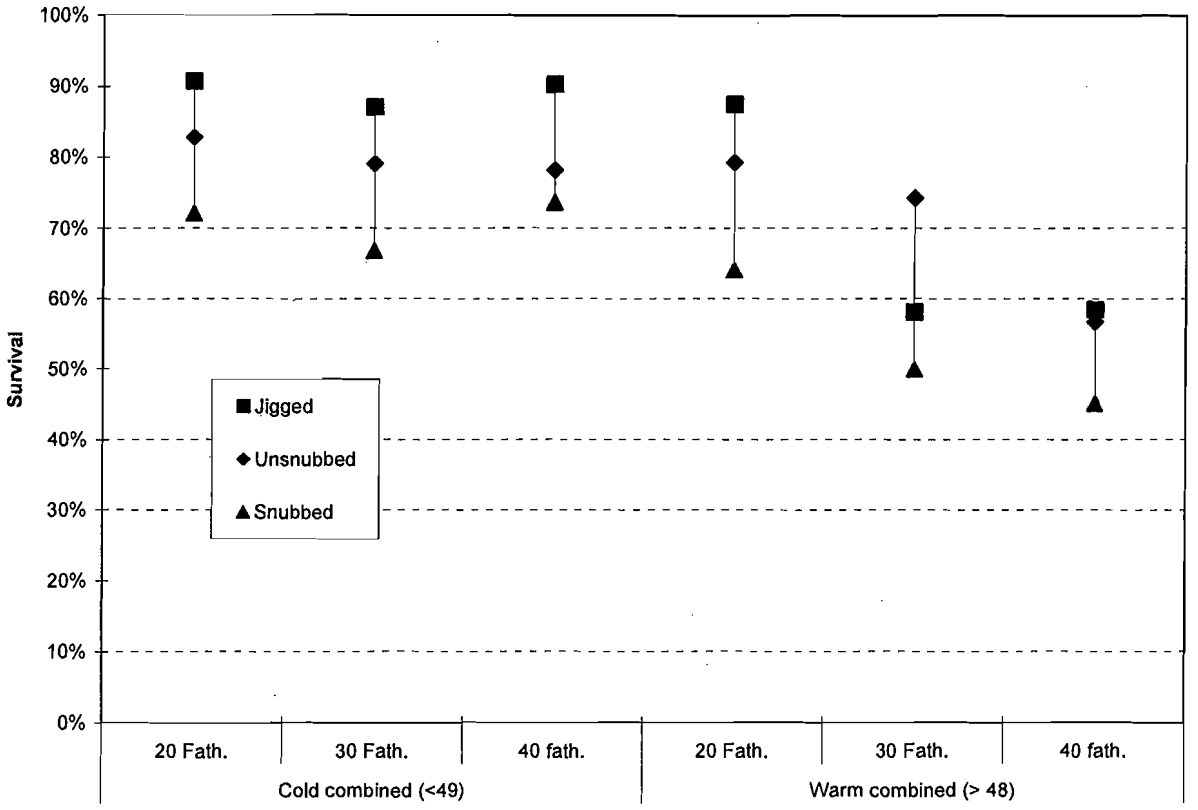

Figure 2: Data grouped by cold combined (<49F (9.4C)) and warm combined (>48F (8.9C)) sea surface temperatures. High mortality of jigged fish in warm water at 30 fathoms was likely due to high live well temperatures on jigged vessel that increased mortality of this treatment.

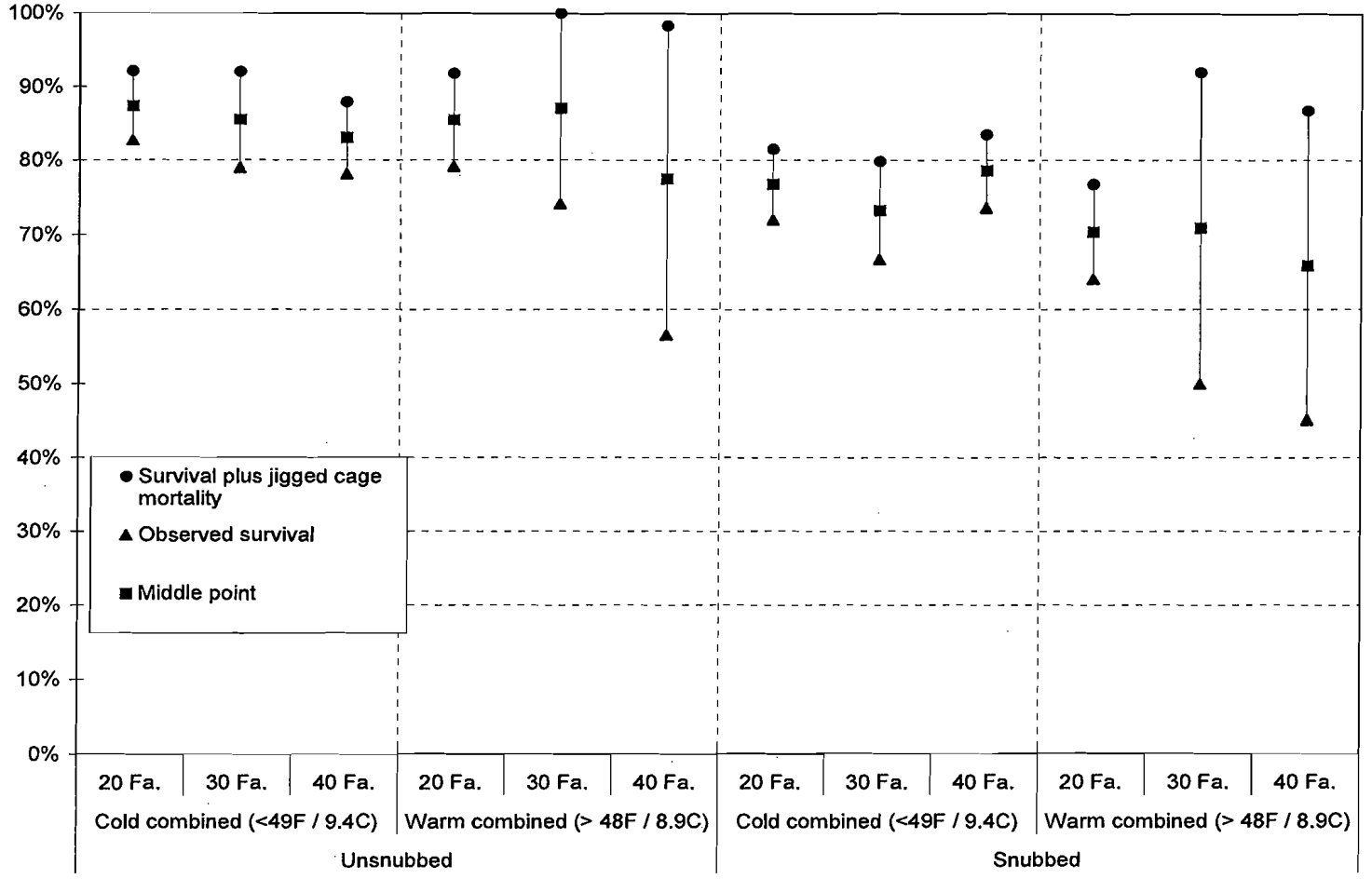

Figure 3: Plot of observed survival (triangle), observed survival plus the mortality on the jigged fish (circle), and the middle point (square).

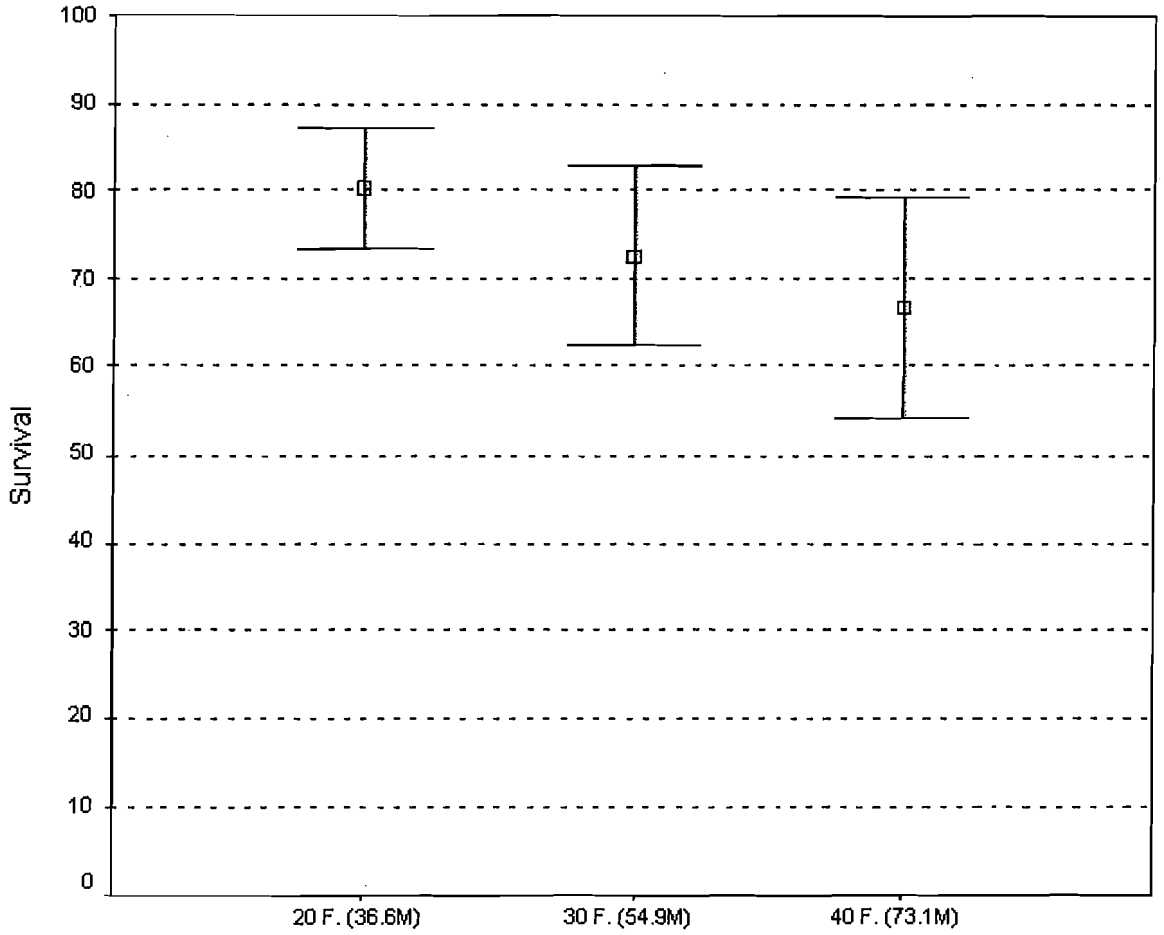

Figure 4: Plot of the 95% confidence interval of the mean of survival between the three depths fished during the study. Depth is in Fathoms.

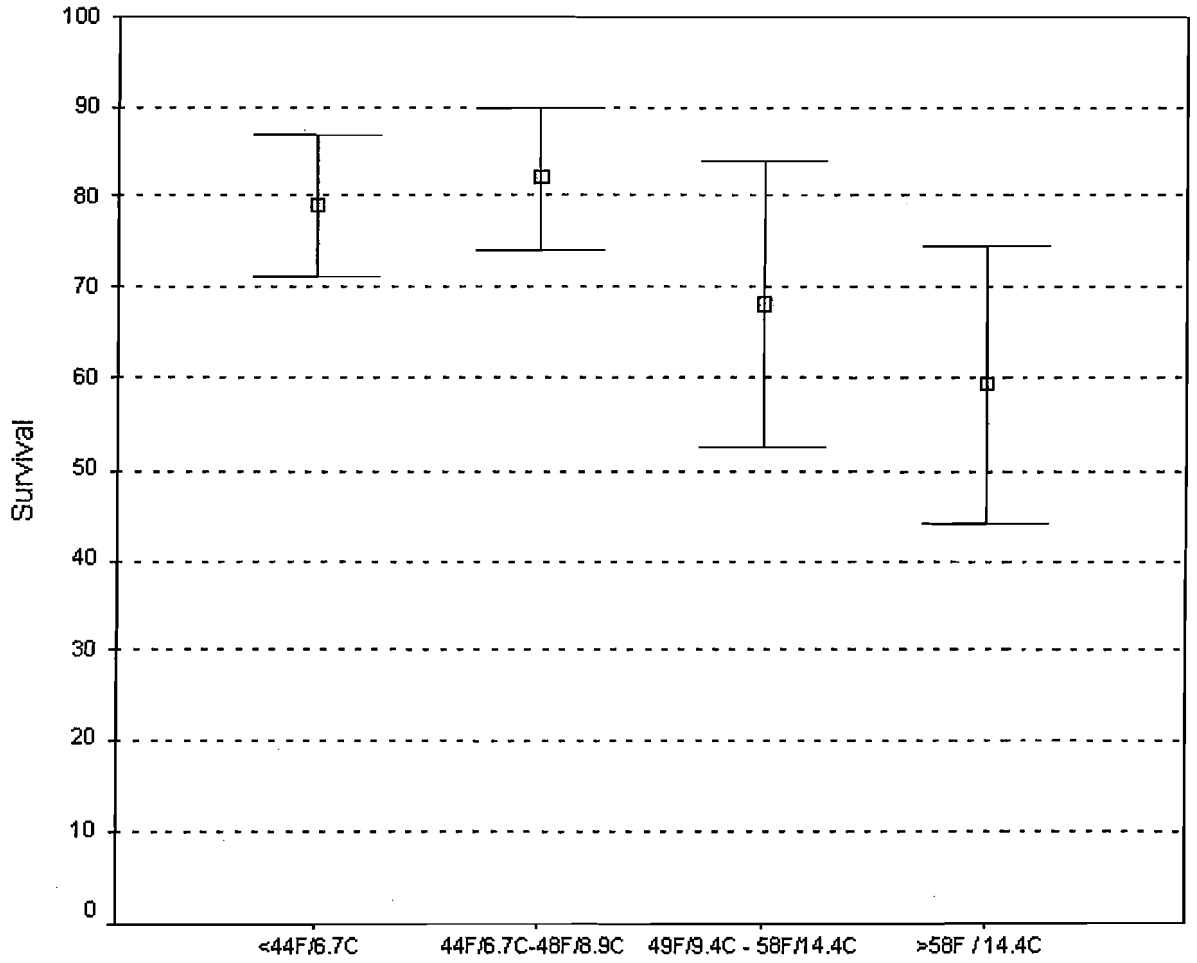

Figure 5: Plot of the 95% confidence interval of the mean of survival between cold (<44F. /6.7C.), cool (44F. /6.7C to 48F / 8.9C.), warm (49F./9.4C to 58F. /14.4C.) and hot (>58F. / 14.4C.) surface temperatures.

