

Northeast Consortium Interim Final Report

Project Title: **Yellowtail Flounder Tagging Study**

Project Leader: Steve Cadrin
NOAA/UMass CMER Program
706 South Rodney French Boulevard
New Bedford, MA 02744-1221
(508) 910-6358
(508) 910-6371 fax
Steven.Cadrin@noaa.gov

Signature: _____

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Abstract

New England fishermen and the Northeast Fisheries Science Center tagged over 45,000 yellowtail flounder in all three New England stock areas. The study was designed to charter commercial fishing vessels to tag yellowtail flounder with conventional disc tags and data-storage tags with the objectives of estimating movement among stocks areas and mortality within stock areas as well as providing growth observations. Preliminary results indicate frequent movements within the Cape Cod and Georges Bank stock areas with a less frequent movement among stock areas. Results are expected to provide information for yellowtail flounder stock assessments and management decisions.

Introduction

Yellowtail flounder is one of the principal resources of the northeast groundfish complex, with major fishing grounds on Georges Bank, off southern New England and off Cape Cod (Figure 1). The fishery for yellowtail is among the most productive and valuable in New England, yielding 12 million lb and \$14 million to U.S. fishermen in 2003 (NMFS 2004). However, with all three stocks currently rebuilding from an overfished condition, the potential yield of yellowtail is much greater than the current yield (the estimated maximum sustainable yield from the three New England stocks is 65 million lb; NEFSC 2002, 2005).

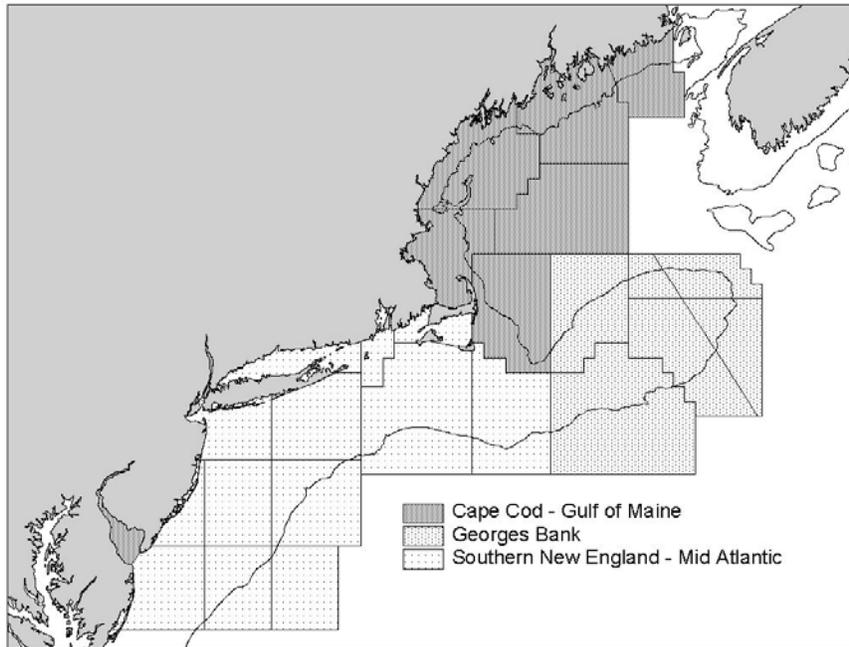


Figure 1. Yellowtail flounder management areas off the northeastern U.S.

Managing the recovery of yellowtail resources and maintaining optimum yield require precise stock assessments and accurate forecasts of the population and fishery. Although yellowtail flounder stock assessments provide valuable information for fishery management advice, several major sources of uncertainty persist (NEFSC 2005). The traditional assessment of Georges Bank yellowtail tends to overestimate stock size and an alternative assessment model indicates substantially less biomass, but the assessment is too uncertain to determine which assessment model is correct (Legault 2005). The source of this uncertainty is not well known, but may result from movement among stock areas, lack of information on the effect of closed areas on population dynamics, insufficient surveying of areas closed to fishing, inaccurate age determinations, misrepresentative sampling of distributional patterns, underreported catch, or inaccurate assumptions about natural mortality (NEFSC 2002, 2003; TRAC 2004).

