

Establishing Discard Mortality Rates for Atlantic Cod Stock Assessments Using a Modified Delphi Technique

Tuesday, July 24, 2012
Mansfield, MA

Introduction

Discard mortality of non-target fish that are returned to the sea is known to occur in both commercial and recreational fisheries. Empirical estimates of discard mortality in commercial and recreational fisheries are variable and generally unsubstantiated. There has been limited discard mortality research and the results are generally not broadly applicable. Atlantic cod discard mortality rates used traditionally for stock assessment purposes are assumed to be 100 percent. However, this amount of mortality has been highly debated. In order to determine more realistic or reasonable estimates of Atlantic cod discard mortality in the Atlantic cod fishery using different gears, the Northeast Fisheries Science Center (NEFSC) convened a workshop among fishermen representing different gear types; academic, State and Federal fishery biologists; and other experts with experience in finfish discard mortality research. Twenty-nine experts participated in the workshop on July 24, 2012 in Mansfield, Massachusetts and mutually agreed on the Atlantic cod discard mortality rates to recommend to NEFSC for stock assessment purposes.

About the Process

Overview of the Delphi Technique

Atlantic cod discard mortality estimates were determined using an iterative decision making process modeled after the Delphi Technique. The Delphi Technique is a group decision making technique developed as part of an U. S. Air Force sponsored Rand Corporation study in the early 1950's, to determine strategic needs of materials for defense purposes. The Delphi Technique seeks to achieve a consensus among group members through a series of questionnaires, discussions and consensus. This technique enables groups to come to agreement on divergent or disparate opinions among a group of experts. The questionnaires are answered anonymously and individually by each member of the group. The answers are summarized and presented back to the group members along with the next questionnaire. This process is often done via e-mail and is repeated until convergence of estimates occurs among participants or a group consensus is reached.

NEFSC Modified Delphi Technique

The modified Delphi technique used during the workshop incorporated an on-line questionnaire conducted by the Gulf of Maine Research Institute (see below), face-to-face discussions among workshop participants, and an in-meeting questionnaire.

On-line Questionnaire – The Gulf of Maine Research Institute conducted an anonymous on-line questionnaire of industry members, scientists and fishermen. Participants were asked to provide their best and most logical guess as to a reasonable estimate of the percentage of cod that die subsequent to discarding during commercial and recreational fishing using four gear types (commercial otter trawl, commercial gill net, commercial hook and line, recreational hook and line). The survey asked if the respondent was a fisherman, scientist or a fishery manager and, if fishing, the type of gear(s) being used. The respondent also was asked to rank their confidence in their discard mortality estimates and what methods they used to determine that level of confidence. They were also asked what type of research or data would be useful in the future (see responses in Appendix).

There were 33 completed on-line questionnaires. Of those who completed the questionnaire, 19 identified themselves as commercial fishermen – 8 otter trawl, 7 gillnet, and 10 hook & line (respondents could select more than one type of gear). There were 5 respondents who identified themselves as recreational fishermen and 13 respondents who were either scientists or fisheries managers. Table 1 represents the discard mortality rates (in percent) by gear type and by category of respondents during the on-line survey.

Table 1. Atlantic cod discard mortality estimates derived from questionnaires during a Gulf of Maine Research Institute on-line survey.

	Otter Trawl		Gillnet		Hook&Line/Longline		Recreational Hook&Line	
	Industry (n=8)	Research (n=9)	Industry (n=7)	Research (n=9)	Industry (n=10)	Research (n=10)	Industry (n=5)	Research (n=12)
Max	50	100	50	100	60	80	50	75
Min	0	60	1	50	0	20	5	20
Mean	13.75	88.22	13.43	76.67	10.30	53.50	19.40	45.58
StdDev	18.24	14.04	18.23	19.36	17.93	18.27	18.22	18.28

Workshop –An independent contractor was hired to facilitate the meeting. Participants in the workshop included 12 scientists, 6 fishermen, 4 fisheries managers, and 7 staff/other participants for a total of twenty-nine. During the workshop, the participants were able to review information, discuss their experiences with different fishing gear, and debate how much to weigh various factors influencing the discard mortality rates for cod. The following facilitated process was used.

1. Background Information

The results of the GMRI on-line questionnaire were presented with minimal initial discussion. The NEFSC staff set the context for workshop by providing background information. A brief overview of the discard mortality rate studies available and current discard mortality rates used in stock assessments were provided. NEFSC staff also discussed how the discard mortality rates are used in the assessment process.

2. Group Discussion

After receiving the background information, the workshop participants began a facilitated dialog. At the outset, the group decided that the hook and line and the longline categories should be separated and not grouped together. It was determined that these are two different gear types with potentially different mortality rates that should be discussed individually.

The group worked collectively through the information that was available on discard mortality rate for each of the five gear types. During each round of discussions, the scientific literature was reviewed as well as the responses to the pre-meeting on-line questionnaire. Industry members provided additional input based on their experiences and the researchers gave context to the discard mortality rate studies and their interpretation of the results. There was ample opportunity for questions, responses, and clarification so the participants had the ability to consider all the factors that may contribute to the discard mortality rate.