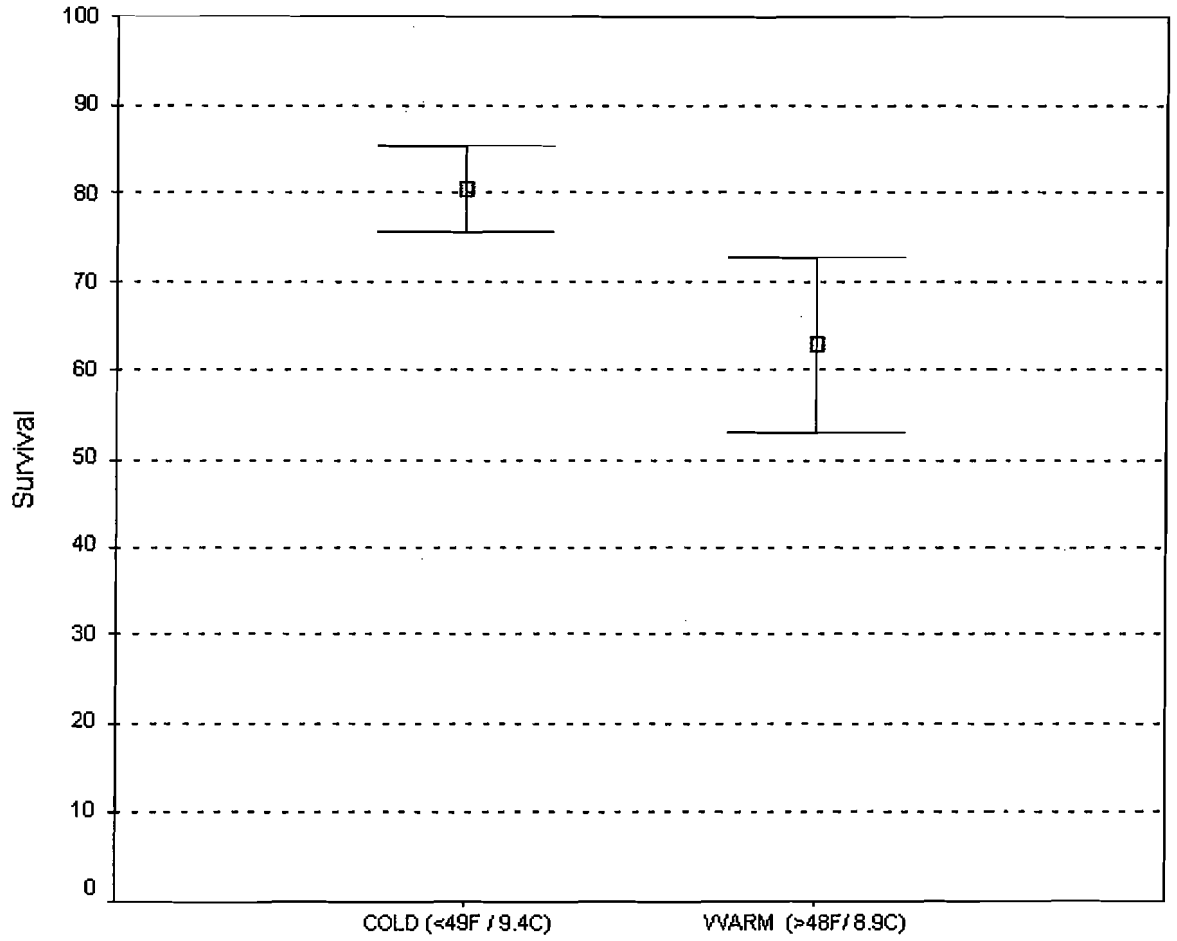

Figure 6: Plot of the 95% confidence interval of the mean of survival between cold water (<49F. (9.4C.) surface temperature) and warm water (>48F. (8.9C.) surface temperature). Cold and cool, and warm and hot were combined.

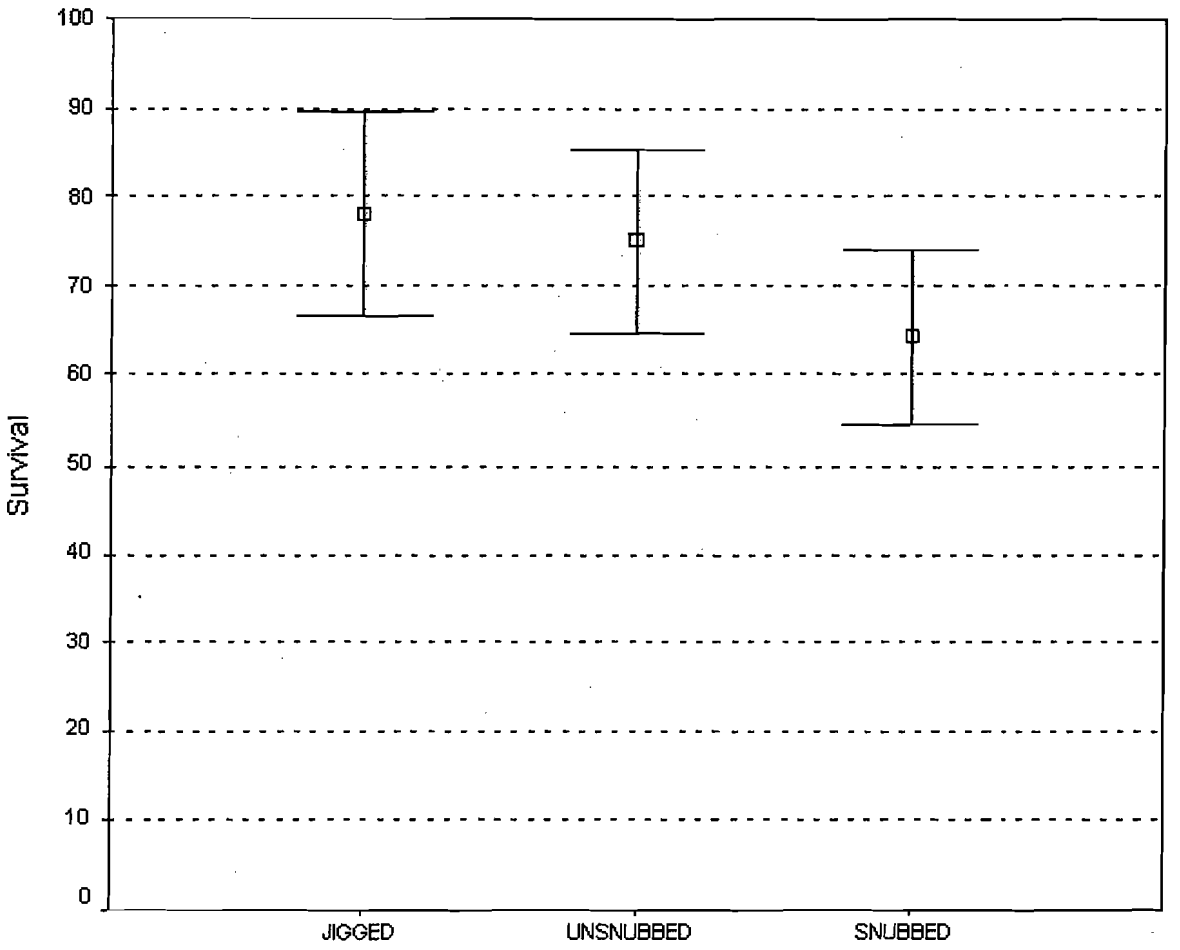

Figure 7: Plot of the 95% confidence interval of the mean of survival between the two treatments and control (jigged fish).

Partnerships:

Previous research on this issue was questioned by the industry because of their concern that the methodology and results did not adequately reflect what was occurring in the commercial fishery (Milliken et al., 1999). Consequently, all phases of this project were a partnership between scientists and fishermen from the development of the initial hypotheses to the field methodology. Mindful of the need to address these concerns, scientists and fishermen collaborated in order to formulate a methodology that would be scientifically defendable and acceptable to industry. A good example is the question of cage density. Each group brought definitive, and quite different, opinions of maximum density to the table. Together, the scientists and fishermen designed and executed a density test that, not surprisingly, yielded a result that was a compromise, solved the problem by meeting the needs of the study, and had good buy-in from both sides. Demonstrating the hands-on work exchange that is one of the greatest benefits of cooperative research, scientists participated in the fishing and retrieval of cages, and fishermen were trained to collect field data electronically.

Impacts and applications:

Information from this project shows that survival of sub legal cod is higher than previous estimates (Milliken et al., 1999) and is influenced by sea surface temperature and depth. This information should be incorporated by fisheries managers and scientists to update discard mortality information, which can improve models used for estimating populations. As management moves towards the use of hard catch limits with full accountability for discards, it will be critical to apply a mortality rate to those discards to ensure an accurate assessment of sub-legal tonnage to the quota. Finally, the seafloor caging techniques developed for the study, especially the durable low-rise cage and the efficient approach that allowed a large sample size, may have utility for future investigators.

Related projects

As previously mentioned, this study built upon handling techniques (i.e. temporary retention of fish in onboard live wells) developed by the participating fishermen for the Northeast Regional Cod Tagging Program (NRCTP). This program is currently in its 4th year of operation, and is funded by NOAA Fisheries Northeast Cooperative Research Partners Program (NCRPP). The investigators also undertook a cooperative pilot study of tagging mortality that also allowed for preliminary investigations into tracking individual fish through to cage recovery and evaluation. The tagging mortality results are summarized in the final report prepared by CCCHFA for the local portions of the NCRPP. This report may be accessed on the CCCHFA website at http://www.ccchfa.org/files/CCCHFA_CodTagging_CompletionReport.pdf.

Presentations

Sanderson, M and M Farrington. 10/24/2005. *Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery.* Oral presentation at NEC annual meeting

Milliken, H., Farrington, M., Rudolph, T. and M. Sanderson. 2006. *Survival of Sub-legal Cod in the Northwest Atlantic Demersal Longline Fishery.* ICES Symposium on Fishing Technology in the 21st Century. Boston, MA USA 30 October -3 November, 2006.

The project was also featured on *New England Outdoor Life*. The producers of this cable television show interviewed project staff and participating fishermen, and accompanied the investigators on a fishing trip. Copies of the segment have been submitted to NEC previously and are available upon request.

Student participation:

High School

Sean Leach
Jared Wilson

College

Eric Brazer	(Graduate Intern, Duke University)
Brettny Hardy	(Graduate Intern, Duke University)
Nichola Meserve	(Graduate Intern, Duke University)

Published reports and papers

Lavalley, K., 2006. *Longliners, scientists team to study cod survival: From confrontation to collaboration, good example of cooperative research*, Commercial Fisheries News, March 2006. pp. 2C.

Rudolph, T, 2005. *CCCHFA Cooperative Research in Action- Juvenile Cod Mortality Study.* Hooked on Cod (CCCHFA Newsletter), Volume 9, Issue 1. March 2005., p.1. Available online at:
http://www.ccchfa.org/pages/media_center/43/pages/files/HOCmarch2005.pdf

Rudolph, T, 2004. *Cooperative Research 2004.* CCCHFA Annual Report, 2004, Available online at:
http://www.ccchfa.org/pages/media_center/42/pages/files/AnnualReport2004.pdf

Rudolph, T, 2004. *Cooperative Research.* CCCHFA Annual Report, 2005, Available online at:
http://www.ccchfa.org/pages/media_center/42/pages/files/AnnualReport2005.pdf

There are no published reports at this time. There is a manuscript in preparation for submission to the North American Journal of Fisheries Management.

Images:

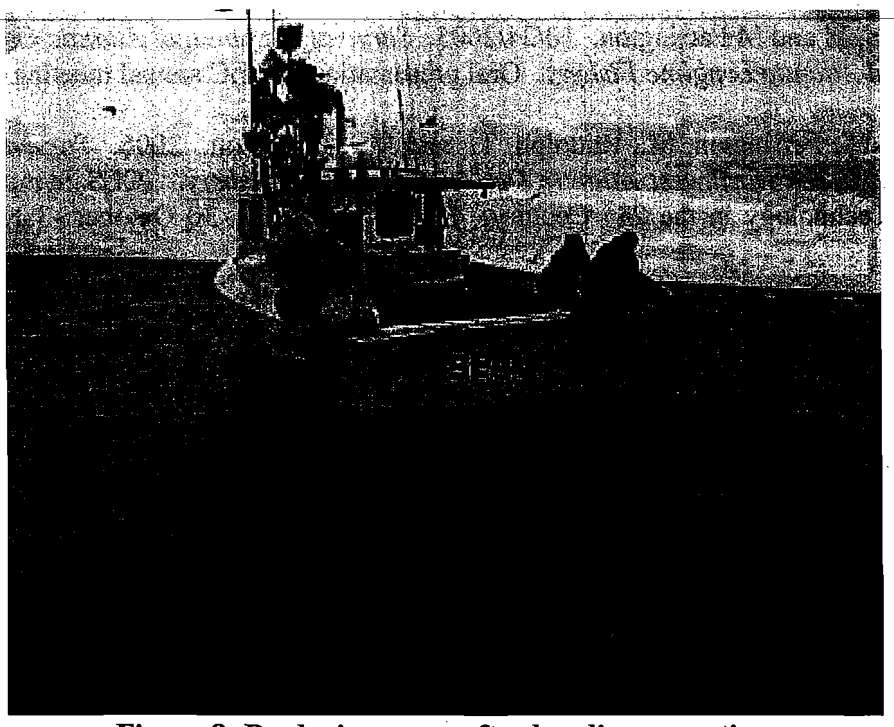

Figure 8: Deploying cages after longline operation.

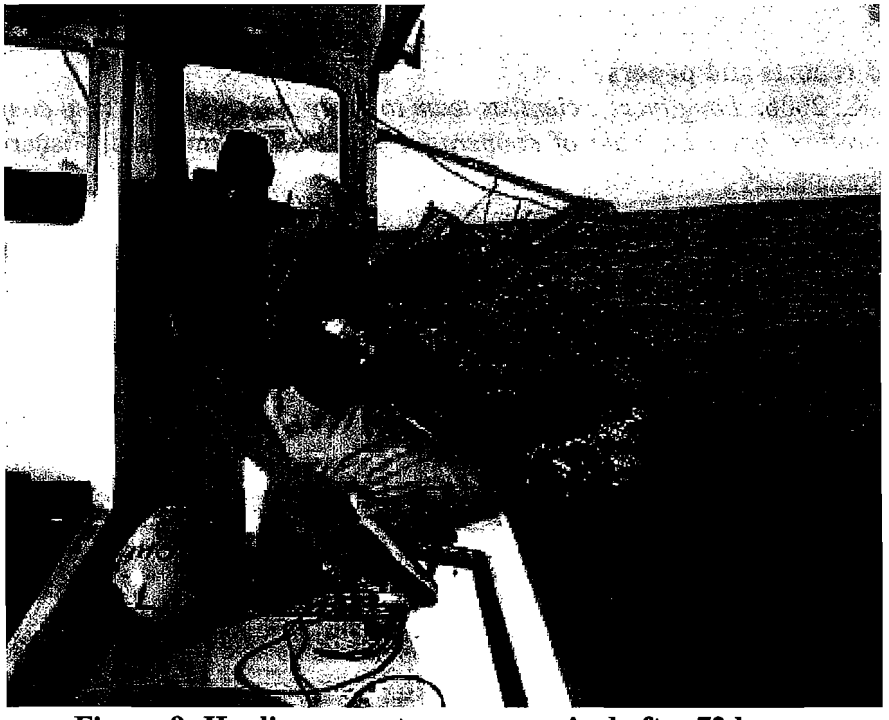

Figure 9: Hauling cages to assess survival after 72 hours.

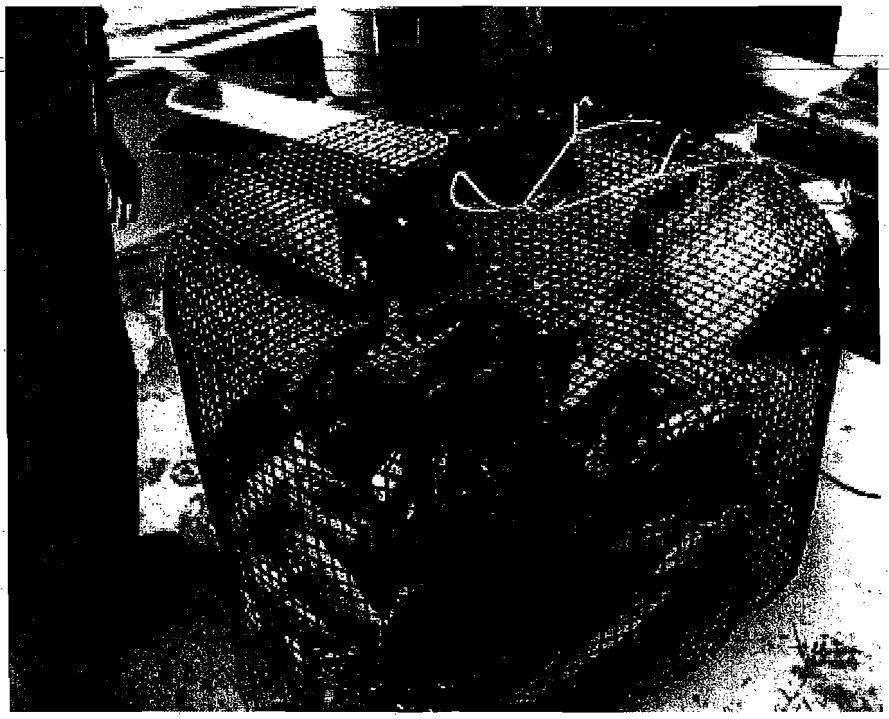

Figure 10: Fish ready for assessment after 72-hour deployment.