The southern New England-Mid Atlantic stock is not rebuilding at an acceptable rate, apparently because fishing mortality has not been effectively reduced, despite management restrictions like the year-round closure of the Nantucket Lightship Area since December 1994 (Cadrin and Legault 2005). Although the stock definition of Southern New England-Mid Atlantic yellowtail was recently revised (Cadrin 2003a), information on movement of yellowtail between southern New England and Mid Atlantic areas, as well as mixing with the adjacent Cape Cod and

Georges Bank resources is limited to historical studies (Royce et al. 1959, Lux 1963). It appears that the recruitment of yellowtail flounder in southern New England (the 2004 yearclass) is stronger than it has been for two decades, and continued tagging will provide an opportunity to study movement of these new recruits.

Status of the Cape Cod-Gulf of Maine yellowtail stock is particularly problematic for northeast groundfish management. The stock assessment has a great deal of uncertainty but suggests excessive fishing mortality and decreasing stock size (Cadrin et al. 2005). Therefore, the status of the Cape Cod-Gulf of Maine yellowtail stock is a focus of groundfish management in the Gulf of Maine. However, some surveys indicate a more stable stock, suggesting that (1) mortality rates have been overestimated or (2) the stock is not a closed population. Movement of yellowtail to and from the Cape Cod grounds is not well known. Population dynamics of Cape Cod yellowtail may be greatly influenced by mixing with adjacent stocks, because the Cape Cod grounds are relatively small in comparison with Georges Bank and the Southern New England shelf (Hart and Cadrin 2004). Although data from historical tag recaptures is available (Royce et al. 1959, Lux 1963), and suggests some mixing with the southern New England and Georges Bank stocks, the studies were not explicitly designed to estimate mortality or mixing rates. These data are up to 50 years old and may not represent the current environmental or stock conditions. The likelihood of older yellowtail moving from the Cape Cod grounds to the northern Gulf of Maine is also not well known.

The yellowtail flounder tagging study was designed to address the major sources of uncertainty in yellowtail flounder assessments. The study provides valuable information on movement, mortality and growth, thereby complementing the current stock assessment methods for yellowtail and improving the reliability of scientific advice for effective fishery management. Furthermore, such cooperative research is building an open working relationship between fishermen, NMFS, state and academic researchers. This proposal was developed with the interaction of fishery scientists and yellowtail fishermen (see Appendix A. Summary of 3rd annual meeting). Through a series of port visits and meetings, industry leaders offer their knowledge of seasonal yellowtail distributions, fishing practices, and practical field experience, and scientists provided input on population modeling, statistical design, and technical protocols. The result is an integrated sampling and analytical plan that is both efficient in the field and technically rigorous for reliable population estimates.

Project Objectives

There are several objectives of the Yellowtail Flounder Tagging Study:

- estimate movement rates among yellowtail fishing grounds
- provide independent estimates of mortality for each stock area
- confirm age determinations
- foster cooperative relationships between scientists and fishermen.

The general approach is based on an experimental design that represents the entire population and an analytical design that models simultaneous movement and mortality. Thereby, the experimental design corresponds to the analytical design, and population estimates support all three technical objectives (movement, mortality and growth) with one study.

All phases of the proposed research, from the field protocol to public outreach, have been developed cooperatively between New England groundfish fishermen, the Northeast Fisheries Science Center and other research agencies. Co-principal investigators represent fishermen from all three major fishing grounds (Georges Bank, Southern New England-Mid Atlantic and Cape Cod-Gulf of Maine). Based on the concerns of fishermen and researchers about uncertainty in stock assessments

and the need for better understanding of yellowtail movements, a cooperative study has been designed to integrate several ongoing yellowtail tagging efforts.

Participants

Steve Cadrin, NOAA/UMass CMER Program, New Bedford MA

Steve has been a fisheries biologist for 20 years, and is responsible for stock assessments of yellowtail flounder. Steve's Ph.D. dissertation was "Stock Structure of Yellowtail Flounder."

Azure Westwood, Northeast Fisheries Science Center, Woods Hole MA

Azure is a marine biologist under contract with NEFSC to coordinate cooperative research on yellowtail flounder. Azure has experience in community-based fisheries science and management from American Samoa, Alaska and New England.