3. Anonymous Questionnaire

At the end of the discussion on each gear type, workshop participants were asked to fill in an anonymous questionnaire regarding the estimated discard mortality rate for that particular gear type. Once the group had worked through each of the gear types and fully vetted potential discard mortality rates for each gear type, the surveys were completed and collected by the facilitator.

4. Reaching Consensus

Results of the second questionnaire were displayed and further discussions ensued. The group reached convergence for all categories after in-depth discussions and debate. Concerns were raised and conversations focused on the concerns until mutually agreeable estimates were agreed on.

Workshop Results

Results from the in-meeting questionnaire were provided to the group in raw form and in aggregate form. The mean, median, maximum, minimum, standard deviation, 25th quartile and 75th quartile were calculated. The group reviewed, discussed, and debated the questionnaire results collectively to determine which numbers to use to establish a range and which numbers to use as the estimated discard mortality rates for each gear type.

There was general agreement among participants that the currently used discard mortality rate of 100 percent is not appropriate. Conversely, the group generally agreed that discard mortality is not equal to zero and should be somewhat higher than 15% to 18%.

The group recognized that there are many factors that contribute to mortality of fish brought up from the bottom of the ocean, pulled out of the water for a time, exposed to ambient air temperature and other physical stresses. In-depth discussions focusing on how the physical stresses, such as barotrauma, temperature gradients, otter trawl or hook damage, and handling by fishermen on deck, helped participants understand the complexity of discard mortality.

Additionally, NEFSC staff explained the use of estimated discard mortality rates as a factor in estimating fishing mortality and its use in stock assessments. The group reviewed a number of discard mortality studies to determine if scientific literature could be used to help guide their estimation of discard mortality. The group determined that a range of discard mortality estimates would be easier to determine, but that a single estimate would be more useful for modeling purposes.

The group determined that there was enough agreement with the outcome of the second questionnaire that the results should stand as the recommended estimates of discard mortality rate to use in the cod stock assessments. The median result for each gear type was selected as the number to use for the discard mortality rate and the range was established based on the 25th and 75th percentiles.

Table 2. Final discard mortality rates for Atlantic cod in various gear and fishery categories. Quartiles (25th & 75th) and median rates are shown for otter trawl, gillnet, longline, hook & line (also jig fishing) and recreational hook & line fisheries are shown.

	Otter Trawl	Gillnet	Longline	Hook & Line	Recreational Hook & Line
25th Percentile	70	68	26	13	20
MEDIAN	75	80	33	20	30
75th Percentile	80	86	39	25	35

Workshop Notes and Discussion

The following is a transcription of notes taken during Atlantic Cod Discard Mortality Rate (DMR) workshop convened on July 24, 2012 at the Holiday Inn in Mansfield Massachusetts. The meeting was convened by a facilitator, Laura T. Singer and there were 29 participants present (See Appendix for list).

Introduction

Loretta O'Brian opened the meeting with a PowerPoint presentation provided by Paul Rago.

- The Georges Bank and Gulf of Maine assessments may use today's results. We wish to solicit field observations from experts like you: fishermen, scientists and managers who have knowledge of fishing operations and associated cod discard mortality rates (DMR).
- Discard mortality use is difficult to assess what its effect on the assessment will be. It may affect or have impact on things like abundance, selectivity of fishing gears, and setting of reference points.

Laura Singer provided guidelines for the workshop. She noted that today's discussion will focus solely on the scientific use of discard mortality rates. The use of DMR by the quota monitoring and management side of NMFS will not be the topic of today's discussions. That may be discussed with participation of the Northeast Regional Office staff at a subsequent workshop. The DMR that we will estimate today and all mutually agree on will be presented to the stock assessment data working group late in August, 2012.

- A science participant pointed out that it is difficult to separate science and management implications.
- Science center staff commented that policies have been inconsistently applied and NERO staff are not available to comments on that point today. We will focus only on the scientific use (in stock assessments) of Atlantic cod DMR in today's meeting.

Use of Discard Mortality Rates from Workshop

A participant posed the question of reasonable expectations from today's meeting in terms of its use in cod stock assessments, where these results will be used outside of the assessment, and will more discussions among others be included.

- The cod assessment working group uses 100% DMR, but it was pointed out that there was great uncertainty in this estimate. Therefore it is being reworked with much broader participation. Today's results will still go to the data working group for consideration and acceptance. The data group will still make a point decision.
- Once the DMR is received by the Stock Assessment Review Committee (SARC) and the Science and Statistical Committee (SSC), they both will review and may or may not get a consensus from them.

- Science Center staff encouraged continued participation in the Stock Assessment Workshop including the data working group meetings.

Results for GMRI Pre-meeting Questionnaire

Laura Singer presented results from a Gulf of Maine Research Institute survey of industry and science communities associated with cod fishing industry. The survey was an initiative by GMRI to help support the workshop. It created a “baseline” DMR to use as an initial starting point in the iterative Delphi process.

- There were 33 responses, (19 fishermen, 5 recreational anglers, 13 academic). Several meeting participants did not get a chance to take the survey. The results showed an overlap between commercial and recreational hook and line fisheries. There were gaps in the otter trawl and gillnet fisheries.