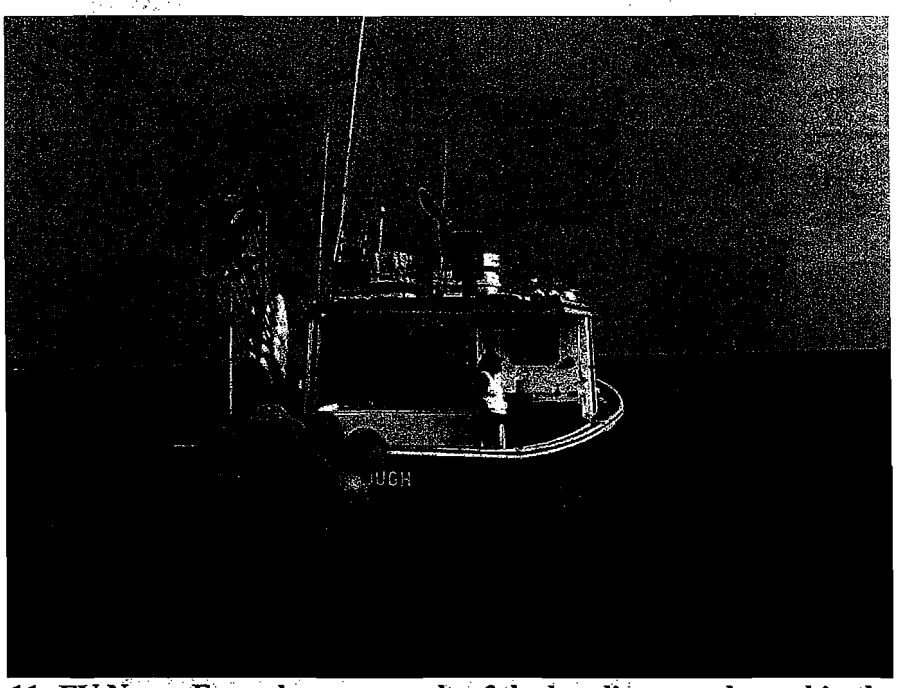

Figure 11: FV Never Enough, an example of the longline vessels used in the study, with cages stacked on fish box awaiting deployment.

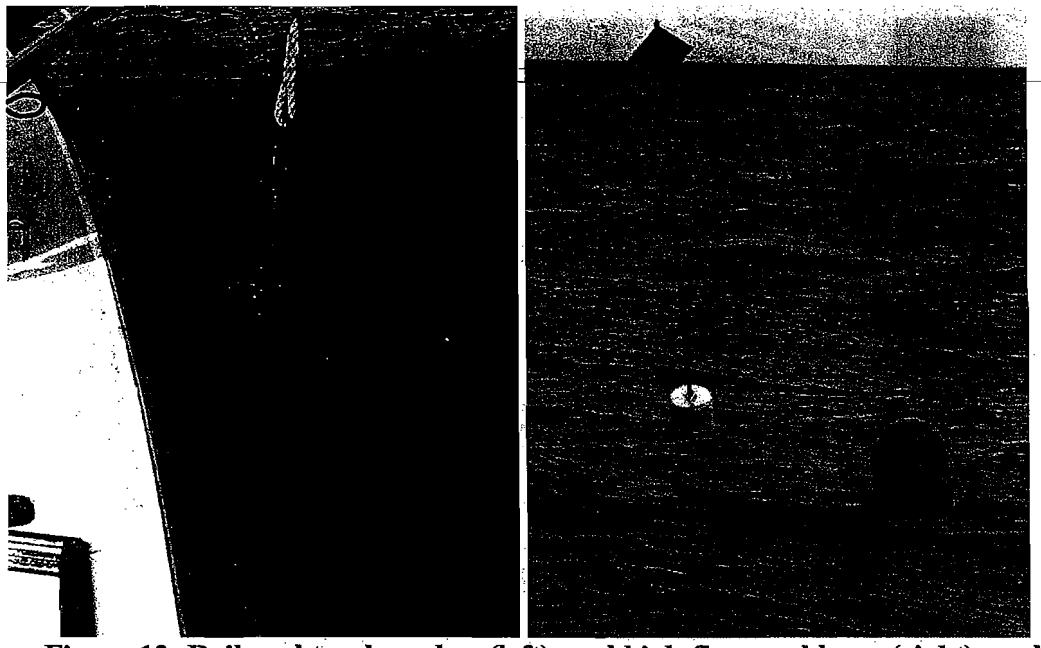

Figure 12: Railroad track anchor (left), and high-flyer and buoy (right) used to secure and mark cage placements

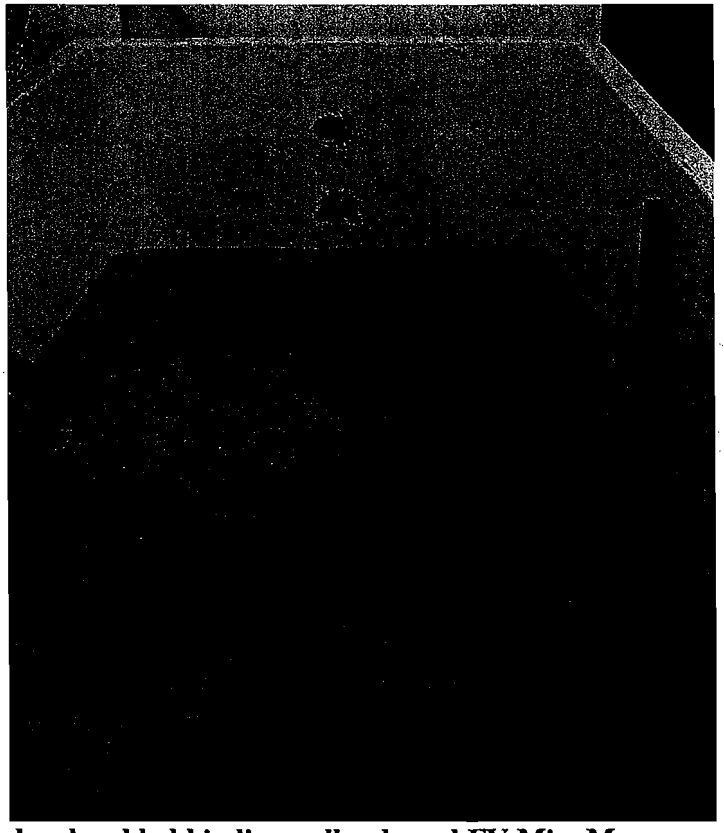

Figure 13: Sub-legal cod held in live well onboard FV Miss Morgan prior to caging

Future research:

Accurate discard mortality information is a difficult thing to tease out. The very act of studying the problem invariably results in a departure from normal commercial or recreational fishing practices. In fact, nearly every thing an investigator does is a potential variable. While there is usually an obvious direction of influence for a given variable, further thought will usually reveal a more subtle possibility of shifting the results in the other direction.

For instance, the usual reaction from fishermen to the seafloor caging technique is that it will artificially inflate mortality- since the fish is subject to additional stresses (caging, lack of food etc.) that would not be a factor if it were simply released. They base this upon observations in which the majority of their discards actively and immediately swim away from the boat, presumably to safety and a long healthy life. However, it must be realized that fish inside the cages are protected from predators larger than themselves that might otherwise take advantage of a stressed, weakened fish that, although it swam away, was unable to protect or hide itself once back in its natural environment. Thus, the cage also can deflate mortality, but the plot still thickens. Further thought swings the pendulum swing back the other way, because the confinement of the fish inside the cage creates the potential for one of the situations most feared by the investigators. Fishermen on Cape Cod refer to it as, "getting flea'd up." A wounded, dying or dead fish in the cage can attract swarms of scavengers that will devour every fish in the cage, resulting in badly inflated mortality estimates because the healthy fish inside had no way to escape.

Investigators wishing to escape this complex web of variables may wish for magic powers that would allow them to breathe underwater, so they could follow a fish around for thirty days after capture to watch whether it lives or dies. They should also throw in a request for invisibility, so that their presence does not scare away predators or stress their subject.

Absent these magic powers, the task requires persistence, patience, and hard work. For just one species, a suite of techniques must be applied, including seafloor caging, tagging, and laboratory study. In addition to the short-term (approximately 72 hours) work like that performed in this study, long-term (approximately 30 days) work must be included. All gear types that interact with a species must be studied, across a full range of environmental variables like depth, water temperature and air temperature. The size and physical condition of the fish can be a factor. Finally, different capture, handling, and release parameters must be contemplated and addressed, such as soak time, deck time, technique used to remove the animal from the gear, and method of release.

Obviously this type of effort requires a long-term commitment on the part of researchers, fishermen, and most importantly, funding. Development of an excellent set of discard mortality parameters for Pacific Halibut is reported to have taken 10 years and 10 million dollars.

Further studies of discard mortality in sub-legal cod should be undertaken, including continued work by the commercial fleets in cooperation with scientists. There may be excellent potential to build and enhance the dataset through opportunistic caging of sub-legal fish during normal commercial fishing operations. This work would be cost-effective; since the vessel is already out working, only relatively small payments would be necessary to recruit industry partners. The work could be focused on times and areas in which the dataset is considered to be weak (i.e. 20 fathom warm water, a gap in this dataset). It is possible that under this scenario the soak time for the cages could run longer than 72 hours, since there would be no rigorous sailing schedule in place. This could easily be considered a positive, as longer times would generate an interesting comparison.

There is also tremendous promise in the use of injury and condition indices to assess the effect of capture on a fish, and to predict the likelihood of survival (Davis 2005). Even more promising, specifically if it can alleviate the need to conduct comprehensive surveys of all species, is the potential to apply predictors, once generated, across a wide range of species (Davis, personal communication, 2005). Follow-up work on sub-legal cod that refines and applies this methodology would be warranted.

References

Carr, H.A., M. Farrington, J. Harris and M. Lutcavage. 1995. Juvenile bycatch and codend escapee survival in the northeast groundfish industry - Assessment and mitigation. A report of the New Englnad Aquarium to NOAA pursuant to Award No NA36FD0091.

Chopin, F; Alverson, DL; Inoue, Y; Arimoto, T; He, P; Suuronen, P; Sangster, GI, 1997. *Sources of unaccounted mortality in fish capture technologies* in Developing and sustaining world fisheries resources. The state of science and management. pp. 149-156. 1997.

Davis, M. W., 2002. Key principles for understanding fish bycatch discard mortality. Can. J. Fish. Aquat. Sci. Vol. 59, pp1834-1843.

Davis, M. W., Behaviour impairment in captured and released sablefish: ecological consequences and possible substitute measures for delayed discard mortality. Journal of Fish Biology (2005) 66, pp. 254-265

Federal Register. 1989. Northeast Mutlispecies Fishery - Final Rule. Fed. Reg. 54(19):4789-4808.

Main J. and G.I. Sangster. 1990. An assessment of the scale damage to and survival rates of young gadoid fish escaping from the cod-end of a demersal trawl. Scottish Fisheries Research Report, 46.

Mesnil, B. 1996. When discards survive: Accounting for survival of discards in fisheries assessments. Aquat Living resour. Vol 9, no 3, pp.209-215

Milliken, H.O., Farrington, M., Carr, H.A., and Lent, E. 1999. Survival of Atlantic cod (Gadus morhua) in the Northwest Atlantic longline fishery. Mar. Technol. Soc. J. 33: 19–24.

NEFMC (New England Fisheries Management Council) 1985. Northeast Multispecies Fishery Management Plan. April 1985.

Neilson, J.D., Waiwood, K.G., and Smith, S.J. 1989. Survival of Atlantic halibut (Hippoglossus hippoglossus) caught by longline and otter trawl gear. Can. J. Fish. Aquat. Sci. 46: 887–897.

Orsi, J.A., A.C. Wertheimer, H.W. Jaenicke. 1993. Influence of selected hook and lure types on catch, size, and mortality of commercially troll-caught salmon. North Am. J. Fish. Manage. 13: 709-722.

Poiner, I.R. and Harris, A.N.M. 1996.Incidental capture, direct mortality and delayed mortality of sea turtles in Australia's Northern Prawn Fishery. Marine Biology 125: 813-825.

Chopin, F; Alverson, DL; Inoue, Y; Arimoto, T; He, P; Suuronen, P; Sangster, GI. 1997. *Sources of unaccounted mortality in fish capture technologies* in Developing and sustaining world fisheries resources. The state of science and management. pp. 149-156. 1997.

Richards, A. and L. Hendrickson, 2006. Effectiveness of the Nordmore grate in the Gulf of Maine Northern shrimp fishery. Fisheries Research 81 (2006) 100–106

Robinson, W.E. and H.A. Carr. 1993. Assessment of juvenile bycatch survivability in the northeast fishing industry. A report of the New England Aquarium to NOAA pursuant to Award No. NA16FL0068.

Rutecki, T.L., T.R. Meyers. 1992. Mortality of juvenile sablefish captured by hand jigging and traps. North. Am. J. Fish. Manage. 12: 836-837.

Ryer, C. H. 2004. Laboratory evidence for behavioral impairment of fish escaping trawls: a review. ICES Marine Science Symposium, 61:1157 1164.

Sangster, G.I., N. Lowry, M. Breen. 1996. Commercial fishing experiments to assess the survival of haddock and whiting after escape from four sizes of diamond mesh cod-ends. Fisheries Research. 25 (3-4), 323-346.

Smith, WT. 1997. Reduction of halibut bycatch and associated mortality in the Bering Sea cod fishery ALASKA SEA GRANT COLLEGE PROGRAM, FAIRBANKS, AK (USA). pp. 205-210. 1996.

Soldal, AV; Huse, I. 1997. Selectivity and mortality in longline fisheries. Fisken og Havet. no. 6, 34 pp.

Technical Evaluation Report

of the
Northeast Consortium cooperative research project,

"Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery"

Anonymously reviewed

July 17, 2007

1. Introduction

This report documents an independent peer evaluation of the project, "Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery." This cooperative research project received funding from the Northeast Consortium in FY2003 and was led by John Pappalardo of the Cape Cod Commercial Hook Fishermen's Association in partnership with Henry Milliken of the National Marine Fisheries Service and Marianne Farrington of the New England Aquarium. This mail review serves as a formal assessment of the completed project and mainly focused on the certification of results, i.e. whether the experimental design was appropriate and if the conclusions are well supported by the data.

2. Reviewer

The following information about the reviewer is provided as evidence of the authority and expertise of the individual and to help authenticate the independent nature of the review process. The reviewer has signed the Northeast Consortium's "Conflict of Interest and Confidentiality Policies for the Technical Evaluation of Projects" agreement. The views expressed do not necessarily represent those of the Northeast Consortium.

The project reviewer has 14 years experience participating, designing and conducting marine fisheries research, much of it using a collaborative approach involving scientists, fisheries managers, fishermen, and other industry partners. The reviewer has worked at the state, federal and university level. Past research involvement has included dock-side and at-sea sampling of fishes, laboratory analyses of age, growth and reproductive structures, gill-net and nearshore long-line surveys, nearshore tagging of estuarine dependent fishes, use of otolith microchemistry to delineate fish stocks, use of side-scan to survey inshore/offshore fisheries habitat, use of hydroacoustics to estimate fish abundance around natural and artificial reefs, fish trap selectivity studies, and estimating survival of sub-legal discards from offshore hook and line and trap fisheries.

3. Documentation

In advance of the evaluation, the reviewer was provided with the project's final report entitled "Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery." It was submitted to the Northeast Consortium on October 19, 2006. Along with the final report, the reviewer received the project's funding proposal, two annual reports, and a popular press article entitled "Longliners, scientists team to study cod survival" published in *Commercial Fisheries News*, March 2006. According to the final report, no manuscripts have been submitted for publication in the peer reviewed literature at this time. Project data was not available through the Northeast Consortium's Fisheries and Ocean Data Management System at the time of the review.

4. Comments and Recommendations of the Reviewer

The reviewer was asked by the Northeast Consortium to address the criteria developed for the evaluation of Northeast Consortium-funded projects that are complete (Appendix

A), noting specific strengths and weaknesses of the project. All criteria were considered, but evaluation was focused on the second section, "Certification of Results."

4a. Project Evaluation

1. Project success: The purpose of the proposed research was to improve the understanding of the survival / mortality of sub-legal cod in the bottom set longline fishery in Southern New England. The specific objective was to quantify mortality of sub-legal cod on Georges Bank during various seasons (water temperatures) and at various depths. The project participants were able to achieve this goal in addition to generating a variety of useful information that may be beneficial for future research and developing numbers useful for management purposes.