David Goethel, F/V Ellen Diane, Hampton NH

David is a Gulf of Maine groundfish fisherman with experience in cod tagging and cooperative research. David has also helped in the experimental design and will continue to help with outreach in the Cape Cod-Gulf of Maine area.

Fred Mattered, F/V Travis & Natalie, W. Kingston RI

Fred is a highliner in the offshore yellowtail fishery and has been instrumental in the development of the industry-based survey for southern New England yellowtail. Fred also provided input for the initial tagging study design and continues to be involved in project management.

Other fishermen who have been involved in tagging and attending planning meetings: Carlos Ageuas (F/V Victory), Bill and Jason Amaru (F/V JoAnne-A III), Rodney Avila Sr. and Rodney Avila Jr. (F/V Trident), Bruce Bannick (F/V Sarah Beth), Ed Barrett (F/V Phoenix and F/V Sirius), Antonio Barroqueiro (F/V Lady of Grace), Tom Bell (F/V Karoline Marie), Tony Borges (F/V Sao Paulo), Ron Borjeson (F/V Angenette), Carl Bouchard (F/V Stormy Weather), Ray and Rich Canastra (Whaling City Auction), Luis Fidalgo (F/V Vila De Ihavo), Steve Follette (F/V Heather Lynn), Jim Ford (F/V Lisa Ann II), Paul Harvey (F/V Ing Toffer II), Manny Marquintos (F/V Victory), Luis Martins (F/V Victory), Shawn McLellan (F/V Elizabeth), Maggie and John Raymond (F/V Olympia), Luis Ribas (F/V Blue Skies), Dennis Robillard, Jr. (F/V Julie Ann) and Jaime Santos (F/V Lady of Grace), Tracy Stubbs (F/V Ing Toffer II) and Proctor Wells (F/V Tenacious), and dozens more have returned tags.

Cooperating Research Agencies

Many people are collaborating on this study and have contributed to its design:

- *NMFS*: Steve Murawski, John Boreman, Frank Almeida, Fred Serchuk, John Hoey, Paul Rago, Larry Alade, Josh Moser, Talia Bigelow, Stacy Kubis, Gary Shepherd, Bill Overholtz, Nathan Keith, Jonathan Duquette, Rob Johnston, Kevin McIntosh, Bill Duffy, Dave Radosh, Chris Legault, Jay Burnett, Sarah Pregracke, Vaughn Silva, Patricia Yoos, Heather Sagar, Earl Meredith, Sarah Babson-Pike, Mike Palmer, Steve Kelly, Erin Kupcha, Katie Lovett, Joe Mello, Anthony Morales and Chris Zanni.
- *MADMF*: Jeremy King, John Boardman, Brian Kelly and David Pierce
- *SMAS*: Dave Martins, Jon Loehrke, Greg DeCelles, Sally Roman, Adam Barkley, Rodney Rountree, Joachim Gröeger, Russ Kessler and Darin Jones
- *RIDFW*: April Valliere and Sarah Pierce

- *Canada DFO*: Heath Stone
- *University of Maryland*: Eric May, Andrea Johnson and Erica Anuszewski
- *Northeast Consortium, University of New Hampshire*: Chris Glass, Rachel Gallant
- *Manomet Center*: Greg Morris and Kris Joppe-Mercure
- *REMSA Observers*: Janine L'Heureux and Meryl Segal

In addition to personnel resources (including all scientific field staff), the proposed study has the support of the Northeast Fisheries Science Center, providing data (e.g., the commercial weighout database, logbook data, observer program information, and the NEFSC survey database) computational hardware and software, toll-free phone support, website maintenance, and scientific research permits. Industry representatives have the ability to communicate the objectives of the project to other yellowtail fishermen, thereby maximizing the potential reporting rate of recaptured tags.

Methods

This project contracts commercial fishermen and their vessels to work with scientists to tag and release yellowtail on all fishing grounds off New England, proportional to geographic patterns of abundance. The geographic design is based on statistical fishing areas, with releases in each area proportional to relative abundance of yellowtail (according to NEFSC groundfish surveys). Such a design allows for the estimation of movement among areas and mortality by area.