Additional Context for Determining Discard Mortality Rates

Mike Palmer presented a White Paper with results from various studies and literature focused on estimating discard mortality rates, or post-harvest survivability rates. This was a summary of research that will be provided to the data working group, but was also valuable to present to this group.

- Survivability factors include: gear type, depth of capture, size of fish, water temperature as well as surface air temperature, soak time, haul duration and on-deck handling.
- The literature documents survivability rates of between 0% to 87%.
- Most studies documented short term survival rates.
- Stock assessments typically use mortality observed on the surface after discard, but there are other sources of discard mortality that generally go unobserved below the surface, such as escapement through net while on the bottom and escapement under the net. Most groundfish assessments use 100% DMR (closer to truth than 0%).
- SNE yellowtail flounder assessment uses 90%.
- Winter Founder?? Gulf of Maine and SNE use 50% (check this)

Discussion

- A participant questioned the emphasis given on “escapement mortality”, but it was recognized that those figures are simply to say that “observed mortality” is most likely an under estimate of total DMR.
- Another participant pointed out that this discussion should not be limited to mobile gear only. Response was that the outcome from this workshop will include estimate of DMR for otter trawl as well as gillnet, hookline and longline, commercial jigging and recreational angling.
- The literature documented the factors contributing to survivability and that there is most likely cumulative effects that when combined contribute additively to DMR.
 - DMR ranged from 17% to 100% for Atlantic cod. Handline < longline<gillnet< otter trawl in increasing order of DMR.

- Size influenced: larger < smaller size of fish
- Depth of capture influenced: shallow < deep
- Temperature influenced: cold < warmer
- A participant explained that caging and repeated deployment (checking of fish) influence wellbeing and survivability of fish in these studies. Studies themselves may increase or decrease survivability.
- Another participant pointed out that there seems to be little empirical evidence on natural mortality. He wondered by there isn't emphasis put into more accurately quantifying natural mortality.
- A participant asked if the definition of "mortality" should be more concise, such as reduced reproductive capacity or increased vulnerability to predation. "How important is this to the discussion today?" "How should this be handled?"
- Response from another participant: "This is why the estimates of DMR are pushed up."
- A science center staff explained that their observations of avian predation were around 50% in juvenile cod. Barotrauma an issue for fish brought up from depth. Later studies showed a decrease in DMR for all fish (excluding the fish with barotrauma).

DMR impact on the Atlantic cod stock assessment outcomes

A science center staff presented how DMR are integrated into the SA model.

The size of discards and assumptions of discard mortality influence the estimates of population size, by gear type, impact of gear type (% of removals by fishery) size of stocks, etc. Some have little impact while others have greater based on fishery size, effort, and other factors. (sensitivity analysis)

- A review of discard mortality or survivability was conducted by the NEFSC. A presentation of the results showed that DMR range from as low as about 13% to 100% by gear type. How applicable are these estimates and how do things like season, gear types, water and air temperatures, etc. affect the DMR? You must consider local conditions and how they affect the DMR up or down.
- One must identify bias and adjust up or down the final estimates.

Discussion

- MA DMF biologist stated that studies are difficult to filter through. The quality of the literature varies and one cannot make conclusions due to quality of research issues.
- NEFSC staff- Some filtering done, but not formally, question of applicability

- MA DMF biologist- problem with cage survivability studies is that the fish don't feed naturally. This creates a positive bias. (???)
- Sector Manager and scientist: discard estimation (actual and assumed) is universal to population. If we refine the estimate and reduce it from 100%, can it be used retrospectively, for the past, then under sectors? (no legal discards)
- NEFSC staff- mortality rate only approved after discard rate collected. If the questions is, "should they be applied over entire time series?" With changes in mesh sizes, regulations, etc. – What has changed over time?
- Sector Manager- size and age discards now. Smaller sizes, younger ages, now.
- NEFSC staff- Length frequency of discards, influenced by trip limits, had some impact but not great magnitude.
- Sector Manager- trip limits drove a lot of legal sized fish to be discarded. Biomass estimates versus stock status affects of mortality rates.
- NEFSC staff- cage studies – sometimes fish were hand-picked for condition (jigged fish), thus real mortality up or down?
- NEFSC staff- discarding prior to 2010 were over legal size. Use length frequency in assessment lends to # at age analysis.
- NEFSC staff- focus on stock status shouldn't play into discussion. Henry's study not heavily weighed due to biases.
- MA DMF scientist- The Davis paper gave factor affecting survival. Should be option to reduce stress over time because some recover and survive.
- NEFSC staff- physiological stress-some recover when not expected. Gear types are very important factor. Physical injury is different for each gear. Davis work all done in simulated conditions (lab) so must not consider that as "real world work."
- MA DMF scientist- some tagged fish recuperate, we've recaptured the same fish numerous times during tagging operations.
- NEFSC staff- we would like those kinds of observations to be quantified and documented if possible.
- NEFSC staff- the jig fishery typically targets larger fish. Some days no discard, on the other hand, commercial charter boats can have up to 70% discard rates – of common pool fishery.

- Fisherman- some changes this year with the 19" total length limit. Smaller fish are being kept on charter boats.