2. Certification of results: This study appears to have generated a sizeable data-set for quantitative analyses. The investigators and participants should be commended for undertaking such a difficult and laborious task. I do have some specific concerns and comments regarding the study and will address them individually, not necessarily in order of importance, referring to page numbers or sections in the final report when possible.

Study design – other variables: As the investigators explain in the future research section of the final report (p. 27), the design of the study is the most important aspect of the project, and sometimes the most difficult. Certainly, all variables can not be controlled or accounted for in a study such as this. Survival or mortality of individuals in this design is solely dependent upon observed categorical variables (i.e., jigged, snubbed, unsnubbed; cold, cool, warm, hot: 20, 30, and 40). While it is likely that these variables contributed the most to survival percentages, additional factors such as fish length, individual fitness, crowding and subsequent interaction inside the gear could have been just as important. However, individual fish that were put into cages were not measured (for length), assessed for condition prior to entry and exit from the live well and most importantly, not tagged prior to cage introduction to follow the fate of the fish. The study was originally designed to tag individuals to document their individual experience. Why did the investigators deviate from this methodology?

Study design – environmental variables: Weather, bottom type, and dissolved oxygen content in the water column were never mentioned as contributing factors in cod survival during the 72 hour caging period. Anecdotal evidence from fishermen that I have worked indicates that strong winds / rough sea conditions can greatly contribute to observed mortality of fish caught in pots. Did any adverse weather occur during the course of the 72 hour trap sets? If so, this should be recorded an accounted for if possible. Was the bottom sandy, rocky or muddy? What about dissolved oxygen (DO) and water temperatures at both the surface and the bottom? Past experience indicates that DO may decrease with water temperature, especially in shallow, nearshore areas. The bottom temperature had to have been quite a bit cooler at depth than at the surface. Whether or not these factors contributed to the observations, they should be mentioned.

Study design – fish density in traps: The investigators approached this design component in a logical way – by evaluating survival of a range of fish densities within pots after a 72 hour holding period. But as in the previous comment section, other potential variables were not addressed. The investigators looked at 15, 30, 45 and 60 fish per cage. Initial reactions by the scientists were that increased fish density (within cages) may contribute to mortality. Unpublished work that I am involved with also found a significant correlation between increased fish density in traps and poor release condition (mortality). In short, fish density may be yet another contributing factor to mortality.

Study design – use of jig caught fish: A control category would indicate a group of fish not subjected to the riggers of capture and release by any fishing method. The jig caught fish do not meet this definition. Because jig caught fish were not randomly selected (i.e., only high quality individuals were selected for caging), it may be inappropriate to include this category as a "control" for the experimental design or even as representative of jigged fish caught by commercial fishermen. Jigging methods (i.e., handline, manual rod and reel, and electric rod and reels) used in this study all have different retrieval rates. To make it even more complicated, not all fish subjected to capture that look healthy remain healthy. Barotrauma, the injury sustained from failure to equalize the pressure of the swim bladder with that of the surrounding environment, may be a contributing factor in observed mortalities for jigged fish. In addition, not all barotraumas present may be visible in fishes subjected to capture (i.e., protruding stomachs, bulging eyes, etc.) – some injuries may be internal. For these reasons, I would consider removing the jigged fish from the control category and including them for comparative purposes only, considering the limitations of the data or better yet, eliminating them from the study design.

Study design – live wells: Why were "hot" (above 58F) live wells brought to 50F or less with saltwater ice? Was temperature and dissolved oxygen content measured for each live well for each trip? What was the bottom temperature on the fishing grounds during this time? Because temperature was determined to be a significant contributing factor to cod mortality – this factor should be further addressed in the results and discussion.

Statistical Analyses: It appears that the selected logistic binomial analysis utilized in this study was appropriate given only percent survival or mortality and categorical dependent variables were used. However, the report barely includes any mention of the analyses conducted and even less of the analytical findings. More information is needed – especially if these findings will be submitted to a peer-reviewed journal. A table listing odds ratios would be more appropriate. If the investigators have individual data available (i.e., fish lengths, condition of fish prior to cage introduction, etc…), they may want to run an ANOVA to try and account for other variables and crosses.

Statistical analyses: I'm not sure if it is appropriate to combine water temperature categories in order to "reduce noise" and increase statistical power. I think this is better left as is (i.e., 4 temperature categories). Results related to water temperature could be

discussed in the conclusions, perhaps indicating what temperature range is most indicative of the longline fishery in relation to landings data.

3. Data accessibility and dissemination of results: The data was not available for peer review at the time of the review. The project final report is complete, however, more elaboration of the statistical methods and results as well as more "discussion" would have been beneficial.

4. Project partnerships: This was a project that required (and achieved) a high degree of scientific – industry partnering. Based on my aforementioned review, more time should have been spent on developing an adequate statistical study design so that final numbers could have been used for stock assessment purposes. For future projects, it would helpful to consult with a statistician and a stock assessment scientist prior to taking the first trip.

5. Project impacts: Information gleaned from this study indicates that survival of sub-legal cod is higher than previous estimates. Conversely, some of these mortalities might have been attributable to possible environmental factors, levels of individual fitness, and handling practices not mentioned. The development of the low-rise cage should have utility for future offshore caging studies.

6. End-users: The data generated in this study will be most beneficial to the longline industry itself, followed by NMFS fisheries biologists and stock assessment scientists. The conclusion section fails to mention what appropriate fishing practices (snubbing v. unsnubbing) should be utilized by the longline industry based on results obtained by the longline industry! Capitalizing on the public success of the project, the investigators should at least give opinions (based on the data) and appropriate reasoning as to which fishing practices, temperatures and water depths were most applicable to sub-legal cod survival.

7. Overall rating: Very good. The project would have benefited from a tighter, more detailed study design. The partnership aspect was excellent.

8. Future research: It may be appropriate to duplicate this study (with the inclusion of tagging and additional variables!!!) for the depth and temperature ranges most utilized by fishermen and/or ranges that produced the most variability (i.e., 40 fathoms; hot water temp, etc.).

4b. Summary/Other Recommendations

The project participants were able to document survival of sub-legal cod caught and released from the longline fishery in New England. It is truly an undertaking to get so many different team members to work together on this project; for that aspect alone, the investigators should be praised. This collaborative study generated useful information that may be beneficial for future and more specific research on this topic. Without addressing other potential variables that did not appear to be accounted for in this study

(if so they were not mentioned in the final report), I would not suggest utilizing the survival percentages as hard numbers for stock assessment / fisheries management purposes. I think that this study provided some great overall trends that can be used to isolate a smaller and tighter study design.

Technical Evaluation Report

Of the
Northeast Consortium cooperative research project,

"Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery"

Anonymously reviewed

July 23, 2007

1. Introduction

This report documents an independent peer evaluation of the project, "Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery." This cooperative research project received funding from the Northeast Consortium in FY2003 and was led by John Pappalardo and Tom Rudolph of the Cape Cod Commercial Hook Fishermen's Association (CCCHFA). Research partners included M. Sanderson of the CCCHFA, H.O. Milliken from NEFSC and M. Farrington formerly of the New England Aquarium.

This mail review serves as a formal assessment of the completed project final report and focused on the certification of results by evaluating the experimental design, data analysis and conclusions.

2. Main findings and conclusions of the evaluation

The project was given an overall rating of "very good" and is an outstanding example of industry driven collaborative research. The project goals and objectives were met. Two hypotheses were evaluated, which were, survival of sub-legal cod would not be affected by sea surface temperature, catch depth or unhooking technique; and mortality of sub-legal cod approaches 100%. The investigators analysis of the data disproved both hypotheses finding survival to be significantly affected by sea-surface temperature, capture depth and unhooking technique. The group also clearly documented that mortality was significantly less than 100% for all evaluated treatments. The reviewer cautions the investigators from making broad conclusions on the delayed mortality and survival of sub-legal cod in the hook and line fishery, especially any recommendations for mortality estimates for fisheries management, due to the short duration of cage studies.

Major concerns regarding the certification of results included; use of control group, criteria used to develop sea-surface temperature ranges, potential within depth treatment affects resulting from increased susceptibility to barotraumas, and caging densities. In addition, the reviewer recommended that the authors addressed size versus mortality and soak time/handling versus mortality.

The reviewer also indicated that the most important conclusion to be made from this project was that the observed mortalities regardless of treatment, were much lower than 100% and lower than previously observed survival estimates (Milliken, 1999). This conclusion should certainly be taken into consideration by management. However, the short-term duration of the project as well as the previously identified concerns would limit the direct use of survival estimates for stock assessment modeling.

3. Reviewer

The following information about the reviewer is provided as evidence of the authority and expertise of the individual and to help authenticate the independent nature of the review process. The reviewer has singed the Northeast Consortium's "Conflict of

Interest and Confidentiality Policies for the Technical Evaluation of Projects" agreement. The views expressed do not necessarily represent those of the Northeast Consortium.

The reviewer has fourteen years of experience in fisheries science and aquaculture. The reviewer has a PhD in Fisheries Science and research experience in both vertebrate and invertebrate physiology. In particular, the reviewer has published research directly pertaining to delayed mortality and fish physiology.

4. Documentation

In advance of the evaluation, the reviewer was provided with the project's final report entitled, "Survival of Sub-lagal Atlantic Cod in the Northwest Atlantic Longline Fishery." It was submitted to the Northeast Consortium on 10/19/2006. Along with the final report, the reviewer received the following documentation;

a) Trade publication entitled "*Longliners, scientists team to study cod survival*" that appeared in the March 2006 issue of Commercial Fisheries News.

b) Pappalardo, J. et al. "*Survival of sub-legal cod (Gadus morhua) in the northwest Atlantic longline fishery.*" FY2003 cooperative research funding proposal.

c) Pappalardo, J. et al. "*Survival of sub-legal cod (Gadus morhua) in the northwest Atlantic longline fishery.*" Annual report submitted to the Northeast Consortium, June 30, 2004.

d) Pappalardo, J. et al. "*Survival of sub-legal cod (Gadus morhua) in the northwest Atlantic longline fishery.*" Annual report submitted to the Northeast Consortium, June 2005.

Project data was not available through the Northeast Consortium's Fisheries and Ocean Data Management System.

5. Comments and Recommendations of the Reviewer

The reviewer was asked by the Northeast Consortium to address the criteria developed for the evaluation of Northeast Consortium-funded projects that are complete, noting specific strengths and weaknesses of the project. All criteria were considered, but evaluation was focused on the second, "Certification of Results".

5a. Project Evaluation

Project Success:

The project was successful in completing the identified goals and objectives. The purpose of the research was to document the survival of sub-legal Atlantic cod in the bottom-set longline fishery. In addition the investigators indicated an interest in

determining the relationship between sea-surface temperature, depth and unhooking technique on survival.

Two hypotheses were evaluated, which were, survival of sub-legal cod would not be affected by sea surface temperature, catch depth or unhooking technique; and mortality of sub-legal cod approaches 100%. The investigators analysis of the data disproved both hypotheses finding survival to be significantly affected by sea-surface temperature, capture depth and unhooking technique. The group also clearly documented that mortality was significantly less than 100% for all evaluated treatments. However, I caution the investigators from making broad conclusions on the delayed mortality and survival of sub-legal cod in the hook and line fishery, especially any recommendations for mortality estimates for fisheries management. Project conclusion should be bound by the characteristics of the project, those being 72 hour survival of cod, caught by hook and line, and <22 inches in length.

Certification of Results:

Overall the project was well designed and evaluated. In general, cage survival studies are scrutinized to begin with, since cage affects are difficult to identify and survival is typically followed over a short period of time (< 5 days). After evaluating the final report, the proceeding comments are my recommendations and concerns. I would suggest investigators address these comments prior to their submitting a manuscript to a peer reviewed publication.

Investigators chose to use logistic binomial regression analysis to evaluate the data. This is a powerful tool and I would commend the investigators for choosing this technique for their analyses. Logistic Regression is useful for situations in which you want to be able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. In this projects case survival is the predicted outcome. Since the dependent variable, survival, is dichotomous the use of the logistic model was a suitable choice for the investigators. Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model, which the investigators did.

When choosing a control group for the experiment, cod were caught almost exclusively by electronic jigging and used as an indicator of cage-induced mortality. If captivity has no lethal impact on the captive fish over the 72 hour period, there should be no observed mortality in the control group. Researchers observed mortality within the control group. The observed mortality was then used to adjust the mortality of the treatment groups to "reduce the noise". This group is not a true control group. Death may be due to captivity stress, but it may also and is more likely to be due to stress and injury from the capture of control fish by electronic jigging. The first problem with using these fish as a control and more importantly to estimate cage-induced mortality, was the capture method. The project is specifically evaluating hook and line induced mortality by release method. By jigging for control fish the researchers essentially created another capture and release method. Secondly, investigators selected only those fish considered strong and healthy. These two conditions not only disqualify the fish as a control but also disallow them from

consideration as another treatment (electronic jigged fish). This should not significantly impact their results. The regression model they chose does not need a true control. The variables, capture depth, sea-surface temperature and release technique can be used without control adjustment to predict survival. I suggest that the investigators reanalyze the data excluding the control group mortality correction. In addition, the investigators might consider having multiple control groups for this type of analysis. One control would be used to evaluate cage-induced affects. These fish should not be caught using hook and line, one suggested alternative would be by fish pot. Another control would be used to evaluate transport process affects from capture to caging.

Additional areas that warrant further explanation are the criteria used to determine sea-surface temperature ranges used for analysis, potential depth range affects and handling affects. Investigators evaluated survival based on four sea-surface temperature ranges. What information was used to identify these as significant temperature differences? The authors should cite literature or describe their reasoning for these classifications. Is it based on the biology of cod or do these temperature stratifications correspond to the seasonal differences that occurred during their field trials? The researchers were clear with their justification of the depth ranges. That being depths which represent regional longline fishing activity. My concern is that within each range values differ by 2 atmospheres or 60 feet. This difference may be significant. In other words, will susceptibility to barotraumas significantly change within each depth range? If possible, this potential affect should be considered. With regard to handling the researchers indicated that gear soak time was always brief and only as long as it took to haul the gear. However, it was also stated that this time ranged from one to four hours. Does soak time impact survival? I realize this analysis would not be possible under the projects methodology however, it may be worth discussing as part of a manuscript. I also was interested in the size range of fish used in the study. Methods indicated that sub-legal cod were used, <22 inches, but there was no mention of size distribution. It would be nice to look at the relationship between survival and size.

Caging density should be further supported. The authors indicated that although the stocking density was high a density test was conducted that indicated no significant affect by densities of 15, 30, 45 and 60/cage. I praise the initiative of the researchers for conducting a density study. However, the authors did not describe the duration of the study or provide statistical evaluation methods or probabilities.

The investigators concluded that capture depth, temperature and handling technique all affect survival of sub-legal cod. Sea-surface temperature had the strongest influence on survival but the group was quick to point out the predictive limitations associated with a short term study. In particular, snubbed fish would certainly suffer a higher mortality than was reported. Infection, disease and feeding difficulties would reduce fitness increasing susceptibility to predation and injury related mortality. The investigators addressed this issue in the conclusion section by pointing out that "if snubbed fish had been assessed past 72 hours, the mortality may have increased due to the resultant jaw injury that may have prevented feeding."

It is my opinion that the most important conclusion to be made from this project was that the observed mortalities regardless of treatment, were much lower than 100% and lower than previously observed survival estimates (Milliken, 1999). This conclusion should certainly be taken into consideration by management. However, the short-term duration of the project as well as the previously identified concerns would limit the direct use of survival estimates for stock assessment modeling.

Data Accessibility and Dissemination of Results:

Project data is not currently available through the Northeast Consortium's Fisheries and Ocean Data Management System. The project was highlighted by the Commercial Fisheries News. Being a broad industry publication serving northern New England the Commercial Fisheries News reaches a wide variety of fisheries stakeholders. The final project report was well written and thorough. The data should be evaluated without the use of the electronically jigged fish mortality estimates.

Project Partnerships:

This project scores high marks for industry collaboration. This was an industry-led project from the beginning. The Cape Cod Commercial Hook Fisherman's Association were not convinced with early cod survival field experiments conducted by the Northeast Fisheries Science Center and worked cooperatively with science partners to design an experiment that reflected normal commercial fishing practices. An amazing number of fish were caught and evaluated by the project partners (>3,700), more than forty people are listed as participants, with twelve (12) commercial fishing vessels and sixteen (16) crew members.