Tag Deployment: Yellowtail are captured using commercial otter trawls with large mesh (6.5") and relatively short tows (30 min). All legal-sized fish (>33cm) in viable condition, and some sublegal sized-fish from low density tows in southern New England-Mid Atlantic are tagged with either Peterson discs or data-storage tags. Releases are during the spawning season (May-August; with the exception of 1% of releases in autumn of 2003). Tag specifications are:

- Peterson Discs; Floy Tag 7/8" round, fluorescent pink, labeled "cooperative-tagging.org, tag#, \$1000 lottery (or \$100 reward), toll free 877-826-2612, provide tags & location and date." Most fish tagged blank on blind side, scales plucked from approximately 10%, tags on blind side labeled "take some fish scales & return to 166 Water Street Woods Hole MA 02543."
- Data-storage tags; Lotek LTD 1100, 32K memory, 8mm x 16mm x 27mm; time (dynamic storage & intervals), depth (+/- 0.04psi up to 735psi) & temperature (+/- 0.19o C), 3 year battery, labeled "tag#, Mail tag, date, location to 166 Water Street Woods Hole MA 02543". Oval disc tag labeled "cooperative-tagging.org, \$100 reward, toll free 877-826-2612."

Tag Recapture and Outreach System: Tag recaptures are from a year-round commercial fishery with some seasonal geographic closures. The reward system for reporting recaptures involves \$1000 lottery tags, 280 high-value (\$100) rewards, and \$100 rewards for returning data-storage tags. The outreach system includes reward posters, brochures, website (cooperative-tagging.org), annual letters to yellowtail fishermen, press releases, and a toll free number (877-826-2612). Every fisherman who reports a recapture is contacted via a phone call and 'thank you' letter with a map detailing movements of the tagged fish. Fishermen who return data storage tags, also receive a graph of the temperature and pressure data from that tag. Mailings and posters about the program have also been distributed to fish processors, fishing associations, NMFS port agents, NMFS Observer Program and research institutions from Nova Scotia to New Jersey. Project hats are given to leading tag returns and collaborators.

In response to suggestions at the 2nd Annual Yellowtail Tagging meeting (May 2 2005, Woods Hole), a new double-sided reward poster with information detailing the project was designed. The poster incorporated pictures of the new \$100 yellow disk tag and new orange scale blanks. Posters are translated in Portuguese, French and Spanish to foster better communication between scientists and fishermen in New Bedford and Canada. To compliment the new database, phone logs have been carefully revised to collect more information without compromising critical recapture information. Scale envelopes labeled with yellowtail tagging pertinent info have been distributed throughout the ports by key cooperators and through mailings. Discussions at the the 3rd Annual meeting (March 1 2006, New Bedford) focused on understanding recapture patterns and increasing outreach to fisheries that catch yellowtail incidentally.

Since the project began in 2003, 103 \$100 rewards have been issued and nine \$1000 lottery drawings have been hosted at fishing venues throughout New England. In addition to the standard “thank you” letters and maps, the project initiated an “Outstanding Partner” Award to the vessel with the most tag returns. A framed certificate and “thank you” letter signed by the Director of the NEFSC is mailed to the partner and posters announcing the merit are distributed for display in fishing supply houses and around the waterfront. This year, the award went to the F/V Voyager I out of New Bedford, MA (Captains Fred Marques and Tony Fernandes).

The toll free number for reporting tags (877-826-2612) is maintained and answered by a project coordinator at NEFSC. The website was updated to include more information and a flashy appearance. Several new features include a “Porthole Page”, new stock assessments, a policy on lottery drawings and recent publications. The website is maintained and updated regularly with press releases, lottery winners, and data tag returns.

Analytical Design

The analytical model is based on the assumption that the observed pattern of recaptures is a function of harvest rate in each area and movement among areas. If the population of tagged yellowtail is representative of the entire population, the estimates of movement and mortality will also be representative. The analytical design will relate the observed number of tag returns (r) to a predicted number of tag returns:

$$1) \quad \tilde{r}_i^t = n_i^t \beta_i^t \frac{F_i^t (1 - e^{-(F_i^t + M)})}{(F_i^t + M)}$$

and tags at the beginning of a time step is a function of abundance at the beginning of the time step in all areas, movement to the area (or residence in the area) and survival in the area:

$$2) \quad n_i^{t+1} = \sum_j \alpha_{ij}^t S_j^t n_j^t$$

where

n_j^t is the number of tags present in area j at time t

β_i^t is the reporting rate in area i at time t .

F_i^t is the fishing mortality rate in area i at time t .

M is the natural mortality rate

$\alpha_{i,j}^t$ is the proportion of tags in area j that move to area i at time t

S_i^t is the survival in area i at time t [$S=e^{-(M+F)}$]

The parameter β_i^t can be calculated as the ratio of lottery tag returns to high value (\$100) tag returns, assuming that all recaptures of \$100 tags are reported. The parameters $\alpha_{i,j}^t$ (movement) and F_i^t (fishing mortality) can be estimated to fit model predictions to the observed frequency of seasonal returns by area.

The number of tag returns and the duration of the study will dictate how many parameters can be reliably estimated. The model has flexible spatiotemporal resolution, so that stock areas can be analyzed by statistical areas, and movements can be analyzed by season, if the number of tag returns supports such detail.

Data

Modifications and improvements to the existing yellowtail flounder tagging database were made in the spring of 2005. The 2003 and 2004 tagging data underwent rigorous quality control procedures, resulting in the correction of many data entry errors. This process, although time consuming, improved the quality of the existing data and resulted in changes to the structure of the database.

Several data fields were added to improve our ability to quickly summarize the release and recapture data and generate GIS maps for outreach. The individual tag release records have been linked to the tow data, resulting in location information for every tag. The quality of the recapture data has been greatly improved through this process. Vessel hull numbers have been added to keep better track of participating vessels. A lookup table has been added that produces the statistical area where fish were recaptured. The addition of fields for data quality coding (i.e.: recapture data and recapture location) has enabled the data to be filtered by quality of data.

The structural changes to the database lead to modifications of our field protocol. The field data sheets were re-designed and preparations for field work were changed to further improve data collection at sea. The data sheets now have record numbers for each fish tagged, tag series are assigned to scientists to improve record keeping, and standardized comment codes related to fish condition have been added. Additionally, prior to field work, tags are organized in sequential order for deployment to minimize recording errors. These changes have greatly improved the quality and efficiency of data collection in the 2005 tagging season.

The transition to a relational database will greatly improve our ability to analyze these data. In the future, we will be able to link to other NEFSC databases such as the weighout and logbook data. Additionally, the yellowtail flounder data are being used as a model for the design of a multi-species mark-recapture database which will house data from all NEFSC tagging projects.

Data from tag releases and recaptures are continually being added to the yellowtail tagging database. When the project is complete, a comprehensive database will be provided to the Consortium. Preliminary data can be provided upon request. The Northeast Fisheries Science Center has dedicated resources to maintain the yellowtail tagging database indefinitely as a part of the NEFSC Data Management System.

Work Completed to Date

Tagging began in 2003 from 7 vessels (35 days of tagging), continued in 2004 (12 vessels, 57 days), 2005 (4 vessels, 23 days) and 2006 (7 vessels, 44 days). A total of 45,653 tags were released from 2003 to 2006 (Table 1).

Table 1. Releases of tagged yellowtail flounder by stock area, tag type and year.

Year	Stock Area	Lottery Tags	\$100 Tags	Data Tags	Total
2003	CCGOM	4,229	50	114	4,393
	GB	4,164	29	56	4,249
	SNEMA	778	9	33	820
	All	9,171	88	203	9,462
2004	CCGOM	2,765	14	33	2,812
	GB	14,587	64	133	14,784
	SNEMA	1,649	14	76	1,739
	All	19,001	92	242	19,335
2005	CCGOM	1,111	10	-	1,121
	GB	4,595	78	134	4,807
	SNEMA	627	12	-	639
	All	6,333	100	134	6,567
2006	CCGOM	3,152	37	-	3,189
	GB	5,186	57	201	5,444
	SNEMA	1,649	7	-	1,656
	All	9,987	101	201	10,289
2003-2006	CCGOM	11,257	111	147	11,515
	GB	28,532	228	524	29,284
	SNEMA	4,703	42	109	4,854
	All	44,492	381	780	45,653

Tank and Cage Experiments

Holding experiments were performed to assess tag retention and tagging-induced mortality. In 2004 and 2005, tank experiments were conducted to assess tag-induced mortality. On the last tow of four inshore tagging trips, 30 fish were kept in a flow-through tank on board, and transported to a flow through holding tank in Woods Hole via oxygenated shipping bags maintained at approximately 10°C. Fish were fed regularly and observed daily. One experiment observed 20 tagged fish and 10 untagged controls for 35 days. They were also held for up to a year to observe tag retention. A second experiment acclimated 30 untagged fish for 2 weeks, after which 20 were tagged. Subsamples were removed from the holding tank at durations of 0, 24 and 168 hrs. Tissue samples around the tag site were preserved and analyzed for histological reaction at the University of Maryland Fish Pathology Lab.

Results from the first tank experiment showed different patterns of mortality which suggests tag-induced mortality may be substantial, but better controls are needed. Results from the second holding experiment showed no histological reaction at the tag sites, so the mortality observed in holding experiments may not be related to tagging. The long-term holding study observed no tags lost, with some fish held for over a year.

In 2005, we received a Project Development Award of \$5,500 from the Northeast Consortium to design small cages and a deployment system that can evaluate tagging-induced mortality of

yellowtail flounder, a necessary component of the tagging study. Cages are cylindrical (6' diameter, 2' high), made of 1-inch coated wire mesh, with two 50" cement runners for stability. Cages were initially deployed in 24-26 fathoms. Our experimental design involved collecting yellowtail in Ipswich Bay using tagging protocol (i.e., short tows with little bycatch of other species and immediate placement in flow-through tanks). We tagged 15 fish and placed them in a cage floating at the surface by the boat. We also placed 15 untagged fish in the cage for control observations. Tagged and control fish were selected using the quality control procedures in the tagging protocol to insure that viable fish are included in the study. Cages were lowered to the bottom. Oceanographic equipment (Hydrolab©) was deployed on a cage during deployment to monitor water quality during the experiment.

After three or four days, cages were hauled to the surface to observe survival of tagged and control fish. The ratio of survival of tagged and control fish was used to estimate tag-induced mortality. Survival of all tagged and control fish is an alternative estimate of mortality that includes that trawl-capture system. Tissues were collected from five tagged fish and three control fish from each cage deployment to assess tag-induced stress. Preserved tissues will be analyzed by the University of Maryland Fish Pathology Lab for histological examination. Tissue analysis is funded by the Living Marine Resources Cooperative Research Center, associated with tank studies for yellowtail flounder. Each of the three cages was loaded with fish and deployed four times (totaling 12 deployments with 360 fish) from June 6 to 20, 2005. Cages were retrieved after three or four days. Fish were inspected for viability and condition and subsampled for tissue analysis.

Results to Date

As of August 29 2006, tags from 3,130 recaptured fish were reported. Preliminary results indicate frequent movements within the Cape Cod and Georges Bank stock areas with a less frequent movement among stock areas. Recapture data indicate 95% residence in Cape Cod-Gulf of Maine (with 5% movement to Georges Bank and <1% movement to southern New England-Mid Atlantic), 98% residence on Georges Bank (with 2% movement to Cape Cod-Gulf of Maine and <1% movement to southern New England-Mid Atlantic), and 50% residence in southern New England-Mid Atlantic (with 39% movement to Georges Bank and 11% movement to southern Cape Cod-Gulf of Maine). However, most movement from southern New England to Georges Bank was from the Nantucket Shoals area.

Eight percent of all lottery tags have been returned; 14% of \$100 reward tags and 11% of data tags were returned. The relative return rate of lottery tags to high-value tags indicates a 57% reporting rate, which is exceptional for a commercial fishery. An analysis of recapture rate by sex, size, condition code and damage code (Table 2) indicates that females had a greater recapture rate than males (particularly small males), fish categorized as 'good' had the same recapture rates as those that were 'excellent,' and all damage codes had similar recapture rates (except 'net marks' which may be excluded from mortality analyses and 'lymphocystis' which is a natural condition).

Table 2. Recapture rate (recaptures/releases) by category.

Sex	recap/rel	Condition	Recap/Rel
female	8%	excellent	8%
male	6%	good	8%
Sex, Condition		Damage Code	Recap/Rel
female, excellent	9%	anal tear	9%
female, good	8%	bruising	8%
male, excellent	6%	ambicoloration	8%
male, good	6%	ripe	8%
		old wound	8%
Female size range		fin damage	7%
33-35cm	8%	sea lice	7%
36-38cm	9%	abrasions	7%
39-41cm	8%	fin tear	6%
42-44cm	8%	anal extrusion	6%
45-47cm	8%	scale loss	6%
48-55cm	9%	net marks	5%
		lymphocystis	3%
Male size range			
33-35cm	7%		
36-38cm	5%		
39-41cm	5%		
42-44cm	10%		
45-47cm	8%		
48-55cm	9%		

Analytical Results

The field protocol and analytical design were peer reviewed at “a workshop to review and evaluate the design and utility of fish mark - recapture projects in the northeastern United States” and considered to be a valid approach to address the project objectives (Tallack et al, eds. 2005). Preliminary applications of the analytical model were reviewed at the 2005 and 2006 cooperators’ meetings. The few recaptures in southern New England present a modeling challenge producing extremely low fishing mortality estimates in southern New England and unrealistically high movement rates into southern New England. Fortunately, fishing partners from southern New England demanded more tag releases in that area in 2006, which should provide better information on movement and mortality in the area. Data analysis will continue as tagged fish are still being recaptured. Results will be presented in the final report and peer reviewed at the 2008 benchmark stock assessments for yellowtail flounder.

Tag retention and Tag-Induced Mortality

Results from the cage experiments indicated low overall mortality of tagged and control fish. Of the 360 fish in the experiment, only 15 died, and more control fish died than tagged fish. Six fish died in the second deployment, which was associated with poor weather conditions and cage movement. Therefore, it appears that the trawl-capture and caging system impose more mortality than tagging. Analysis indicates no tag-induced mortality, because more control fish died than tagged fish, and approximately 3% mortality from the capture and cage system. Removal of data from a cage where sandfleas were observed eating live fish, suggests a 1% mortality from the trawl-capture system.

The cage experiments were considered so successful and efficient that they were also conducted on Georges Bank in summer 2005. Although deploying cages offshore was more difficult, results also suggested low to negligible tag induced mortality. In 2006, cage experiments were conducted with each release event to improve estimates of tag-induced mortality. Preliminary results confirm a minimal tag-induced mortality.

Data-storage tags

Sixty data-storage tags were returned, indicating distinct off-bottom movements (Cadrin and Moser 2006). All tags at large more than one month indicated distinct off-bottom movements. Off-bottom movements were typically in evening hours, between 18:00 and 22:00, lasting an average of four hours, ascending to an average of 15m off-bottom (Cadrin and Westwood 2004). The frequency of off-bottom movements varied geographically, an average of once every ten days off Cape Cod, and once every three days on Georges Bank.

These results illustrate how archival tags enhance the interpretability and power of tagging studies. Until recently, the well-studied yellowtail flounder was thought to be a "sedentary" fish, feeding on epibenthic fauna and limited to relatively shallow, sandy habitats. This strict habitat preference and the discontinuous distributions of such habitats were considered to limit movement among offshore banks and shelves, thereby maintaining geographic stock structure. The movement patterns indicated by disc tags likely involves passive drift in midwater currents, similar to patterns observed for other flatfish species. Therefore, the use of electronic tags reveals an important aspect of yellowtail behavior that was not apparent after decades of intense research. Data tagging will continue in 2006, with the addition of deploying 100 geolocating tags on yellowtail flounder near Closed Area II on Georges Bank.

Partnerships

The greatest resources available to the project are its personnel. Fishermen and researchers have cooperated to develop the general approach and technical details of the tagging study through several meetings from Rhode Island to Maine. All cooperators were invited to three meetings to reflect on field work, review results and plan future work. Six fishermen and 33 scientists attended the first meeting in Woods Hole on January 14, 2004. Seven fishermen and 29 scientists attended the second meeting in Woods Hole on May 2, 2005. Twenty-one fishermen and 13 scientists attended the third meeting in New Bedford on March 1, 2006. Detailed summaries of the meetings are available online (www.cooperative-tagging.org).

Impacts and Applications

The results from this study will benefit researchers and managers, helping to improve the management of yellowtail resources. New information on yellowtail movement, independent estimates of mortality and confirmation of age determinations should be useful for academic, state, and federal scientists and will be important information for fishery managers (i.e., the New England Fishery Management Council). The cooperative approach used in the experimental design is being continued throughout the data collection, analysis and interpretation stages of the study. Therefore, results and conclusions will be a product of all cooperators.

Co-principal investigators and other cooperators will meet annually to review results to date. Results will be posted on the website (cooperative-tagging.org) and presented to stock assessment workshops (e.g., SAW, TRAC), management meetings (e.g., groundfish committee) and industry groups (e.g., fishermen's forum, Fish Expo) in the form of technical reports and visual

presentations. Estimates of mortality and movement, as well as growth confirmations will be prepared for the 2008 benchmark assessments of all yellowtail flounder stocks, for consideration in the determination of stock status.

Related Projects

This study was designed to complement the programmatic surveys and fishery sampling for yellowtail flounder stock assessments. It is coordinated with the Southern New England yellowtail tagging study conducted by the School for Marine Science and Technology, and the Yellowtail Industry Based Survey funded by NMFS Cooperative Research Partners Program. The tagging funded by the Northeast Consortium continues the initial yellowtail tagging funded by NMFS Stock Assessment Improvement Program in 2003. Tagging protocols, material and results are shared with Canada Department of Fisheries and Oceans to provide observations on eastern Georges Bank for the cooperative study. The holding studies are supported by a separate project development grant from the Northeast Consortium, and histological analyses are supported through a Living Marine Resources Cooperative Research Center grant. The geolocating tags efforts are funded by the NMFS Advanced Sampling Technology Working Group.

Presentations

Azure Westwood was awarded ‘Best Poster’ at the 2004 International Council for the Exploration of the Seas Annual Science Conference (September 19-29 2004, Vigo Spain) for the poster “The use of electronic tags to study fish movement: a case study with yellowtail flounder off New England.”

Steve Cadrin presented “Movement of Yellowtail Flounder: A Cooperative Tagging Study” at the Ninth Flatfish Biology Conference (December 1 2004, Westbrook CT).

Steve Cadrin presented “Tagging Yellowtail Flounder with Commercial Fishermen” at the 61st Northeast Fish and Wildlife Conference (April 17-20 2005, Virginia Beach VA).

Larry Alade has two presentations accepted for the 2005 American Fisheries Society Annual Meeting (September 2005, Anchorage AK): “Application of a Mark and Recapture Model to Historical Data for Yellowtail Flounder off New England” and “A Pilot Study on Tag-induced Mortality of Yellowtail flounder (*Limanda ferruginea*)”

Steve Cadrin presented the keynote address for AFS Southern New England Chapter meeting “Advanced Technology for Fishery Science: experiences with archival tagging” (6/14/06 Fall River MA).

Student Participation

- Larry Alade is a doctoral student at the University of Maryland Eastern Shore working on developing the tagging model for yellowtail flounder as his doctoral research under the NOAA Educational Partnership Program.
- Henry Jackson was an undergraduate student at Jackson State University who provided technical support for the 2004 holding study as a NEFSC summer intern.
- Erica Anuzewski is an undergraduate student at the University of Maryland Eastern Shore working on the 2005 holding study as a LMRCRC intern.

- Jon Loehrke, Greg DeCelles, Talia Bigelow, Sally Roman and Adam Barkley are students in the NOAA/UMass CMER Program, assisting with yellowtail tagging.

Published Reports and Papers

- Alade, L., S.X. Cadrin, T.J. Miller and E.B. May. 2006. Performance of a movement-mortality model on simulated Yellowtail flounder data. A. Fish. Soc. Proceedings (available online at www.fisheries.org).
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