Discard Mortality Rate for Commercial Hook & Line

The group transitioned to a discussion of the DMR for specific gear types. The facilitator began the discussion by reviewing the range of overlap between the fisherman and scientist responses to the GMRI questionnaire. The DMR for commercial hook & line was between 20-60% based on the survey results from GMRI.

Discussion

- Fisherman- should it be a range or are we looking for a single number? He felt like the lower end of that range should be lower, say 10-15%. He expressed concerns with survey results. Only 30 people responded to the survey.
- MA DMF scientist- information on fishery- not all injury results in death, or immediate death, some fish may live up to a month and die from infection from wound during fishing interaction. They may not feed as efficiently, be more prone to predation, etc.
- Fisherman- in jig fishery, 90-95% are hooked in mouth, no gut hooking. Survival better. No crucifier used, so hooks are not ripped out and cause more damage.
- MA DMF staff- MA DMF tagging project. 2,000 fish tagged, two years at liberty, conditions of fish at time of catch and release, were recorded. Scale = 1 excellent, 2 some injury, 3 severe damage. 6 fish were fitted with acoustic tags- 50% mortality observed.
- These fish were jig caught, 30 days post release, 25% return rate after year, occurred in April – July, recaptured fish condition 2 fish- 5% recaptured, fish were sublegal 24" or less – 19% mortality. All sizes had 17% mortality rate.
- NEFSC scientist-temperature and depth have big impacts.
- NEFSC scientist- could be applied seasonally, but much more difficult
- NE Aquarium scientists- summer months lead to high mortality
- MA DMF scientist- 2 rates? Warm vs. cold?
- Graduate student- can NEFOP observers estimate conditions of discards?
- NEFSC staff- the RAMP technique has been tried and analyzed. There is potential there. It is not applicable retroactively (back in time) (go with range)
- NEFSC staff- splicing seasons for ages (Length at age??) not reasonable.

- NE Aquarium scientist- temperature variable is a major factor for hook gear.
- Fisherman- the hook fishery is mostly fall and winter or early spring. October-March
- NEFSC scientists- numbers like 16% to 17% are tough to explain or use in an assessment model. Rounding numbers more palatable. Agree?
- Sector manager- A reasonable range is 5-15%
- MA Scientist- 16-17% is more like a “floor” range than a realistic range for stock assessments. It is important to consider bottom temperatures rather than top as there is a big difference.
- Maine DMR scientist- Oct. – Nov. GOM bottom temps. Lower than warmer times?
- NEFSC scientist- temperature differential is more important.
- NEFSC staff- currently no discard estimate is applied to handline fishery because there is no information available- next assessment we may pick one so your input is valuable.

After the discussion, workshop participants were asked to fill out a questionnaire with their estimate of discard mortality rate for commercial hook & line gear.

Discard Mortality Rate for Recreational Hook & Line

The group transitioned to a discussion on recreational hook and line.

Discussion

- Recreational & Commercial Fisherman- commercial fishery mostly jig when you’re talking about single hook and line. Recreational fishery introduces bias and there are differences in handling. Time on deck varies greatly, captains and crews try to get fish back in the water faster. 10% of his business?? Varies greatly-captains, crews etc. varies greatly. Tagging in 1993-1990. 200-300 fish tagged. 22-25% returns. 10% over commercial. Will this also include recreational anglers? Yes? Would rate be higher?
- Sector manager- conversations quicker when less information available. Note of concern.....
- Fisherman- recreational anglers’ trips are shorter in duration. 4 hours generally in duration.
- MA DMF scientist- more information on party charters than individual anglers.

- NEFSC scientist- GOM variable. Party charter: 15% (50%) 1993:65%
Private anglers: 75% (50%) 1993: 16%

Workshop participants were asked to fill out a questionnaire with their estimate of discard mortality rate for recreational hook & line gear.

Discard Mortality Rate for Commercial Otter Trawl

The next gear type discussed was commercial otter trawl.

Discussion

- New England Aquarium scientist- more categorical approaches possible? Otter trawl 0-50% industry; 60-100% researchers; 20-100% ???
- Sector manager/scientist- there must be a difference in DMR between pre and post sector management regime. Would this number really be applicable to the entire time series?
- MA DMF scientist- tables 8-12 [referring to Mike Palmer's white paper] have differing numbers for various studies (last 4) using various methods. Top 4 discard mortality studies average around 70%.
- Sector manager- 70-100% seems like a reasonable range. (75%-85%) (19%-1963 data? I think this means that the 1963 data are questionable)
- Fisherman- tow durations are important to take into consideration. Most studies used 15-30 tows and used special handling of fish on deck. That does not reflect normal commercial fishing operations.
- NEFSC scientist- caution advised in using average and interpreting ranges. Mean, median, mode, discussion on statistical measures of central tendency. We may want to consider other measures and not just an average.
- Fisherman- there are real differences in gear types, otter trawl, gillnet, hook line, hook and line, etc. Not sure
- Fisherman- flounders versus cod and size differences make differences in tow duration, and survivability. Cod tows are shorter, focused tows on Middle Bank (Stellwagen Bank) not all fish brought aboard (tripped the bag). The DAS and sector are different management regimes-not equitable.
- Fisherman- sectors have changed the way fishing is done. We can't use long tows anymore. Market is focused on quality product. We are now using codend sensors, we haul back when we know we have 3,000 to 4,000 lbs. in the bag. GOM in Nov. through Arp. Water temps. are colder. YT flounder tows are very short. (may encounter cod)
- 70% mortality (20-30 k Lbs. tows)