Project Impacts:

The most important conclusion to be made from this project was that the observed mortalities regardless of treatment, were much lower than 100% and lower than previously observed survival estimates (Milliken, 1999). This conclusion should certainly be taken into consideration by management when reviewing fishing mortality estimates. However, the short-term duration of the project as well as the previously identified concerns would limit the direct use of survival estimates for stock assessment modeling.

From a research and experimental design standpoint this project provides a framework for additional delayed mortality work for both hook and line as well as other commercial fisheries.

End-Users:

The data should be made available on the Northeast Consortium's Fisheries and Ocean Data Management System. In addition, outreach materials could be developed for the hook and line fishery that detail ways of enhancing survival of sub-legal cod and fish in

general through best handling practices. The research steering committee of the NEFMC, as well as groundfish management teams should be given summaries of these research findings.

Overall Rating:

Very Good

Future Research, Comments and Guidance:

The Northeast Consortium should continue to support survival experiments for commercially important species. This project in particular poses additional questions regarding depth and surface-water temperature affects on discard survival of cod. Other topics of interest would include the impact of size, handling time, and air temperature on survival, as well as development of methodologies for long-term survival observations.

I would recommend that the authors review the current scientific literature available on discard mortality estimation prior to submitting a manuscript to a peer reviewed journal. The majority of cited literature are not current (not within the last five years).

Technical Evaluation Report

Of the
Northeast Consortium cooperative research project,

"Survival of Sub - Legal Atlantic Cod in the Northwest Atlantic Longline fishery "

Anonymously reviewed

July 31,2007

1. Introduction

This report documents an independent peer evaluation of the project, ""Survival of Sub - Legal Atlantic Cod in the Northwest Atlantic Longline fishery." This cooperative research project received funding from the Northeast Consortium in FY2003 and was led by Joe Pappalardo of CCCHFA in partnership with NOAA and New England Aquarium. This mail review serves as a formal assessment of the completed project and focused on project objectives, methods, results etc.

2. Reviewer

The following information about the reviewer is provided as evidence of the authority and expertise of the individual and to help authenticate the independent nature of the review process. The reviewer has signed the Northeast Consortium's "Conflict of Interest and Confidentiality Policies for the Technical Evaluation of Projects" agreement. The views expressed do not necessarily represent those of the Northeast Consortium.

The reviewer has biology background and 30 years experience as a fishermen, research and development scientist for a major fishing company, federal government fish technician, international foreign fisheries observer, and provincial government policy advisor and manager.

3. Documentation

In advance of the evaluation, the reviewer was provided with the project's final report entitled, "Survival of Sub - Legal Atlantic Cod in the Northwest Atlantic Longline fishery." It was submitted to the Northeast Consortium on July 31,2007. Along with the final report, the reviewer received the project's funding proposal and guidelines and evaluation criteria for technical evaluation, conflict of interest policy and form, final report writing instructions, and template. Project specific included funding proposal, annual reports 2004,2005 and final report 2006 and project article from Commercial Fishing News.

4. Comments and Recommendations of the Reviewer

The reviewer was asked by the Northeast Consortium to address the criteria developed for the evaluation of Northeast Consortium-funded projects that are complete (Appendix A), noting specific strengths and weaknesses of the project. All criteria were considered, but evaluation was focused on the second, "Certification of Results."

4a. Project Evaluation

The main findings are that the project has met its stated objectives, and provided valuable additional data and conclusions on the subject of bycatch survival. Due to the complexity of variables and parameters, and results of the previous experiment, (Milliken et al 1999) consideration should be given to repetition and or expansion of the experimental protocol to further give confidence to the results of this experiment.

Most of the results were predictable and I suggest expected to those with knowledge of gadoid biology and reaction to capture and holding related to depth and temperature.

I thought the experimental design methods and analysis were adequately described and that the approaches to experimental design, methods, and data analysis were sound The data was accurate, precise, and believable. Inconsistencies or anomalies were identified and dealt with in the data and documentation The results and conclusions seem supported by the data. The results and conclusions contribute to a better knowledge of this issue and gaps and or future work is identified and seems appropriate.

Noted comments:

Jigged is not clearly described, as fish were caught with bait and / or actually jigged with unbaited jiggers which tend to be more damaging and stressful on the caught fish. Perhaps one method could have been used for better control, but this is a minor point with individual fish grading for condition

Cage density of captured cod - This was an issue and was addressed by a holding experiment, but only in one experiment. Fifty fish per cage of this size is still a high density, and although fish do school densely, the natural in situ density of cod would likely be much lower, and could have subliminal or subtle stress density effects on weakness and mortality.

1. **Data accessibility and dissemination of results:** The structure of data and presentation of the information seems a good level to promote digestion and understanding by industry and the public, and is not for the most part too scientific to cause a lack of interest or understanding. The final report complete, sufficient, and understandable to end-users. The future research piece is very enjoyable and avoids the dryness and technical nature of reporting on scientific experiments, which perhaps makes the paper a bit more approachable to public and fishermen.

2. **Project partnerships:** The project as described involved fishermen as key participants throughout the course of the project, including project design, data collection and analysis, and application of the results or products. This is an excellent model to both carry out experiments efficiently and economically as well as to build understandings and relevant measure s between industry and the regulator. Assumptions of mortality on stock calculations are very important to fishermen and what they may have available as a resource.

3. **Project impacts:** The project has or could have an impact on the assumption used in calculating stock assessments. This is very important for fishermen and also important for scientists form a scientific and socio-economic point of view. It also promotes industry science cooperation in working on a positive outcome to both parties.

4. **End-Users:** Most stakeholders could benefit from knowing, fishermen and scientists a s well as environmental groups, in order to aid in understanding of impacts on mortality, better survivability for science assumptions, and increased resources for industry who use longlining as a fishing method.

5. **Overall rating.** I would rate the project as very good due to the incorporation of industry and a simple but effective and practical experimental protocol and use of scientific methods that focused on a very important, relevant and answerable question.

6. **Future research.** Given the importance of the subject, the scientific principle of prediction and repeatability and the varied results of the first experiment, another experiment to confirm trends and results would appear justified. If there is real consideration of a change in fishing mortality assumptions by the scientific authority, this research should be given high priority.

7. **Additional comments and guidance.**

4b. Summary/Other Recommendations

Overall a good project incorporating real life meaningful connection and utility by using scientific methods and directly incorporating stakeholder resources commitment and knowledge.

Appendix A

Evaluation Criteria

The reviewer was asked by the Northeast Consortium to address the criteria listed below, noting specific strengths and weaknesses of the project. Reviewers are asked to consider all criteria but focus their evaluation on the second. The criteria were developed for the Evaluation of all Northeast Consortium-funded projects that are complete.

8. **Project success:** Did the project accomplish its stated goals and objectives?

9. **Certification of results:** Is there adequate description of the approaches to experimental design, methods, and data analysis? Were these approaches appropriate? Are there other approaches that the participants could have considered or used? Are the data accurate, precise, and believable? Are the results and conclusions well supported by the data and statistically valid? Can the

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Updates NEC report on same subject: Recv'd 1/29/08

Survival of Sub-legal Atlantic Cod in the Northwest Atlantic Longline Fishery

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Keywords: Survival, longline, cod, *Gadus morhua* ,

Abstract

This study investigated the survival of sub-legal Atlantic cod, (*Gadus morhua,*) discarded in the U.S Northwest Atlantic longline fishery and examined the effects of handling technique, sea surface temperature, and capture depth on survival of the discarded fish. Longline caught cod were either removed from the hook by hand (unsnubbed) or removed by allowing the hydraulic hauler to pull the fish against the parallel steel cylinders placed vertically on the gunwale, causing the hook to pull through the jaw (snubbed). Jigged caught fish served as a control in the survival experiments. Once caught, live fish were placed in underwater cages, and short-term survival, was assessed after holding the fish for a minimum of 72 hours. Survival was analyzed using three water depths and four sea surface temperature (SST) strata. Cod survival in these strata ranged from 31% to 100%. Depth and SST affected survival more than the de-hooking technique. Survival was higher in shallow depths and at lower temperatures. Unsnubbed fish had higher survival rates than snubbed fish.

15 **Introduction**

16

17 Given that perfect selectivity can only be approximated in fishing gear, undersized or
18 juvenile individuals are inadvertently taken as part of all commercially harvested marine
19 catches. Federal fisheries regulations require that undersized individuals of commercially
20 important species taken in the northeast multispecies groundfish fishery be returned to the
21 sea ((Federal Register, 1989; NEFMC, 1985) and the National Marine Fisheries Service
22 (NMFS) has highlighted research on discard mortality rates as a priority. Estimating
23 bycatch survival has been the focus of many investigations. The actual survival of
24 bycatch depends on complex interaction of factors such as species type (Carr et al., 1995;
25 Robinson and Carr, 1993; Poiner and Harris, 1996; Smith, 1996), individual injury levels
26 (Milliken et al., 1999; Main and Sangster, 1990), gear type (Carr et al., 1995; Rutecki and
27 Meyers, 1992), fishing depth (Neilson et al., 1989), duration of set (Robinson and Carr,
28 1993), handling time (Neilson et al., 1989; Robinson and Carr, 1993), and fish age (i.e.
29 length) (Milliken et al., 1999; Neilson et al., 1989, Davis, 2005).

30

31 Bycatch survival in commercial fisheries is poorly understood. Developing quantitative
32 methods to accurately assess discard mortality requires an understanding of the factors
33 that contribute to this mortality, how mortality is defined within each context, and
34 measuring variables under commercial fishing conditions (Davis, 2002). Because
35 bycatch survival affects the biomass of cod in the northwest Atlantic an undefined
36 estimate of true survival may negatively affect the success of fishery management
37 (Chopin et al. 1997; Mesnil 1996; Davis 2002; Ryer 2004). Unless the survival of
38 bycatch is specifically quantified for a species, assessing the status of that stock, setting

appropriate fishing levels and developing an optimum yield may be problematic (Chopin et al. 1997; Mesnil 1996; Ryer 2004).

Discarded groundfish (including cod)) in the bottom trawl and gillnet fisheries are assumed to suffer 100% mortality. The assumption that 100% of the discarded cod and other species do not survive in the longline fishery is not supported by previous research in the USA groundfish longline fishery (Milliken, et al., 1999) or in other fisheries using longline gear (Neilson et al., 1989, Orsi et al., 1993). Bycatch in the longline gear have high survivability as compared to other fishing methods. Soldal and Huse (1997) found no mortality of 18 sub-legal haddock that had the hooks ripped from their mouths. The survival of Atlantic halibut (*Hippoglossus hippoglossus*) caught by longline was 77% compared to 35% caught by trawls (Neilson et al., 1989). The survival of juvenile sable fish (*Anoplopoma fimbria*) was much higher when captured by hand jigging (81%) than in traps (25%), presumably because of the decreased incidence of secondary bacterial infection resulting from skin abrasions caused by the traps (Rutecki and Myers, 1992). An increase in the survival of hook caught Chinook salmon (*Oncorhynchus tshawytscha*) occurred when circle hooks were used instead of lures. This decreased the incidence of gut hooking and decreased mortality due to the less abusive nature of the injuries (Orsi et. al., 1993).

The only previous evaluation of the survival of sub-legal cod in the northwest Atlantic demersal longline fishery (Milliken et al., 1999) assessed fish that had been placed in cages and returned after 72 hours to the depths at capture. Survival rates ranged from

22% to 47% for fish that were snubbed and 38% - 63% for fish that were carefully removed from the hooks (Milliken et. al. 1999). However, "control" fish that were individually captured by jigging (handgear, comprising handlines, manual rod and reel, and electric rod and reel) and carefully removed from the hooks also encountered significant mortality. Hence, the study results may not have accurately estimated survival of sub-legal sized cod as the caging process and experimental techniques may have influenced survivability (Milliken et. al. 1999). The need for better data and the concerns of fishermen and managers alike about the previous study combined to necessitate additional work. An ambitious and rigorous research protocol that included input from the fishing community and which addressed factors such as seasonality and depth of capture was deemed essential.

The objective of this study was to document the survival of sublegal cod captured in the bottom-set (demersal) longline fishery in New England. This study focused on the effects of season (sea-surface temperature), depth of capture, and unhooking technique.

Methods

Cod were collected by commercial vessels fishing southeast of Cape Cod (Figure 1). For each sampling event, defined as a day on which actual fishing took place, two to four vessels fished commercial bottom set longline gear and rod and reel gear to capture cod. After capture, sub-legal cod (<56 cm) were held in on-board live wells until 50 fish had been collected, and then placed in cages that were subsequently lowered to the seafloor. The cages were retrieved after at least 72 hours and the condition and health of the cod

examined and recorded. Fishermen were responsible for determining suitable experimental fishing areas within each required season-depth strata.

Fish were originally intended to be collected during all four seasons. However, , the investigators recognized that the seasonal variable of concern was sea water temperature and therefore aimed to sample in each of four sea surface temperature (SST) categories as follows: Cold <6.7° C; Cool 6.7-9.0° C; Warm 9.1-14.4° C; Hot > 14.4° C. The categories were determined by the industry partners, as these temperatures prevail during each season. On occasion, the research was delayed because the temperature changes had not occurred by the time of the scheduled sampling event.

The study was also designed to assess survival across different capture depths, and to investigate the interplay between season and depth. Cod were sampled in depths of 37 meters (range- 27-46m), 55 (range 46-68m), and 73m (range 68-72m) [20, 30, and 40 fathoms respectively]. These depths encompass where most regional longline fishing occurs (J. Pappalardo, Cape Cod Commercial Hook Fishermen's Association, pers. comm.) The depth at which the gear was set was typically close to the targeted depth but, because there was a range of depths along the length of the string, it was decided to keep these depths as categorical data as opposed to continuous data

Within each temperature and depth combination, three different treatments were conducted: snubbed, unsnubbed, and jigged. Snubbed and unsnubbed fish were removed from the demersal longline gear in a fashion that followed as closely as possible the

removal of fish during normal commercial fishing operations. These two treatments included the first 50 fish caught off a given string regardless of condition. While dead fish were not tanked or caged to avoid attracting scavengers, they were still counted as mortality towards the sample size.

The jigged fish were intended to act as a control to indicate cage-induced mortality. As such, only healthy looking sublegal fish exhibiting no major injuries were selected for the 50 fish sample; dead, weak or injured fish were not used or counted.

For each of the twelve sampling strata (four sea surface temperature by three depth strata), a minimum of 150 sub-legal fish were obtained in each of the three treatments. The sub-legal fish were measured, assessed for condition and placed in live tanks, with an emphasis on limiting handling time. Information recorded for each fish included: handling technique, depth of capture, air, surface and bottom temperature, size of fish, time of capture, and behavior upon placement in the live well. In addition, the stamina of the fish was rated into one of four categories (Vigorous, Moderate, Limp, or Dead). The location of any hook wound was recorded (Mouth, Eyes, Gills, Gut, or Body), as was the severity of the wound (None, Slight, Moderate, Serious, Severe). Finally, any apparent effects of barotrauma were noted (Eyes, Stomach, Vent etc.) The cod were kept in the live wells until 50 fish were collected or haul-back was completed. To minimize tanking time in cases when the sample was achieved early in the haul, participating fishermen would buoy off the longline gear mid-haul to sink the cage.

In conducting the field research, 1-2 commercial longline vessels were accompanied to the fishing grounds by 1-2 jig vessels that caught the control fish. All fish were placed in holding tanks, caged, and sunk using the same techniques. Each longliner and jig vessel had onboard a captain, crew, and technician/scientific data collector (tech/SDC). This tech/SDC was either a scientist or a technician recruited from the local fishing industry and trained by an experienced scientist. No sooner than 72 hours, a vessel returned to haul all the cages. Survival of the fish in the cages was assessed and recorded. This protocol was based on work by Sangster et. al. (1996), which showed that the majority of the mortality attributable to the capture process occurs in the first 72 hours. Following retrieval, the cages were brought back to port until the next sampling event.

Each longline vessel fished a bottom set longline consisting of 366 meters of mainline with 300 12/0 circle hooks spaced every 1.2 meters, constituting one bundle. Three to four bundles were strung together to constitute a string, and 3-4 strings were set per fishing day to arrive at a total effort of approximately 3,600 hooks per day. Strings of hooks were placed in close proximity to minimize any bias that could result from collecting fish from different areas (i.e. depths and temperatures). Bait type was kept consistent across a given fishing event. The fishery studied does not utilize long soak times, as fishing events are strictly timed to the tidal cycle. The gear is set just before slack tide, and hauled as quickly as possible. As such, soak time is always brief, ranging from as little as an hour to a maximum of about 4 hours. Set time, set location, set depth, and soak time were all recorded.

