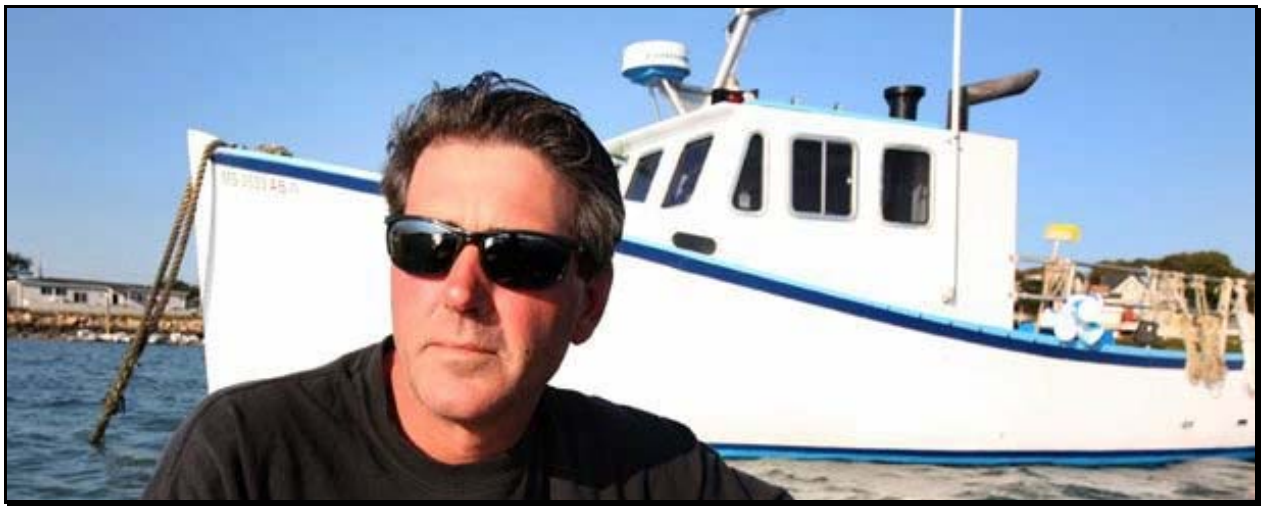
POTYEAR: Determining the Seasonality of Cod Pots

Award Number: 09-048



Period of Performance: 6/30/2008 - 6/30/2011

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Capt. Marcella passed away on 18 March 2010 after an illness.

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Names in **bold** played a key role in project design and implementation.

Project Objectives

Our goal is to continue to develop cod pots. To accomplish this goal, we have identified the following objectives:

1. To compare catch rates and sizes of Atlantic cod captured in Norwegian and Newfoundland cod pots;
2. To compare catch rates and sizes of Atlantic cod over eight months;
3. To observe Atlantic cod behavior to bait and to cod pots.

A worldwide interest in investigating and improving fish potting currently exists, with active research projects in Canada, the Faroe Islands, Iceland, Norway, Sweden, France, the United Kingdom, and the United States. Interest in potting extends to the Southern Hemisphere, and to Asia. Potting is becoming increasing popular based on trends toward lower energy, lighter impact fishing gear and to gear that causes less harm to target and non-target species and habitats. Pots

offer a source of apparently undamaged, healthy fish for tagging and other scientific studies. Releases of undersized and unmarketable fish from pots have low or zero release mortalities in our previous research (Pol and Walsh 2005). Pots also are an alternative survey and harvest method for areas inaccessible to trawling, such as coral reefs and hard bottom. On the negative side, use of pots may increase buoy lines in the water and risk injury to marine mammals.

Interest in Massachusetts in pots arose from occurrence of “overharvest” (this term includes regulatory discards – otherwise landable fish that are discarded due to regulations) – catches that exceed daily allowable landing limits. Where overharvest occurs, damage or wasteful mortality (which harms rebuilding) may result if a particular gear catches too many fish. Or, fish may be left in the water for harvest the next day, with loss of quality. In these cases, a gear that can catch and hold fish harmlessly, or that allows discard with low or no mortality, will improve stock rebuilding and economic return. Pots appear to be a gear with these characteristics.

The Northeast Consortium supported the first successful study where Atlantic cod were caught in fish pots in our region. Pol and Walsh, working with Marcella and using a pot designed by the Centre for Sustainable Aquatic Resources in Newfoundland, Canada, were successful at catching Atlantic cod, up to 13 in one pot haul, in the Massachusetts Cod Conservation Zone (CCZ) off Boston in May and June 2005. However, the captured cod tended to be below minimum landing size and average catch rates were not economical. Further investigation in the same area by DMF working with Marcella in December 2005 - February 2006 with comparisons to nearby multimesh gillnets had similar low catch rates, and suggested that cod in pots were smaller and hungrier than cod caught in nearby gillnets. However, the sampling area was restricted and the number of samples and the number of pots used were very low in this small study. Underwater filming showed cod attracted to, but not often entering, the pot.

We hosted (and the NEC supported) an international workshop on gadoid harvest with pots (GACAPOT) in Gloucester in 2006 that examined progress on catching haddock, cod and related fish in pots. One conclusion drawn from that meeting was the necessity of lining up the entrance of the pot with the bait plume caused by the movement of water over the bait. Norwegian scientists have designed their pots to float and rotate in response to current. Underwater observation of their pots show >95% of fish approach the pot from the downcurrent direction, where the bait scent is pushed by the current and detected by fish. Cod may not be able to find an entrance if it is not directly oriented with the bait plume.

A second important conclusion from GACAPOT was that fish in general and Atlantic cod specifically are only vulnerable to pots during certain times of year. This vulnerability is seen in all fishing gears, and may be due to hunger levels, presence of prey or predators, migration, spawning status, or temperature, or a combination of these and other factors. Therefore, in development of pots, it is of primary importance to establish when cod are maximally vulnerable to pots. This knowledge can then be used to define when and if further experiments on the details of pot design and deployment are necessary to improve catch rates, and to establish where and when experiments should be carried out for maximum exposure to cod.

Cod pots need further investigation and development to be successful. We envision this project as the most useful next step: to conduct overnight sets for four days per month in Massachusetts state waters of both Newfoundland and Norwegian designed cod pots, across eight months of a year (November-June). We also propose to conduct filming of fish reaction to bait using underwater cameras. The results of this work will quantify catch rates in pots across 8 months, compare effectiveness of two pot designs, and determine the best time to catch cod with pots. This project will strengthen a scientific-fishing partnership, a team that shares scientific and fishing expertise with one another, to develop an innovative gear on a commercial vessel.

Methods and Work Plan

The Newfoundland cod pot designs (NF) (Figure 1) are all pyramidical when fishing and are constructed in three ways: two are 6.5 ft x 6.5 ft x 41 in and consist of a steel frame with netting panels; one of these designs is collapsible, saving deck space. The third type is 6 ft x 6 ft x 41 in and made from polyvinyl-coated wire mesh. All three have netting attached at the top: 30 meshes of 4-in diamond mesh with a float that creates the pyramid of netting on top. Each pot has two entrances on opposite sides with 16-in diameter circular rings. Previous research showed these three designs did not fish differently from one another. They need some repair work to be made as similar to one another as possible.

We will contract with a netmaker to construct 10 pots following the Norwegian design (NO) (Figure 2). These pots are collapsible two-chamber rectangular pots made of netting, designed to float and move with the current. They have one entrance, are made of netting and are approx. 44 in x 20 in x 53 in.

Figure 1: Setting a Newfoundland-style cod pot

We plan to operate from the northern edge of the Cod Conservation Zone to off Scituate, Massachusetts. We will remain in Massachusetts waters and use a non-Federally permitted vessel to avoid the complexity of obtaining an Experimental Fishing Permit. Use of pots and access to closed areas can be obtained through a permit from the Division of Marine Fisheries, which has been obtainable in the past.

We have identified the months of November through June as times when cod can be caught using longline bait in the study area. We will deploy pots in pairs (but fished as singles) of one NO design and one NF design with 0.25 nm of each other. Bait will be standardized to clams which are known to be effective (Pol et al. 2007). Set locations will be determined using fishing experience, an echosounder and jigging.

Figure 2: Norwegian floating pot

Pots will be set and hauled on four consecutive days in each month. Catch will be identified, weighed, and measured. In cooperation with the Cod Tagging Program of the School of Marine and Atmospheric Science and Technology of the University of Massachusetts-Dartmouth, cod will be uniquely tagged and released. Fin clips will be collected from fish that are extruding eggs or milt to assist microsatellite genetic studies of cod by Dr. David Berlinsky of the University of New Hampshire. We do not intend to kill or land any fish and we expect fishing mortality to be low or zero. Pots will be hauled and remain on land between months.

Operational and biological data will be collected by DMF biologists, including catch composition and weights for all species, lengths for Atlantic cod (and other species as practical), set and haul times and locations, pot type, weather conditions, depth, temperature (surface and bottom) and tag data. Data will be entered into a customized Access database which will be provided to the NEC at the conclusion of the study.

The field work will continue for eight months; our goal is 32 sea days with 10 pairs of pot catches per day. Catches will be analyzed using pot type and month as factors; after exploratory analysis of the data, appropriate parametric or non-parametric analysis will be conducted.

Additionally, we will conduct at least one filming session each month. An underwater camera will be attached to a pot and a live-feed will be observed and recorded on the F/V *Ann Marie*, using a filming rig previously developed for this vessel. We will initially investigate the effect of removing the sides from an NF pot, and observe fish behavior in reaction to hanging bait. Behavior will be analyzed quantitatively later in the laboratory. We intend to progress to observation of reaction to entrances and other pot factors. Temperature probes will be attached to each pot to identify temperature effects on catch.

Table 1: Timeline for conduct of the POTYEAR project

2008					
Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Acquire permit; Database development				Set/haul pots	Set/haul pots
Repair NO pots; have NF pots built; move pots to Hull; order bait				Film behavior	Film behavior
					Data audit and entry

2009								
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul - Aug**	**Sep -Nov**	**Dec**
Set/haul pots	Set/haul pots	Set/haul pots	Set/haul pots	Set/haul pots	Set/haul pots	Data and video analysis	Final report writing	Submit final report
Film behavior	Film behavior	Film behavior	Film behavior	Film behavior	Film behavior			
Data audit and entry	Data audit and entry	Data audit and entry	Data audit and entry	Data audit and entry	Data audit and entry			

Work Completed to Date

Capt. Marcella retrieved a NO style pot on 2 October 2009 that had been lost in December 2008. It was entangled with lobster gear without a buoy.

SMAST and DMF personnel have tagged 401 cod with t-bar tags. Thirteen DST (depth, salinity, and temperature-recording) tags have been applied, and fourteen fin clips for genetic testing by David Berlinsky have been collected.

Pots were moved to Hull in November 2009 for the final paired trials, set and hauled, and returned to storage. Data from that and previous trips were entered into the project database.

A review of the budget revealed sufficient money for more fieldwork. Because filming opportunities had been so limited due to weather and poor visibility, a plan was developed to attempt one more deployment during April 2010. Highest cod pot catches were observed in April 2009, so the timing of the final deployment was matched to the presumed highest density of cod.

Following notification to the NEC, plans were developed for additional filming. Prior to April, our industry partner, Bob Marcella, passed away. An expedited Scientific Letter of Acknowledgement (LOA) was requested and quickly obtained from the Northeast Regional office of the National Marine Fisheries Service to allow participation by Capt. Chad Mahoney of Hull, who was identified and briefed on the project by Capt. Marcella prior to his death.