- New England scientist- studies should be carried out with longer tows. We don't know when fish enter the net. Tow duration, time on deck and temperatures are most important factors.
- NEFSC scientist- before sectors, is 100% mortality close? Georges records 1980's
- Fisherman- would suggest that the pre-sector DMR was closer to 85-90%
- NEFSC scientist- is pre vs. post sector separation appropriate?
- Sector manager/scientist- interesting, but mortality rate may be higher now, though discards are down- can't split bags, mostly juveniles discarded now
- New England Aquarium scientist- ?? tows mitigate small fish mortality.
- MA DMF scientist- post-release mortality (fish die sometime later or get preyed upon) – so 70% is a “floor” not a “ceiling”
- Fisherman- short tows on Middle Bank (pre-sectors)/GOM because big bags of fish
- 70-85% too high – 50% more likely, a little low, not a big difference pre vs. post sectors.
- 60-70% would be acceptable to fishermen.
- NEFSC scientist- should we be considering cod targeted or non-targeted trips?
- NEFSC scientist- targeted behavior very difficult to determine
- MA DMF scientist- concerned with compounding mortality – observed, post-release, predation, unobserved. These can all add up to 100% mortality, but we know studies show some level of survivability.
- MA DMF scientist- we must interpret these studies with caution, were they technically reviewed, peer reviewed?
- Two scientists remarked here: not under commercial conditions
- Fisherman- GOM- always short tows, not a lot of discard and quickly put back into the water- quite a bit less than 85-90% mortality.
- Sector manager- 65-85% is acceptable. Don't think that we have the capacity to do pre + post sector analysis.

- Fisherman- DAS and trip limits up, volatility – he revised his estimates made earlier to 65-70%
- NEFSC scientist- who survives better, YT founder or cod?
- Fisherman- Cod survive better
- New England Aquarium scientist- flounder survive better, less barotrauma
- UMASS Dartmouth scientist- there are very different stress levels between cod and flounders. Cod are much more vigorous and his experience in tagging flounders has shown that cod are much more robust. Their swim bladders are restored within hours/if not a couple of days (predation is still a problem)
- Fisherman- water depths and barotrauma in studies- 50 fathoms vs. 90-100 fathoms (more in studies) could they be treated separately?
- NEFSC scientist- CA fisheries - > 100% mortality when discarded but small nets, so little discards.
- MA DMF scientist- 6.9% returns on otter trawl tagged fish in the NE cod tagging study
- Fisherman- small fish sorted within 12-15 minutes -> all depends on quantity caught. Do we have GMRI cod tagging returns rates? (17-20+%)
- Fisherman- at least 15% over 757 days.
- NEFSC staff- cod tagging procedures not same as commercial fishing
- ME DMR scientist- short tows but no special handling of fish.
- MA DMR scientist- 5% return only applies to life fish (some % already done)
- Fisherman- I think that during our tagging operations we handled the fish even more than commercial fishing does.
- NEFSC scientist- tow duration for stocks over time -> relatively constant over time. All tows where cod discarded ->could include YT tows, etc.
- Fisherman- would rather see tows 80-90% cod.

After the discussion, workshop participants were asked to fill out a questionnaire with their estimate of discard mortality rate for commercial otter trawl gear.

Discard Mortality Rate for Commercial Gillnet

The group then transitioned to gillnet discussions.

Discussion

- MA DMF scientist- 60% - paper 2010 literature.
- Fisherman- 2 categories 1) day boats 24-48 hours; 2) trip boats 15 hours soak
- NEFSC scientist- soak duration-> majority of discards=soak time < 48 hours (Georges and GOM)
- Sector Manager- seal and dogfish predation high=discards 90% on long soaks
- Weight discard mortality rate toward day trips at 24-48 hours.
- 3.2% return rate for commercial gillnet tagged fish
- 5.2% return rate from research gillnet tagged fish

Workshop participants were asked to fill out a questionnaire with their estimate of discard mortality rate for commercial gillnet gear.

Discard Mortality Rate for Commercial Longline

The final gear type discussed by participants was commercial longline.

Discussion

- 36% from literature (ranged from 54% - 17%)
- Temperature and depth contributed most to discard mortality rate in study (Milliken, et al.)
- 25%-35% range from discard mortality rate study with tows less than 4 hours; this is a conservative estimate with short sets, cold water, and limited hooks
- May want to take into account unobserved mortality
- Perhaps 10-15% on low end

The final estimate for commercial longline was completed on the questionnaire.

Discussion of Final Discard Estimates

The questionnaires were collected and tabulated. The results were presented to the group for discussion. Mike Palmer explained the use of the median and the 25th and 75th percentiles as one way to evaluate the data. It was agreed that the median was the best representation of the consensus of the group. The group discussed rounding the final

numbers for convenience when used in the assessment, but ultimately decided that the recommendations from the workshop should stand as the median numbers and not a rounded number.