Each vessel was equipped with live tanks sufficient to hold 50 fish. Live wells were aerated with circulated seawater or aeration pumps with air stones. When sea surface temperatures were high (above 14°C), live wells were chilled with saltwater ice to 10°C or lower to prevent live well induced mortality. Each of the longline vessels fished its gear at a predetermined depth. The first 50 sub-legal cod captured on each string were removed from the hook in one of two ways. Prior to fishing, a coin was tossed which determined which treatment would be followed for the first string, and then treatments were alternated on subsequent strings. Once assigned, a given treatment was followed until 50 fish were caught, or the end of the string was reached

The unsnubbed treatment group was unhooked by hand, without allowing the fish to contact the fair lead roller (a set of steel cylinders that guide the line and used to restrain the fish) and without allowing the force of the hydraulics to pull the hook out. The snubbed treatment group was de-hooked by allowing the fish to contact the fair lead roller, and the force of the hydraulics was used to pull the hook through the jaw. The result is that the hook often tears flesh, breaks the jaw, or causes other injuries.

Another group of cod were caught by handgear and used as an indicator of potential cage-induced mortality. Handgear is defined as handlines, manual rod and reel, or electric rod and reel, equipped with terminal tackle consisting of 2-5 hooks with bait or artificial lures and a weighted jig. Vessels in this study used electric rod and reel almost exclusively, and the practice is referred to as "jigging". The fish in this group were caught in the same area as the longline sets and placed in cages in close proximity to

those with the longline fish, but instead of using the first 50 fish, the control cages contained 50 healthy-looking, non-injured fish. The study took advantage of the handling techniques developed by jig vessels contracted by the CCCHFA for the Northeast Regional Cod Tagging Program.

Fish were transferred by dip net from the live well to cages tethered alongside the vessel, and no more than 50 fish were placed in each cage. Transfer time was recorded, and a final count of the number placed into each cage was documented. Each cage was closed and secured, and lowered to the bottom at a controlled rate (typically 1 to 2 minutes depending on depth).

Because of concerns for the high center of gravity of the cages used in the previous cod mortality study (Milliken et. al., 1999) rigid low-rise cages with cylindrical shapes and integrated bottom weights were designed and tested in local waters and showed great promise. The overall volume of the round cages was approximately $1.4m^2$ (0.6m high with a 1.2m diameter), comparatively small as compared to Milliken et al. (1999).

Prior to the study, there was concern and disagreement about the number of fish that could be placed in the cages before their density would affect their survival. A density test was performed in which eight cages were filled and sunk, two each with 15, 30, 45 and 60 cod respectively. No differences in mortality were observed after 72 hours and it was decided that 50 fish was a practical density.

Cages were set as singles, with one anchor, one buoy line, one buoy, and one high-flyer per cage. Anchors were 80-pound sections of steel railroad track with bridles constructed of a steel shackle, 12 inches of chain, and 4 feet of polypropylene rope. Buoy lines were 0.8 or 0.86 cm line that varied in length depending on the depth. Buoys were large, low drag, poly-balls. High-flyers were 3.6 meters long and equipped with radar reflectors. All gear was fully compliant with the requirements of the Atlantic Large Whale Take Reduction Plan, including commercially purchased swivel-style weak links incorporated into the buoy lines.

Data were collected on Palm Pilots purchased and equipped with Smartlist to Go software. This offered the efficiency and accuracy of a date-time stamp for each entry, and eliminated the need for keypunching and associated errors. Paper datasheets were provided as a backup.

To evaluate discard survival, a logistic binomial model was developed using survival as the dependent variable, and 3 levels of sea surface temperature (SST), 2 levels of depth, and 3 treatments as categorical predictors. All main effects, all 2-way and one 3-way interaction were compared on the basis of the Aikaike Information Criterion (AIC) with AIC values differing by >6 assumed to be not supported by the data (Burnham and Anderson, 2002). Models were analyzed using Systat 10.

In addition to the binomial logistic comparison, the data were also tabulated (Tables 1,2,4,5) and graphed (Figures 2-4) to show the percent survival associated with various

treatments and parameters. The mean and 95% confidence intervals were also graphed (Figures 5-8). To investigate the data further by combining temperatures the data was grouped by cold (SST $\leq$ 9.0°C) and warm (SST > 9.0° C) and analyzed by adding the mortality of the jigged fish to the rate of survival (Figure 4). A middle point was added to the data between these two points. This was presented to show the possible range of mortality for the different treatments. Additionally, survival for the different treatments was compared by plotting the means and the 95% confidence intervals for the different parameters (e.g., depth, sea surface temperature and catch / dehooking method) using Systat 10. Finally, the data were compared using an F-Test for differences within the treatments and parameters tested (Table 6).

RESULTS:

On fourteen different days, two to three vessels fished and caught 3,764 sub-legal cod that were assessed for survival[1] at three different depths and four temperature categories (Table 1). For all treatments, survival following caging ranged from 31% to 100% (Table 2) not accounting for any mortality associated with the handling and caging process. On average, survival rates were higher at lower sea surface temperatures (SST< 9°C (Figs 2 and 6)) and in shallower depths (Figs. 3 and 5). Temperature and depth had a greater influence on survival than treatment (Fig. 2-3). When the data were grouped into cold ($\leq$ 9°C) and warm (> 9°C) truncated categories (Tables 4 and 5, Fig. 3 and 7) it becomes evident that warmer sea surface temperatures reduced survival at the two deeper depth

[1] This does not include fish used to test cage density, or fish that were tagged and assessed.

245 zones (55 and 73m.). At the shallower depth (37m), the effect of the warmer sea surface
246 temperature on mortality is not apparent.
247
248 A logistic regression model including all main effects, all 2-way interactions and the 3-
249 way interactions provided a slightly better fit to the data (AIC= 2151) than the only
250 acceptable competing model, one containing only Treatment, Depth, Temperature and
251 Temperature*Depth (AIC=2154). A plot of predicted values from both models showed
252 the same pattern of clear differences among treatments with minor differences in survival
253 estimated using the more complex model (the one including the 3-way). Because both
254 models provided similar results and the AIC values differed by less than 6, the less
255 complex model was selected. Odds ratios generated from this model (Table 3) suggest
256 survival is affected more by sea surface temperature and depth, than by treatment. The
257 estimated probability of survival is approximately five times greater (5.245 [95% 3.242-
258 8.486]) at the lowest sea surface temperature (<6.7°C) as compared to the warmest sea
259 surface temperatures (>14.4 °C) (Table 3). Additionally, the probability of survival is
260 almost to six times greater (5.768) at a depth of 37 meters as compared to 73 meters. The
261 survival odds for jigged when compared to unsnubbed fish is twice as high (2.031), but
262 the survival when snubbed is compared to unsnubbed is about half (0.563).
263
264 The results of the F-test within the treatments and parameters (Table 6) showed
265 significant differences in survival between fish from 37 meters versus 55 meters, and
266 from 37 meters versus 73 meters. A significant difference in survival was detected
267 between fish from cold (< 6.7°C) versus hot (>14.4°C) and between and cool (6.7-9.0°C)

versus hot water. No difference in mean survival was detected among the different treatments (jigged, unsnubbed and snubbed).

DISCUSSION:

Depth, sea surface temperature and handling technique all affected discard survival. Although handling technique had less effect on survival then depth and sea surface temperature, if the snubbed fish had been assessed past 72 hours, mortality may have been higher due injuries from snubbing affecting subsequent feeding or promoting infection.

Survival was lower when sea surface temperatures and depth were highest. The high sea surface temperatures occur in the summer when the bottom temperatures are actually the lowest of the year (~ 6-10°C) (Mountain, 1989). In the winter, mixing occurs that warms the bottom waters thus reducing the difference between bottom and sea surface temperatures. In our study area, in the deeper depths and during the summertime, the fish are being forced through water that is often 10°C greater than where they reside. The resulting temperature change can result in barotrauma and is a likely stressor that may have resulted in the greater observed mortality of the sub-legal cod.

Discard survival rates in this study were higher than reported in a previous study in New England (Milliken et. al. 1999). Although the results of the two studies differ, the larger sample size, reduced handling time, and improved caging techniques suggest that the survival rates attained during this study are a closer representation of fishing mortality on

292 sub-legal cod when compared to the previous study (Milliken, et. al., 1999). Additionally,
293 the current results should be representative of the discard survival rates in the fishery
294 because the study was conducted under actual fishing conditions.
295
296 Removing the cod by the unsnubbed technique (i.e., twisting the line with the gaff, which
297 causes the fish to be released with minimal injury), did not appreciably slow the onboard
298 operations and was the preferred method by the fishermen involved in this study. Since
299 the probability of short-term survival using this technique is almost twice as high and
300 long-term survival is likely greater, widespread adoption of the unsnubbed technique by
301 the industry would be of great benefit.
302
303
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References

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd Edition. Springer-Verlag, New York, New York, USA. 488 pp.

Carr, H.A., M. Farrington, J. Harris and M. Lutcavage. 1995. Juvenile bycatch and codend escapee survival in the northeast groundfish industry - Assessment and mitigation. A report of the New England Aquarium to NOAA pursuant to Award No NA36FD0091.

Chopin, F., D.L Alverson, Y. Inoue, T. Arimoto, P. He, P. Suuronen, G.I. Sangster, 1997. Sources of unaccounted mortality in fish capture technologies; IN: Hancock, D.A. (Ed.) Developing and Sustaining World Fisheries Resources. The State of Science and Management. Proceedings of the Second World Fisheries Congress. CSIRO Publishing pp. 149-156.

Davis, M. W., 2002. Key principles for understanding fish bycatch discard mortality. Can. J. Fish. Aquat. Sci. 59:1834-1843.

Davis, M. W., 2005. Behaviour impairment in captured and released sablefish: ecological consequences and possible substitute measures for delayed discard mortality. J of Fish Bio. 66: 254-265

Federal Register. 1989. Northeast Multispecies Fishery - Final Rule. Fed. Reg. 54(19):4789-4808.

Main J. and G.I. Sangster. 1990. An assessment of the scale damage to and survival rates of young gadoid fish escaping from the cod-end of a demersal trawl. Scottish Fisheries Research Report. 46, 28p.

Mesnil, B. 1996. When discards survive: Accounting for survival of discards in fisheries assessments. Aquat Living Resour. 9:.209-215

Milliken, H.O., Farrington, M., Carr, H.A., and Lent, E. 1999. Survival of Atlantic cod (Gadus morhua) in the Northwest Atlantic longline fishery. Mar. Technol. Soc. J. 33: 19–24.

Mountain, D.G. & Holzwarth, T.J. (1989) Surface and Bottom Temperature Distribution of the Northeast Continental Shelf. NOAA Tech. Memo. NMFS-F/NEC 7:32 pp.

NEFMC (New England Fishery Management Council) 1985. Northeast Multispecies Fishery Management Plan. April 1985.

Neilson, J.D., K.G. Waiwood, and S.J. Smith, 1989. Survival of Atlantic halibut (*Hippoglossus hippoglossus*) caught by longline and otter trawl gear. Can. J. Fish. Aquat. Sci. 46: 887–897.

Orsi, J.A., A.C. Wertheimer, H.W. Jaenicke. 1993. Influence of selected hook and lure types on catch, size, and mortality of commercially troll-caught Chinook salmon. North Am. J. Fish. Manage. 13: 709-722.

Poiner, I.R. and Harris, A.N.M. 1996. Incidental capture, direct mortality and delayed mortality of sea turtles in Australia's Northern Prawn Fishery. Mar. Biol. 125: 813-825.

Chopin, F; Alverson, DL; Inoue, Y; Arimoto, T; He, P; Suuronen, P; Sangster, GI. 1997. *Sources of unaccounted mortality in fish capture technologies* in Developing and sustaining world fisheries resources. The state of science and management. pp. 149-156.

Robinson, W.E. and H.A. Carr. 1993. Assessment of juvenile bycatch survivability in the northeast fishing industry. A report of the New England Aquarium to NOAA pursuant to Award No. NA16FL0068.

Rutecki, T.L., and T.R. Meyers. 1992. Mortality of juvenile sablefish captured by hand-jigging and traps. North. Am. J. Fish. Manage. 12: 836-837.

Ryer, C. H. 2004. Laboratory evidence for behavioral impairment of fish escaping trawls: a review. ICES J. Mar. Sci., 61:1157-1164.

Sangster, G.I., N. K. Lehmann and M. Breen. 1996. Commercial fishing experiments to assess the survival of haddock and whiting after escape from four sizes of diamond mesh cod-ends. Fish. Res. 25 (3-4), 323-345.

Smith, 1996. W.T. Smith, Reduction of halibut bycatch and associated mortality in the Bering Sea cod fishery. In: Solving Bycatch: Considerations for Today and Tomorrow. Alaska Sea Grant College Program Report No. 96-03, University of Fairbanks (1996), pp. 205–209.

Soldal, A. V., and Huse, I. 1997. Selection and mortality in pelagic longline fisheries for haddock. Council Meeting,. ICES CM 1997/FF:14

393

Date caught	Temperature category	Depth (Meters)	Jigged		Snubbed		Unsnubbed	
			Alive	Dead	Alive	Dead	Alive	Dead
12/28/2005	(<6.7°C)	37m.	147	11	32	10	87	15
1/6/2006	(<6.7°C)	55m.	129	29	69	37	35	19
1/24/2006	(<6.7°C)	73m.	152	14	87	35	50	10
6/9/2004	(6.7-9.0°C)	37m.	49	5	42	17	73	8
11/26/2005	(6.7-9.0°C)	37m.	37	8	14	7	61	23
5/17/2005	(6.7-9.0°C)	55m.	65	0	66	30	67	8
1/11/2006	(6.7-9.0°C)	73m.	146	14	45	10	94	26
12/5/2005	(6.7-9.0°C)	73m.	35	8	25	11	50	18
6/21/2004	(9.1-14.4°C)	55m.	38	38	13	3	22	3
6/9/2005	(9.1-14.4°C)	73m.	48	25	24	32	63	31
6/30/2004	(9.1-14.4°C)	73m.	13	15	85	54	98	27
8/10/2005	(>14.4°C)	37m.	111	16	34	19	84	22
8/6/2005	(>14.4°C)	55m.	67	38	73	83	105	41
8/2/2005	(>14.4°C)	73m.	61	47	45	101	51	104

394

395

396 Table 1: Number of alive and dead cod upon retrieval and evaluation by date, sea surface
397 temperature, depth and treatment.

398

399

	Depth	Jigged	Unsnubbed	Snubbed
Cold	37m.	93%	85%	76%
SST<6.7°C	55m.	82%	65%	65%
	73m.	92%	83%	71%
Cool	37m.	87%	81%	70%
SST 6.7-9.0 °C	55m.	100%	89%	69%
	73m.	89%	77%	77%
Warm	37m.		NO DATA	
SST 9.1-14.4 °C	55m.	50%	88%	81%
	73m.	60%	74%	56%
Hot	37m.	87%	79%	64%
SST >14.4°C	55m.	64%	72%	47%
	73m.	56%	33%	31%

400

401 Table 2: Percent survival for the three treatments by depth and by sea surface

402 temperature.

403

Parameter	Odds Ratio	Upper	Lower	p-value
CONSTANT				0.004
SST_<6.7 °C	5.245	8.486	3.242	0.000
SST_6.7-9.0 °C	4.785	6.305	3.631	0.000
SST_9.1-14.4 °C	3.968	5.746	2.741	0.000
DEPTH_37m.	5.768	8.892	3.741	0.000
DEPTH_55m.	2.34	3.015	1.817	0.000
TREATMENT Jigged	2.031	2.959	1.394	0.000
TREATMENT Snubbed	0.563	0.732	0.434	0.000

404
405

406 Table 3: Odds ratio with upper and lower limits and probability value for the different
407 parameters tested. Higher odds ration equate to more effect on the model, which
408 means a greater influence on survival. Odds ratios were calculated comparing: (1)
409 the lower sea surface temperatures to the sea surface temperature >14.4oC, (2) the
410 lower depths to the 73m depth, and (3) jigged and snubbed treatments to
411 unsnubbed.