As part of preliminary catch analysis, a generalized linear mixed models (GLMM) procedure was attempted in order to analyze length-related differences in pot performance. We collaborated with Dr. Antonello Sala of the Italian National Research Council's Institute of Marine Sciences on this analysis. GLMMs are particularly useful because: set-to-set variation, usually discounted in typical analysis, is incorporated when determining effects; the results are simple and easy to

interpret; and comparison of the impact of pot design can be length-based. That is, the results describe the impact of pot design across the range of fish sizes seen in the study.

Pol developed a procedure to merge and import data from temperature loggers deployed on each pot into Access and R. He also learned how to plot temperature and location using GIS-style R plots. Szymanski reviewed bottom temperature data from loggers deployed on pots and discovered anomalies in the June 2009 values; for other months, the bottom temperature differences between pots and between days appear negligible. The highly fluctuating June bottom temperatures appear to be related to unusual Northeast storms.

Data audit procedures were in process at the time of reporting in preparation for final analysis. SMAST Institutional Animal Care and Use Committee (IACUC) reporting was completed.

An abstract describing preliminary results was submitted and accepted for a Theme Session on Development of Environmentally Responsible Fishing Gear using Knowledge of Fish Behaviour at the ICES Annual Science Conference in Nantes, France between 20-24 September 2010. Pol is a co-convenor of the session.

Several unexpected difficulties arose during the last 12 months.

1) The passing of Capt. Marcella was a serious loss in terms of expertise, insight, and knowledge of the functioning and deployment of cod pots. His death is a setback to pot development.
2) A combination of dangerously bad weather and poor underwater visibility continued to prevent any serious underwater filming. No substantial footage was collected despite a dedicated effort in times of high abundance.
3) We have been unable to obtain as-built plans for the Norwegian-style pots despite commitments from the builder, Capt. Pinkham.

Results to Date

It is still too soon to place too much weight on the results of the project to date. With that thought in mind, a few musings can be made. They are organized by the three project objectives.

1. Compare catch rates and sizes in the two pot designs.

Pots were set with one Norwegian style pot and one Newfoundland style pot in pairs, with the idea that both pots would sample the same fish, and catches would demonstrate which pot was more attractive or better at holding captured fish. Pairs where at least one Atlantic cod was caught in one of the pots do not suggest any immediately obvious difference in effectiveness between the two types of pot (Figure 3).

For example, pairs in December, March, and May suggest that the Norwegian pots caught more fish – the data points are mostly above the equal catch line. However, in April, the month with the largest catches so far, June, and November the data points are more spread. The ambiguity of this preliminary analysis suggests that deeper analysis is necessary.

A look at the size frequencies by month (Figure 4) shows indications that the catches differ by

length: smaller fish are being caught only in the Norwegian pots. Above legal size, few cod are caught overall, and a difference might be seen in pot catches of legal fish, too. The results from the GLMM (Figure 5) show a preliminary model of significantly better catches of cod below 43 cm, no significant difference between about 43-55 cm, and better catches in the Newfoundland pots between 55-70 cm. (Note that in the figure, overlap of the dashed line at a proportion of 0.5 by the gray confidence interval means no significant differences between pots; where the gray area is above the dashed lines, the Norwegian pots caught more of that size fish; where the gray area is below, the Newfoundland pot caught more of that size of fish.)

This preliminary result is not surprising for small fish, because the mesh size of the Norwegian pots is smaller, and therefore likely to block escape of smaller fish than can swim out of the Newfoundland pots. The difference in larger fish (legal size for cod is 56 cm) is a bigger problem for the possibilities of a fishery. Final analyses will have to examine this finding carefully – the GLMM procedure is complex and requires care when fitting a model. This procedure will be carefully reviewed before making final conclusions.

More species were captured in the Norwegian pots (Table 2). This observation is consistent with the retention of smaller cod due to smaller meshes; most of these species are smaller fish that may have escaped from the larger meshes of the Newfoundland-style pots, perhaps during hauling.

The addition of floatation to the Norwegian pots appears to have solved the problem of catching lobsters previously reported. Only 9 lobsters were caught after floatation was added; forty-six were caught prior to modification in March 2009.

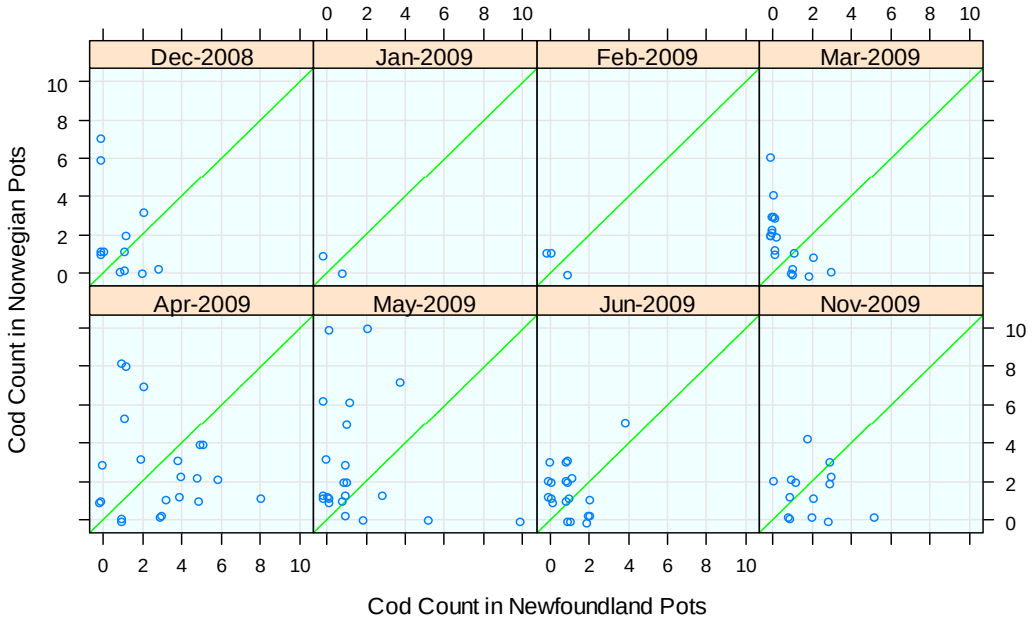

Figure 3: Catches in pairs of Newfoundland and Norwegian pots by sampling month. The green dashed line is the equal catch line.

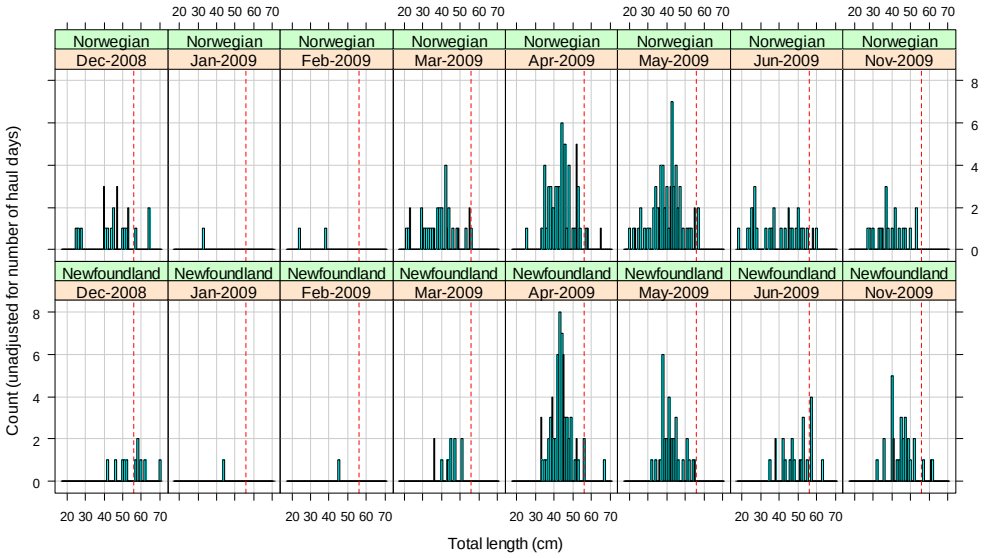

Figure 4: Length frequencies for Atlantic cod caught in Norwegian (top row) and Newfoundland (bottom row) style pots by month (columns). Counts are raw, and have not been adjusted for unequal effort in December. The red line

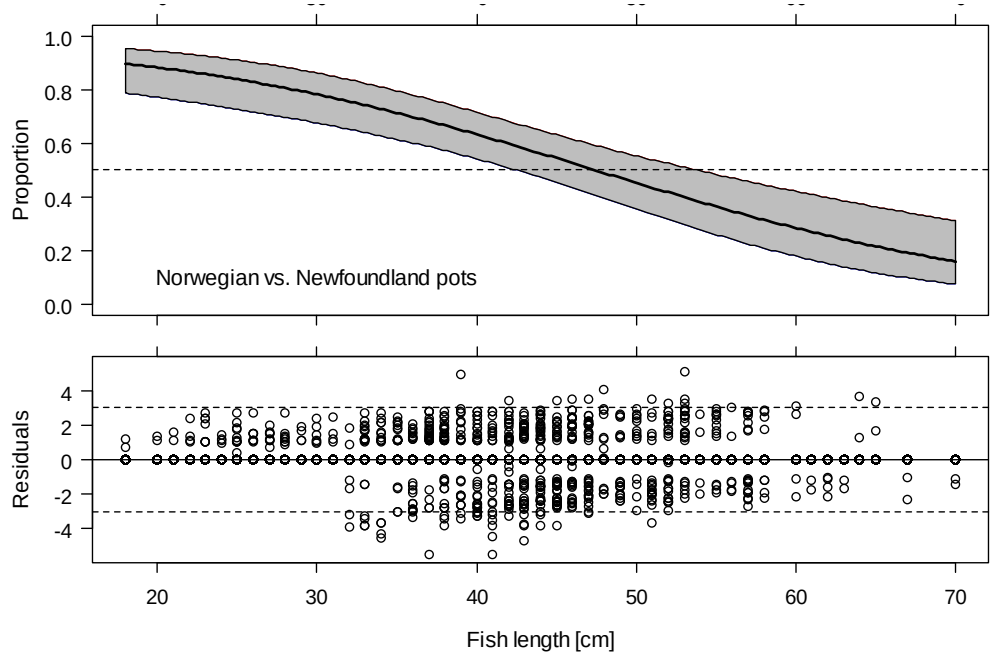

Figure 5: (top) Generalized Linear Mixed Model of cod catch comparisons of Norwegian and Newfoundland style cod pots, using haul as a random variable and residual values (bottom plot). The gray region is a 95% confidence interval; where it overlaps the 0.5 dashed line, no significant difference is found. Areas above the line show significantly higher catches in the Norwegian pot; significantly higher catches for Norwegian pots are found where the gray region is below the dashed line.

Table 2: Catches in pots by type, in counts, from December 2008-November 2009.

Species		Count	
		Norwegian	Newfoundland
Cod, Atlantic	*Gadus morhua*	226	189
Cunner (Yellow Perch)	*Tautogolabrus adspersus*	79	3
Pollock	*Pollachius virens*	69	2
Lobster, American	*Homarus americanus*	45	10
Dogfish, Spiny	*Squalus acanthias*	16	
Crab, Jonah	*Cancer borealis*	13	4
Hake, Red (Ling)	*Urophycis chuss*	7	1
Crab, Rock	*Cancer irroratus*	4	
Sea Raven	*Hemitripterus americanus*	2	5
Ocean Pout	*Macrozoarces americanus*	2	2
Herring, Atlantic	*Clupea harengus*	2	
Lumpfish	*Cyclopterus lumpus*	1	
Redfish, Nk (Ocean Perch)	*Sebastes sp*	1	1
Cusk	*Brosme brosme*	1	
Crab, Northern Stone	*Lithodes maja*		5
Flounder, Winter (Blackback)	*Pseudopleuronectes americanus*		1

2. Comparison of catch rates and sizes of Atlantic cod over eight months.

Catches were dramatically different between months (Figure 4), with April and May showing the largest catches. January and February had near-zero catches. We do not believe these catches are due to an inability to find fish. We used multiple methods to find cod, including use of an echosounder, jigging, reports from lobstermen of cod in lobster pots, and catches by longline fishermen. It appears that these catches reflect a lack of availability or presence of cod in the area.

3. Observation of cod behavior to bait and cod pots.

As reported above, dangerous weather and poor visibility have limited observations. We have established the ability to film, but have not been able to. Our attempt to collect more video in the months since the prior report has not been successful. Poor visibility in April 2010, during additional filming time, was not successful.

4. Other observations

The Norwegian pots are much easier to handle: they are lightweight, and collapsible. However, they may not be as durable as necessary, and in future versions, the flotation should be separate from the pot structure to ensure positive buoyancy.

Future Work

Data audit will continue. The original work plan allowed for analysis and final report writing to be conducted for six months following the conclusion of fieldwork. Fieldwork was concluded in April 2010; following that timeline, we would anticipate a final report in November 2010.

Impacts and Applications

We are quite pleased with the size of the catches and the ease of handling the Norwegian pots. We feel we have begun defining times when future research or a fishery could occur. We expect that these results will be of value to the network of cod pot researchers that has been established through ICES as we work together to improve pot catches, by determining differences between these two pot designs. We also intend to continue to develop pots locally, and therefore this information is valuable to local fishermen who may be interested in pots as an alternative gear. Scientists who need a supply of cod that are in excellent health (for tagging, stress studies, etc) should consider use of these designs. Further, managers may find this gear type to be a useful alternative to harvest practices in specific areas. However, at this time, pots are not yet ready for widespread commercial use.

Related Projects

This project provides tagging opportunities for SMAST personnel, overseen by David Martins and Steven Cadrin, and through them, fin clips for genetic research by Dr. David Berlinsky of the University of New Hampshire.

Partnerships

Robert Marcella and DMF developed a strong collaboration and, with each participant bringing independent and overlapping expertise, mutual respect as well as healthy discussion of decisions. Pol and Marcella worked together to define the project objectives and direction, the study area and times of year when the project should be conducted. They jointly considered logistics of deck handling of pots and number of pots that could be handled in a day. They worked together to find and acquire an adequate bait supply, storage, and delivery method for the project. Marcella provided lead on determining timing of monthly fishing activity, maintenance and storage of pots, and set location, and has primary responsibility for determining safe working conditions due to weather and deck activity. Pol provided lead on database development, data analysis, and report writing. Szymanski leads the sea sampling and coordination with SMAST personnel. Capt. Mahoney stepped in and provided a vessel and his knowledge of fish distributions following the death of Capt. Marcella.

Marcella, Mahoney, and 5 crewmen (one or two at a time) have been involved directly with the project, with a network of other fishermen advising us on possible locations of Atlantic cod. Kelo Pinkham constructed the pots. At this point, more than ten scientists from DMF and SMAST have participated in sampling and tagging.

Presentations

None

Published Reports and Papers

None

Data

All electronic data from this project are being entered into a customized Access relational database, and will be provided to the Northeast Consortium Fisheries & Ocean Database at the same time as final report submittal.