Concluding Remarks

Each member of the group was asked to make a final concluding remark at the end of the workshop. Comments below are transcribed from notes take during the workshop:

- NEFSC staff- I am very supportive of this process, I think it to be defensible, positive and a very collaborative approach to solving difficult problems.
- NEFSC staff- I am optimistic that this process will address the concerns of the Science and Statistics Committee (New England Fishery Management Council's SSC) and allow these estimates to be used during the upcoming Atlantic cod stock assessment.
- Fisherman- I think this is a unique process. It was a learning opportunity. It will be most important to "follow-through" with the outcomes from this workshop. I am interested in the follow-up process. I would like to receive the minutes (notes) from this workshop.
- Executive Director of Industry Research Foundation- I am impressed with this process. It is particularly important to follow this logic and make it available to the public so those not present can understand how this process worked. I hope for more work of this nature in the future.
- Fisherman- I support this kind of process.
- Fisherman- I hope industry will be able to support this and provide further information.
- Researcher- I feel a sense of ownership in this process. I support it.
- State Fish Biologist- I feel these are much more realistic discard mortality estimates than the 100% mortality assumption currently used. I feel a need to move forward with more empirical research that may confirm the results of today's meeting.
- Sector Manager- Today I learned about discard mortality and how it is used in stock assessments. This was a valuable workshop.
- Sector Manager- I think this group consensus process is good. I think that industry participation could be increased. They [industry] can provide more day-to-day observations. Some of the discard mortality or survivability research is dated or not established under current management schemes. Some of the old research is not applicable to our discussions today.

- Sector Manager/Fish Biologist- If these numbers move through the assessment process, it will show that our input is meaningful. That will motivate more industry participation in these kinds of efforts.
- State Fish Biologist- There was lots of expertise involved in this workshop. This was an honest discussion and proved to be a powerful tool.
- NEFSC Fish Biologist- It was interesting that opinions and input changed (on the part of the scientists) after discussions with industry members. This will result in updated information.
- Fisherman- I was surprised how the numbers changed throughout the day. I think this is a good process.
- NEFSC Cooperative Research staff- I am very encouraged by the collaboration today. The NEFSC Director and his Deputy are very supportive of these kinds of efforts, i.e., fishermen, scientists and managers working together to establish mutually agreeable processes that solve fishery assessments and improve management. I am optimistic that NOAA Leadership will support more efforts such as today's workshop.

Appendices

Announcement and Agenda

Establishing Discard Mortality Rates for Atlantic Cod Stock Assessments Using a Modified Delphi Technique

Tuesday, July 24, 2012

Holiday Inn, Mansfield, MA

Meeting Objective: Use New England groundfish fisheries experts to discuss and come to an agreement on the best estimate of discard mortality for Atlantic cod (*Gadus morhua*), by gear type and fishing sector.

Overview of Process: The discard mortality estimates will be determined using an iterative decision making process. Experts will provide their best and most logical guess as to a reasonable estimate of the percentage of cod that die subsequent to discarding during commercial and recreational fishing using four gear types (commercial otter trawl, commercial gill net, commercial hook and line, recreational hook and line) through an anonymous pre-meeting questionnaire. The estimates will be compiled and presented to the experts during a face-to-face meeting on July 24, 2012. Additional information on discard mortality rates will also be provided by the Northeast Fisheries Science Center to set the context for discussion. After receiving the information, the experts will be asked to refine their estimates through a second anonymous questionnaire. The results will be compiled and provided to the group for discussion and debate. The group will discuss, defend, and clarify the discard mortality rate estimates and another round of estimates will be solicited through an anonymous questionnaire and the results discussed. This process will be repeated until convergence occurs among all estimates provided by the experts.

Outcome: Estimates of discard mortality will be established for the major gear types used for cod in New England. These estimates will be used during cod benchmark stock assessments.

Meeting Agenda:

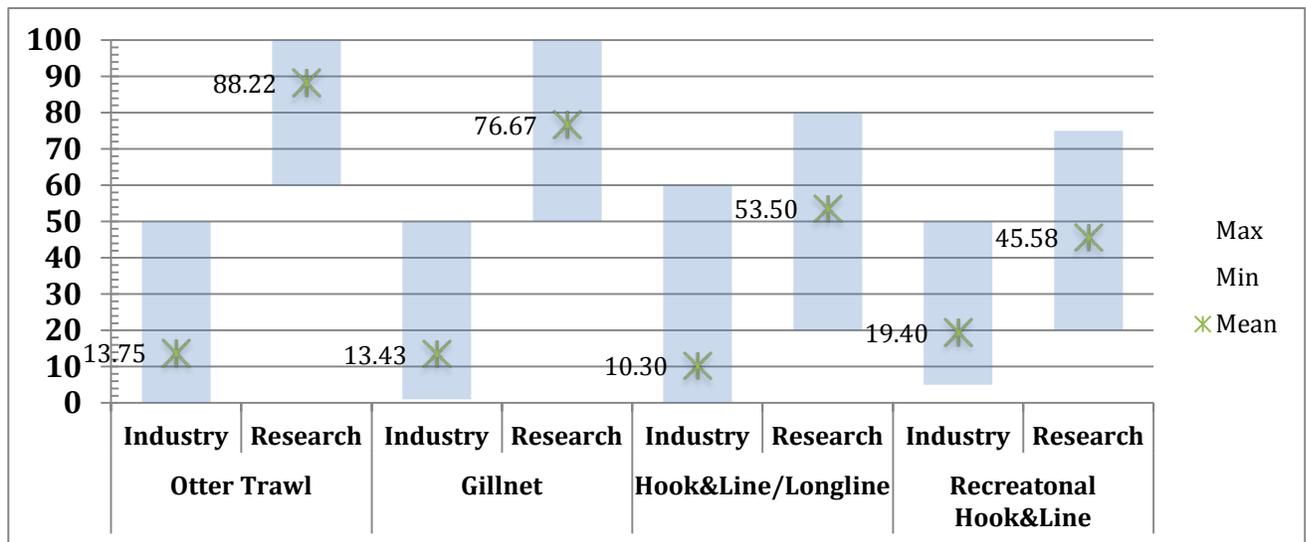
- 10:00** **Welcome/Introductions** – *Loretta O'Brian, Mike Palmer & Earl Meredith, NEFSC*
- 10:15** **Agenda for the Day and Explanation of the Process** -*Laura Singer, Facilitator*
- 10:35** **Present Results from Pre-meeting Questionnaire** – *Laura Singer*

- 11:00** **Providing Additional Context and Information to Determine the Discard Mortality Rates (DMR)** – *Mike Palmer & Loretta O'Brian, NEFSC*
- History of DMR Determination in the Northeast
 - DMR Studies
 - How DMR is Used in Stock Assessments
- 12:30** **Distribute and Complete Questionnaire**
Based on the results of the Pre-meeting Estimates and the information provided by NEFSC regarding discard mortality rates, participants will be asked to take a moment to complete a brief questionnaire to provide another round of estimates for discussion
- 12:45** **Break for Lunch**
- 1:30** **Setting the Discard Mortality Rate by Gear Type**
Results from the questionnaire will be provided. The group will have an opportunity to discuss, defend, and clarify the discard mortality estimates. We will decide if there is enough agreement on the estimates of discard mortality rate to use in the stock assessment or if another questionnaire would be useful for the group.
- 4:00** **Adjourn**

Discard Mortality Workshop Participants July, 24, 2012

NAME	AFFILIATION
Earl Meredith	NEFSC/Cooperative Research
Loretta O'Brian	NEFSC/Population Dynamics Branch
Mike Palmer	NEFSC/Population Dynamics Branch
Carolyn Woodhead	NEFSC/Cooperative Research
Sally Sherman	Maine DMR
Terry Alexander	Otter Trawl Fisherman
Henry Milliken	NEFSC
Mike Pol	MADMF
Mark Szymanski	MADMF
John Mandelman	New England Aquarium
John Haizan	NEFS 13
Daniel Salerno	NEFS 5
Stephanie Rafael-DeMello	NEFS 9
Linda McCann	NEFS 7&8
David Martins	MADMF
Steve Cadrin	SMAST
Tim Tower	Charter Boat Fisherman?
Doug Zemeckis	SMAST
Micah Dean	MADMF
Bill Hoffman	MADMF
Hilary Dombrowski	NE Hookers Association
Tom Dempsey	CCCHFA/NEFMC
Peg Parker	CFRF
Fred Mattera	CFRF/Otter Trawl
Loretta O'Brien	NEFSC
Tom Williams	
Ariele Baker	NAMA
Cherrie Patterson	NH Fish & Game
Laura Taylor Singer	Facilitator

GMRI's Pre-Meeting On-line Survey Results



What key information or data did you use to establish your estimate(s)?

- Observations of cod after capture, some knowledge of scientific literature
- Length of tow, towing depth, and the amount of trash in cod end all contribute to mortality.
- Survival is contingent on many factors and should be listed as a range, which I cannot do in this survey. It is clear that survival in fixed gear fisheries is dependent on both environmental (e.g., depth, water temp) and operational (e.g., soak time, dehooking/removal method) factors.
- published results and conclusions
- Data from 2 years of hook & line sampling of spawning cod for tagging experiments (n = 2000+ fish). Over 88% of cod were released in good condition, 7% of cod were released in poor condition, and 6% of cod died during capture. A subsample of cod released in good condition (n=61) were implanted with acoustic tags and 5% were determined to die post-release, based on observed movements. Approximately 5% of cod released in poor condition were later recaptured, yielding a very conservative post-release mortality of 95%. When combined, these data indicate a discard mortality of 18% for cod of all sizes and 22% for cod < 24".
- personal experience
- Used to be an observer. Saw the condition of fish that came up. Also rec fish. Trawls - dragging fish along all mashed together for hours and then quickly pulling them up from a great depth - not good for survival. Sitting on a dry deck while waiting to be sorted...more death. Getting fish picked over the side - more death. Can't imagine many survive. Gillnet - held relatively stationary in the water for 24-plus hours. Roughly removed from netting that probably damaged their gills. May be pulled up quickly from significant depths. May be difficult to remove and spend a fair amount of time out of the water. Longline - May be hauled relatively quickly, depending on catch. Cod tend to be removed carefully versus being ripped off the hook in the crucifers like dogfish, etc. Longliners put the cod back quickly. However, with handlining, the automatic reelers may pull fish up too quickly and damage them as far as survival goes. With recs, fish tend to come up rather slowly, but folks tend to dawdle and take photos and not properly return the fish to the water after keeping it out for a considerable amount of time. With all gears, discards from highgrading will be at 100%, raising discard mortality rates. I think my estimates were decent as far as the different gears' relation to each other, but exact numbers...? Pretty confident with otter trawl, though. Those fish have it rough.
- Review of numerous research reports

- Observation of fish swimming vigorously. Lack of dead fish on bottom where we have been fishing.
- for hook fishing I am very confident. Gillnet fishing is very tough to calculate because nets left out untended for days has a large mortality that is never recorded as the fish die and fall out of the net before it is hauled. It is insane to try to make estimates based on haul back observer coverage of this fishery because of the fact that sea fleas, wrinkles, dog fish and other predators eat cod fish in these untended nets.
- Combination of observations onboard commercial fishing vessels and information gathered from the published literature.
- Literature , biology of fish, configuration of gear
- I started with the available scientific literature and then selected a middle value from the range of experimental values. Next I considered other local factors such as the length frequency of the discards and discard reasons. Finally, I recognized that the published studies have largely only considered short-term survival in the absence of predation and assumed that the published estimates are underestimated by some unknown amount so I added some additional mortality to the published rates (post-local effect consideration).
- Published scientific studies
- Tracking of acoustically tagged cod post release
- Experience, and the fact that tag-and-recapture studies are an approved method of research that demonstrates that 100% discard mortality is not accurate.
- visually watching fish swim down
- field observations over many trips and years
- First off what is your definition of mortality? NMFS uses anything caught that is not kept. My definition is any fish that does not swim away. If i catch 500 lbs. of cod and release 40lbs. or so, two or three small cod might not swim away.
- Whether the fish actively response to stimulation and resuscitation underwater upon release, swimming to the bottom and not resurfacing. Fish damaged by hooks (gut hooking, eye hooks, etc) were included in the 10% discard mortality. This estimate includes fish caught with treble hook jigs. I am an avid cod fisherman with years of experience. I had to enter a number for commercial gears, but my estimates for commercial gear should be ignored.
- Day to day observations- also I correlate my thoughts by asking observers at days end what my cod discards were.
- experience in catching and releasing them
- I helped develop tagging protocols for cod. I have also held trawled cod in cages to study mortality.
- I never discard any fish, therefore none of my discards die.
- no catch
- eVTRs and its probably overestimated ems is also used
- 27 years of handline , longline and gillnet experience primarily on cod.
- have 4 cameras aboard
- Visual record Short cod are released alive and swim back down.
- The only cod that didn't swim straight to the bottom were ones that were swallowed hooked or had damaged gills
- Health of fish at released and time out of water.

What additional information or data would be useful to help improve your confidence in your estimate(s)?

- Carefully controlled research
- Take discards, put them in cages to check on survival rates over several days. I did this with a fluke grant to check on survival rates.
- Long term survival studies where fish are returned to the water without the benefit of being protected and brought to the bottom in a cage.
- comparative analysis of recapture rate from research and fishery tag releases
- tag reporting rates; tag shedding rates
- gear specific research

- A study of discarded fish involving assessing certain characteristics of the fish before they are returned to the water and how these qualities affect survivability. Stomach/eyes bulging, predator damage, other types of physical damage, is the fish moving at all, even?, etc. Perhaps a tank/fish box onboard a fishing boat to keep fish in salt water that would have been discarded to see how many go belly-up in what amount of time. Granted, nobody will be fish-picking them in the head and gut in front of researchers...
- Predation mortality estimates
- Very difficult to assess long term survival. Tagging and recapture of discards is one approach.
- Sadly it makes no sense to get involved in this discussion because anyone who has been around the New England fishing industry over the last 30 years has seen this huge flaw about the gillnet fishery and no gives a shit good by COD FISH!
- Study of discard mortality from recreational fisheries.
- Additional scientific studies that looked at long-term survival of discards under realistic conditions, both in terms of fishing and handling practices, but also in terms of post-release. One possible way to get at this is through acoustic tags, though this would require cod residence in a particular area over a prolonged period of time.
- The study used 1 gear (jigs) and relatively shallow (50 m). Need info for other hook types and in deeper water.
- some tagging information
- Long term watch of released fish.
- This information should only apply to small charter boat and recreational fishing, Fish dropped from 6 to 12 feet above the water from head boats would have a significantly higher mortality rate (stunned fish do not swim down and remain on the surface to be picked off by birds, sharks, etc.).
- Studies to determine what percent of live discards survive. The government assertion that none survive is foolish.
- Cod mortality is most prevalent on small fish brought to the surface rapidly into warm surface water. Also fish that are mishandled such as throwing them over with picks suffer mortality. I think cage studies should be done for all gear types to get better estimates on gear induced mortality.
- none
- come fishing with me
- holding tank studies