412
413

Temperature	**Cold combined (≤9.0°C)**			**Warm combined (> 9.0°C)**		
Depth	**37m.**	**55m.**	**73m.**	**37m.**	**55m.**	**73m.**
Treatment	% Survival					
Jigged	90.7%	87.0%	90.2%	87.4%	58.0%	58.4%
Unsnubbed	82.8%	79.1%	78.2%	79.2%	74.3%	56.7%
Snubbed	72.1%	66.8%	73.7%	64.2%	50.0%	45.2%

Table 4: Survival by treatment of sub-legal cod when data are grouped by cold (≤9.0° C) and warm (> 9.0° C) sea surface temperatures.

Treatment	**Unsnubbed**					
Temperature	**Cold combined (≤ 9.0°C)**			**Warm combined (> 9.0°C)**		
Depth	**37m.**	**55m.**	**73m.**	**37m.**	**55m.**	**73m.**
	% Survival					
Survival + jigged cage mortality	92.1%	92.1%	88.0%	91.8%	100.0%	98.3%
Observed survival	82.8%	79.1%	78.2%	79.2%	74.3%	56.7%
Middle point	87.4%	85.6%	83.1%	85.5%	87.1%	77.5%
Treatment	**Snubbed**					
Temperature	**Cold combined (≤ 9.0° C)**			**Warm combined (> 9.0°C)**		
Depth	**37m.**	**55m.**	**73m.**	**37m.**	**55m.**	**73m.**
	% Survival					
Survival + jigged cage mortality	81.5%	79.8%	83.5%	76.7%	92.0%	86.8%
Observed survival	72.1%	66.8%	73.7%	64.2%	50.0%	45.2%
Middle point	76.8%	73.3%	78.6%	70.5%	71.0%	66.0%

Table 5. Survival for snubbed and unsnubbed sub-legal cod when data are grouped by cold (≤ 9.0° C) and warm (>9.0° C) sea surface temperatures and the mortality experienced by the jigged fish is added to the survival. A midpoint is also provided.

425

Depth (M)	Sig Dif.
37 v. 55	*
55 v. 73	NO
37 v. 73	**
SST (C)	**Sig Dif.**
Cold (< 6.7) v. Cool (6.7-9.0)	NO
Cold (< 6.7) v. Warm (9.1-14.4)	NO
Cold (< 6.7) v. Hot (>14.4)	**
Cool (6.7-9.0) v. Warm (9.1-14.4)	NO
Cool (6.7-9.0) v. Hot (>14.4)	**
Warm (9.1-14.4) v. Hot (>14.4)	NO
Treatment	**Sig Dif.**
Jig v. Unsnubbed	NO
Jig v. Snub	NO
Unsnubbed v. Snub	NO

426

427 Table 6. F-Test results for differences in survival within (1) Depth, (2) Sea surface
428 temperature, and (3) Treatment. "*" = significant at $\alpha < 0.1$, "**" significant at $\alpha < 0.05$.

429

Figure Legends

Figure 1. Study area shown in red.

Figure 2. Data grouped by depth and sea surface temperatures. No fish were collected at 37 Meters in warm water.

Figure 3: Data grouped by cold combined ($\leq$ 9.0C) and warm combined (> 9.0C) sea surface temperatures. High mortality of jigged fish in warm water at 55 Meters was likely due to high live well temperatures on jigged vessel that increased mortality of this treatment.

Figure 4: Plot of observed survival (triangle), observed survival plus the mortality on the jigged fish (circle), and the middle point (square).

Figure 5: Plot of the 95% confidence interval of the mean of survival between the three depths fished during the study. Depth is in meters.

Figure 6: Plot of the 95% confidence interval of the mean of survival between cold (< 6.7C), cool (6.7C to 9.0C), warm (9.1C to 14.4C.) and hot (>14.4C.) surface temperatures.

Figure 7: Plot of the 95% confidence interval of the mean of survival between cold water (<9.0C surface temperature) and warm water (> 9.0C surface temperature). Cold and cool, and warm and hot were combined

Figure 8: Plot of the 95% confidence interval of the mean of survival between the two treatments and jigged fish.

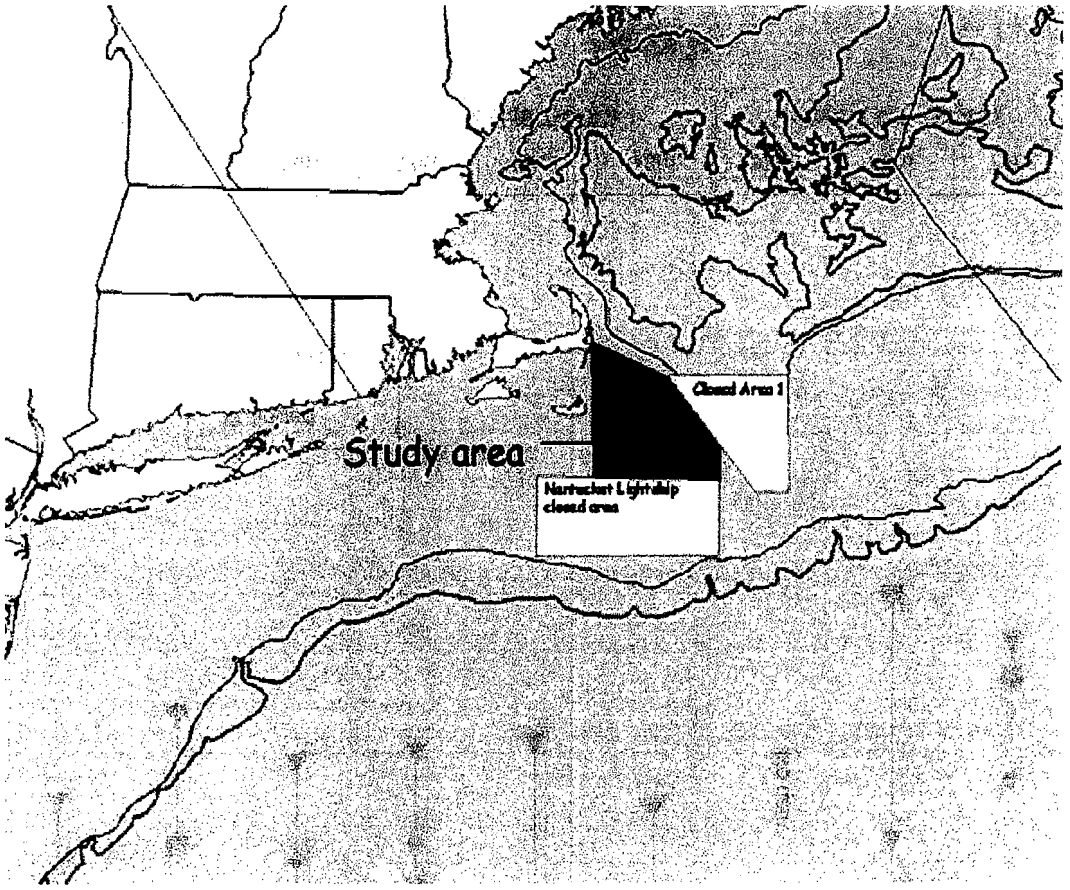

Figure 1

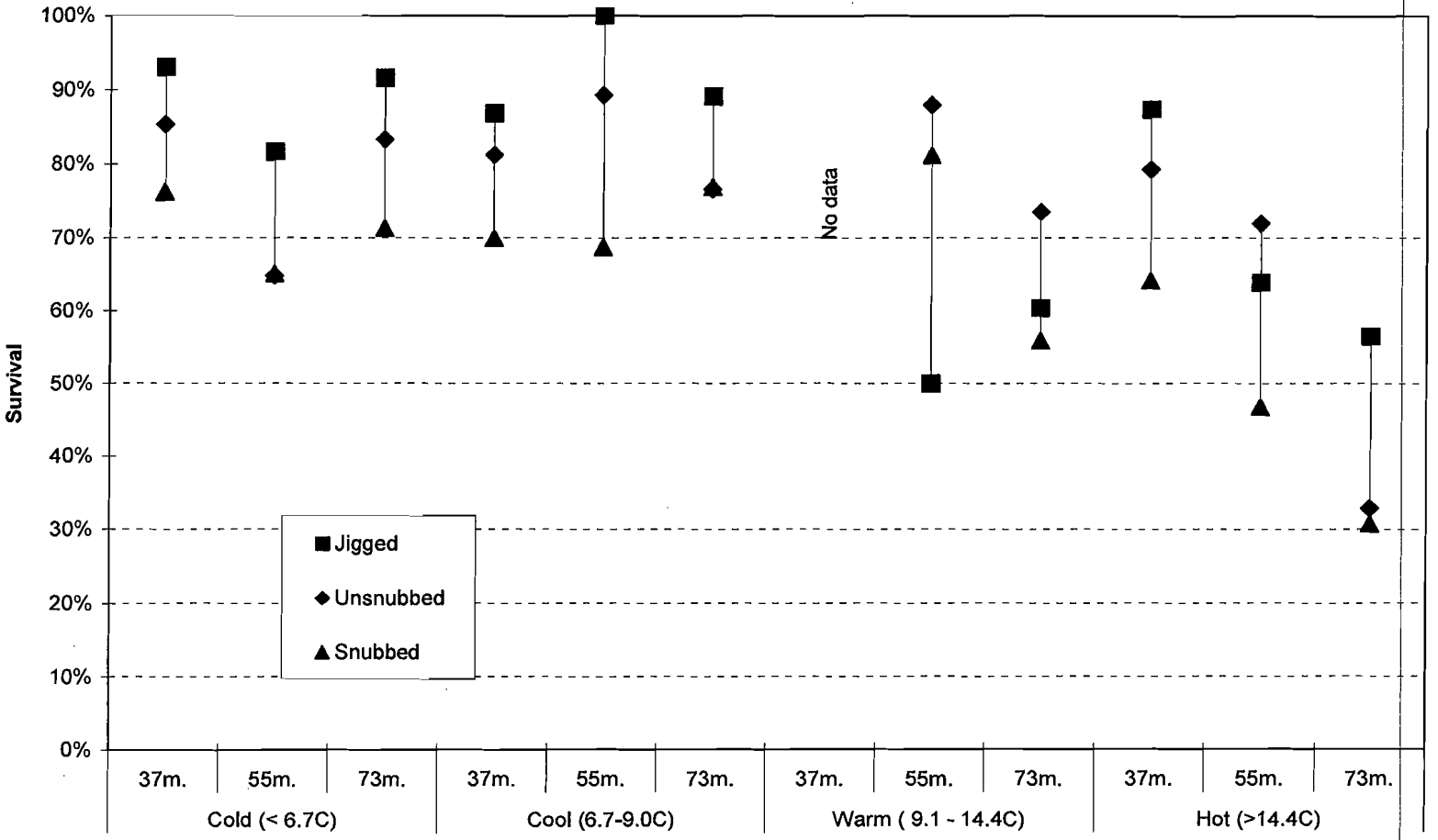
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Survival
No data
Jigged
Unsnubbed
Snubbed
37m.
55m.
73m.
Cold (< 6.7C)
Cool (6.7-9.0C)
Warm (9.1 - 14.4C)
Hot (>14.4C)

Figure 2:

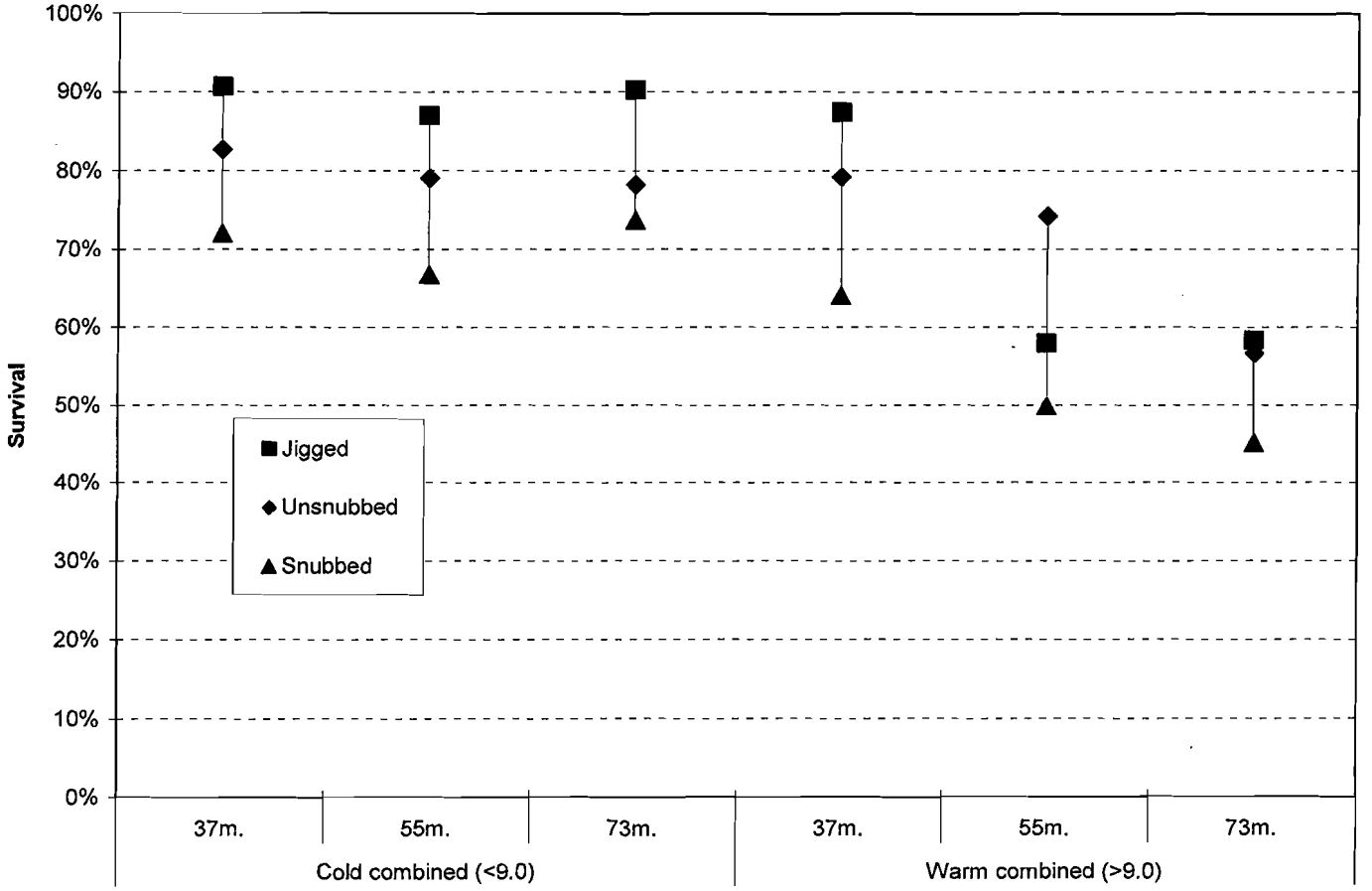
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Survival
Jigged
Unsnubbed
Snubbed
37m.
55m.
73m.
37m.
55m.
73m.
Cold combined (<9.0)
Warm combined (>9.0)

Figure 3:

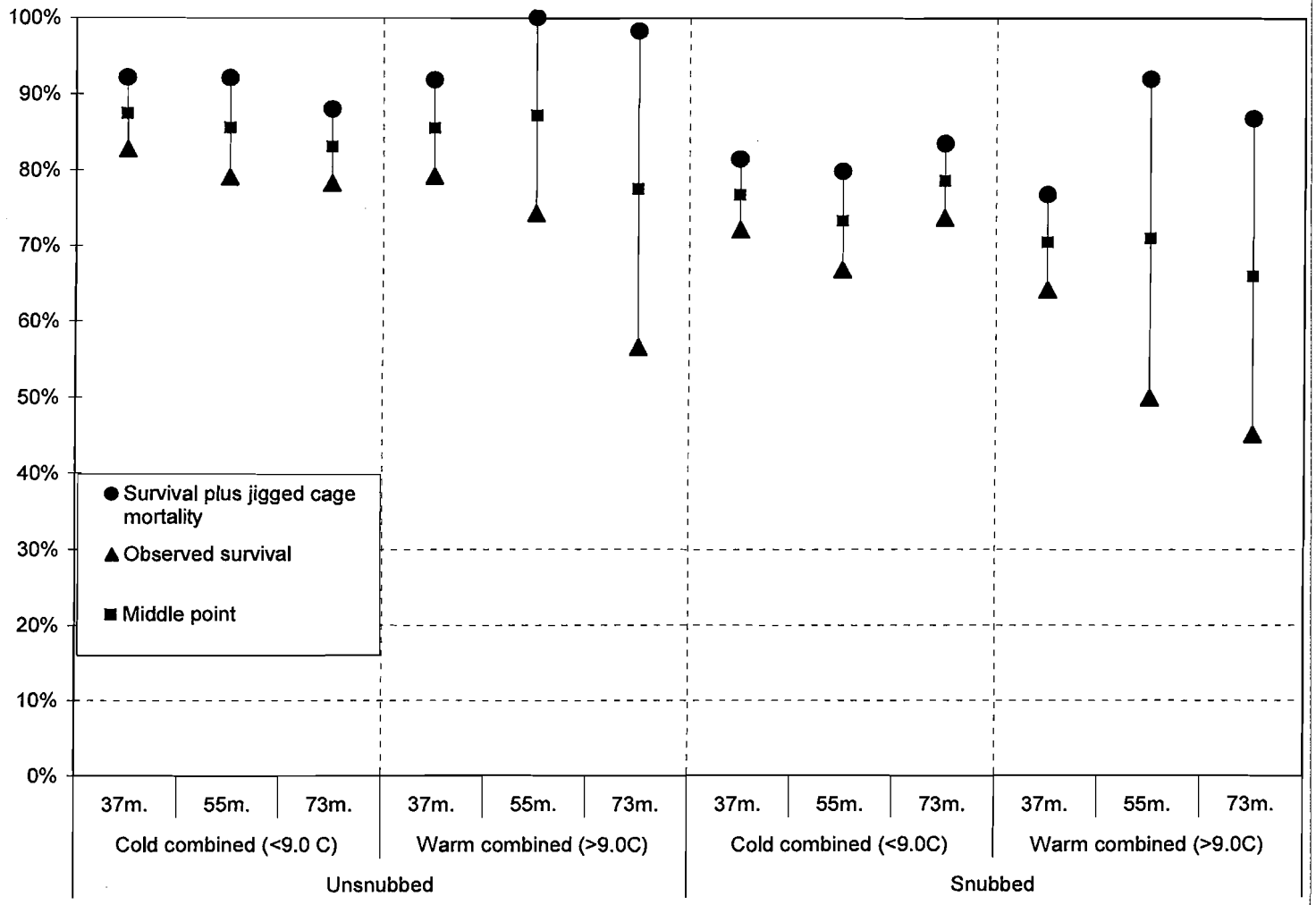
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Survival plus jigged cage mortality
Observed survival
Middle point
37m.
55m.
73m.
37m.
55m.
73m.
37m.
55m.
73m.
37m.
55m.
73m.
Cold combined (<9.0 C)
Warm combined (>9.0C)
Cold combined (<9.0C)
Warm combined (>9.0C)
Unsnubbed
Snubbed

Figure 4:

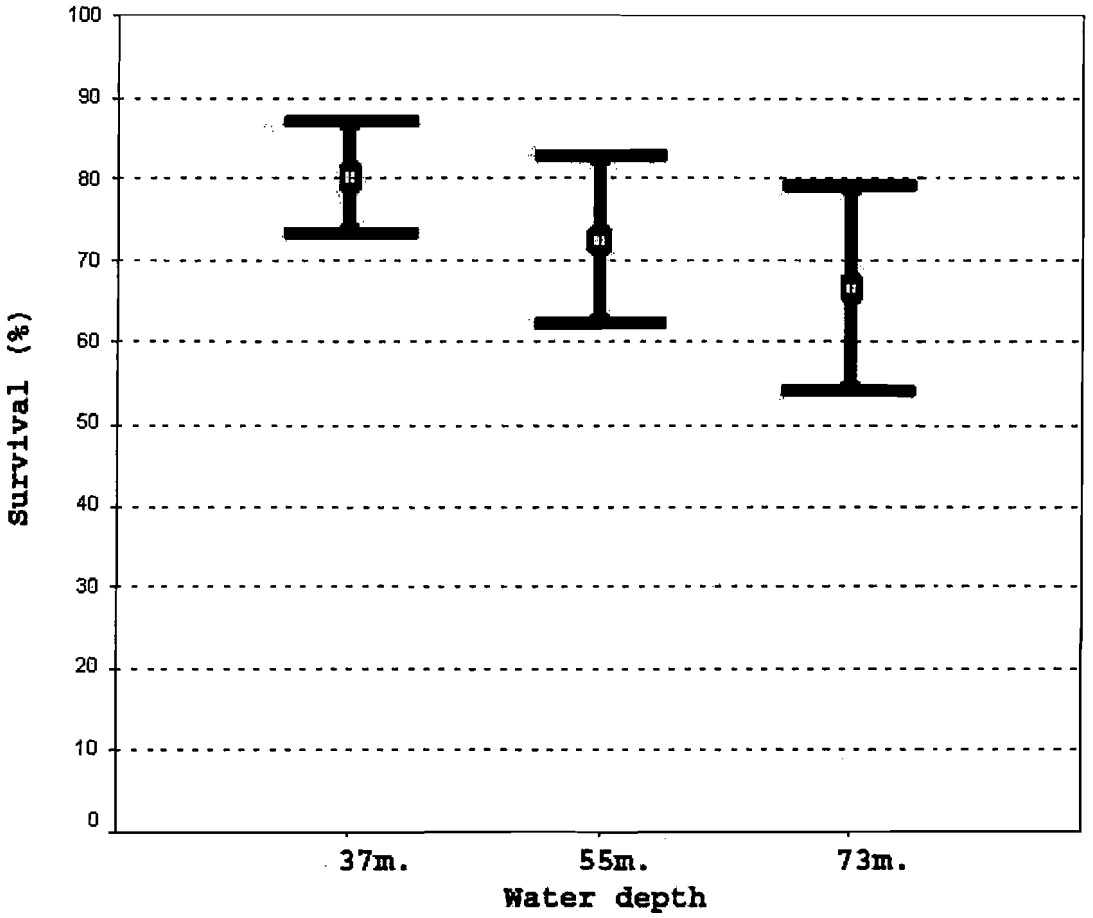

Figure 5:

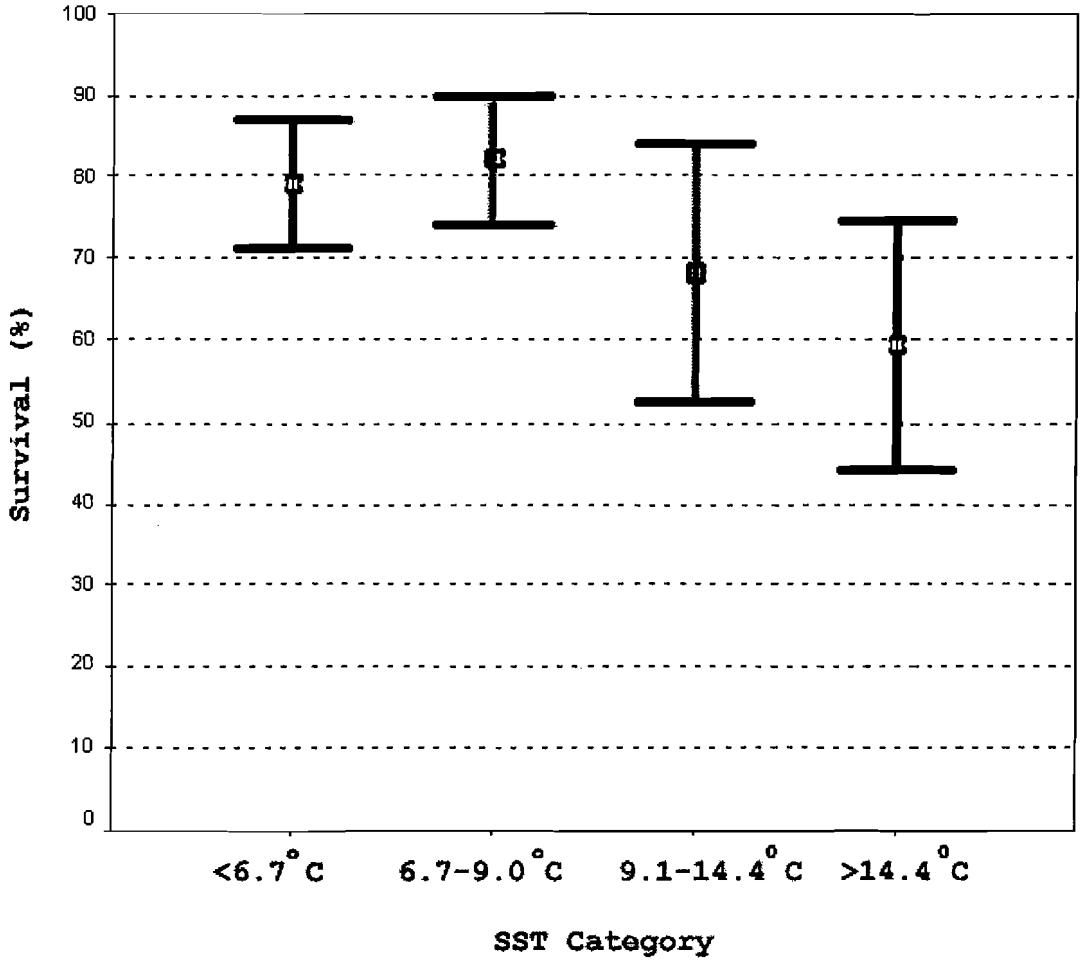
100
90
80
70
60
50
40
30
20
10
0
Survival (%)
<6.7°C
6.7-9.0°C
9.1-14.4°C
>14.4°C
SST Category

Figure 6:

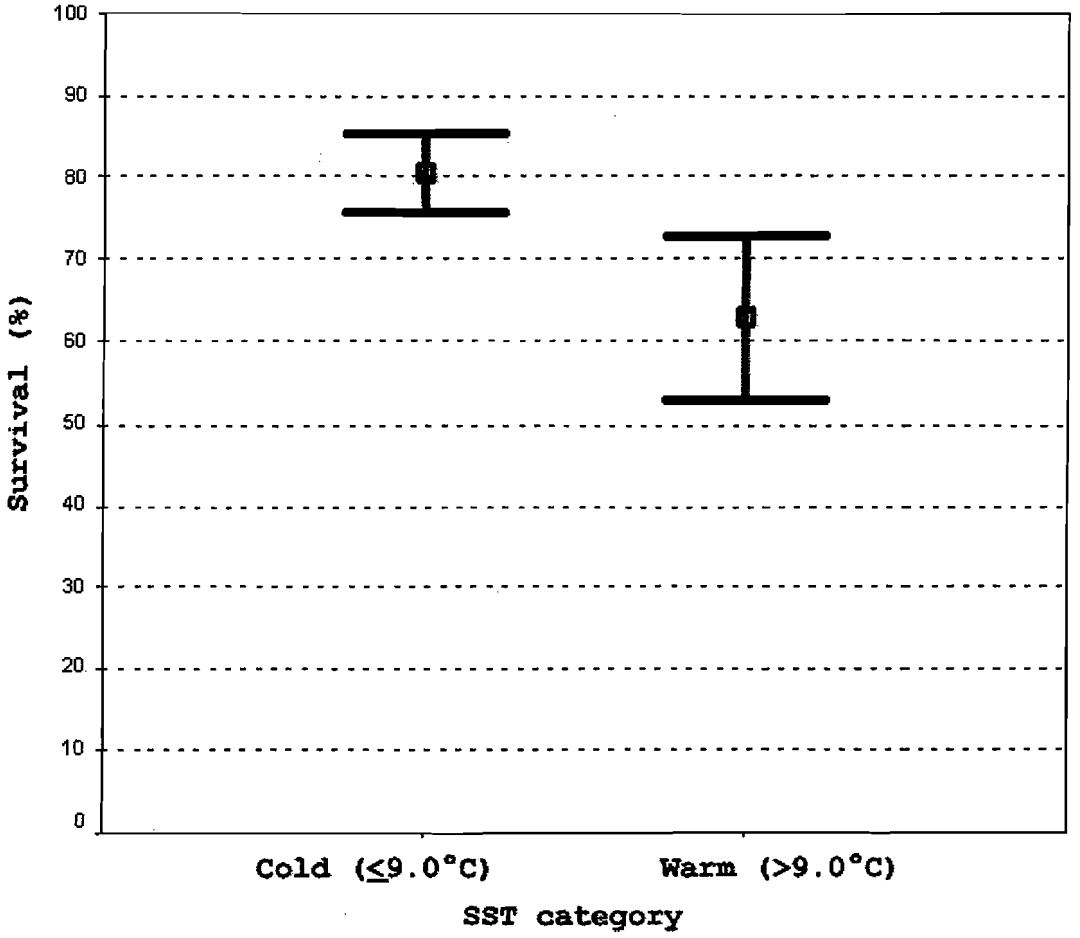
100
90
80
70
60
50
40
30
20
10
0
Survival (%)
Cold (≤9.0°C)
Warm (>9.0°C)
SST category

Figure 7:

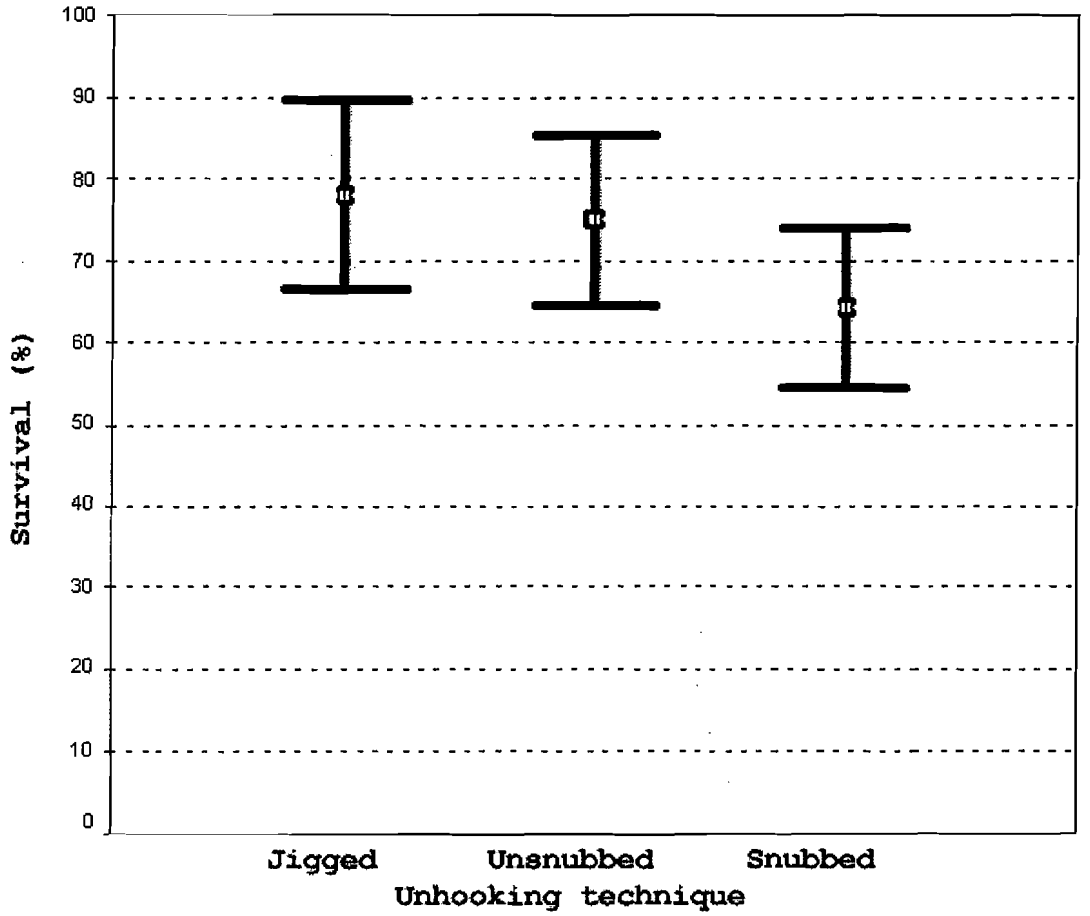
100
90
80
70
60
50
40
30
20
10
0
Survival (%)
Jigged
Unsnubbed
Snubbed
Unhooking technique

Figure 8: