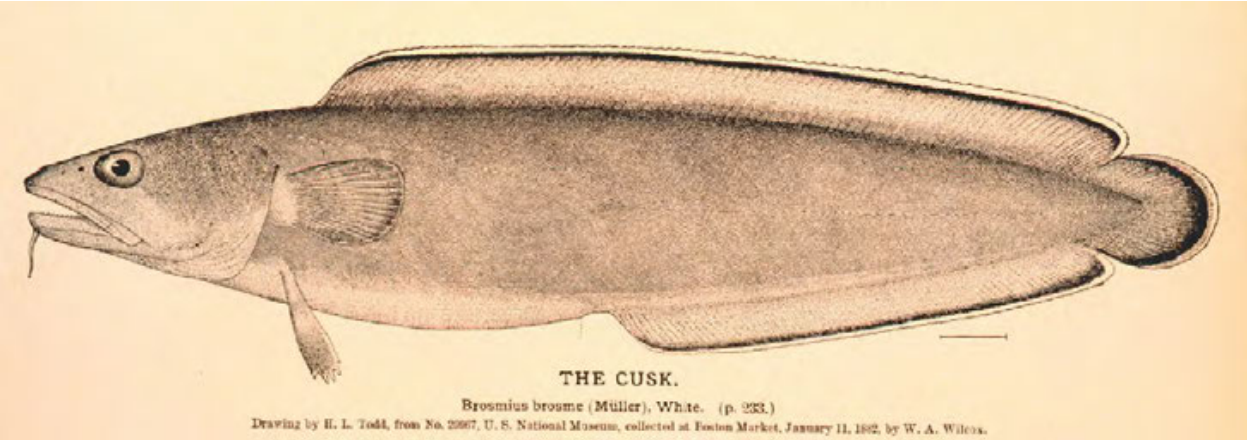
Workshop on
Proactive Conservation Planning for Northwest Atlantic Cusk

December 7-8, 2011, Gulf of Maine Research Institute, Portland, Maine



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Acknowledgements

We would like to thank our participants for making the time at short notice to attend this two-day workshop, and to contribute to a stimulating and highly informative two days. We specifically thank our presenters: Dr. Jon Hare, Loretta O'Brien, Lei Harris, Kim Damon-Randall, Earl Meredith, Kohl Kanwit, Trish DeGraaf, Graham Dr. Sherwood, Diane Borggaard, Debra Duarte, Kate Burns, Bonnie Dr. Rogers, Steve Eayrs and Mike Pol. We also extend our sincere appreciation to three industry members in particular, who each participated in our panel session: Marc Stettner, Tim Tower and Jason Joyce.

This workshop was coordinated by the Gulf of Maine Research Institute, on behalf of and in collaboration with the NOAA National Marine Fisheries Service, Protected Resources Division. Funding for this workshop was provided by the National Marine Fisheries Service.

Executive Summary

In December 2011, the Gulf of Maine Research Institute (GMRI) (on behalf of and funded by the National Marine Fisheries Service (NMFS), Protected Resources Division) coordinated a 2-day workshop on 'Proactive Conservation Planning for Northwest Atlantic Cusk'.

Cusk, which is a data poor species, became a NMFS "species of concern" in 2004; as such, it is a species for which there are concerns regarding the status and threats, but for which insufficient information is available to indicate a need to list the species under the Endangered Species Act (ESA). Cusk was identified through the Proactive Species Conservation Program, which encourages proactive conservation efforts in order to preclude the need for listing in the future. As NMFS has initiated a status review for the species to determine if listing is warranted under the ESA, cusk is also a NMFS candidate species.

By inviting a wide range of participants with backgrounds in science, management and fishing, this workshop is the first large-scale effort at improving our understanding of cusk in the Gulf of Maine. Furthermore, it is hoped that through the efforts of this workshop and discussions on ways to reduce the threats to this species, NMFS can avoid listing cusk as endangered or threatened in the future. More detailed workshop goals are outlined in the first presentation (by Kim Damon-Randall).

The workshop was structured around presentations, breakout discussion groups, and a cusk dissection. This format encouraged constructive discussion, and the exchange of ideas and knowledge between both commercial and recreational industry representatives and scientists, gear specialists and fisheries managers. This report provides summaries of: each presentation and the discussions that followed; the information provided by a panel of three commercial and recreational fishermen; the breakout sessions on Day 1 and Day 2, in addition to full group discussions; and the final prioritization of the short-term conservation mitigation actions identified.

A wide variety of issues, concerns, facts and unknowns were identified over the course of two days. Presentations addressed a number of subject areas, including: the stock statuses in both US and Canadian waters; management differences between the two countries; research progress on cusk in Maine and in other countries (Canada, Norway, Iceland); fishery landings and bycatch over time, and cusk interactions by gear type; habitat and survey options and limitations; and gear mitigation approaches. Of particular interest to many was the discussion on barotrauma research that has been carried out on Pacific rockfish species, and how this work may apply to cusk in our efforts to reduce discard mortality.

The wrap-up session for the two days was captured in both the Full Group Discussion on Day 2 (which focused on options for cusk surveys and gear/bycatch mitigation) and during the Review of the 'Market Place'[1]. It was during the latter, in particular, that a list of prioritized actions was developed to identify proactive approaches to improve information on cusk, and mitigate the impact of incidental catch of cusk. The seven prioritized actions (not in order of priority) were as follows:

1. Lobster trap barotrauma survivability study that includes tagging and the use of cameras to monitor whether cusk escape from lobster traps after recompression.
2. Party/charter industry: implement hook-oriented tagging, bait, and survivability research.

[1] Each break out group identified key actions needed on the issue being discussed – these were then posted on a wall known as the 'Market Place'. Participants from all breakout sessions then reviewed these actions and 'signed up' to specific actions they are willing to be engaged in.

3. Develop a questionnaire for both commercial and recreational fishermen to build our baseline knowledge of cusk, and if possible, enhance the assessment.
4. Establish an industry-based fishery-independent longline survey.
5. Life cycle and age validation analysis.
6. Implement discreet area research in Penobscot Bay and Stellwagen National Marine Sanctuary (SBNMS).
7. NMFS should further explore the use of VTR and observer data to enhance the stock assessment.

Workshop Agenda

Day 1		
8.30	**Breakfast, brief networking**	**Alexa Dayton, GMRI**
8.50	Purpose and Goal of Workshop	Kim Damon-Randall, NMFS
9.00	Format for Workshop (including participant introductions)	Kate Burns, GMRI
9.10	What we know in the U.S. (lifecycle, genetics, stock structure, distribution, habitat and climate change)	Dr. Jon Hare, NMFS
9.25	The status of cusk in the U.S.	Loretta O'Brien, NMFS
9.40	What we know in Canada, (lifecycle, stock structure, stock assessments, distribution, habitat)	Lei Harris, DFO
9.55	Cusk management and conservation in Canada	Lei Harris, DFO
10.05	Cusk management and conservation in the US	Kim Damon-Randall, NMFS
10.20 – 10.30	**Break**	
10.30	A panel of recreational and commercial fishermen discusses catching cusk	Tim Tower, Marc Stettner, Jason Toyce
10.50	Opportunities for cooperative research	Earl Meredith, NMFS
11.05	Q&A and Full Group Discussion. Status assessment and stock structure; What do we know? What do we need to do? Are there gaps? What can we do about these? Who can help?	Moderators: Kate Burns, Alexa Dayton, Laura Taylor Singer
12.15	**Lunch**	
1.00	Research in Maine	Kohl Kanwit, Maine DMR
1.15	Research with the industry at GMRI	Graham Sherwood, GMRI
1:30	Cusk data from NMFS commercial and recreational fisheries databases	Diane Borggaard, NMFS
1.40	Observed cusk records	Debra Duarte, NMFS
1.55	The Fishing Area Selectivity Tool	Kate Burns, GMRI
2:05	Barotrauma: can captured cusk survive if returned to the water?	Bonnie Rogers, Ocean Associates Inc (NMFS SWR contractor)
2.20-3.20	Breakout Session: Group 1 – Barotrauma in cusk	Moderated by: Laura Taylor Singer (Group 1)

	Group 2 – Stock assessment & surveys	and Kate Burns (Group 2)
	Break	
3.30 – 4.30	Full Group Discussion: Stock assessments for cusk	Moderated by Kate Burns, Alexa Dayton, Laura Taylor Singer
4.30	Review of "Market Place," participants 'sign up' to actions they are interested in pursuing.	
5.00	**Finish**	
5.30	**Social and cusk quiz!**	
6.30	**Dinner**	

Day 2		
8.00	**Breakfast and reconvene**	
8:15	Additional thoughts from yesterday's presentations or discussions	
8.30	Gear research and mitigation	Steve Eayrs, GMRI
8.45	Gear research and mitigation continued	Mike Pol, Mass DMF
9.00-9.15	Gear analysis of observer data	*Debra Duarte, NMFS*
9.15 – 10.30	Breakout Session: Group 1 – Lobster trap & Trawl gear Group 2 – Hook gears	Moderated by: Laura Taylor Singer (Group 1) and Kate Burns (Group 2)
10.30 -10.45	**Break**	
10.45 – 12.00	Full Group Discussion: Surveys for cusk	Moderated by Kate Burns
12.00	Review of "Market Place," participants 'sign up' to actions they are interested in pursuing.	
12.15 - 1.00	**Lunch**	
1.00 – 2.00	Full Group Discussion: Mortality mitigation options by gear type	Moderated by Kate Burns
2.00	Review of "Market Place," participants 'sign up' to actions they are interested in pursuing.	
2.15	Cusk dissection	
2.30 -2.45	**Break**	
2.45 – 4.30	Planning implementation of actions	
4.30 – 4.50	Wrap-up session	
5.00	**Finish**	

Day 1

Workshop Purpose and Goals (Kim Damon-Randall, NMFS)

It was reiterated that this workshop is being held to provide a forum for the exchange of information on cusk and its habitat, as well as methods to mitigate and reduce bycatch impacts to aid in the restoration of this species. This workshop will serve as an information gathering opportunity, where the goal is to seek individual expert opinion, data, ideas, comments, or recommendations from individual participants. This information will be shared and discussed and ultimately, will help inform proactive conservation efforts by identifying potential methods and actions for mitigating threats to the species.

Cusk are considered to be a data poor species. There have been very few focused research studies on cusk. The primary mechanism for researching stocks in the Northeast is the NEFSC trawl survey which is not really an effective tool for assessing the abundance and full distribution of this species since it prefers complex habitats that are not effectively sampled with trawl gear. It was noted that NMFS recognizes the fishing industry and others, such as gear and species specialists, have extensive knowledge of the habitats and species in the region and thus, is keen to use this workshop as a learning opportunity, to determine ways of moving forward in a manner that reduces the risks to cusk, in order to preclude the need to potentially list cusk under the ESA in the future.

The primary goals of the workshop were outlined as follows:

- Learn from industry - meet and work with the commercial and recreational fishing industry, gear specialists, species specialists, and fishery management experts to identify measures to reduce potential threats to cusk (following a similar process for both Atlantic wolffish and Atlantic Bluefin tuna resulted in both of these species not being listed, despite being petitioned).
- Identify existing data gaps.
- Identify proactive conservation efforts and research to reduce the amount of cusk taken as incidental catch in commercial and recreational fisheries, while not negatively impacting the industries.
- Identify fishing gear modifications/measures worth exploring to reduce bycatch and identify some other future research needs.
- Cusk & ESA - this workshop is essential to helping us to find a way to work proactively to restore this species now. If we can collaborate on ways to reduce the threats to this species that we can begin implementing, we will be able to consider these efforts in any ESA listing determination under the Policy for Evaluation of Conservation Efforts (PECE) analysis and possibly obviate the need to list the species if listing is determined to be warranted.
- Foster partnerships for future cooperative efforts to help restore cusk throughout their range in the Northwest Atlantic. These efforts will be undertaken through programs such as the NEFSC's cooperative research program with fishermen and others and internally through our dedicated research funds.

Workshop Format (Kate Burns, GMRI)

Kate Burns (GMRI) gave a summary of basic ground rules for the day. In particular, it was noted that everyone present should be given the space to speak, we are all here to learn from each other, whether or not we agree with the observation being presented.

Breakout Discussions

Conversations in the breakout sessions are intended to be very action-focused; we will be thinking about what is 'achievable' and these actions will then be posted in what is known as the 'Market place', to allow for follow-up after the workshop. During each breakout discussion, we will be identifying a number of:

- **Facts:** What do we already know, e.g. data available, resources, etc.
- **Metrics:** What would success look like?
- **Issues:** Questions, concerns, problems or barriers.
- **Actions:** Things we can start working on in a short timeframe.

Finally, this workshop is an opportunity for networking. And finally, we are not here to lobby for management changes, but rather to identify areas for mitigation and proactive measures to improve the status of cusk.

Discussion points:

- If NMFS has not been petitioned to list cusk as an endangered species, why are we here today?
- There is a big difference between what the assessment says and what industry sees.

Presentation by Dr. Jon Hare, NMFS: What we know in the U.S. (lifecycle, genetics, stock structure, distribution, habitat and climate change).

Jon Hare is an oceanographer, and climate change specialist and he has been spending time looking at what might happen to cusk and other species over the next 150 years. Jon noted that he is not a cusk expert.

- The cusk life-cycle is typical of marine fishes; Small planktonic (water column) eggs, Small planktonic (water column) larvae, Juveniles settle from the plankton to the bottom, Adults are bottom (i.e. benthic) oriented; we know the least about the late juvenile/benthic stage. The cusk life cycle is 'slow' compared to other species in the region, cusk have large length-at-maturity and low growth rate, and studies have indicated that 'slow' species are slower to respond to change/perturbations.
- Cusk distribution: Cusk are found across the North Atlantic; In U.S. waters, they are most abundant in the deeper waters of the Gulf of Maine, they extend northward in Canadian waters along the Scotian Shelf. Cusk is primarily a Gulf of Maine (GOM) species, the southern extent of their distribution appears to be the waters just south of Cape Cod.
- Cusk genetics & stock structure: Microsatellite analysis defines cusk into discrete genetic groupings and these groupings are separated by deep water and distance. Genetic studies

have indicated that the deep parts (>1000 m) of the ocean appear to form a boundary to cusk – where the habitats are connected by shelf, there is more mixing between populations.

- Cusk Stock structure: There is no information regarding stock structure within the Western North Atlantic; there is some evidence that cusk move little from bank to bank (which promotes discrete stocks); Cusk have planktonic eggs and larvae (which promotes a unified stock); cusk in the Northwest Atlantic is assumed to be one population unit, but there hasn't been much genetic work done in our region, so this assumption may not be correct. We do need to consider that GOM cusk are linked to other local populations through the Northwest Atlantic.
- Habitat: From the trawl survey data, it is indicated that cusk are a moderate deep-water fish, preferring depths of 100-200m; larger cusk are found in deeper waters. Cusk like complex, boulder reef type areas predominantly; substrates like rocks, corals, ledges and banks. Cusk prefer moderately cold temperatures (6-9 degrees C).
- Cusk & Climate change: One change noted is that cusk are found in deeper, more southerly Gulf of Maine waters in more recent years (the corresponding slides provide a schematic of these changes: the blue circle represented the areas where cusk were found in the 1960/70s, while the red circle represents observations in more recent years). A research group has been developing a habitat model for cusk, it includes information on bottom temperature and bottom 'roughness' or complexity. The model looks at the difference between these two pieces of information. Figures were presented that depict the model's projection of cusk distribution currently, and then with a 1.5 degree C and 3 degree C increase. Temperature changes force a decrease in habitat, coupled with a decrease in suitable substrate; the result is that habitats will become more fragmented and spread apart.
- The list of ecological questions/data needs by Jon include:
  - An improved understanding of the distribution of seafloor habitats
  - Where is juvenile habitat?
  - Do fish move deeper as they grow?
  - Is there stock structure in the Northwest Atlantic (genetics / movement)?
  - How would habitat fragmentation affect cusk?
  - Cusk physiology – temperature, acidification & depth effects
  - Cusk trophic interactions (current data is basic, detailed information is limited)

Discussion points:

- **James Sulikowski: Do we know anything about fecundity?** In Canada, an 82 cm fish was found to have ~4 million eggs (Lei Harris).
- **Tim Towers: When I was a kid, cusk were everywhere from 20 feet to 50 feet**, but you don't see this now – I think that the increased presence of lobster gear is to blame.
- **Marc Stettner: Is this not just a reflection on what gear was used in the 60s**? Juveniles (2-3 lbs) were found in shallower waters traditionally (Ted Ames);
- **Alexa Dayton: Do cusk like to be in dense aggregations?** No (unidentified participant).
- **Marc Stettner: How do you know that they won't evolve to deal with climate change?** We don't know that they won't (Jon Hare).

- **Terry Alexander: How soon can we expect 1.5 degree and 3 degree temperature changes.** A 1.5 degree change may be by the end of this century, 3 degree change may be more like 200 years from now. It's hard to tell, these are just models that come with many assumptions, but 0 degree change is not realistic (Jon Hare). **What does this mean for juvenile habitat?** We're not sure, as we don't have a good handle on what constitutes juvenile habitat yet (Jon Hare).
- **Maggie Raymond: Will the answers to your list of questions come from the fishery**? You won't get them from the trawl survey. Industry certainly have a role to play in this (Jon Hare).

Presentation by Loretta O'Brien, NMFS: The status of cusk in the US

- The cusk stock area is defined as statistical squares 511-515, 521, 522, 561, 562, 464, 465: (see the grey statistical squares on slide 2 of this presentation).
- Catch: Catch history is evident from the late 1880s to the present day: catch records peaked in the 1980s (longliners had contracts to target cusk); in the late 1990s to 2000s, the catch was primarily bycatch and thus dropped dramatically – the catch data comes from the dealer reports and Vessel Trip Reports (VTRs).
- Seasonal pattern: there is very little pattern; on average quarters 1,2,3 each account for a bit more than 25% of the catch while a little less than 20% is caught the 4th quarter.
- Gear: The dominant gear types are trawl and longline, these flip back and forth in terms of the primary capture method; gillnets are the third most dominant gear. These data are federal data, but they do include state landings and inshore waters; 2001 was the peak year for cusk landings from lobster gear, but if lobstermen don't report any bycatch of cusk, then this won't show in these data.
- Length-frequency: all gears seem to select a similar size cusk (45-100 cm), and this picture is consistent over time; the 2005 data may include discards, hence some smaller fish are seen here also.
- Cusk VTR data: Where does each gear type catch cusk? Trawl gear lands the most cusk from the central GOM; gillnets are catching the most cusk inshore; longliners catch cusk both inshore and offshore; lobster traps, catch cusk mostly inshore, though there is less information for this gear type; handline data is fairly sporadic. The distribution of cusk effort is derived from VTR data and lobstermen don't complete VTRs unless they hold another type of federal permit that requires trip reporting.
- Bottom Trawl Survey: The bottom trawl survey was designed back in 1963 primarily for groundfish and particularly haddock. The time series is 2011-1963, so 48 years. There seems to be a good match between trawl survey data and cusk observations reported through VTR data. Though the survey is not designed specifically for cusk, the net is a multispecies net, and all species captured are recorded.
- Biomass indices: If you take the average of cusk biomass observed from 1960-1970, and compare it with more recent years (i.e. 1989-2010), the drop in mean weight per tow (81% in the spring survey, 76% in the fall survey) seems to be consistent what is being communicated by industry, i.e. we are not seeing as many cusk inshore.

- Survey mean length: The mean length of cusk was higher earlier in the time period 1963-1988 (63 cm / 25") than in 1989-2010 (49 cm or 19"). A 6" decline in mean length is pretty substantial, and matches the decline in mean biomass/tow. NMFS does not age cusk on a regular basis, but they did recently and found that the oldest cusk observed was 12 years in age; they also found that males mature larger than females (which is unusual), and that cusk may be maturing as young as ~4 years, which is fitting with other gadid species in recent years. ***Correction note:*** *The age ~4 years is a correction by Loretta O'Brien from the originally stated ~2yrs*. [See aging discussion on page 15; aging methods for cusk are still being developed. ***Information added post-workshop:*** *Subsequent discussion with Icelandic age readers indicate that they age cusk similarly to the NEFSC, rather than the radiocarbon bomb estimate of max age 39/mature at 10.*]
- 2009 cusk stock assessment: A variety of models were attempted (Survey method, Production model, Statistical Catch at Length Model) but none of these were able to be accepted owing to the 'one-way trip' in the biomass data (declining biomass), the conflicting signal of decreasing catch but maximum length not increasing; given the declines seen, there is a lack of contrast in the data. If the catch is declining, you would expect the mean length to increase, but it has not – mean length remains low. A heuristic (back of the envelope) model was developed (by Paul Rago) – see slide and final slide.
- Heuristic Model: The method is based on both the catch and survey data, where assumed maximum and minimum survey catchability (q) and fishing mortality (F) estimates are applied to biomass equations to create six possible time series of biomass. A plausible 'envelope' of stock biomass is determined by 1) taking the minimum of the high biomass estimates (low q and low F) in each year of the derived time series to determine the upper envelope and 2) taking the maximum of the low biomass estimates (high q and high F) in each year of the derived time series to determine the lower envelope. This method is ad hoc, but does provide a feasible estimate of cusk biomass; The average of the minimum and maximum envelope values for 1968-1990 is 22,289 mt and for 1991-2008 the biomass average is 5,171 mt, indicating a biomass decline of ~75% over the time series.
- Points made in summary:
  - Cusk is mostly a bycatch fishery;
  - US discards higher then landings;
  - Trawl survey likely underestimates abundance;
  - Current analytical modeling: results not feasible;
  - 'Envelope' avg. population: 22,000 - 5,000 mt.

Discussion points:

- **What data do you need to improve your estimates of biomass?** To improve abundance data, we need a longline or trap survey (at least a 10 year time series). The way the assessments work, you need to be able to account for all removals – that's just how the models work. There are still [bycatch] data that are not represented here, as the lobster vessels are not observed by NMFS (Loretta O'Brien).
- **Terry Alexander: Why would anyone discard a cusk, you wouldn't?** In Maine, you have to discard cusk from lobster gear (Kelo Pinkham).
- **Marc Stettner: Why do the min/max biomass time series in the envelope method overlap?** Typically they wouldn't. The reason is probably due to the similar declining trend

in both the survey and the catch (both used in the method), and the inherent variability of the survey (Loretta O'Brien).

Presentation by Lei Harris, Department of Fisheries and Oceans Canada (DFO): What we know in Canada (lifecycle, genetics, stock structure, distribution and habitat)

- Distribution in Canada: Cusk distribution (presented based on halibut industry survey (HS) data) is: Labrador to Georges Bank, GOM, Western Scotian Shelf and the slope, cusk is uncommon off Newfoundland and is rare in the Gulf of St. Lawrence and the inner Bay of Fundy.
- Habitat: Adult cusk prefer structured, hard bottom habitat, including boulders, rocks or pebbles and coral. They are occasionally found on mud, but rarely on sand. They have been found to hide in crevices. They are caught from depths of 20-1185 m (deepest set in HS), though they may occur deeper. Their preferred depth range is 400-600 m, based on high catch-per-unti-effort (CPUE) in the halibut industry survey. The preferred habitat of juvenile cusk is not known. Habitat requirements for spawning are also unknown.
- Cusk Biology: Cusk are slow moving, sedentary and solitary. The cusk diet is little known because the stomachs evert (turn inside out and are thus often empty) when they are brought to the surface. DFO has diet samples from ~150 cusk and based on these, cusk appear to feed on invertebrates, e.g. crab (dominant prey species), shrimp and squid, and also fish (silver hake, redfish and herring). Cusk have been found in the diets of cod and halibut, so they are also a prey species themselves.
- Growth and Ageing: No one is ageing cusk at the moment, and when it's done, it's quite difficult. Cusk otoliths are difficult to read (particularly from larger specimens). Preliminary radio carbon bomb dating suggests an 82 cm fish aged at 39 years. These new ageing data suggest that cusk may reach maturity at 10 years, and as such, cusk is considered slow-growing and long-lived.
- Reproduction: Reproduction information has been collected from port sampling data. These data suggest that 50% maturity is around 41 cm (males at 44 cm and females at 39 cm). Cusk is a relatively fecund fish, with ~4 million eggs observed on an 80 cm fish. The maximum cusk length observed in Canada is 118 cm.
- Spawning: Ichthyoplankton data and maturity studies indicate cusk spawning on the Scotian Shelf from May to August, with peak spawning occurring in June. Port samplers have observed cusk in spawning condition as early as March.
- Early life history: The buoyant eggs are 1.3-1.5 mm in diameter with a pinkish oil globule. Pelagic larvae are ~4 mm in length when they hatch and they migrate to the bottom when they are ~50 mm in length.
- Genetics and stock structure: A phylogenetic study of cusk was carried out using mitochondrial DNA; this study included samples from Georges Bank and Scotian Shelf (majority of samples), Newfoundland, Greenland, Norway, and the Mid-Atlantic Ridge. No obvious geographic pattern in distribution of the mitochondrial diversity was detected, so in Canada cusk are considered a single stock and are managed that way. The stock area includes 4VWX5Z (see slide 'Fisheries and Survey Trends').

- Challenges in assessing status: Earlier fisheries data are less reliable. Changes in management for quota species and for bycatch species are a problem for interpreting catch data. Unreported fishing mortality is an issue. There is no dedicated survey (the CA bottom trawl survey is not considered a reliable survey for cusk). No good ageing data exists and there is no quantitative assessment.
- Trends in abundance: We don't have historical georeferenced data for smaller vessels, so this is just CPUE data for larger longline vessels (tonnage class 2,3) in area 4Xnopqu; these data are only for July-September because area closures come into play in October and that would affect the data. Cusk abundance appears to have declined ~40% since the 1980s; this decline in CPUE may have stabilized, or may have declined slightly in recent years.
- Trends in Distribution: Generally speaking, wherever longliners (in 4X) are fishing, they are catching cusk; this is just presence-absence data, so it tells us nothing about how many cusk are observed with each observation. For the time period presented (1986 – 2006) the range (% of 5-minute blocks with cusk observations) is ~75-95%; the prevalence (% of trips with cusk catch) is ~65-80%. Overall, there is no trend seen, while the catch rates are now lower, the industry report that they are catching cusk everywhere, just at lower levels.
- Survey data: There is no dedicated survey for cusk. The research vessel (RV) survey data will not be presented because of its limitations (inappropriate gear type, bottom coverage and depth for cusk). Industry surveys have only short time series. The Halibut [Longline] Industry Survey data is considered most useful; this data begins after the decline seen in commercial CPUE, it is a fixed station design. Based on these data, CPUE fluctuates without trend and 2011 was the highest CPUE in the time series.
- Cusk Status in CA: Abundance is less than in the 1970s and 1980s. Cusk are still widespread and are commonly caught. We have some indicators of status, but no estimate of abundance; the magnitude of decline is not known.

Discussion points:

- **Marc Stettner: Do Canadian data conflict with US data?** No, decline is evident in both (Lei Harris).

Presentation by Lei Harris, DFO: Cusk management and conservation in Canada

- Commercial fishing: Cusk is caught as bycatch, and this bycatch is landed from groundfish fisheries (mostly longline fisheries targeting cod and haddock). It is illegal to land cusk from crustacean fisheries (crab, lobster) so cusk has been discarded bycatch from these (mostly invertebrate trap) fisheries since 1999.
- Cusk Management: Cusk bycatch landings have been controlled through fleet 'caps' since 1999; this allows for the regulation of a fishery's impacts on cusk, while allowing directed fishing for other groundfish species to continue. These caps are allocated to each fleet through a share arrangement and landings against this cap are monitored during the year. Once the cap has been reached, all catch of cusk must be discarded. [For precise 2011 caps, see slide 'Cusk Caps 2011']. Caps are highest for fixed gears, because these gears are responsible for most of the cusk catch.

- Other conditions in 2011: Trip limits were implemented since it appears that some people were found to be targeting cusk; if anyone appears to be targeting cusk they can be charged for observer coverage to monitor their trips – the problem of targeting cusk has declined in recent years. Detail on trip limits is as follows:
  - 4VWX fixed gear, cusk not to exceed 25% of the round weight of the directed species and the trips' landings should not exceed 4,000 lbs round at any time.
  - 5Z fixed gear, cusk not to exceed the lesser of 15% of the amount of cod, haddock and pollock combined onboard the vessel or 3000 pounds round weight.
  - Any license holder found to be deliberately or consistently exceeding limit is required to have additional observer coverage at their expense.
  - DFO may close the fleet's fishery if this occurs.
  - All gears except <45' fixed gear (FG) are subject to 100 % dockside monitoring (DMP) of landings. The <45' FG vessels are subject to a minimum of 25% DMP and the actual level is closer to 50% (100% for FG<45' in 5Z).
- Longline Landings and Effort: Highest reported longline landings since 1970 were ~6,300 mt in 1972, 1973 and 1982; it should be noted that in these earlier years, records of 'cusk' may have also included misreported cod and haddock. Longline landings were recorded at ~500 MT in 2010 when the cap was set at 570 mt.
- Areas of highest landings: The areas with the highest [longline] landings in Canadian waters are between German Bank and Browns Bank, off the NE peak of Georges Bank and in the Fundian Channel.
- Special Sampling Program, 2005-2007: This program looked at lobster bycatch; cusk and other species had been landed legally until 1999, and anecdotal information suggested that bycatch may be high. Industry were reluctant participants at first, but with time participation was good and the results were really helpful. The sampling took place between 2005 and 2007 in two different areas (Lobster Fishing Areas (LFA) 34 and 41) which are two key lobster fishing grounds. In LFA 41 (an offshore area with 8 license holders), over 14,000 traps were sampled across 7 trips; these fishermen were catching cusk in deeper waters between the banks. In the inshore LFA 34 it was easier to get out on trips, because there is higher fishing effort (>1000 fishing licenses); 201 trips were sampled and >70,000 traps, cusk were caught all over the shelf, but cusk catch rate was still highest in deeper waters.
- Lobster fishery bycatch: Cusk bycatch inshore in LFA 34 is higher (461 in 2005/2006 and 344 in 2006/2007) than offshore in LFA 41 (25 in 2005/2006). DFO also requested information on cusk condition and used this to estimate mortality of bycatch. Bycatch mortality rates are lower in LFA 34 (49%) than in LAF 41 (86%) but despite this, the estimated bycatch mortality is higher in LFA 34 (226 and 169) than in LFA 41 (22); this is a factor of having ~1,000 lobster licenses in LFA 34, so even at a lower CPUE, this amounts to considerable bycatch mortality. DFO has no estimates of bycatch or bycatch mortality for other LFAs, or for other fisheries (e.g. the crab fisheries).
- Species at Risk Act: Wildlife status in Canada is assessed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). The federal government decides whether to list under the Species At Risk Act (SARA). DFO has the option to list as designated by COSEWIC, not list, or refer the case back to COSEWIC and request that they consider additional data.

- CUSK and SARA: The COSEWIC Assessment took place in May 2003, and stated "The main population … has been in decline since 1970. Over three generations, the decline rate is over 90%, and the fish occurs in fewer and fewer survey trawls over time. Fishing, unrestricted until 1999, is now capped but remains a source of mortality." This led to the cusk designation of 'threatened' and cusk was being considered for legal listing under SARA. In April 2006 DFO referred the assessment back to COSEWIC for further information since not all available information had been used in the assessment; in December 2006 COSEWIC decided not to include additional information, and instead reaffirmed their original assessment without reassessing the species, citing a lack of new information. It has been a very slow process but the regional listing is now complete and a listing decision will likely take place in 2012.
- Summary of Status:
  - There is no estimate of abundance;
  - The magnitude of decline in abundance is not known (current commercial CPUE around 40% of 1980s);
  - Some evidence suggests that the decline has ceased;
  - Cusk are currently under consideration for legal listing under SARA.

Discussion points:

- **Paul Hoffman: What was the average cusk per 100 traps?** There is a range by area: inshore the cusk per trap for each area was 0.001; in deeper waters it was 0.5 per trap; bait was not standardized. Those fishing inshore hardly see any cusk, those fishing offshore do see cusk (Lei Harris).
- **Aaron Dority: What is the status of some of the other stocks?** Cod are not doing very well, generally the state of CA's groundfish fisheries is not great – I don't know the % of decline (Lei Harris).
- **Diane Borggaard: Can you talk a bit about recreational fishing?** There is no recreational lobster fishing, rod and reel would be the only source but I haven't heard of any (that doesn't mean it does not happen); I don't have numbers but it doesn't seem it be as much of an issue as in the US (Lei Harris).

Presentation by Kim Damon-Randall, NMFS Protected Resources Division: Cusk management and conservation in the US

- ESA Status Review: Cusk has been a "species of concern" for several years (since 2004): a species of concern is a species for which there are concerns regarding the status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA. As a species of concern, cusk is not protected under the ESA. Cusk was identified through the Proactive Species Conservation Program which encourages proactive conservation efforts in order to preclude the need for listing in the future.
- Cusk as a candidate species: Cusk became a "candidate species" when NMFS initiated a status review in March 2007; NMFS' decision was based on the 2003 COSEWIC determination that the Canadian stock should be designated as threatened, and concern over declines in abundance of cusk recognized in both Canadian and U.S. waters.

- ESA Status Review Timeline:
  - March 2007 - NMFS initiated status review
  - August 2008 - Completed draft peer reviewed
  - Late 2008 - Peer review indicated need to consider additional information (particularly recreational landings)
  - 2009 - NEFSC initiated modeling effort to develop population trajectories
  - 2010 - NEFSC determined not feasible to develop reliable population trajectories
  - February 2010 - Qualitative Threats Assessment Workshop
  - April 2010 - Initiated climate change pilot project
- <u>ESA Overview - What can be listed under the ESA:</u> A species, or a sub-species may be listed; also distinct population segments of a vertebrate species. This means a population that is 'discrete' or markedly separate based on physical, physiological, ecological and behavioral factors (genetic or morphological differences can be used). Also, the population must be 'significant', i.e. it occupies a unique ecological setting, its loss would result in a significant gap in the range, evidence that the population is the only surviving natural occurrence, or that the population differs markedly from others in genetic characteristics.
- <u>ESA Overview – Continued:</u> The ESA specifies that a species is threatened or endangered if any one or more of the following five factors is (are) met:
  1. Present or threatened destruction, modification, or curtailment of its habitat or range;
  2. Overutilization for commercial, recreational, scientific, or educational purposes;
  3. Disease or predation;
  4. Inadequacy of existing regulatory mechanisms;
  5. Other natural or manmade factors affecting its continued existence.
- <u>Primary Threats for cusk:</u> The primary threats noted for cusk include:
  - Incidental catch in commercial fisheries;
  - Recreational catch;
  - Inadequacy of existing regulatory mechanisms for fisheries;
  - Habitat loss and degradation, increasing distance between habitat patches.
- <u>Qualitative Threats Assessment:</u> In February 2010, a group was convened to provide information for the status review of cusk based on its data poor nature. Cusk experts ranked a variety of proposed threats in a spreadsheet; **habitat fragmentation** and **recreational/commercial bycatch** were the two threats that were ranked as posing a moderate or high risk to the continued existence of cusk.
- <u>Climate change and cusk:</u> Preliminary results indicate that there is potential for: 1) a decrease in habitat, but not an extirpation from the Gulf of Maine, and 2) increased fragmentation of habitat. The final results will be incorporated in the ongoing status review on this species under the ESA.
- <u>Next steps:</u> Specific next steps include:
  - Complete cusk climate change project winter 2011/2012.

    - Complete status review and associated listing determination in 2012 – NMFS haven't made a decision yet, that is why we are here, ideally we'd be able to reduce the threats so that we don't have to list the species.
    - Proactive conservation efforts are needed & important, for example:
        - Options/measures to reduce commercial & recreational fisheries bycatch;
        - This is an important consideration for NMFS when determining whether listing cusk under the ESA is warranted.
        - The method applied is PECE analysis (Policy for Evaluation of Conservation Efforts).
- Potential funding through NMFS:
    - Proactive Species Conservation Program Grant
    - Species of Concern Internal Grant Funding
    - Species Recovery Grants to States

Discussion points:

- **Mike Pol: The threats listed, are these based on knowns or theorized threats?** The latter, we're hoping to get ideas out of this workshop regarding ideas to mitigate discard mortality (Kim Damon-Randall)
- **Maggie Raymond: Do you not consider the huge reduction in groundfish effort to be a mitigative action?** Yes we do (Kim Damon-Randall).
- **Marc Stettner: It seems like there might be obvious reasons for the declined trend in the last 10 years?** It's the trend that we're worried about, not the actual numbers (Kim Damon-Randall).

Panel Discussion - Marc Stettner, Tim Tower, Jason Joyce: A panel of recreational and commercial fishermen discusses catching cusk

- Marc Stettner: I have a jigging and tub-trawl permit; we don't target cusk (bycatch only), I personally catch anywhere from 0-25 lbs cusk in a day, usually 0-4 cusk per trip, and cusk is important because the price/lb adds to the profits and helps with the fuel costs. If I couldn't land cusk, this would impact me. I don't catch them in muddy areas, they're extremely bottom selective. **Q: Where do you fish?** I fish out of Portsmouth, Scantum, occasionally on Platts in depths of 200-300 feet on average. **Q: Do you see a seasonal change in abundance?** I haven't seen any changes personally, I haven't noticed any specific time frame either – there seems to be more concentration in the spawning season, but I catch them from March through September (which is my fishing season). **Q: Have you been engaged in collaborative research?** Yes, using video cameras to assess cusk abundance in fine scale areas. **Q: Do you see damage to the cusk you catch?** The majority do evert [stomachs turn inside-out] and the eyes are often bulging. **Q: Is this impacted by hauling speed?** I'm not convinced that bringing them up slower will help, my sense is that it's the depth they're coming up from that is more important. **Q: What size fish do you catch?** ~14-30" [estimate, based on hand gestures]. When they're feeding they're aggressive.
- Tim Tower: I love cusk and hake. I've targeted cusk most of my life. In my deep sea business we target areas where we think we will get our biggest cusk and hake, generally in areas up

to 100 fa water. [***Further clarification after the workshop:*** *The Bunny Clark has 41 all tackle/line class/Junior angler International Game Fish Association (IGFA) world records, 19 Maine state all tackle records and 11 Maine state Junior angler records – from various angling fish species found on shelf waters in the northwestern Atlantic*]. Two of the all-tackle world records were cusk. Our largest became a state record but was disqualified for world record status due to the hook displacement index. The fish was large enough to be the largest ever caught but not under IGFA rules. I've noticed that for some areas, e.g. Wilkinson, if you fish the small hard peaks off, cusk won't be back for more than ~10 years [***Further clarification after the workshop:*** *If these peaks are isolated and separated by great distances for cusk to travel (i.e. Wilkinson's Basin) there is very little lateral movement. You don't find cusk in the mud so the chances of these places being repopulated straight away is pretty slim*]. In contrast, on Platt's Bank which is a bank of similar depth, but with hundreds of small hard peaks and edges, you can fish them off of the small hard peaks and they'll be back after 2-3 years, or less [***Further clarification after the workshop:*** *I think this is because the bottom is fairly hard between these peaks, lending itself to a common food source, the depth doesn't present a barrier and the peaks are easier to find- this makes a big difference for repopulation. And when the cusk find these peaks, they tend to stay and it remains a great fishing spot for cusk. The same is true for some of the other shallower hard banks like Jeffrey's, Fippennies, Cashes and Sigsbee. As long as the fishing pressure remains the same, I think you will always have cusk there. As soon as the pressure increases in these outer banks, you will see a tremendous decline in areas - probably similar to the toothfish (Chilean sea bass) saga. So lateral or transverse movement or migration to repopulate areas for cusk is more prevalent on the shallower banks.*]. **Q: Are they adult or younger cusk when they return?** Adult; there are specific places where fish will come back to (it's the same for cod and pollock). When you're targeting peaks or humps on muddy bottom, my theory is that when you fish them off, it's harder for them to repopulate because of the separatedness of the humps. Cusk never didn't use to be a deep water species, in the 1970s you used to catch them inshore; I used to fish 1000-1500 hooks in the spring/fall and we'd catch 2000-6000 lbs of cusk overnight; you could try the same thing today and not catch enough to fill a fish tote. We typically fished for cusk in 25 to 40 fathoms of water. I think the lobster fishery inshore has really depleted the cusk. The inshore area is fished to death by lobster gear, recreational gear, towed gear – we're not seeing cusk in these waters like we used to. When lobstering during the 1960s, we generally fished with redfish racks for bait. When (lobster) shedder (i.e. molting) season time came, we would switch over to herring for bait. When we hauled our traps again, they would be sometimes filled with cusk (unlike when fishing with redfish bait), enough so that it was hard to break a 4 foot trap over the rail. This happened well inshore at a time when no one fished more than 3 miles off. We fish lobster gear everywhere now. And we don't see the cusk (in close) where we used to when I was a kid, nor do we see very many of them up to 12 miles off shore. If you want cusk you have to find a place that no one has fished either with lobster gear or hook gear. **Q: Where do you fish out of?** Ogunquit. **Q: Where do you find the big cusk?** On the top of Platt's you'll sometimes find big (20 lb) cusk, but the big fish are usually in wrecks, in deeper water, and places where gillnets and dragger gear can't get to and the area is too small to set hook (longline) gear. I think the main reason you catch them in deep water is because there isn't the same fishing pressure in deeper waters. **Q: What gear do you use?** We use jigging gear for everything, when we target cusk we use squid heads as bait – we take the head off the body of the squid, take out the beak, take the treble (terminal) hook off the jig, thread the squid head on the stock of the hook and put the hook back on the jig so the "arms" of the squid head dangle past the turn of the hooks. You'll catch any cusk around that can see it.

- Jason Joyce: I'm a lobster fisherman and I also fish tub-trawl from May-August, which is when I mostly catch cusk. When lobstering in the fall we set our traps on mud bottom, which is generally not where the cusk are; if you go just inside of where you'd set the lobster gear, and set your traps up on the hard bottom, you'd catch cusk [**Definition: "up on the bottom"** means putting your gear on a structure coming out of the soft bottom; this is where they try to put their gear]. I don't target hard bottom because I don't want to lose my gear, so I don't see that many cusk when I lobster. Up until 3 years ago, when we were allowed to use float rope on lobster trap trailer warps [**Definition: a "trailer" is any trap after the first/header trap along a string**], I would set trap gear on structured/rocky bottom and would catch cusk. Due to the whale regulations prohibiting float rope, most lobstermen don't set their traps in the areas with jagged/rocky/structure bottom, because the traps become snagged on the bottom and then they get lost. One time when fishing with tub-trawls, in one spot every hook (of 50) were loaded with cusk and they were floating the line up; to me this suggests that it's not the hauling process that damages them.

Discussion points:

- **Ted Ames: Do you fish quite a range?** I fish out of Swan Island, an area of about 40 miles. The area around Mt Desert Rock is quite good for cusk. Year-round it would be Columbia Ledge, the Haddock Nubble, Outer Falls (Jason Joyce).
- **Marc Stettner: Don't get too tied up on the hard bottom theory**, one area where I catch cusk reliably is actually mud bottom with minor relief (that has been confirmed in the video survey he's doing with GMRI).
- **Loretta O'Brien: From your experience of being on the water all these years, do you have any insight into where the smaller cusk would be – the smallest caught on the bottom trawl survey is about 9"?** I've never caught small cusk (Mark Stettner); We've caught the small ones on the banks mostly (~12"), The Fingers, between hard bottom features – the hook size they use means you don't catch smaller cusk, small cod will bite any hook, but not small cusk [which suggests differences in the two species' behavioral feeding patterns and mouth morphology] (Tim Tower).
- **Kate Burns: What differences have you seen in the last 5 years?** We never went back inshore because you can't catch them there so you wouldn't please your customers that way (Tim Tower). I haven't seen a change (Jason Joyce). I haven't either (Mark Stettner).
- **Paul Hoffman: I've seen differences when using different lure colors, have you?** No, we use bait rather than lures to target cusk (Tim Tower).
- **Pingguo He:** We catch small (8-9 cm) cusk in shrimp trawls.
- **What's the biggest cusk you've caught?** 42" / 112 cm (Tim Tower).
- **Ben Haskell: Is Amen Rock a good place for cusk?** You used to catch them there, but I haven't seen any there in 20 years (Tim Tower). On Cashes, not on the ledge but around it, you catch loads of cusk (John Shusta).
- **Have you found anywhere good for spawning cusk?** One July, fishing ~10 miles east of Ogunquit, we'd anchored up on this hard peak and we saw what looked like hake on the sounder. With 16 anglers on board, we caught 7 fish totes at ~120 lbs/~30 fish per tote in about one hour. These cusk were of all sizes and included smaller ones; some were up to 20 lbs and 36" plus. Most of the fish had clear eggs running out of them; there were very few

males. It was a very healthy looking local population of fish. In about 9,000 fishing trips taking anglers since 1976, I have only seen this three times (Tim Tower).

Presentation by Earl Meredith, NMFS: Opportunities for cooperative research

- The Northeast Cooperative Research Program (NCRP) started in 1999; its mission is to bring scientists, managers and fishermen together to work on problems together, and to provide management with better, real-time science.
- Numerous funding opportunities have been made available over the years, for example earmarks for the Northeast Consortium (NEC), Research Set-Aside (RSA) programs which are essentially industry funded, and Congressional Budget line items for NOAA fisheries.
- Funding levels have bounced around over the years – in 2005 the Congressional Budget line item for cooperative research was zeroed out and Congress eliminated many earmarks.
- In the last 2 years the cooperative research funding has been tied to roll-out of the Sector Program here in the Northeast Region ($6M to was allocated to provide technical support to the Groundfish sectors).
- We're still waiting to know what our actual budget will be for 2012, but it's likely to be ~50% of what it was last year, since the sector support budget has halved.
- The cooperative research review report/strategic plan for 2010-2014 was highlighted; this summarizes ~$12M worth of cooperative research work and outlines the direction that the cooperative research is headed.
- One recommendation made in this strategic plan was to develop cooperative research 'networks' where a more integrated program could have greater impact on fisheries cooperative research. In September 2010, the NCRP initiated the Conservation Engineering Network, which in turn, funded seven different research networks: four of which include GEARNET, SQUIDNET, FAST and REDNET; the latter was featured in this month's Commercial Fishing News.
- The NCRP works directly with the New England and Mid-Atlantic Fishery Management Councils and the Atlantic States Marine Fisheries Commission. All research priorities are derived by the Councils' and the Commission' informational needs for fisheries management.

Discussion points:

- **Terry Alexander: How do you intend to enable hotspot bycatch avoidance?** This will be covered in a later talk by Kate Burns (Earl Meredith).
- **Kate Burns: Do you think the NCFR program will be able to support cusk research needs**? It's too early to say right now, because we don't really know how much money we will have to spend. Becoming involved in the Study Fleet program may be one way to improve fishery dependent data available to better understand cusk population dynamics (Earl Meredith).

Presentation by Kohl Kanwit, Maine DMR: Research in Maine

- This is an overview of what research has been carried out by the Maine Department of Marine Resources (ME DMR), not all research in Maine.
- Longline survey (2007-2008): This survey began as a halibut survey, but cusk were being caught too, so it became a combined survey. This was a collaborative research program with 4 longline fishermen. In the 1st year we gridded up the GOM and sampled many deep areas as we had no real baseline data to go by; cusk were sacrificed and biological samples collected (otoliths, gonads). It wasn't uncommon to see no cusk and then get 3-4 in a row. Because this survey was designed for halibut, the sampling season was spring which may not be optimal for cusk.
- Survey design: In each grid, the guys fished 300 hooks. In the 2nd year, for 100 of those hooks they were required to test different hook sizes. All hooks were circle hooks; we used herring and frozen mackerel as our two baits; the gangion length was standardized, temperature data was collected. The guys had some flexibility in how to set their 300 hooks; 100 had to be in the center of the grid, but the others could be spread within a 2 mile radius of the center if the bottom type seemed better elsewhere.
- Length-weight data: The data were consistent across both years, with cusk measuring ~50-90 cm in length, and weighing ~1-8.5 kg. The largest cusk observed were males, though the length-weight data showed comparable weights by length.
- Analysis: Data from the longline survey were analyzed using a generalized linear model (GLM) and a generalized additive model (GAM) to model the relationship between fish density and spatial/environmental variables (location, depth, hook size and bottom type). The GLM performed better than the GAM and results from this analysis showed that bottom type and depth are the first and second most important factors for cusk distribution.
- Otolith reference collection: Tim Bennett and Trish DeGraaf with the help of a contract technician, Amanda Harden, have sectioned and digitized 451 cusk otoliths. There is still a lot of discrepancy between the estimates. Maximum age estimates ranged from 14 – 40, cusk otolith rings are very difficult to decipher. Other hard parts (vertebrae and fin rays) were also collected to try, and different methods of otolith preparation were applied; they even had an otolith aging workshop with experts from the west coast and discussed cusk. Future work may require radio carbon bomb analysis (the testing of nuclear bombs left markers in fish from the 70s); because they haven't tested bombs in recent years, you could only do this on fish collected in that time period, but it might help with identifying older fish. The costs for this are however, quite high: ~$500-600/sample.
- Mortality study: Saltonstall-Kennedy (SK) funding was received in 2010 to undertake a mortality study. NOAA/NMFS purchased pop-up satellite archival tags (PSAT) to be used in the effort and field work took place in 2011. A total of 12 contract trips (longline and traps) were undertaken, but no cusk were caught. The project was saved by a volunteer fisherman from Jonesport (Jason Alley). We were trying to assess mortality, not really movement. We used PSATs rather than cages to avoid limitations associated with holding fish (no predation, food, meshing injury etc.). We used the condition grading (1-4) that Lei Harris used. We don't have much data yet, and not much analysis has been done yet. Only strong cusk were tagged, one assumed dead (tag popped off) after 2 days; one survived at least one month before the tag popped off on schedule; one survived one month but then seemed to die at the surface or was preyed upon; another survived one month but was then near the surface for a few days before the tag popped off; and one more popped off after a couple of

days. The lobsterman did not adapt his fishing technique for this tagging – the point was to assess the impact of (regular) lobster fishing on cusk mortality. Holding a cusk for 15 minutes before tagging is not recommended – they get progressively worse – you need to get them over ASAP. They just keep inflating once they're up – they can look OK at first, but then they just keep expanding.

- Future research in ME: Yong Chen (University of Maine) is looking at a fishery dependent fixed gear survey. ME DMR has not yet replaced Kohl with another groundfish person. ME DMR will be happy to pass this data along for continuation, but they have no funding to pursue ageing work or anything else.
- Survey suggestion: Work with the lobstermen to design a survey.

Discussion points:

- **Do you think that tags came off, rather than it being mortality?** It's certainly possible, there are limitations to tagging (Kohl Kanwit).
- **What temperature did you hold the fish at on deck? (Graham Sherwood).** We didn't, we just got them straight over; when we tested holding them it was just a live well, so ambient temperature (Kohl Kanwit).
- **Pingguo He: Do you really think that if a cusk stays down for 2 days that it died? How would it stay down for 2 days?** I'm thinking it was probably stress from tagging, and then it got weaker and died, and maybe when it's close to the surface but not at the surface, it might be just weak and can't swim down (Kohl Kanwit). *It may also be that if it's in a kelp area, it's caught on the kelp just below the surface (Shelly Tallack).*

Presentation by Dr. Graham Sherwood, GMRI: Research with the industry - Video and hook-and-line survey to further knowledge of cusk distribution and habitat preferences

- The project I'm presenting is a great example of how collaborative research can work – a fisherman (Marc Stettner) had an idea for surveying cusk; it took 2 rounds of proposals to get it funded, but we started in 2011.
- The issue: How much of the decline in landings is due to a real decline in abundance, rather than a decline in effort. If you look at the decline in abundance from the trawl surveys, the question may really be where is the 'true' bottom for cusk, what if it is well below what is seen? Have we overestimated the % decline? As a population declines, you may have an initial contraction of its distributional range to its ideal habitat, but it may stabilize from here.
- A question of habitat: Plenty of species prefer hard/complex bottom, e.g. monkfish – it was thought that there were no large monkfish, but it's just that they weren't in the surveyed areas, because they're on complex bottom, and a GMRI monkfish RSA study has demonstrated this, sampling with gillnets. Monkfish living in complex habitats have higher trophic positions – there is a trophic advantage for large monkfish to inhabit complex bottoms, which may be better for foraging for larger prey. Do cusk prefer complex (rocky) habitats?

- Fine-scale sampling over a range of habitats: To assess this, we planned to conduct fine-scale sampling over a range of habitats in the Western Gulf of Maine (WGOM). We quantify the habitat using a drop video system and then quantify the cusk using a video system (noting visitation rates) and with CPUE data (from hook and line gear). Our hypothesis is that cusk abundance (visitations & CPUE) will increase in more complex habitats, and we may see diet and growth differences by habitat.
- Preliminary results: Four of ten days have been completed to date. Using a camera mounted on a V-Fin (more stable camera down to about 500 feet) we have sampled in the WGOM (New and Old Scantum). Cusk sightings have been captured, and 12 cusk have been captured (fishing is only intermittent since the focus is on video work).
- Video footage: The video footage seems to support the notion of territorial behavior; cusk appear to just hang out and then dive into dens. We may not see many cusk if we tow the camera, because it might just spook the cusk. Just anchoring and simply dropping the camera for a while may improve sightings – you'll still get visitation rates on different habitats.
- Summary:
  - This project received funding as an NEC development award.
  - The method being used looks feasible for collecting fine-scale data on cusk habitat preferences and behavior;
  - Early data support our hypothesis - Cusk have only been found and captured so far in complex habitats;
  - Evidence of disturbance avoidance behavior (hiding under rock);
  - What does this mean for catchability?

Discussion points:

- **Chris Glass: What are you doing about analyzing the videos and impact of camera lights?** So far we've done better anyway at monitoring at < 200 m depth, so we may have to limit the depth of the study so that we don't need to use the lights. Infrared lights may be an option, though we don't have them yet. When you turn on the lights, you decrease the depth field, so this is also a factor (Graham Sherwood).
- **Loretta O'Brien: A point of clarification about the landings, landings represent removals, and they do not indicate abundance;** the survey would be an index of abundance, not the landings. CPUE is no longer used in estimating abundance, because there have been so many changes in effort/management that make using CPUE inappropriate (Graham Sherwood).

Presentation by Diane Borggaard, NMFS: Cusk data from NMFS commercial and recreational fisheries databases

- This presentation is a review of what is contained in the pre-workshop background material (see Appendix 2, page 50; with associated caveats), in case participants did not have a chance to review the information and in case it's useful for participants to consider during the breakout sessions. Much of this information has already been presented or discussed; I'm showing the data in a slightly different way and to further highlight what information is available.

- VTR data 1996-2010: Shows that there has been a decrease in commercial landings (pounds), but an increase in recreational landings (individual fish). Recreational data from the Marine Recreational Fisheries Statistics Survey (MRFSS) shows a similar trend. Cusk are typically kept rather than discarded.
- VTR data 2004-2010: This more recent time frame of data shows that of the gear types with most cusk catch, the majority of cusk are caught with bottom longline (53%), then otter trawl for bottom fish (23%) and then sink gillnets (17%); lobster traps represent just 6% of the catch, and hand line just 1%. The dominant gear type fluctuates over time.
- VTR data and hotspots: Statistical Area 515 (eastern Cashes, The Swells) seems to be a cusk "hotspot," for commercial gear (otter trawl, bottom longline and sink gillnets). For both commercial and recreational hand gear, the "hotspots" are statistical areas 513 and 514. The "hotspot" for lobster gear is Statistical Area 464. Are these hotspots changing over time? Looking at the last two slides, these charts compliment the trends shown earlier in the catch over time for commercial and recreational fisheries from 2004-2010. How much of this is a result of management changes is unclear right now. We are interested in hearing from industry on what this data may mean and how we should interpret it.
- Commercial and Recreational data: The VTR data indicate that cusk may be caught as far south as the mid-Atlantic (and there are some South Atlantic reports), but this is not evidenced in the MRFSS data – why?

Discussion points:

- **Regarding catching cusk as far south as the mid-Atlantic**: People may be misidentifying the species for ocean pout, eel pout, conger eels, etc. (various industry representatives).
- **Terry Alexander: Much of your data starts before log books were required (1994/1995) – how did you come up with these data for these times before log books?** Port sampling data and interviews with fishermen (Loretta O'Brien).

Presentation by Debra Duarte, NMFS Observer Program: Observed cusk records

- NE Fisheries Observer Program: The primary gear types being covered include: gillnet, bottom trawl, bottom longline and scallop dredge. In Fiscal Year 2011, a total of 14,879 seadays, by 201 observers/at-sea monitors. The Observer Program has a training facility in Falmouth, MA and this houses about 50 support personnel (data editors/debriefers, data auditors, trainers, area leads, etc.).
- Caveats to observer data: With only a 3-week lead time for data preparation, it has not been possible to capture everything. Trends might not be generalized over all records; the data are dependent on fishing effort, regulations, variable observer coverage rate, etc.; we cannot extrapolate these numbers to the entire fleet; the data have not been standardized for effort (soak duration, haul duration, string length, etc.). More complex analysis is needed to tease apart interrelated factors. We try to be randomized, but in some areas we have 100% coverage and in other areas we have 10% coverage – so there is only so much these data can tell you.
- All observed cusk records, by gear: The data being presented are all observed cusk records, by gear type. 'Percent occurrence' means the number of observed hauls with cusk/number

of observed hauls (see slides in Appendix 3, page 201). Only hauls in the cusk stock area (Gulf of Maine and northern Georges' Bank) are included in percent occurrence.

- Seasonal trends: There are no obvious seasonal trends; cusk observations are more dependent on where fishing is happening in each season. The Haddock Special Access Permit (SAP) (fall) area seems to show a lot of cusk interactions.
- Catch by month: There is a slight decline in the summer, but only the raw data are presented, and the average weight has not been standardized by soak time etc.
- Catch by depth: Most cusk are reported from >75 fa, with little variation between 75fa and 150+ fa.
- Catch disposition: 78% of cusk records are kept (86% by weight). There has been no significant change in kept:discard ratios over the 10 years of data presented here. Cusk discards due to regulations are from the shrimp fishery.
- Species ID: Observers are trained and tested on their species identification skills. In 2007 they implemented an ID Verification Program: Observers are required to send in samples/photos. For cusk 59 samples between 2009 and 2011 were correctly identified as cusk, compared with 5 samples incorrectly identified. When cusk are misidentified, it is usually for hake and ocean pout.

Discussion points:
None

Presentation by Kate Burns, GMRI: The Fishing Area Selectivity Tool

- The concept is about avoiding hotspots using spatial (near-real time and historical) data, using information about where fish ARE to help you determine where you target and where you avoid.
- Currently it's being used to investigate the presence of cod/spawning cod relative to the rolling closures.
- Should we explore how this tool could be used for cusk?

Discussion points:

- **Terry Alexander: Who are you working with?** Yesterday's FAST workshop in Boston had representatives from most sectors (Kate Burns).
- **Terry Alexander: How many boats are you collecting data from?** So far, none (Kate Burns).
- **Loretta O'Brien: It seems like this type of tool would be better for schooling fish, so since cusk don't school, maybe it's less useful.** Yes, this tool may not be relevant for cusk, but the concept of where not to go is relevant (Kate Burns).
- **Marc Stettner: Spawning cusk are not like spawning cod** – there are no obvious places, it's different every time.
- [The group felt no need to discuss FAST further within this workshop.]

Presentation by Dr. Bonnie Rogers, Ocean Associates Inc (NMFS SWR contractor): Barotrauma - Can captured cusk survive if returned to the water?

- Barotrauma in rockfish: With over 60 species of rockfish on the west coast, this is a problem in various species. The main discard mortality problem for rockfish is barotrauma, due to gas expansion in the swim bladder during rapid ascent. Rockfish have a gas bladder to regulate their buoyancy as they move to deeper or shallower waters, and when they are brought up on a fishing line this gas, due to laws of physics, expands to a greater volume. The rockfish swim bladder is not connected to the throat so they can't off-gas quickly enough.
- Gas expansion: The greatest change in pressure occurs in the first 60 feet of water. If the fish is at neutral buoyancy when captured, the gas volume could increase upwards of 500%, which means that the gas bladder could tear, leak, or rupture. The gas make-up (relative mix of nitrogen and oxygen) will also vary and may contribute to this process.
- Factors affecting injury: The original gas volume at depth (which determines whether the fish is neutrally buoyant, negatively buoyant or positively buoyant) can affect this, as can the species type and/or body shape. Swim bladders in different species have different thicknesses, which affects the permeability, elasticity and rate of healing. Differences in water temperature also play a role in barotrauma (this is likely a contributor to the issue of continual inflation seen in cusk at the surface) as can differences in depth at capture. Finally, fast or slow tissue transport determines how much a swim bladder and other tissues will give way to gas expansion.
- Signs of barotrauma: Typical signs of barotrauma include: exophthalmia (or "pop-eye"), stomach eversion and swim bladder tear. These signs may be different for different species, and external signs are different from internal (e.g. hemorrhaging). Of relevance to cusk, fish that show high degrees of stomach eversion generally do not exhibit swim bladder tears or ruptures. The cusk shows high degrees of stomach eversion, thus it is possible the swim bladder or cloacae may not be giving way under pressure.
- Recompression methods & survival: Various devices have been developed to recompress and improve survival probability for fish: e.g. Inverted barbless hook, disposable gaffs, crates, devices and clamps. Many studies show recompression can work well. For example, cage drop studies have found high survival in rockfish, but of critical importance is getting the fish down to depth as soon as possible.
- MRI slides: Using MRI equipment to investigate the damage of internal organs, the images confirm the external symptoms observed, e.g. over-inflated swim bladder, forcing the stomach to evert, and gas expansion in the orbital space behind the eyes causing 'pop-eye'.
- Organ segmentation: What you see on the outside may not show you what's going on inside the fish; even when no damage is seen, it may still be there. Dissections confirm the damage seen in the MRI images.
- Exophthalmia / Pop-eye: Gas expansion in the orbital space behind the eyes causes pop-eye. Rogers put rockfish in a recompression chamber on deck and transported these fish back to the lab before undertaking vision tests.

- Vision tests: An optokinetic behavioral eye test was carried out (this counts eye movements in response to visual stimuli (black and white bars of different widths, rotating at different speeds). Vision was functional after recompression (for 4 days) and vision improved over time; this experiment was repeated 30 days later and the rockfish showed significant improvement in vision, both for bar width and speed, so this is a good sign that vision injury is recoverable.
- Remarkable recovery in rockfish: 1. Low visual impairment (Brill et al. 2008, Rogers et al. 2011), 2. High post-release survival (Parker et al. 2006, Hannah and Matteson 2007, Jarvis and Lowe 2008, etc.), 3. No histological damage in various tissues, except rare rete mirable hemorrhage (Pribyl 2010 dissertation); 4. Swim bladder healing (Pribyl 2010 dissertation); and 5. Tagged fish detected after 2 yrs. (Lowe et al. 2009)
- Evidence for long term survival in rockfish: Rockfish findings have been similar to other barotrauma injuries; vision is recoverable if the fish recompressed within 10 minutes of capture. I do not know how this applies to cusk, but it's likely that all the gas is staying inside the cusk.
- Application to cusk: Is catch-and-release an option for cusk? Questions to consider include: Are internal injuries lethal upon rapid ascent? Is it possible to prevent stomach hooking, using e.g. circle hooks? Does gas escape the body through cloacae, tears, etc? What is the post-release survival rate? Which method is best: venting, recompression etc.? Cusk advantages for barotrauma research: Cusk is a monotypic species (it is a single species with no recognized sub-species, so all cusk should be the same): differences always intraspecific; cusk is sedentary/benthic species so it could recover on bottom; cusk is a gadid and Pacific cod (*Gadus macrocephalus*) barotrauma studies show 24-hr bladder healing (Nichol and Chilton 2006).
- Venting: Venting the cusk [e.g. with a needle] may be an option, but you have to be careful to not pierce other organs (e.g. the heart) when venting, otherwise that will certainly cause death. The stomach should come back in naturally once the gas has left, so you do not have to push the stomach back in.
- Resources:
  - Rogers' Rockfish information website: http://rockcodfishing.wordpress.com
  - FishSmart.org & NOAA regional workshops on barotrauma are coming up 2012
- References:

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Discussion points:

- **Chris Glass:** World Wildlife Fund (WWF) has just released the results of its latest Smart Gear Contest, and one of them is a **fish release trigger** with a depth release (device was shown to workshop participants).
- **Mark Stettner: Is the swim bladder not connected internally in rockfish?** Rockfish are physoclistic, so they slowly on-gas using a special organ at one end of the swim bladder and slowly off-gas also through the swim bladder. While the swim bladder of physostomous fish is connected directly to the stomach so they can let gas out very quickly (Bonnie Rogers).
- **Jason Joyce: With lobster traps, maybe we can just put the cusk back in the 'kitchen' (the front part of a lobster trap, where catch enter the trap) and re-set the trap to see if cusk will make their way out again once at depth.** You could piggyback on Jim Manning's new video study to see if the cusk swims out (Jon Hare).
- **Lei Harris: I've seen liver damage in our cusk dissections – is there any evidence that liver can regenerate?** A colleague of mine has looked at various organs in rockfish and has found no cellular damage, but if you're seeing such obvious damage with the naked eye it may be a different story for cusk (Bonnie Rogers).

Breakout Session - Day 1

For this breakout session, workshop attendees participated in discussions within the following two groups:

- Barotrauma in cusk;
- Stock assessment for cusk.

Breakout Discussion 1: Barotrauma

Moderator: *Laura Taylor Singer*

FACTS – Barotrauma Breakout Discussion

- Congress is in the process of reviewing the Endangered Species Act. [**Note:** This comment was identified in the breakout discussion; NMFS believes it is important for the summary to note that Congress continually reviews various laws.]

METRICS – Barotrauma Breakout Discussion

- Possibly prevent the need to list the species under ESA;
- Safely and effectively return cusk bycatch so they survive (i.e. no dead, wasted fish);
- Methods feasible to the industry.

ISSUES – Barotrauma Breakout Discussion

- We need to identify health of cusk population:
  - What is population size of cusk?
  - Do we have a problem?
  - Does health of surviving cusk matter?
- There is concern about wasting fish even if there is no current problem with the population. Recreational charter vessels report capturing cusk (up to 20 per trip) as do lobster vessels (roughly 4 per year).
- Key initial questions:
  - What is the initial mortality of cusk across fishing gears?
  - Is the act of bringing cusk to the surface fatal (already) (i.e. is there any chance of survival??)?
- What experiments/trials/research can be done without huge resources? How can industry contribute if willing to participate in short-term studies to make them cost-effective?
- Physiology and discard mortality both need to be understood to evaluate the effects of barotrauma on cusk.
- How serious are barotrauma injuries to cusk?
- Is there any scientific usefulness of dead cusk? Is the current otolith data held by NEFSC useful to anyone to address key age structure questions?
- We need to understand the trauma/injuries from barotrauma (eyes/organs).
- What is the impact of barotrauma on internal organs of cusk?
- Can cusk recover from these traumas?
- Is the use of a disposable gaff feasible, and if so, is there any additional risk associated with the use of a gaff (e.g. infection)?
- Do lobsters or crab eat cusk?

ACTIONS IDENTIFIED – Barotrauma Breakout Discussion

- Conduct study similar to West Coast cage and decompression experiment.
- Focus on shoal areas, and study the lobster offshore and nearshore grounds, but don't bother with inshore.

- Develop and implement studies that combine the disciplines of morphology, physiology, behavior and acoustic tagging to get a complete picture of cusk. (First step may be using spaghetti tags to track fish movement.)
    - Take advantage of current acoustic arrays that have been deployed for other work.
    - Conduct tagging without surfacing and using video.
- Use available dogfish cages to drop cusk back down to depth and video survival.
- Do dissections to view the status of internal organs.
- Assess the current condition of fish coming up from longlines already.
- Explore potential survivability from venting compared to decompression methods.
- Conduct a RAMP study (Reflex, Action, Mortality, Predictor) to develop a gauge for cusk behavior.
- Experiment with mitigation measures used in the West Coast (i.e. milk crate method of release and pressure devices).
- Test survivability relative to time on deck.
- Test effectiveness of moving cusk from kitchen to parlor sections of lobster trap and re-setting trap works as a mitigation measure; start by utilizing lobstermen involved in eMOLT video work being done by Jim Manning at NEFSC

Breakout Discussion 2: Stock assessment and surveys for cusk

Moderator: *Kate Burns*

FACTS – Stock assessment and surveys for cusk:

- Existing data sets:
    - The ME DMR halibut longline survey: 3 hook sizes were tested, 12, 14, 16; this is a 2-year data set
    - Available NMFS data:
        - Observer data: gear, location, soak time, target species, catch species and lbs.
        - Vessel trip report data: gear, location, approx., soak time, catch species, lbs.
        - Dealer data: vessel, gear, catch species, lbs.
        - We have a good estimate of natural mortality.
    - Port biological sampling data: vessel, gear, catch, species, individual lengths, otoliths collected.
- The dealer and bio-sampling data can be cross-referenced with VTR and observer data using the VTR#.

METRICS – Stock assessment and surveys for cusk:

- Documentation of compiled existing data sources, including:
    - observer data
    - Electronic Vessel Trip Reports (eVTR)

    - others?
- A survey that provides more than one function (e.g. abundance, movement, history, sustainability).
- A semi-quantitative (assessment/hindcast/nowcast) that industry and government agree with.
- Improved biomass data.
- Improved life history information: in particular, for growth and reproduction.
- Improved understanding of the health of stock through:
    - Length frequency and Distribution information.
    - Recruitment estimate;
    - Validated age estimates;
    - Reliable estimate of discard in lobster traps;
    - Develop an appropriate survey tool;
    - Attain reliable reporting of cusk in all gear both landing and discards.

ISSUES – Stock assessment and surveys for cusk:

- How do we define 'abundance', 'decline', 'sustainable'?
    - Is the cusk population declining, and if so, what is the magnitude of the decline and is it continuing?
    - What does a natural (unexploited) age/size distribution look like for cusk?
    - We need to understand the spatial distribution of cusk, both current and historic.
    - Data continuity is critical to put new data into historical context.
- Data questions:
    - What will it take to turn a 'data poor' species to 'data adequate'?
    - What are the minimum data needs to prevent cusk from being listed?
- Modeling questions:
    - Can we calibrate assessment survey types? E.g. Trawl/longline, US/CA?
    - Should we use a reef-fish assessment model?
    - Incorporate habitat maps, Gulf of Maine wide.
    - Can hard bottom habitat be used as a proxy for cusk presence?
- Survey questions:
    - Can cusk abundance be measured acoustically?
    - If the current stock assessment method isn't working, we should involve fishermen in future survey efforts: identify a few key locations (e.g. areas of known concentrations) and focus on these.
- Life-history questions:
    - What is the movement rate of cusk?
    - What is the population structure?
    - We need more information on life history traits, e.g. age and growth, and reproduction.

    - We need to incorporate this knowledge/information into the stock assessment process if another stock assessment is carried out.

- Spawning & Juveniles:
    - What do we know about the spawning behavior of cusk?
    - Can cusk vocalizations be used to detect spawning aggregations?
    - Where is the cusk nursery?

ACTIONS IDENTIFIED – Stock assessment and surveys for cusk:

- Survey related:
    - Design and undertake interview surveys: for the lobster industry and the recreational industry, to understand industry's perspective of what is going on with cusk. Consider expanding this to include lobstermen, shrimpers, trawlers/draggers. Ask "how many cusk do you see and where?"
    - Survey recreational boats e.g. a sampling program at the docks.
    - Expand the sentinel survey (Penobscot East Resource Center) and study fleet (to include lobster gear and increase coverage on longline gear).
    - Ask observers to record cusk information (length, spawning) during lobster trips.
    - Undertake outreach with various sectors of industry to request information on catch rates, fish size, bag guts (for diet studies), and bag otoliths (for ageing studies).
    - Combine survey efforts with other factors, like survivability.

- Tagging & recompression:
    - Conduct a tagging study to determine cusk movement/growth: This might be a movement study combined with an underwater release method, multiple tag types, inject the cusk with tetracycline to help with ageing efforts.
    - Promote practices in recompression release methods across all fisheries.
    - Coral reef fish type recruitment/replacement study? (on optimal habitat) advice from SEFSC?
    - Party observer data for tagging length growth data real-time fishing information.
    - Use the boulder ridges of SBNMS as a sentinel site for intensive study of cusk population biology.

- Data related:
    - Establish a data foundation to enable research questions.
    - Conduct selectivity study using observer data cusk bycatch in lobster industry.
    - Re-model/estimate bycatch in ME fishery considering spatial, seasonal, and depth factors as well as actual estimated industry effort.
    - Somehow derive CPUE for longline and lobster gear using VTR data, some future fishing-independent survey or cooperative longline/trap survey combined with continued CPUE. We could "ground-truth" CPUE estimates and create a model to approximate past CPUE and provide a longer series of survey data.

Full Group Discussion – Day 1: Status assessment and stock structure.

What do we know? What do we need to do? Are there gaps? What can we do about these? Who can help?

Moderators: *Alexa Dayton, Laura Taylor Singer, Kate Burns*

Discussion points:

- **Terry Alexander: Cusk biomass should never be close to cod biomass estimates – it should be something like 10% of what the cod estimate is.** You're talking about trawl gear, do you also fish other gears? Across different gear types, do you get the same relative abundance of cusk/cod in trawl gear and gillnet gear? (Jon Hare). *Yes, in gillnets (Terry Alexander).* Longliners would have roughly the reverse proportions versus draggers and gillnets, there are more cusk in longlines than other gears (Merrie Cartwright*). People need to take the 'envelope estimate' with a grain of salt; it was developed simply to give us a ballpark figure. To get a real biomass estimate, we'd need to have a model and data that we could accept, and we don't (Loretta O'Brien).*
- **Kate Burns: What would be useful in terms of survey data, given that there hasn't been a directed survey on cusk?** A longline survey would likely be the best gear to use for a survey (Loretta O'Brien).
- **Marc Stettner: There's been so much change in management (closed areas, fish size, mesh, size, gear requirements, etc.), do you take these changes into account when interpreting the catch data?** We're aware of the changes in management, we did a stock assessment, but we were not able to get an answer. I can't tell you what the size is relative to e.g. cod, haddock, etc. (Loretta O'Brien). *From a fishermen's point of view, it's crucial to match up regulation changes with changes seen it the data and take this into account in the assessments (Marc Stettner).* We did used to catch a good amount of cusk in the surveys in the 1960s, and we've seen this distribution contract and abundance go down – so now we're down to the confined area of the rocky, less fished habitat (Loretta O'Brien).
- **Maggie Raymond: You may want to look at the lobster and deep water red crab fishery data?** I have observed cusk during deep water red crab commercial fishing, but in 2006 during a 10-day trip when we sampled over 13,000 red crab, we recorded only 16 organisms that were not red crab, and none of these were cusk. I definitely don't think it's a common occurrence though it may be worth asking (Shelly Tallack).
- **Maggie Raymond: Has anyone considered the possibility that the cusk we fish in US waters is at the limit of cusk distribution range, in contrast to cusk in CA waters?** What you're seeing the US waters is considered to be the same stock as the Canadian cusk population; I don't know enough about what is going on in the US to be able to say if the cusk in the US is at its southern distribution (Lei Harris). *Cusk in the US is at its southern distribution range (Jon Hare).*
- **Maggie Raymond: I'd suggest more observer coverage in the trap fisheries.** They'd really need to set up dedicated trips in offshore waters; our bycatch data is limited because our goal is to look at discards of lobsters, not bycatch. Observing on lobster boats is not mandatory in ME (Kathleen Reardon). *We have seen cusk in the shrimp trawl data, but in low numbers* (Debra Duarte)*.*
- **Lei Harris: How many lobster licenses are there in Maine?** About 1,200 federal lobster permits with a trap limit of 800 – we don't see many cusk in state waters in Maine. I fish

inshore to ~8 miles offshore and we don't see many (Jason Joyce). [There are around 6,200 Maine State permits].

- **Maggie Raymond: What about the cusk hotspots? Could you survey there?** You could set up a volunteer program, with self-reporting (Jon Hare). The window of opportunity (unless you have guys fishing hard bottom) would be spring (Tim Tower).
- **Have there been any tagging or movement studies?** No, they're hard to tag because their mortality is so high (Lei Harris). There doesn't appear to be a lot of movement compared to other species; some sign of aggregation in the spring (Loretta O'Brien). I've never heard of draggers catching a school of cusk; so these fish aren't moving all over the place (Tim Tower).
- **Kate Burns: Are there longliners in the industry who would be interested and available to do a survey?** There aren't too many longline boats up this way, mostly down in MA.
- **Earl Meredith: Is the VTR data from the headboats being used?** Yes, for the last 5 years, we've been able to get length-frequency data from the recreational industry data that we didn't used to be able to collect (Loretta O'Brien).
- **Marc Stettner:** We need to come up with a way to sample these smaller cusk, maybe video surveys; I bet that when that trawl comes nearby that juvenile cusk dart for cover.
- **Aaron Dority:** Our Sentinel project has covered quite a few fishing locations from Machias Bay south to Swans Island.
- **John Shusta: With the recreational industry, charter vessels have to report their trips, but there are so many recreational vessels that do not have to report, but I see people throwing over cusk because they don't want to keep them, so you're missing a huge part of the recreational industry catch record. I'd guess it's at least double what you've estimated.** There is an estimate from the Marine Recreational Fisheries Statistics Survey (MRFSS) included in the figures presented – it may not be accurate, but it is in there. There is a new method coming out and hopefully it will be a better estimate (Loretta O'Brien).
- **Kate Burns: What would be the ideal data you could collect to use in the stock assessment?** It's obvious that the trawl survey is not the ideal way, and so longline survey would be great, but you'd need at least 10 years (Loretta O'Brien). *In Canada there are fewer longliners now, though it's the same people every year, and there have been changes in the sampling structure. We also use commercial data, though there are problems with that. The longline sets are 1000 hooks per set, so about 50,000 hooks per year (Lei Harris).*
- **How can we try to sample juveniles?** Hook size did not significantly impact catch of cusk or halibut in the ME DMR halibut survey (Kohl Kanwit). *If you're after juveniles you should try fish traps (Kelo Pinkham).* It's a waste of time using traps for a survey in ME – there are too many traps out there for a cusk to happen to enter your one test trap out of 1,000. The answer is to work with lobster men – you won't get the small cusk, but you will get cusk (Kohl Kanwit). *The red crab industry report their data, you could look to see if they catch cusk (Maggie Raymond).* During my trips on red crab boats, I've not seen any small cusk, and only 16 non-crab species were observed in a trip when I measured 13,000 red crab (Shelly Tallack). *We're using some settlement catchers (lobster traps with rocks in them) to try to sample juveniles (James Sulikowski).* You could also revisit the hours of video from benthic

habitat survey (completed by Jon Grabowksi, while at GMRI), there are 100s of hours (Graham Sherwood).

- **Ben Haskell: The Stellwagen Bank National Marine Sanctuary** would be a great place for an intensive study of cusk, because it has so much ideal cusk habitat. We have access to research vessels and tools for non-invasive survey methods. We also need to figure out a way to look at gut content effectively. *Need information on movement of adult cusk, limited movement is implied. Use Stellwagen bank, acoustic techniques and an array (Jon Hare).*
- **Marc Stettner:** We need to know more about the feeding habits of juvenile cusk – they may not be eating what the adults are.
- **Loretta O'Brien: We need to revisit ageing techniques for cusk** – we don't really know if we're looking at fish that live to 50 years, or 20 years… Kohl will be presenting more on this (see page 15).

FACTS - Status assessment and stock structure:

- NMFS considers dealer data to be more reliable than VTR data, due to bias of self-reporting and changes in how fishermen fish;
- VTR landings can be compared with dealer data to check but for the majority of the fishermen, cusk is a bycatch and may be discarded – this is why longliners are better to target because they target cusk.

METRICS - Status assessment and stock structure:

In the next 3-5 years, verify if the current estimated trends in cusk population are the same, increasing, or decreasing in abundance.

ISSUES - Status assessment and stock structure:

- We need more information from various gear types to improve stock assessment. Specifically, we need information on:
  - Diet/feeding habits;
  - Abundance and location (depth and habitat type);
  - Migration patterns.
- Surveys can be expensive and a long time series is needed (example from NCRP);
- Short-term surveys may not answer questions people are asking … we need a long-term survey;
- Diet work could be examined in a short time frame;
- Potential ESA listing is based on best available information so what information can be collected without long-term survey?
- Compliance issues and "divide and conquer" cultural changes in the fishing industry may impact the usefulness of VTR data;
- Is there a subset of fishermen that can be used (who haven't been impacted by management changes) so data is not bias (i.e. impact of closed areas on fishing behavior);
- Issues/concerns were raised about the design of a tagging study;

- Look at ways to collaborate with industry (example: recreational fishery collaboration out on west coast).

ACTIONS IDENTIFIED - Status assessment and stock structure:

- Examine Current Data:
  - Analyze available VTR data by longliners and charter/rec vessels to get a better CPUE;
  - Mine data on ichthyoplankton;
  - Correlate landings data with current habitat maps to get more information on cusk habitat.

Short-term Surveys:

- Pilot industry based survey (IBS) for estimate of abundance and distribution:
  - Conduct Pilot Depletion Study to determine catchabilty of cusk by long line;
  - Calculate Biomass estimate based on (longline landings data? Or IBS survey?);
  - Conduct every other year for 3-6 years;
  - Initial data could be compared with what is currently assumed as the trend;
  - Longer term survey could show trends.
- Pilot Lobster Trap Tagging Study:
  - Addresses bycatch issue/question;
  - Expands information about migration;
  - Provides population estimate in a specific area;
- Capitalize on Current Time at Sea:
  - Develop and implement volunteer/opportunistic pilot tagging study in specific areas to address migration;
  - Expand current sentinel survey (Penobscot Bay) and use boulder ridges off SNMS as sentinel site for intensive study of cusk population;
  - Expand use of the Northeast Fisheries Science Center Study Fleet Infrastructure to lobster gear and increase coverage and longline gear;
  - Have observers record cusk when on lobster trips.
- Network Among Scientists:
  - Coordinate and Collaborate with researchers on halibut/hake/wolfish research and piggy-back on ongoing field work.
- Network with Industry:
  - Survey fishermen to get a sense of how often they interact with cusk, where cusk are recruiting , and capture reproductive information;
  - Identify network in industry to target and interview.
- Outreach with various sectors and request catch rates, fish size, gut samples, and otoliths.
- Replicate coral reef fish-type recruitment/replacement study (on optimal cusk habitat "islands")? (Could we get advice from the Southeast Fisheries Science Center (SEFSC)?

Long-term survey/work:

- The ideal would be a 10-year time series that included landings data;
- There is potential to combine a cusk survey with surveys for other species, e.g. wolfish;
- Look at landings from three fishing grounds over time: e.g. Jeffreys, Platts, and Cashes.

Day 2

Additional thoughts from yesterday's presentations or discussions

- **Lei Harris: Two points of clarification regarding ageing:** For the CA radio bomb sampling, DFO had a number of samples >30 years. Also, it was clarified that NMFS estimates maturity at age 2, not age 7; this is a big difference from DFO's estimate of 10 years.

Presentation by Steve Eayrs, GMRI: Gear research and mitigation

- Disclaimer: I don't know much about cusk other than having caught and eaten one once!
- What do we know about how and where cusk are caught? Most of what is presented on this first slide is based on comments from yesterday. Cusk have a preference for rocky or pebbly locales, rarely smooth bottom. They are caught at a variety of fishing depths, in waters >100–600 ft. Cusk are reported in catch data by gear type: cusk are caught in bottom longlines, gillnets, trawl gear and by rod and reel, accepting a variety of baits and jigs. Cusk represent bycatch in lobster traps; one question I have is whether derelict gear causes mortality in cusk?
- So how do we decide where and how to apply gear conservation measures? Maybe a good starting point is to look at the whole catch cycle, and use this as a framework for the fishing operation.
- The catch cycle framework: (see Appendix 3, page 233). This framework highlights the complexity of the entire fishing operation, and it is a systematic, in-depth way of thinking about the operation. It gives us a greater understanding of the factors that influence gear selectivity and efficiency and that selective processes occur throughout the catching cycle, from the time fishermen leave the dock until the fish are landed. The framework applies to any gear and does not differentiate between cusk as a target or non-target species. The framework helps us identify how little knowledge we have of the relative impact/importance of specific factors that affect selectivity and where the knowledge gaps lie, so that we can prioritize future research. The framework shows a series of steps, that interplay to determine what portion of the available cusk are retained:
  - **searchability** = f (the application of fishermen knowledge and skill, searching equipment, timing & duration,…);
  - **vulnerability** = f (cusk behavior i.e. habitat, migration, vertical distribution,…);
  - **bait selectivity** = f (fished location & depth, olfactory response, swimming performance,…);
  - **bait/hook selectivity** = f (bait attractiveness & size, hook size & design,…);
  - **hook selectivity** = f (hook design, gear design, predators,…);
  - **onboard selectivity**= f (fish handling, predation prior to hauling, management regulations, market preferences and needs,…).
- So where do we start? To take proactive steps to conserve cusk, we could:

- Nail down when, where, and how cusk are caught (published and anecdotal information on fishing mortality);
- Identify threats to fishing mortality (retention, discards, predation, drop-out mortality, etc.);
- Identify data gaps & opportunities to reduce mortality based on the fish capture flowchart;
- Prioritize next steps: We have some idea about retention and discards, but do we know anything about predation and drop-out mortality? When we know more of these questions, we'll be able to prioritize the next steps.

- Environmental Management System (EMS): This is a 4-step process (Plan, Do, Check, Act). This process does work and is already being implemented in pockets of the fishery here in Maine. This systematic approach can also be applied to cusk. For example, at this workshop we're beginning to *plan* (identify project scope, assess environmental impacts and related legislation) and we're about to start establishing our goals and priorities for action.
  - **Plan:** identify project scope, assess environmental impacts & related legislation (context), establish goals & priorities for action;
  - **Do:** develop environmental policy & management program (objectives, targets, roles & responsibilities, & implementation of prioritized actions);
  - **Check:** performance measurement of actions;
  - **Act:** document performance & outcomes; provide evidence of steps to improve performance; serve as a platform for future corrective action.

Discussion points:

- **Ted Ames: In your EMS system, you develop a plan and then do it, but do you need to do a pilot scale test before applying it to a whole fishery?** You can adjust the scale of EMS during the planning, if you want to test it pilot scale first, then make this your plan/objective under the EMS approach (Steve Eayrs).
- **Laura Ludwig: At the Gulf of Maine Lobster Foundation, we have a project for "Derelict Fishing Gear Recovery and Disposal". In over 3,500 ghost gear traps hauls, not one cusk was observed, but other finfish were.** I think cusk can swim in and out of traps as much as they want (Steve Train). *And frankly that point was made not because I believe that all derelict traps ghost fish, but to raise the topic and get the discussion out there (Steve Eayrs).*

Presentation by Mike Pol, Massachusetts Division of Marine Fisheries: Gear research and mitigation continued

- So where do we start? To take proactive steps to conserve cusk we could: Collate published and anecdotal data on fishing mortality (when, where, and how); Identify key threats to stock mortality; Identify data gaps; and then Prioritize the next steps. Steve and Mike have started collating published and anecdotal data on fishing mortality. This workshop is helping to identify the data gaps.
- Conservation Engineering Approach: These are the type of things that we (gear researchers) think about, and maybe there is something about cusk that is different that can

be easily separated from other species. Often much of this data is not known, unpublished data is often just as useful as published data. Also, looking through your own personal libraries/data at past studies you may find you have information on cusk, and can then share ideas with others. A typical conservation engineering approach might include the following process:

- 1) Understand the capture process in all its detail (using Steve's example, consider all the multiple steps);
  - searchability, time = f (application of fishermen knowledge & skill, searching equipment, timing & duration,…);
  - vulnerability = f (cusk behavior, i.e. habitat, migration, vertical distribution,…);
  - encounters = f (fished location & depth, olfactory response, swimming performance,…);
  - bait, hook selectivity = f (bait type & attractiveness, hook size & design,…);
  - hook retention = f (hook design, gear design, predators,…);
  - onboard selectivity = f (handling, predation, mgt., markets,…);
- 2) Find the "known knowns":
  - **Types of information:** Behavior, distribution, catch records, physiology, habitat, life history, feeding habits, food preferences; there are typically, many gaps.
  - **Sources of information:** Fishermen's experience and practice, Databases – VTR, catch reports, etc., Scientific libraries (these focus on successes), Reports (often less-successful but useful), Personal libraries (overlooked tidbits), Networks (local, national, international).
  - **Similar species as models:** Other snaky demersal things? Wolffish, ocean pout, white hake, tilefish, etc.
- <u>3) Develop a common knowledge about the species behaviors</u>: Cusk like boulder bottom and mud bottom; cusk are soft bodied; cusk are small mouthed, cusk are described as "Benthic and sluggish fish not known to undertake migrations"; cusk are sound producing; cusk are aggressive toward bait and species; cusk are tolerant of conspecifics.
- <u>4) Existing studies on gear and size selectivity:</u> In Norway, they target cusk with pots and longlines and they have carried out bait studies: squid yielded higher catch rates of cusk than herring or mackerel, and squid bait caught 9% more cusk than mackerel bait on longlines. Icelandic bait and hook size studies have shown a size/catch effect with hooks (in contrast to what Kohl found with the DMR study), where larger hooks caught fewer cusk; and larger baits caught more large cusk. MA DMF studies revealed the following:
  - In haddock bait tests for longlines, cusk were only caught with herring (versus clams or Norbait 700E) in a longline bait test using 11/0 circle hooks in 8 overnight sets in Mass. Bay in 2007;
  - Cusk were only caught in flatfish gillnets (not in cod gillnets, dual leadline, or lead-added floatline gillnets) in 35 overnight soaks in Mass. Bay in 2000-2002;
  - Cusk were second-most common bycatch in a haddock gillnet selectivity trial in WGOM in 2004 (4.5" – 6.5" mesh);
  - MA DMF Cod pots only caught one cusk.
- <u>5) What are the data gaps?</u> There seem to be huge data gaps, in particular, we need to:
  - Continue searching information sources;

  - Design experimental approach to provide answers;
  - Prioritize efforts.

- Network VS Competitive Approach: I'm a big fan of networks, you're more likely to get a good product out of networks, because they're: outcome oriented, inclusive, people-based and efficient. Examples of research networks that I'm involved in are:
  - REDNET: 40+ people working toward sustainable redfish fishery;
  - GEARNET: Technology transfer and small-scale gear experiments with 10+ groundfish sectors.

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Discussion points:
None.

Presentation by Debra Duarte, NMFS Observer Program: Gear analysis of observer data

- Catch by gear: 41% of all observed longline hauls have caught cusk; this is the highest compared to all other gears.

- Dominant gears by target species:

  - When targeting haddock: trawl and longlines catch cusk.
  - When targeting cod: bottom trawl and gillnet
  - When targeting pollock: bottom trawl and gillnet
  - When targeting monkfish: bottom trawl
  - When targeting flounder spp: bottom trawl

- Catch by target, gear: Haddock longline sets have the highest interaction rate for cusk, followed by drift gillnets for hake,
- Hook gear trends: A total of 2024 out of 4911 (41%) observed longline hauls caught cusk with an average of ~12lbs per haul; Handline and auto-jig did not catch high levels of cusk though this could be just what they were targeting and where they were fishing. For handline/rod and reel, 1 haul = 1 fishing session/drift, not one hook drop.
- Longline trends: There is no correlation between cusk catch rates and hook type (brand, pattern, size), or the distance between hooks, but bait effects are seen in these data. Clams are not good for catching cusk, and this is seen also for hauls that are a mix of herring and clam. Squid catches slightly less cusk than herring and mackerel do, though the data have not been standardize by location, etc. so it may be a factor of where they're these vessels are fishing.
- Closed Area 1 Haddock Hook SAP: We've seen a slight decrease in cusk occurrence over the years, though we may be seeing an increase in cusk catch for 2010 data.
- Gillnet trends: Drift sink gillnet data: 252 of 1446 hauls had cusk (17%), with a total of 3754 lbs and an average of 2.6 lbs/haul. For anchored sink gillnets: 782 of 18,393 hauls (4%) yielded a total of 9788 lbs; with an average of 0.5 lbs/haul.
- Gillnet mesh sizes: 6.5" has the highest interaction with cusk, but this is also the most common mesh size used, so this might just be an artifact. Overall, it seems that larger mesh sizes will interact less with cusk. There is possibly some correlation with net height, but this needs further analysis. Cusk are rarely found in nets with tie-downs (~1%).
- Trawl trends: There is no difference between large and small mesh and net liners do not have a noticeable effect. Diamond mesh is more likely to catch cusk than square mesh (7% VS 2%) though the average weight of cusk caught in each is the same. There is less data available for the haddock separator trawl and the Rhule trawl (these are newer gears, so we only have a couple of years of data), but they seem to catch less cusk, so one question may be whether cusk behave more like cod (since these gears are designed to avoid cod)?
- Pot/Trap Trends: The NMFS observer program doesn't cover these trips very often, so there is not much to say about these gear types. No cusk have been recorded in observed trips between 2000 and 2010.
- Length by gear type: Similar average fish length in anchored gillnet, drift gillnet and bottom trawl; in longline gear cusk are slightly shorter and cusk observed in shrimp trawls have been much smaller (~20 cm), however, it's a smaller dataset.

Discussion points:

- **John Higgins: Does the observer program have information on how big is the drift gillnet fishery and where it takes place?** Yes, we have that data and I can give it to you if you're interested (Debra Duarte).

- **Kelo Pinkham: How much confidence do you have in the observer's identification of cusk in the shrimp trawls?** In newer data we have more confidence because we do have a pretty stringent ID verification process (Debra Duarte). *I was asked if I'd been catching juvenile cusk in my shrimp trawl, because the observer had mis-identified small fourbeard rockling as cusk (Kelo Pinkham).*
- **Within a gear type, there may be some fisheries that we're missing,** it comes down to budget and guidelines for how many trips of each kind we're tasked with covering (Debra Duarte).
- **Earl Meredith: The NEFSC Cooperative Research Program has funded a number of new gear types**, and one gear type in particular that may change the trend you've presented here is the topless shrimp trawl – you may see fewer cusk caught with these gears.

Breakout Session – Day 2: Cusk avoidance through gear selectivity

For this breakout session, workshop attendees were separated into groups by gear type:

- Lobster traps and trawl gear;
- Hook gears: recreational jigging, commercial hand gears and longline.

Breakout Session 1: Investigating lobster trap and trawl gear interactions with cusk

Moderator: *Laura Taylor Singer*

OBJECTIVE:

Determine if cusk is a bycatch issue for the lobster fishery ("issue" = interact significantly so as to impact lobster industry if cusk is listed under ESA):

- Quantify mortality of cusk bycatch in lobster fishery;
- Determine if cusk can escape and survive when hauled and re-deployed.

FACTS:

- Lobster traps spend more time offshore;
- Of the 3,300 ghost gear traps recovered through the GOM Lobstermen Foundation's program, no cusk were found as bycatch (could be due to most gear grappled back from non-rocky bottom?)
- There is very minor, but real, bycatch in lobster trap gear based on ME data;
- Lobster fishermen noted that they must discard cusk caught in Maine state waters (with the exception of personal use, they are not permitted to retain or land cusk). [**Note:** Following the meeting, Maine DMR clarified that state regulations specify that lobstermen cannot sell cusk caught in their traps. Cusk can be taken by hook and line, but the harvesters need a commercial fishing license];

- The MA inshore survey has only caught one cusk during entire history of survey.

METRICS:

- Determine if cusk is a bycatch issue for the lobster fishery ("issue" = interact significantly so as to impact lobster industry if cusk is listed under ESA);
- Quantify mortality of cusk bycatch in lobster fishery;
- Determine if cusk can escape and survive when hauled and re-deployed.

ISSUES:

- Lobster Traps:
  - Does the design of trap gear (size and hoops/heads) influence the ability to catch cusk?
  - What is the residence time of cusk in traps on the bottom?
  - How big is the bycatch problem in the lobster fishery?
  - Do spaghetti tags work in cusk?
  - Changes in fishing behavior (i.e. sinking groundline) change the potential interactions with cusk.
- Trawl gear:
  - Are juvenile cusk really found in shrimp trawls? Is 10% an accurate number?
  - What are the impacts/changes in cusk bycatch with topless trawl? Ruhle trawl? Other recent gear changes?
- Important considerations:
  - Representatives from the gillnet industry and offshore (Area 3) lobster fishery are missing from the discussion.
  - Area 3 lobstermen fish in deeper water and should be involved in tagging/release work.

ACTIONS IDENTIFIED – Lobster trap interactions with cusk

- Network with Industry:
  - Go to Zone F (tonight) and ask fishermen to report interaction with cusk. Assigned to Steve Train (Industry) who will report to Kathleen Reardon (ME DMR).
  - Work to connect with Area 3 Lobstermen on cusk bycatch questions. *Assigned to Diane Borggaard (NMFS), to connect with Bob Ross (NMFS).*
- Build off of Maine Sea Sampling Program:
  - Quantify cusk bycatch using ME lobster sea sampling data;
  - Ask sea samplers to record state of cusk returned to water;
  - Collect information on: time on deck, depth of trap and type of bait;
  - Remodel/estimate bycatch in ME fishery considering spatial, seasonal and depth factors as well as actual estimated industry effort. *Assigned to Jeanie Cushman (graduate student at University of Maine at Orano (UMO) and Kathleen Reardon (ME DMR).*
- Query DMF lobster sampling data for cusk by catch. *Assigned to Mik e Pol (MA DMR).*

- Initiate a Tagging Study:
  - Initial step - Look at other tagging studies in Norway for efficacy of using spaghetti tags;
  - Partner with lobstermen in closed area for area-specific tagging study:
    - Avoid lights on camera;
    - Stratify study by factors thought to affect survival and barotrauma (e.g. depth, temperature, time out of water, etc.);
    - What is the survival rate of cusk returned to water in a trap?
  - Use tagging information for mark-recapture estimates of abundance.

If cusk DO escape	**If cusk DO NOT escape**
• Expand study to broader area: • Build off participants in eMolt to video and tag – speak to Jim Manning about tagging cusk. <u>Investigate Techniques and Educate Lobstermen:</u> • Investigate optimal methods to return cusk safely and effectively to depth; • Educate lobstermen on why and how to safely return cusk - leaving cusk in trap and setting back alleviates issues if air bladder is not damaged.	<u>Research options for mitigation:</u> • Mechanisms to recompress; • Consider gear modification studies and/or use of other tools (i.e., trap, milk crate, quick release device); • Look at cusk bycatch based on trap head design (hoops vs. hake mouth). <u>Practice avoidance:</u> • Encourage fishing in areas without cusk.

ACTIONS IDENTIFIED: Trawl gear interactions with cusk

- Explore data available at the UMO to explore cusk bycatch in shrimp trap fishery: *Assigned to Jeanie Cushman (UMO graduate student)*
- Check bycatch data in Canada: *Assigned to Lei Harris (DFO).*
- Confirm finding of interaction between shrimp trawl and juvenile cusk:
  - Separate observer trawl data by year to verify fish identified by observers.
  - Collect cusk caught in shrimp trawls to confirm identification and provide biological samples of juveniles;
  - Review observer data related to bycatch of cusk in shrimp fishery
- Contact Sally Sherman (ME DMR) regarding DMR trawl survey catch of cusk. *Assigned to Jeanie Cushman (UMO graduate student).*

Breakout Session 2: Investigating hook gear interactions with cusk

Moderator: *Kate Burns*

FACTS – Hook Gear Interactions with cusk:

- Discard mortality is high;
- Cusk seek out and hide in holes;
- Hook size #12 circle, hook or larger is best for catching cusk;
- Cusk are associated with structured hard bottom habitat;
- Cages are available for a low cost/volume study on survivability.

METRICS – Hook Gear Interactions with cusk:

- Industry has confidence in the science of the stock assessment.

ISSUES – Hook Gear Interactions with cusk:

- Do circle hooks improve post release survivability?
- We don't know much about spawning behavior in cusk?
- Fishing effort, catch and impacts:
  - What threat does any given sector of the fishery pose?
  - What is total fishing mortality including discards?
  - We have imperfect knowledge of fishing effort especially, pots and the recreational effort.
  - We don't know impact of recreational fishery.
  - It's hard to talk about gear conservation/selectivity efforts with hook gear if we don't really know what the objective is: is this discussion about trying to avoid cusk? or are we talking about improving our ability to purposefully catch cusk to obtain additional data (e.g. for a survey? For biological information?).
- What size cusk are people catching and has this changed?

ACTIONS IDENTIFIED – Hook Gear Interactions with cusk:

- Survivability studies from hook gear (all gears) should be priority.

Cusk Dissection

Trish DeGraaf (Maine DMR) demonstrated dissection methods and otolith removal on a cusk.

Full Group Discussion – Day 2: Surveys for cusk and gear mitigation options.

One key question that was asked in both gear conservation engineering breakout groups was "are we trying to avoid cusk, or are we trying to target cusk to obtain additional data for cusk – what would be we trying to achieve through gear conservation research?"

These are two very different gear objectives; therefore, it was decided that instead of continuing with a second breakout session on gear conservation, we should bring the whole group together and discuss opportunities for cusk surveys of all varieties and gear mitigation options.

Moderators: *Kate Burns, Laura Ludwig, Laura Taylor Singer*

Surveys for cusk

Discussion points:

- **Steve Eayrs: The two overarching issues we need to address are:** (1) that we need more information for stock assessments, and (2) we also need to figure out how to reduce unintended mortality.
- **Earl Meredith: The NEFSC Cooperative Research Program has funded many surveys over the years,** but surveys are a time series which means 3-10 years before they start paying off. When you think about a survey, you need to have clear objectives, and when you think about surveys, don't think long-term because they're so expensive. Look at ways to collaborate with industry.
- **Kate Burns: What types of surveys could be achieved with limited budget and in a short time frame?** With diet, you'd need to cover several areas since it seems that cusk diet is adaptive to what prey species is available (Merrie Cartwright). *In CA fishermen collect stomachs and preserve them in seawater (2 handfuls of salt, prevents further digestion) (Lei Harris).* Many spots aren't sampled anymore (John Higgins). *Even with just one (longline) survey of the entire area, you'd get a feel for abundance, distribution, hotpots, etc. It would still be informative, but ideally you'd need about 6 years of data (even if it was every other year); this would give you a series to indicate any trend in abundance, abundance stability, decline, etc. (Loretta O'Brien).* The State of Maine doesn't have a groundfish person right now and funds are really tight; the longline survey was really expensive. The best option is to piggyback on other commercial sampling options when possible (Trish DeGraaf).
- **Mike Pol: Why are we doing a survey if we want to improve the stock assessment? Would one year of survey really be useful?** You have to be realistic about what money is out there – if you want to do a stock assessment on cusk, you need a time series from a longline survey for 10 years, and accurate reported landings of discards and landings. On the west coast they survey every three years due to money constraints. You might be able to make it a multispecies survey, e.g. cusk, wolffish (Loretta O'Brien). *I'm not sure that a short-term survey would answer the questions that people want right now (Lei Harris)*.
- **Laura Ludwig: If people are interested in a trap-based survey, do we need to look at trap design? Is there anything out there to inform us on what trap design might improve cusk catches (for a trap-based survey)?** Basically the bigger the better (Mike Pol).
- **Kim Damon-Randall: The stock assessment and the ESA listing determination are two different things** – if NMFS were petitioned, we would have to make a determination based

on what information is out there right now [rather than being able to do a new stock assessment].

- **Tim Tower: How much do you use VTRs? Mine are very accurate, I enter them into my own database each day; my discards are estimated and are probably accurate to +-10%.** We do use VTR data and it informs us on the quantity of removals. Cusk are not regulated, so there is no real motivation to misreport for cusk, unlike e.g. cod (Loretta O'Brien).
- **Shelly Tallack: Could we instigate a short-term, multi-gear/integrated questionnaire survey that goes out to all commercial gears and recreational vessels (including private vessels), with questions that tap on their current catch rates, but also trends they've observed?** We have to comply with paper reduction act, and can't survey more than 10 people in any given survey, and can't use survey monkey either (Kim Damon-Randall). *But could this be contracted out to get around this? We could include questions about where fishermen see small cusk, and spawning cusk. (Shelly Tallack)*
- **Tim Tower: Most people, and especially fishermen, don't trust the government and what they will do with your data.** Fisheries used to be unregulated and fishermen used to talk to each other, and would sort things out between each other; now that has all changed and fishermen don't communicate the way they used to, it's more about divide and conquer.
- **Lei Harris: Since there are problems using VTR data, is there a subset of data for certain longline vessels that you can trust, or that were not affected by closed areas?** There aren't that many longline vessels out there now (Loretta O'Brien). *Can you derive past CPUE data from VTR-based effort estimates and catch data; it would be a more accurate estimate than catch alone (Merrie Cartwright).* The VTR data is just not trusted sufficiently, we used to use CPUE data until 1994, but now we don't use it because the data is not sufficiently accurate. The dealer reports are the data that are considered more accurate and they often don't match up to what the VTRs say (Loretta O'Brien). *The reliability of the landings on the VTR is more accurate than the discards; you might be able to use the VTRs of any vessels reportedly targeting cusk since you can use their landings data (Debra Duarte).*
- **Lei Harris: Collaborate with researchers working on other species, save money, e.g. halibut, hake, wolffish, etc. e.g. cusk eggs, cusk larvae.** We could ask that any industry surveys also request information on reproduction and spawning of cusk (Shelly Tallack).
- **Steve Eayrs: Why don't we take advantage of some of the fishermen who've expressed interest here today, carry out a pilot study, quick and dirty tagging project. The** danger of doing this is that if recaptures are too soon after release, you only get so much information from your recaptures (Tim Tower).
- **John Higgins:** Having the right person out there talking to the right fishermen, you'll get more information than you could even think of questions to ask.
- **Kim Damon-Randall: Can we take tissue samples for future genetic work?** The observer program has been collecting cusk samples for a couple of years, so there are samples available (these were actually requested by NMFS) (Debra Duarte).

Gear mitigation options.

Discussion points:

Longline gear

- Maybe **hook size** could be mandated to larger hook sizes across the board, since this would hopefully at least only lead to catches of larger fish. This is something that could be instigated through the State of Maine and or ME DMR. *The DMR survey did assess hook sizes 12, 14, 16, but saw no effect (Trish DeGraaf).*
- **What would a study to address this look like (Kate Burns)?** Set 3 strings of 100 hooks side by side, testing different hook sizes (Matt Brenner). *If you start going too large of a hook size, you'll start reducing your ability to catch haddock because they have smaller mouths (Paul Hoffman).* It might work to use large hooks in areas dense for cusk (Steve Train). *But for example, inshore of Jeffrey's Ledge your primary species are haddock and cusk, so you'd lose your haddock by switching to a larger hook (Paul Hoffman).*
- **Steve Eayrs: Is there enough longline effort in the GOM anyway to justify worrying about this?** Not really, this is a bit of a moot point (Matt Brenner).

Lobster gear

- **Curt Brown: To test whether cusk will survive/recompress if you discard them in lobster traps;** put them in the 'kitchen' with cameras rigged to the traps and tag these fish also to get more long-term indicators of survival.
- **Ted Ames: To mitigate cusk bycatch mortality out of lobster traps,** we could try the recompression techniques and also tag the cusk and monitor for survival and population in that local area. *This would be a proactive way for the lobster industry to get involved in mitigating the cusk problem (Curt Brown).*

Trawl gear

- **Kilo Pinkham: In my experience, I don't see cusk when shrimping – was that 9% [referring to the observer data presentation, see page 18] really a valid data point?** This needs to be looked into more (Debra Duarte). *An action request from this discussion was for observers to send biological samples of these 'cusk' to make sure that they are actually cusk, and for dissection (Lei Harris).*

Gillnet gear

- **Ted Ames: We never really saw cusk when we fished gillnets, even though they had found cusk when fishing longlines. We never used tie-downs. The gillnet fishery is probably not really an issue.** I would have to revisit his gillnet data to check, but he's pretty sure that cusk were probably only caught in the smaller mesh sizes, which is not really an issue anyway (Mike Pol).

Recreational hook fishery

- **Kate Burns: Which recreational fishermen are targeting cusk and which are discarding? Why do they discard/keep?** If someone hasn't caught anything else and they want to take something home, they'll take a cusk because it's good to eat. Many smaller

recreational boats will throw them over because they want to catch cod instead (Tim Tower).

- **Kim Damon-Randall: Could you use a camera/cage discard method to sell customers on releasing cusk?** It's worth us finding out straight away whether sending them back down in traps does or does not improve survival – if it's not effective, then there is no point doing it on a wider scale (Mike Pol).
- **Kathleen Reardon: We're talking about mortality for discarded cusk, is NMFS looking to have fishermen stop catching cusk?** No, not unless cusk is listed under the ESA (Kim Damon-Randall).
- **Earl Meredith: Could you put a size limit on cusk caught by the recreational fishery? And if so, could the state require this?** Yes, the state could (Melissa Vasquez). *Then you might have fishermen put those 'undersized' fish back, if they live (Earl Meredith).* There's no point putting them back if they don't survive – we need to know this first (Steve Train).
- **Loretta O'Brien: Could you test the effectiveness of recompression first, to see if this will even work before testing in traps?** It's pretty time intensive, the experiment would take days because you have to slowly decompress them after being in the chamber (Bonnie Rogers). *You could test this easily in a crate with a camera – send it down 10 fa, 20 fa, 30 fa, etc…. and watch how the fish does (Kilo Pinkham).* We have gear available that could be reconfigured and used for sinking/camera work with fishermen for different hook gears. We also have many tags left over from the cod tagging project; you might have to put money into getting direct feed cameras that can go deep enough (Shelly Tallack).
- **Mike Pol: If they survive, does this mean they're not impaired? We may need a parallel study on looking at exactly how much damage is incurred with barotrauma.** If their swim bladder is sufficiently damaged, they may not be able to make sound, find mates, find habitat etc. Even simple dissections will show us things like are there bubbles in the heart, is the liver damaged, other organs etc. (Bonnie Rogers). *Dissections in CA have shown damaged livers (Lei Harris).* Livers are often shredded on cusk, coming out of the mouth – possibly due to pushing past the teeth (Tim Towers).
- **Kate Burns: Can work start to grow awareness within the recreational industry?** If we find areas that are dense in cusk, can we put e.g. a hook size limit in, i.e. only large hooks to avoid juvenile cusk (Matt Brunner). *But we don't catch juveniles so this is a moot point (Tim Tower).*
- **Lei Harris: If we switched to clams in hook gear, would these retain catches of cod/haddock while reducing catches of cusk?** We mostly use clams anyway because they're easier to store, we only use herring/mackerel on trips where we target cusk (Tim Tower).
- **Debra Duarte: Is the bigger impact the lobster industry? Do we even need to worry about hook size?** The recreational fishery may be the bigger issue – is changing recreational hook sizes feasible or necessary (Melissa Vasquez)? *It would be worth looking at, even though it would likely affect haddock catchability (Tim Tower).*

- **Ed (Industry representative, last name unknown):** Are we trying to reduce mortality of cusk, or unintentional mortality? And are we targeting charter/head boats or private recreational guys[2]? If the latter, it may be more about simple education.
- **Mike Pol:** Could findings from a study on recreational hook size be transferred to longline, or vice versa?
- **Kate Burns: Are the recreational guys in the room interested in being involved in some studies on this?** Cusk can often save a trip for charter/head boats, so they are an important species (Tim Tower). *We could use GMRI interns for good sampling effort on charter boats (Steve Eayrs).*

Review of "Market Place"

This session served as a wrap-up session where the full group reviewed the "Actions identified" during each of the breakout sessions, and prioritized these into a short list of those actions deemed most urgent and also attainable in light of the lack of funds currently committed for working on cusk.

Funding: Very little is known regarding upcoming funding opportunities. Although the 2012 NOAA budget has been approved, neither the NMFS NEFSC Cooperative Research Program nor the Northeast Regional Office Protected Resources Division knows their respective 2012 budgets yet. Consequently, how much money is available, and when any funds will be available are not known.

When discussing each action below, the following 'project planning' criteria were also considered, though in some cases, only the people involved were identified:

- Who wants to be involved, who else can help?
- What resources do we need?
- What timescale is realistic?
- Do we need funding?

[2] 'Private recreational' refers to individuals who fish out of their own (or a friend's vessel), in contrast to a 'charter' vessel that usually takes ~6-8 paying clients, or a 'party' or 'head' boat that takes larger groups (up to ~30) of paying customers.

Prioritized, short-term actions

	ACTION	WHO	WHEN
1	**Lobster survivability study that includes tagging and the use of cameras to monitor escape from lobster traps after recompression.**		
	• Volunteer reporting of cusk to be reported to DMR, particularly from the offshore zone.	Kathleen Reardon (ME DMR)	
	• The approach of "put a cusk in your kitchen" will be tested, and this might also serve as a good outreach slogan.	Curt Brown (GMRI) & Jeanie Cushman (graduate student, UMaine)	Curt can begin to test this in the winter of 2012; Jeanie will incorporate this into her graduate studies, with a completion date of ~2 years.
	Resources: Relatively low cost at this stage. Cameras may be needed to verify cusk escape from the 'kitchen'.		
2	**Party/charter industry: implement hook-oriented tagging, bait, survivability research.**		
	• Combine this with efforts carried out by Jason Joyce, Curt Brown – i.e. releasing from traps – datasheets & protocols can be similar for both gear types.	Shelly Tallack, Tim Tower, Matt Brunner, interns?	Short-term solution: early 2012
	• Use cloud technology to help build all relevant documents/sampling protocols.		
	• Reach out to other charter boat associations, e.g. Northeast Charter Boat Captain's Assoc., Stellwagen Bank Charter Boat Assoc.	Shelly Tallack	
	Resources: Interns stipends, travel budget, staff time coordination, application of data will be limited to the geographic scope and depth of sampling. Use caging equipment and tagging supplies remaining from past studies.		
3	**Develop a questionnaire for both commercial and recreational fishermen to build our baseline knowledge of cusk, and if possible, enhance the assessment.**		
	• Scope out ideas/options: paper survey? Web-based? Interviews? Phone app?	Shelly Tallack / GMRI	Early 2012
	• Combine this with in-depth interviews with a certain number of fishermen	GMRI	
	• One venue that might be useful to begin the discussion with more industry members is the Maine Fishermen's Forum	GMRI/Steve Train	March 2012
	Resources: A certain amount will be required, particularly if we feel the need to provide incentives to complete the questionnaire.		

4	**Establish an industry-based fishing-independent longline survey.**		
	• Establish an ad-hoc IBS Committee, tasked with deciding on: the study design, standardized gear, what resources are needed, who would conduct the work, etc.	Include Henry Milliken (NEFSC)	Longer-term, assuming that funding becomes available
	• Network with current initiatives and/or develop a volunteer network: Capitalize on ME DMR's work, piggy-back on other ongoing surveys/research	Halibut Alliance of ME, Jason Joyce, Ted Ames, Shelly Tallack	Short-term solution: early 2012
	• Design standardized protocol and develop materials (datasheets) needed.	Shelly Tallack	
	Resources: Tetracycline and some $$ for cameras		
5	**Life cycle and age validation analysis**		
	• Can we get ageing/tagging information from other countries, i.e. Norway?	Mike Pol	
	• Initiate a captivity study?		
	• We need to increase the priority of cusk within the Northeast Fisheries Science Center.	Loretta O'Brien	
	Resources: These efforts would be resource intensive.		
6	**Implement discreet area research in Penobscot Bay and Stellwagen National Marine Sanctuary:**		
	• Investigate options for utilizing the Penobscot acoustic array – is this only in the rivers? If so, it won't help.	Graham Sherwood, Kim Damon-Randall, Property and Environment Research Center (PERC), industry	
	• Options in the Stellwagen National Marine Sanctuary?	Ben Haskell, Kate Burns, John Annala, Peter Auster, Rodney Rountree	
	Resources: Not discussed.		
7	**Use VTR and other observer data to enhance stock assessment:**		
	• Encourage fishermen to complete VTRs accurately for cusk – explain how these data are used and therefore, why their accuracy is important.	NMFS (Loretta O'Brien)	
	• Juvenile bycatch sampling in shrimp trips.	NMFS (Debra Duarte)	
	Resources: Not discussed.		

Appendix 1 - List of attendees

First Name	Last Name	Organization	Email
Ed	Unknown	Industry Member	-
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Merrie	Cartwright	NMFS, Fisheries Data Services Division	merrie.cartwright@noaa.gov
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Jeanie	Cushman	University of Maine	jeanie.cushman@gmail.com
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Trisha	DeGraaf	Maine Department of Marine Resources	trisha.degraaf@maine.gov
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Debra	Duarte	NMFS, Northeast Fisheries Observer Program	debra.duarte@noaa.gov
Steve	Eayrs	Gulf of Maine Research Institute	steve@gmri.org
Chris	Glass	University of New Hampshire	chris.glass@unh.edu
Andy	Haney	Industry Member	-
Jon	Hare	NMFS, Supervisory Research Oceanographer	jon.hare@noaa.gov
Jim	Harkins	Industry Member	captainharkins@hotmail.com
Lei	Harris	Department of Fisheries and Oceans Canada	lei.harris@dfo-mpo.gc.ca
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Sarah	Laporte	NMFS: Protected Resources Division	sarah.laporte@noaa.gov
Laura	Ludwig	Gulf of Maine Lobster Foundation	laura@gomlf.org
Earl	Meredith	NMFS, Cooperative Research Program	earl.meredith@noaa.gov

Loretta	O'Brien	NMFS, Population Dynamics Branch	loretta.o'brien@noaa.gov
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Mike	Pol	Massachusetts Division of Marine Fisheries	mike.pol@state.ma.us
Maggie	Raymond	Associated Fisheries of Maine	maggieraymond@comcast.net
Kathleen	Reardon	Maine Department of Marine Resources	kathleen.reardon@maine.gov
Bonnie	Rogers	Ocean Associates, Inc., contracted by NWFSC	bonnie.rogers@noaa.gov
Graham	Sherwood	Gulf of Maine Research Institute	gsherwood@gmri.org
John	Shusta	F/V Special J	jshusta@easternia.com
Bonnie	*Spinnazola*	*Atlantic Offshore lobstermen's Association*	*bonnie@offshorelobster.org*
Marc	Stettner	Industry Member	ijigcod@mindspring.com
James	Sulikowski	Industry Member	jsulikowski@une.edu
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Steve	Train	F/V Hattie Rose	fvhattierose@aol.com
Melissa	Vasquez	NMFS Sustainable Fisheries Division: Fishery Policy Analyst	Melissa.Vasquez@noaa.gov
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Carl	*Wilson*	*Maine Department of Marine Resources*	*carl.wilson@maine.gov*

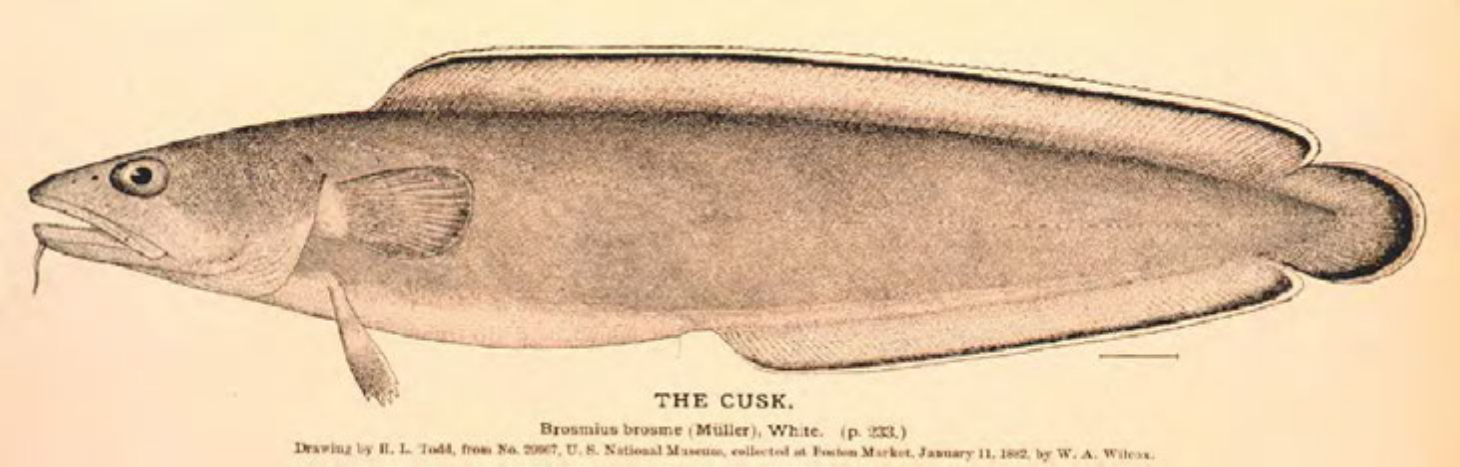
Note: Names in italics were not able to attend, but had been invited.

Appendix 2 - Background materials provided by NMFS

NOAA Fisheries Service and the Gulf of Maine Research Institute Presents a

Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

Status, Management, Cooperative Research, and Reducing Bycatch Mortality



December 7-8, 2011

Gulf of Maine Research Institute

Portland, Maine

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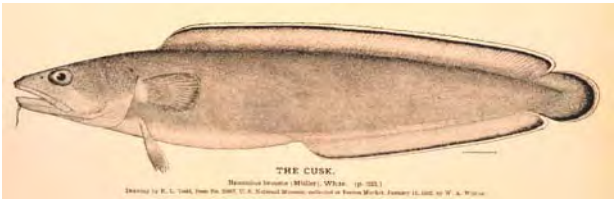
Appendix 3. Charts of statistical areas including Gulf of Maine, Georges Bank, Long Island……38
Sound and New York NEMFIS area, Southern New England, Massachusetts Bay and Cape
Cod NEMFIS area, Rhode Island Sound, Cape Cod and the Islands NEMFIS areas, East of Nova
Scotia, and Mid-Atlantic areas.

Note: This information provided is to help facilitate discussions at the workshop. As noted, some data provided are preliminary and subject to change.



Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

December 7-8, 2011
Gulf of Maine Research Institute
Portland, Maine

Agenda

Facilitators: Alexa Dayton, Kate Burns and Shelly Tallack
Report Preparation: Shelly Tallack

(note, 5 minutes for Q&A is included in the time allotted for each speaker)

Agenda	**Day 1**
8.30	Breakfast, brief networking: Alexa Dayton, GMRI
8.50	Purpose and Goal of Workshop: Kim Damon-Randall, NMFS
9.00	Format for Workshop (including participant introductions): Kate Burns, GMRI
9.10	What we know in the U.S. (lifecycle, genetics, stock structure, distribution, habitat and climate change): Dr. Jon Hare, NMFS.
9.25	The status of cusk in the U.S.: Loretta O'Brien, NMFS
9.40	What we know in Canada, (lifecycle, stock structure, stock assessments, distribution, habitat): Lei Harris, Department of Fisheries Canada
9.55	Cusk management and conservation in Canada: Lei Harris
10.05	Cusk management and conservation in the US: Kim Damon-Randall
10.20 – 10.30	*Break*
10.30	A panel of recreational and commercial fishermen discusses catching cusk
10.50	Opportunities for cooperative research: Earl Meredith, NMFS
11.05	Q&A and Full Group Discussion. **Status assessment and stock structure; What do we know? What do we need to do? Are there gaps? What can we do about these? Who can help?** Moderator: Shelly Tallack
12.15	*Lunch*
1.00	Research in Maine: Kohl Kanwit, Maine DMR
1.15	Research with the industry GMRI: Graham Sherwood, GMRI
1.30	Cusk data from NMFS commercial and recreational fisheries databases: Diane Borggaard, NMFS

1.40	Observed cusk records: Debra Duarte, NMFS
1.55	The Fishing Area Selectivity Tool: Kate Burns, GMRI
2:05	Barotrauma: Can captured cusk survive if returned to the water?: Bonnie Rogers, NMFS
2.20-3.20	Breakout Session (2 groups) • **Can we identify hotspots and apply bycatch avoidance strategies?** • **Improving cusk survival**
3.20 – 3.30	*Break*
3.30 – 4.30	Breakout session continues, with participants switching topics.
4.30	Review of "Market Place," participants 'sign up' to actions they are interested in pursuing. (Each break out group will determine key actions needed on the issue being discussed. These will be posted on a 'Market Place' – along a wall, to be reviewed by participants from other breakout sessions. Participants will be asked to prioritize and 'sign up' to actions they are willing to be engaged in).
5.00	*Finish*
5.30	Social and cusk quiz!
6.30	*Dinner*

Agenda	**Day Two**
8.00	*Breakfast and reconvene*
8:15	Additional thoughts from yesterday's presentations or discussions
8.30	Gear research and mitigation: Steve Eayrs, GMRI
8.45	Gear research and mitigation continued: Mike Pol, Mass DMF
9.00-9.15	Gear analysis of observer data: Debra Duarte, NMFS
9.15 – 10.30	Breakout Sessions (groups breakout by gear type) • **Cusk avoidance through gear selectivity**
10.30 -10.45	*Break*
10.45 – 12.00	Breakout Sessions continue • Break out participants choose topic(s) to be discussed (e.g. continued discussion of gear selectivity)
12.00	Review of "Market Place," participants 'sign up' to actions they are interested in pursuing.
12.15 - 1.00	*Lunch*

1.00 – 2.00	Breakout Session (1-2 group(s)) • **Can recreational and commercial fishermen assist with strategies for cooperative research on cusk? What are the opportunities, barriers and considerations?**
2.00	Review of "Market Place," participants 'sign up' to actions they are interested in pursuing.
2.15	Cusk dissection
2.30 -2.45	*Break*
2.45 – 4.30	Making actions happen. (We break into smaller groups of people who have 'signed up' to actions. Review metrics. What do we need to achieve success? Who can help? Who can follow up, etc.? What timescale is realistic and can we set dates?)
4.30 – 4.50	Feedback from each group on their plan of action
4.50	Summary and closing remarks
5.00	*Finish*

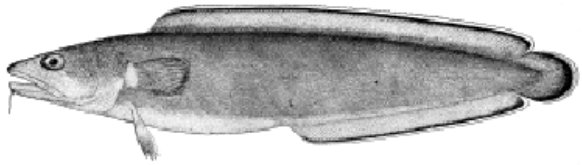
Status of Fishery Resources off the Northeastern US:

Cusk (*Brosme brosme*) by Loretta O'Brien

NMFS Northeast Fisheries Science Center

Resource Evaluation and Assessment Division

Compiled by NMFS Northeast Region for the 2011 Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk



Last revised: September 2010

Cusk

by

Loretta O'Brien

Distribution, Biology, and Management

The cusk, *Brosme brosme*, is a deep-water species that is distributed on both sides of the Atlantic on hard-bottom areas. Although the stock structure is unknown, the greatest concentrations of cusk off the US coast occur in the central part of the Gulf of Maine and extend onto the western Scotian Shelf (Sosebee and Cadrin 2006; Harris et al. 2002; **Figure 19.1**). Spawning occurs in spring and early summer; eggs rise to the surface, where hatching and larval development occur. Juveniles move to the bottom at about 5 cm (2 in) in length, where they become sedentary and rather solitary in habit. Individuals commonly attain lengths ranging from 46 to 76 cm (18 to 30 in) and weights between 2.3 and 4.5 kg (5 and 10 lb). The major prey items of cusk in the Gulf of Maine are crustaceans, primarily toad crabs and pandalid shrimps (Collette and Klein–MacPhee 2002). Cusk from the Gulf of Maine reach median maturity at length at 37 cm (15 in) for females and 44 cm (17 in) for males at approximately ages 4 and 5, respectively. Median length at maturity for cusk in Canadian waters is estimated to be about 41 cm (16 in) (Worcester and Smedbol 2008). Cusk from the Scotian Shelf area are late maturing, attaining sexual maturity by age 7 for females and age 5 for males and are relatively slow-growing, with maximum age greater than 14 years (Oldham 1972).

The principal fishing gear used to catch cusk includes otter trawls, linetrawls, gillnets, and longlines. Fish landed by these gears range in size from 31 cm (12.2 in) to 120 cm (47.2 in). Recreational fishing has historically represented less than 10% of the landings; however, since 2006, recreational landings have accounted for 15–25% of the total catch. Foreign catches are minor. The Canadian fishery was restricted to a bycatch quota of 1,000 mt during 1999–2002 and 750 mt in 2003 (DFO 2008). The US fishery for cusk is not under management. In 2009, total combined US and Canadian landings were 334 mt, 30% less than in 2008.

The Fishery

Annual landings averaged about 2,600 per year during the late 1960s to early 1980s, peaked at

4,200 mt in 1982 and then declined to 1,800 mt in 1988. Landings increased to 3,100 mt in 1992, but subsequently declined to a record low of 707 mt in 2000 (**Figure 19.2, Table 19.1**). Gulf of Maine landings generally account for more than 60% of the US harvest. During 1995–2008, the US accounted for 26% of the total US and Canadian commercial landings. In 2009, US landings were 48 mt, 14% of the annual landings.

Historically, otter trawls have accounted for between 50 and 87% of the US landings of cusk. During 1991–1994, 1997–1998, and 2005–2008, the majority of US landings were taken by bottom longline gear, also known as linetrawls. In 2009, the otter trawl and gillnet fishery accounted for the majority of the cusk landings. The majority of Canadian landings of cusk are taken as bycatch in the longline fisheries (DFO 2008).

Research Vessel Survey Indices

During 1963–1986, NEFSC autumn bottom trawl survey biomass indices fluctuated about an average of 1.7 kg per tow, but since that time have declined (**Figure 19.3**). The biomass index reached a record low in 2007 and then increased during 2008–2009. The mean length of cusk caught in the autumn research survey has declined from an average of 63 cm (25 in) during 1963–1988 to 49 cm (19 in) during 1989–2009 (**Figure 19.4**).

Summary

Annual landings have fluctuated, but generally declined after 1984, and survey biomass indices have also declined since 1985. The ratio of landings to survey biomass indices was relatively stable during 1964–1987, but then increased during 1988–1998, implying increased exploitation (**Figure 19.5**). Exploitation rates subsequently declined. The stock is currently at a low biomass level.

Table 19.1. Recreational and commercial landings of Gulf of Maine cusk (thousand metric tons).

Category	1990-99 average	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
US recreational	0.01	0.02	0.02	0.01	0.04	0.04	0.05	0.17	0.17	0.16	n/a
Commercial											
US landings	0.9	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
US discards	1.0	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	n/a
Canada	0.9	0.5	0.8	0.7	0.6	0.6	0.5	0.5	0.6	0.3	0.3
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.8	0.9	1.1	1.0	0.9	0.8	0.8	1.0	1.1	0.7	0.3

For further information

Collette, B. B., and G. Klein–MacPhee (Eds). 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine, 3rd edn. Smithsonian Institution Press, Washington, DC. 748 pp.

Department of Fisheries and Oceans (DFO). 2008. Recovery potential assessment for cusk (*Brosme brosme*). Canadian Science Advisory Secretariat Science Advisory Report, 2008/024.

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Worcester, T., and K. Smedbol 2008. Proceedings of the Maritimes Region Science Advisory Process on the Recovery Potential Assessment of Cusk (*Brosme brosme*). Canadian Science Advisory Secretariat Proceedings Series, 2008/008. 20 pp.

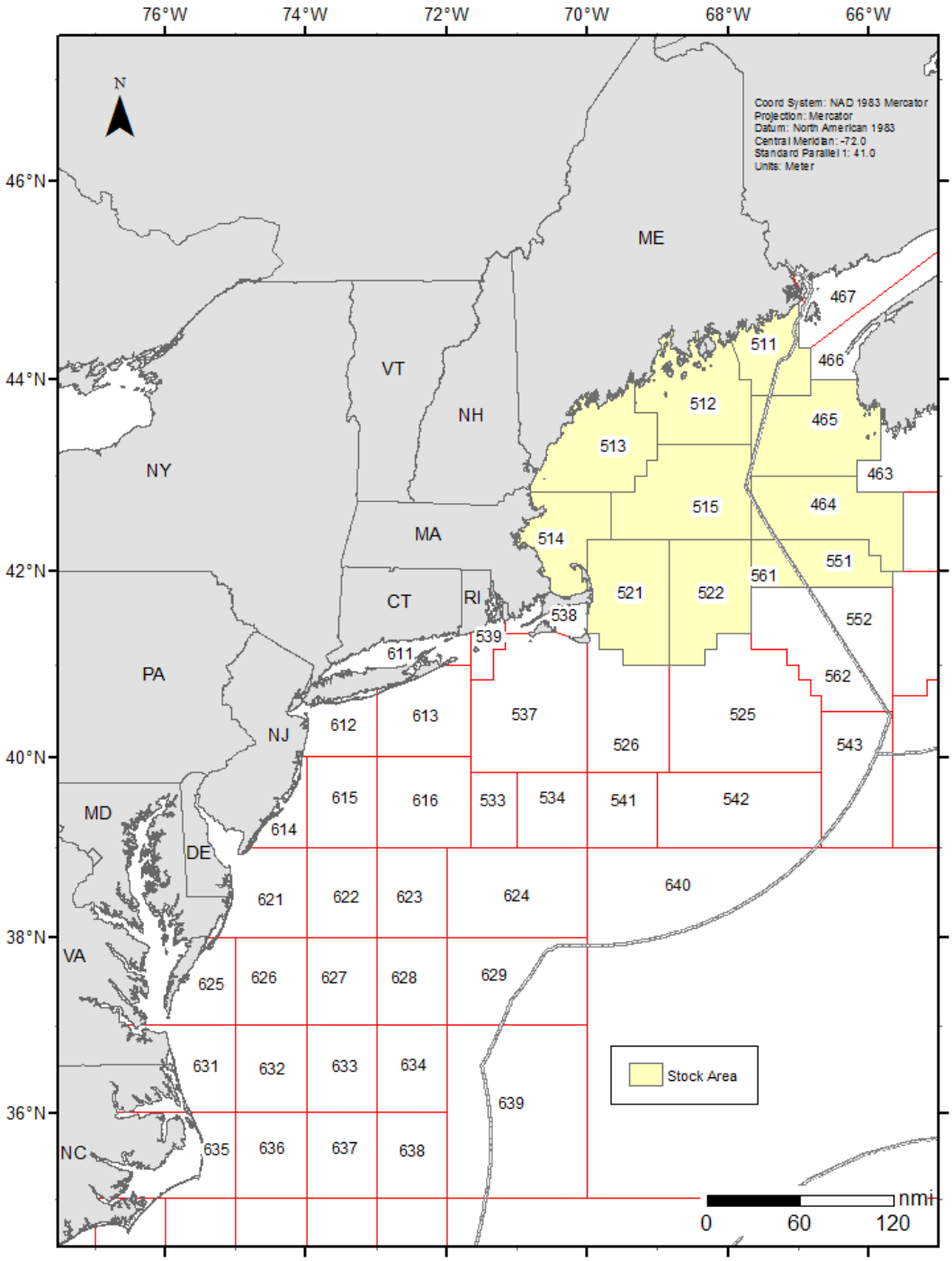


Figure 19.1. Statistical areas used to define the cusk, *Brosme brosme*, stock.

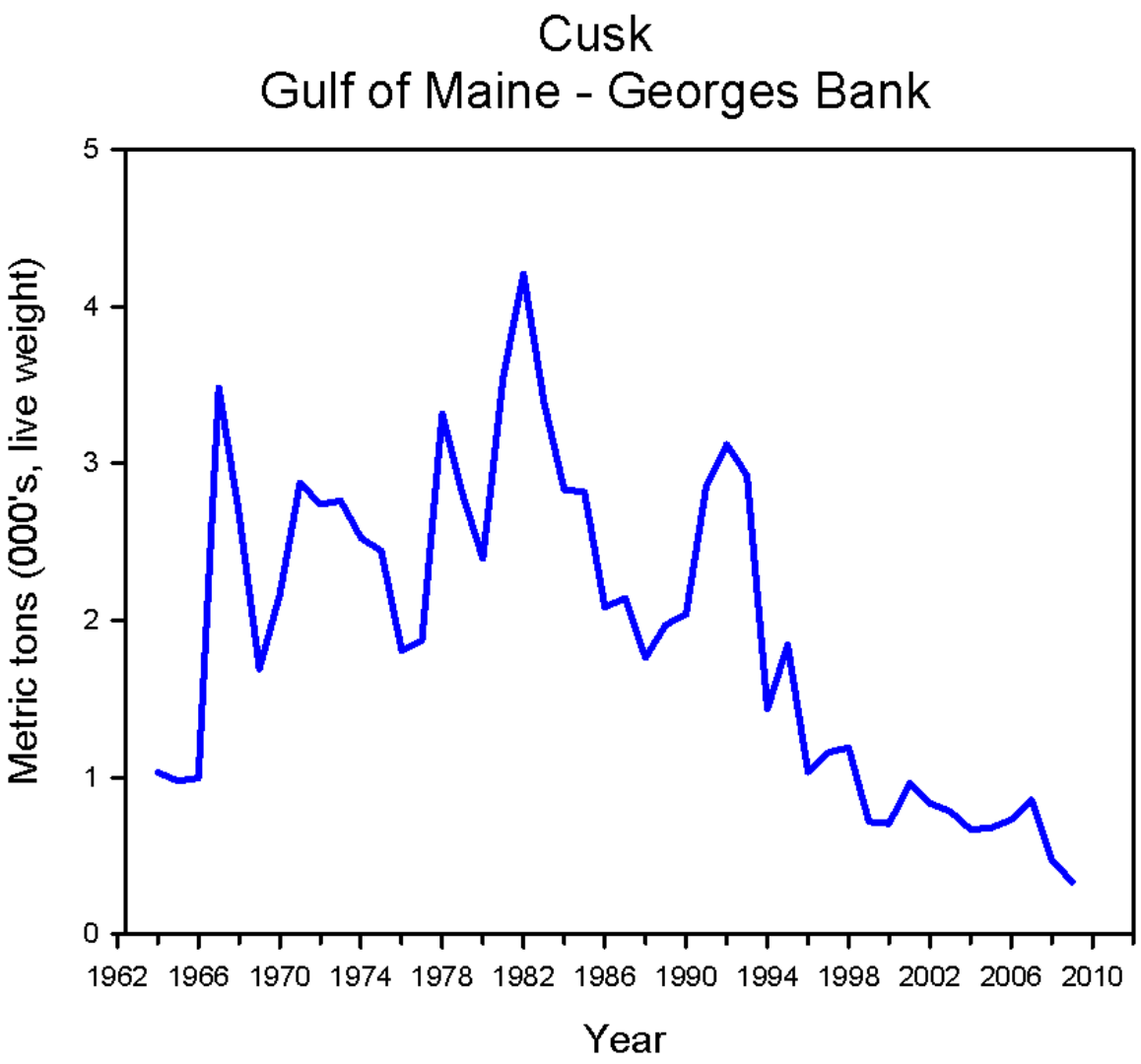


Figure 19.2. Total commercial landings (US + Canada) of cusk from the Gulf of Maine-Georges Bank region, 1964-2009.

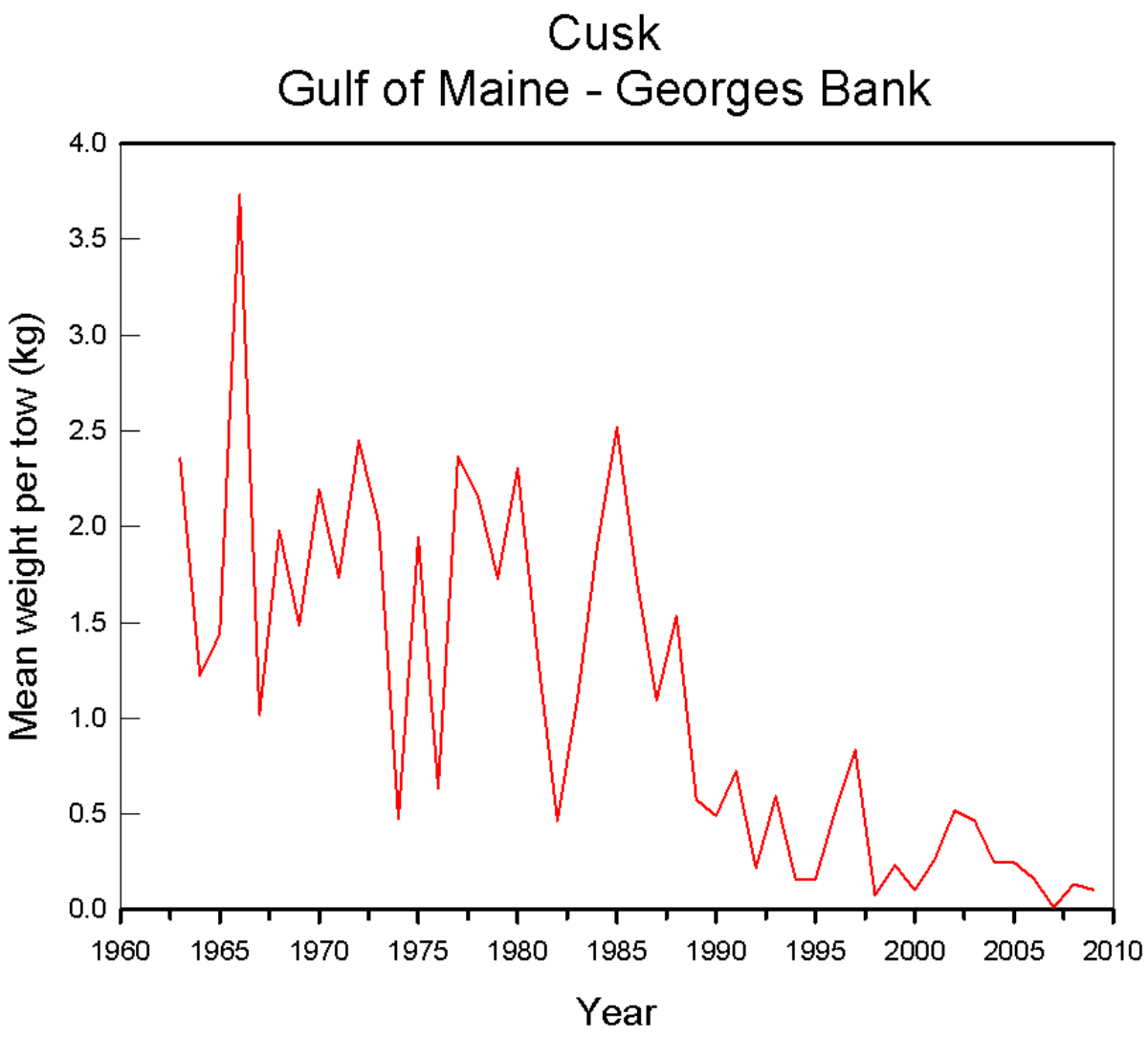


Figure 19.3. Biomass indices (stratified mean weight per tow) of cusk in NEFSC autumn bottom trawl research vessel surveys, 1963-2009.

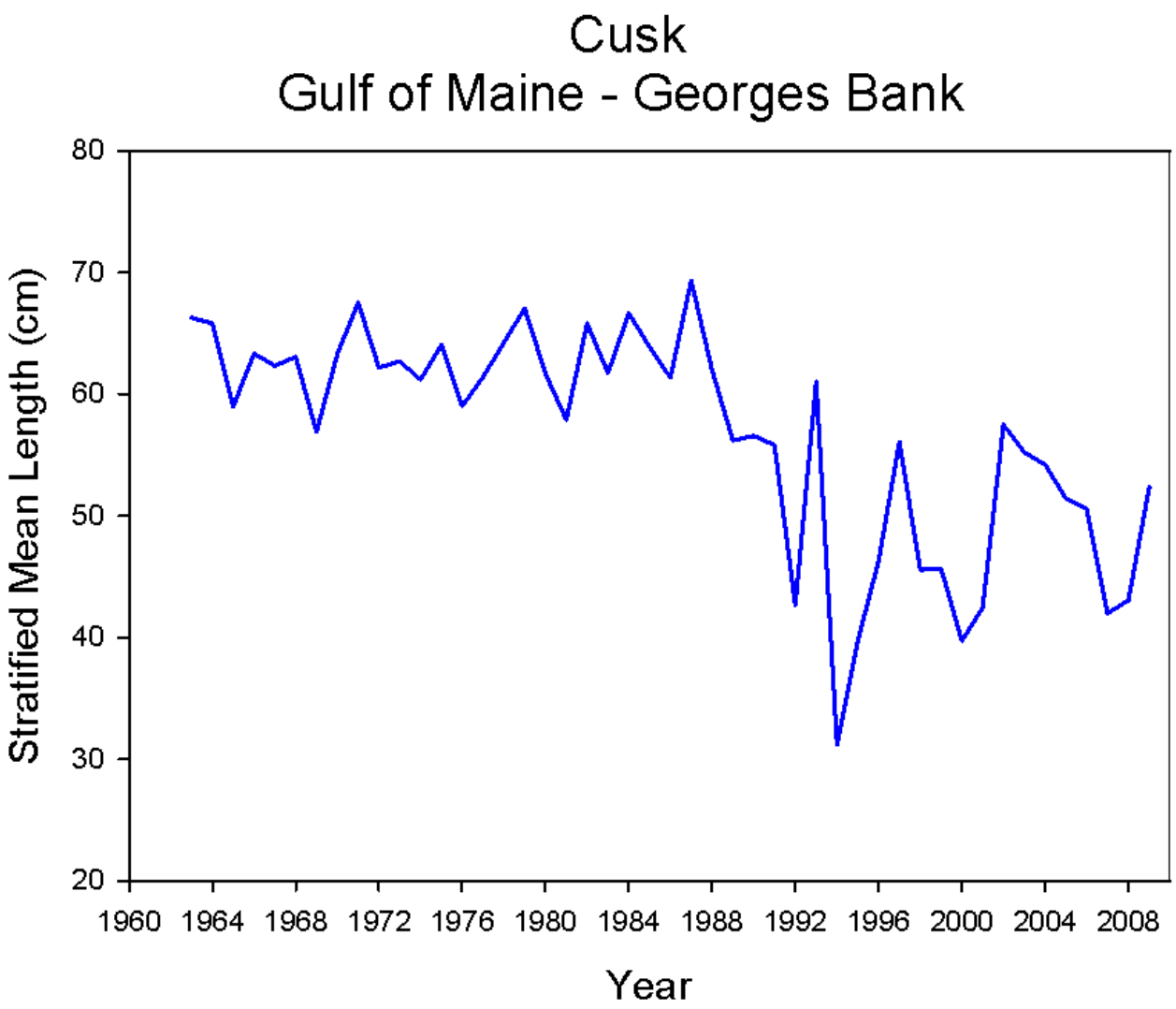


Figure 19.4. Stratified mean length (cm) of cusk in NEFSC autumn research vessel surveys, 1963-2009.

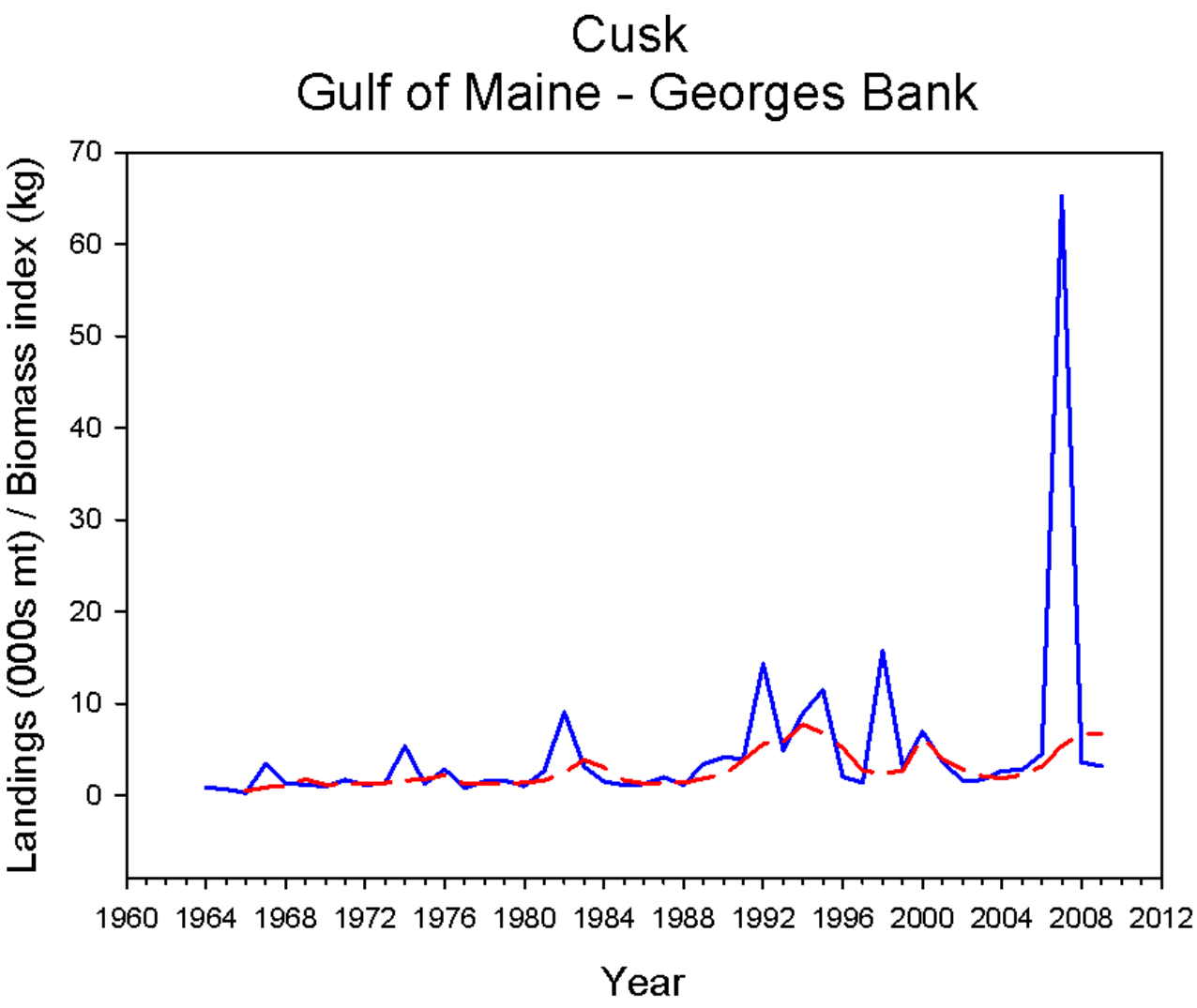


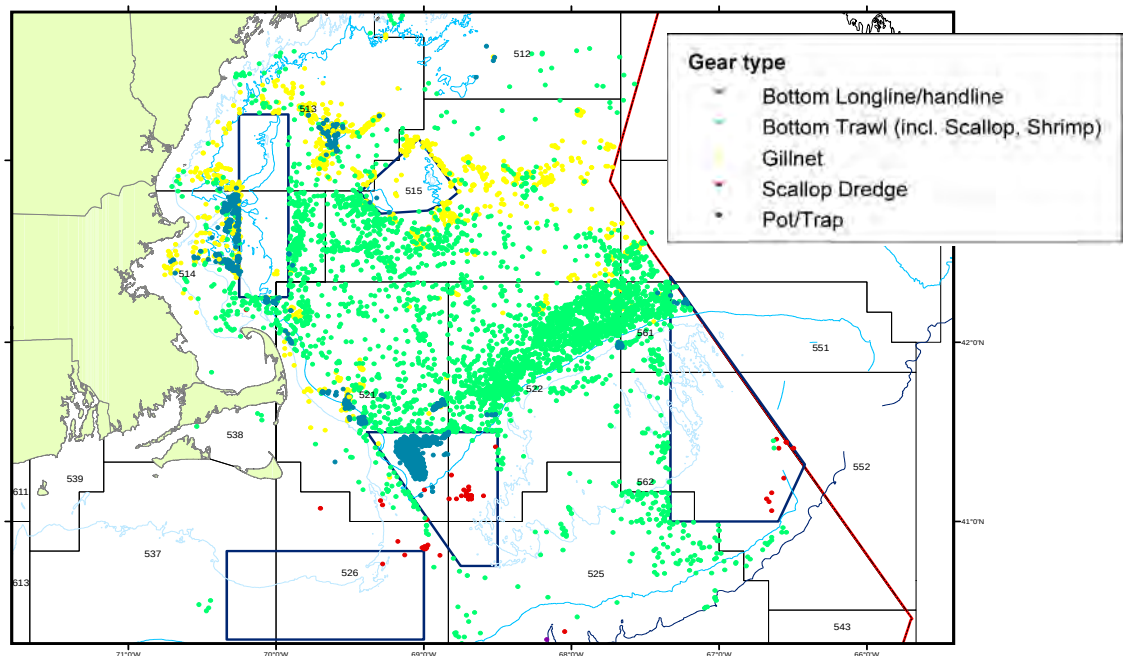
Figure 19.5. Ratio of landings/biomass index as an indicator of relative exploitation of cusk, 1964-2009. Dashed line is the 3-year moving average

Trends in Cusk Data Collected by the

NMFS Northeast Fisheries Observer Program from 2000-2010

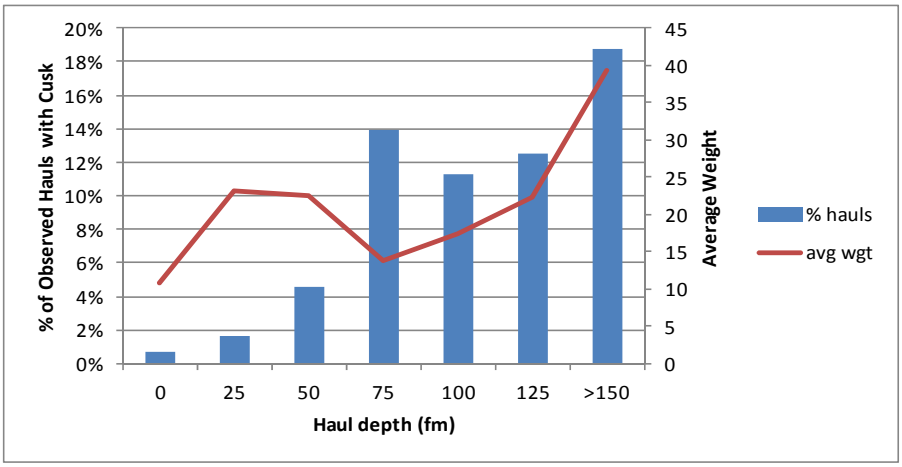
Compiled by NMFS Northeast Region for the 2011 Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

Trends in Cusk data collected by the Northeast Fisheries Observer Program
Calendar Years 2000-2010



Map: Points indicate haul locations of cusk catches (not by weight); color indicates gear type

- The majority of observed cusk records across all gear types occur in the Gulf of Maine and the northern edge of Georges' Bank
- Longline gear has highest rate of interaction with cusk
- Many cusk records are localized in the Closed Area I Haddock Hook SAP
    - The seasonal closure of this area causes a temporal trend of higher cusk interaction from October to December



Graph: Blue bars indicate percentage of hauls with cusk present, red line indicates average pounds of cusk per haul; only includes statistical areas where cusk are commonly found

- Cusk are encountered more frequently in deeper areas (>75fm)
- Most cusk recorded are kept
    - No significant changes in overall kept/discard behavior in last 10 years

National Marine Fisheries Service, Fisheries Sampling Branch
Preliminary Materials for Cusk Workshop at GMRI, Dec 7-8, 2011, Portland, ME

Cusk Data from the NMFS Northeast Fishing Vessel Trip Report (VTR) and Marine Recreational Fisheries Statistics Survey (MRFSS) Databases – Figures 1-22

Commercial Versus Recreational Catch of Cusk

Northeast Fishing Vessel Trip Report (VTR) Data from 1996 through 2010 show that there was a steady decrease in commercial cusk catch during this time span, from 810,286 pounds (lbs) in 1996 to 41,956 pounds in 2010 (see Figures 1 and 4). However, the opposite trend has been observed in recreational catch with 5,577 individual fish being caught in 1996 to 27,444 in 2010 (see Figures 2, 3 and 4). A higher proportion of cusk catch is kept in commercial fisheries than the ratio of kept to discards in recreational fisheries (see Figures 1 and 2). A comparison of total discards in all fisheries to discards with the lobster pot fishery shows that lobster pot discards of cusk are high and account for, on average, approximately 80% of all discards (see Figure 5).

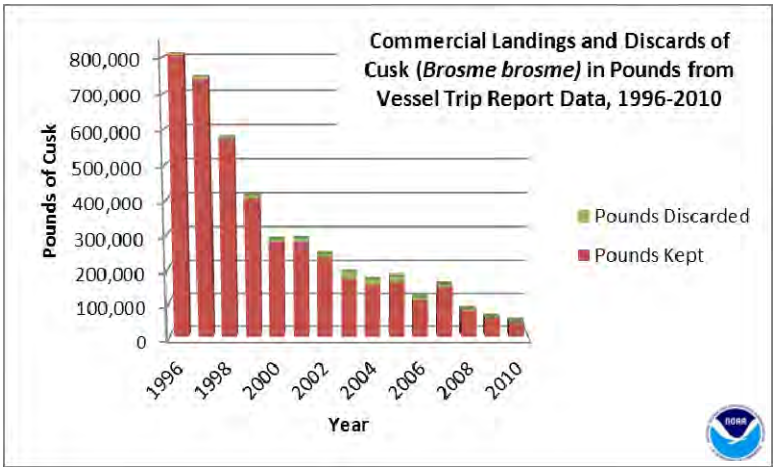


Figure 1. Commercial landings and discards of cusk (Brosme brosme) in pounds from 1996-2010. Landings include all areas and gear types. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

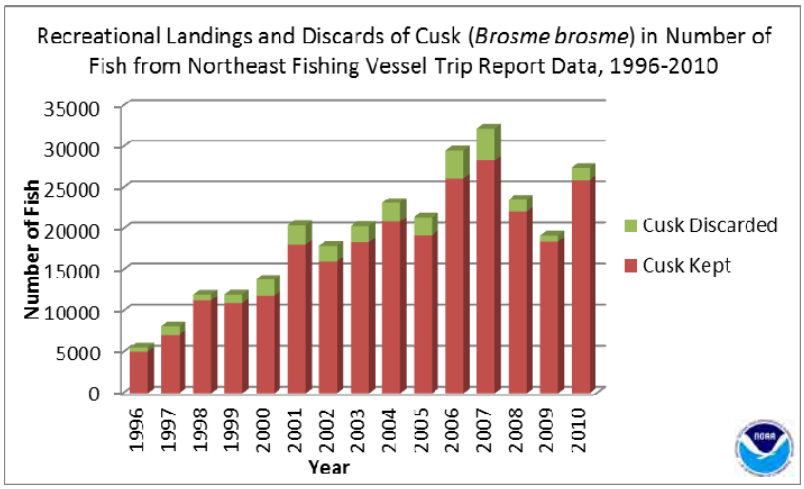


Figure 2. Recreational landings and discards of cusk (Brosme brosme) in numbers of fish from 1996-2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

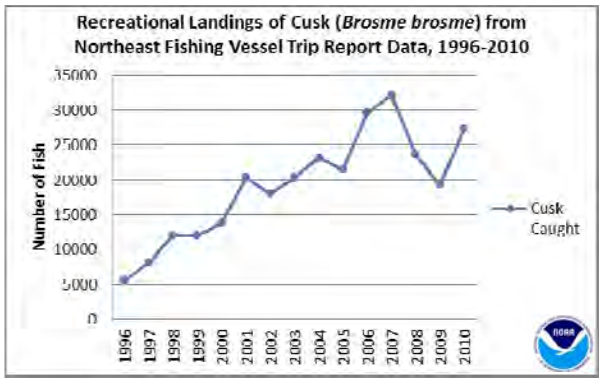


Figure 3. Recreational catch of cusk (Brosme brosme) by individual number of fish recorded from 1996-2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

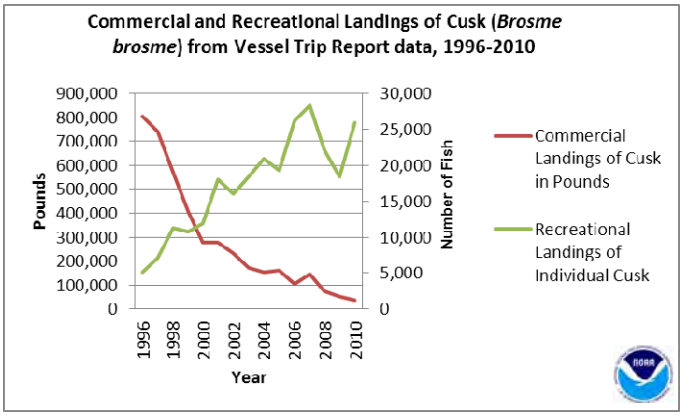


Figure 4. Commercial and recreational catch of cusk (Brosme brosme) from 1996-2010. Commercial landings are recorded in pounds of cusk. Recreational landings are recorded by number of fish. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

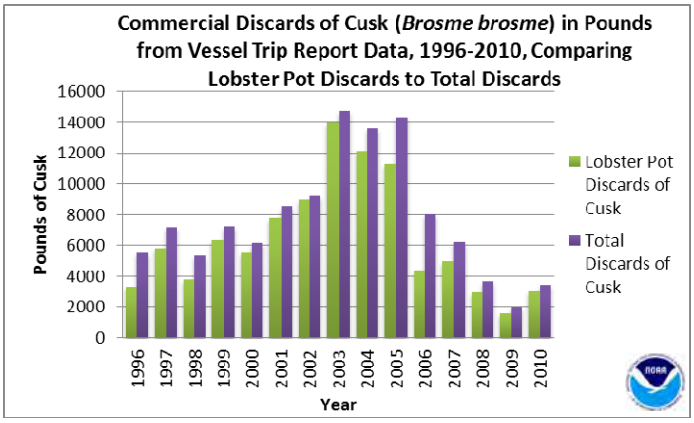


Figure 5. Comparison of the total discards of cusk (Brosme brosme) in all fisheries to discards of cusk in lobster pot fisheries from 1996-2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

Cusk Catch by Gear Type

VTR data show that the majority of cusk catch in commercial fisheries from 2004-2010 occurred in the following gear: Bottom Longline (LLB), Otter Trawl Bottom Fish (OTF), and Gill Net Sink (GNS), with LLB contributing to 53%, OTF 23%, and GNS 17% of the total catch during those years (see Figures 6 and 7 for graphics and Appendix 1 for gear code explanation). Lobster Pot (PTL) and Hand Line/Rod and Reel (HND) gear exhibited the next greatest catch of cusk from 2004-2010 with 6% at 47,692 lbs and 1% at 11,546 lbs of the total catch respectively.

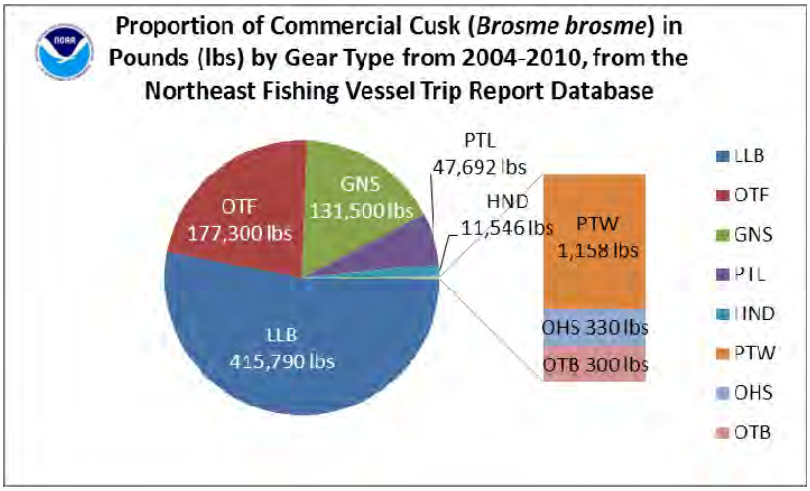


Figure 6. Proportion of commercial catch (landings and discards) of cusk (Brosme brosme) in pounds from 2004-2010 by gear type. Graphs excludes gears with total catch less than 300 lbs. For gear code explanation see Appendix 1. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

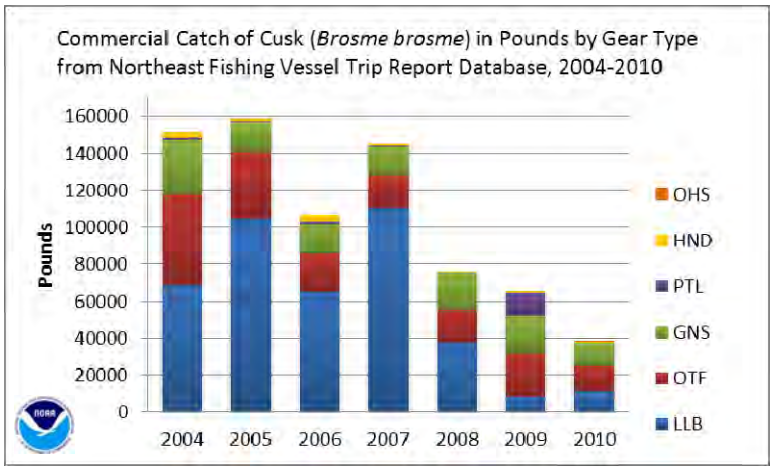


Figure 7. Commercial catch (landings and discards) of cusk (Brosme brosme) in pounds by gear type from 2004-2010, illustrating each gear type contribution yearly to the total catch of cusk. Catch of cusk was reported in nine other gear types for this time period; however, this graph excluded gears with total catch less than 300 lbs. For gear code explanation, see Appendix 1 (e.g. Longline Bottom (LLB), Otter Trawl Bottom Fish (OTF), Gill Net Sink (GNS), Lobster Pot (PTL)). Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

Cusk Catch by Statistical Areas

Data from the Northeast Fishing Vessel Trip Report (VTR) database show the highest catch of cusk including all commercial gear types from 2004-2010 occurred in the following statistical areas (SA): 515, 521, and 513, with total catch exceeding 100,000 lbs total for that time period (see Figure 8 for graphics, and Appendix 2 for SA map). Areas 522, 512, 561, and 464 all showed a total catch of cusk between 2004-2010 to range from approximately 28,000 to 52,000 lbs. From 1996 to 2010, highest total catch of cusk was reported from the same areas (see Figure 9) suggesting that cusk are continuing to be caught in the same general range. VTR data showed that areas of highest total catch of cusk in lobster pot (PTL) gear from 2004-2010 varied from the other major contributing fisheries with 53% of all cusk catch in PTL gear being in area 464, with the next highest catch found in areas 465, 561, and 515 contributing to 12%, 9% and 9% respectively of the total cusk catch in PTL gear (see Figure 10).

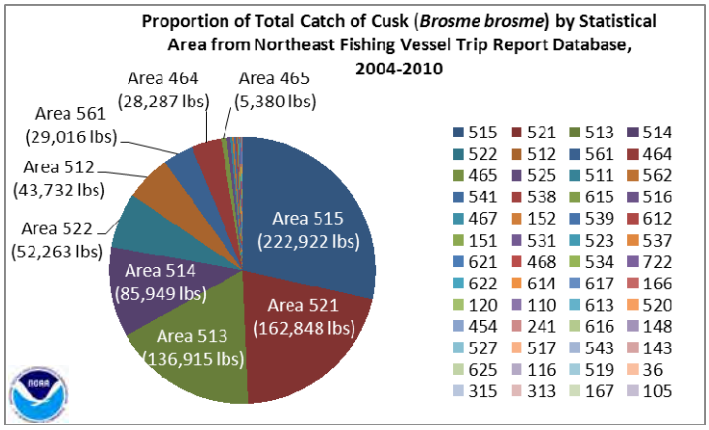


Figure 8. Proportion of total commercial cusk (Brosme brosme) catch (landings and discards) by statistical area from 2004-2010. For statistical area map see Appendices 2 and 3, or Figures 11-17. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

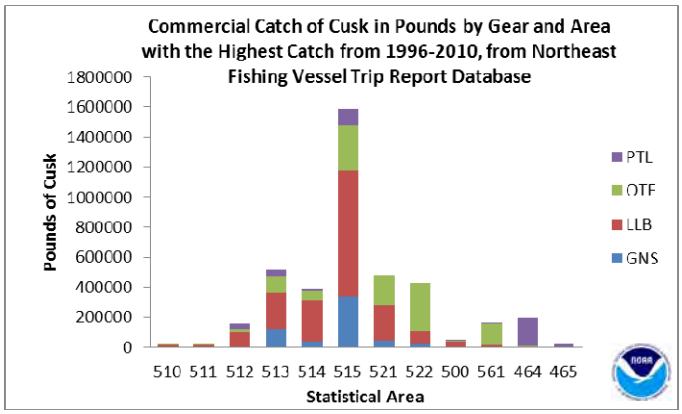


Figure 9. Commercial catch (landings and discards) of cusk in pounds by Lobster Pot (PTL), Otter Trawl Bottom Fish (OTF), Long Line Bottom (LLB), and Gill Net Sink (GNS) gear in statistical areas with the highest catch from 1996-2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. For statistical area map see Appendices 2 and 3, or Figures 11-17. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

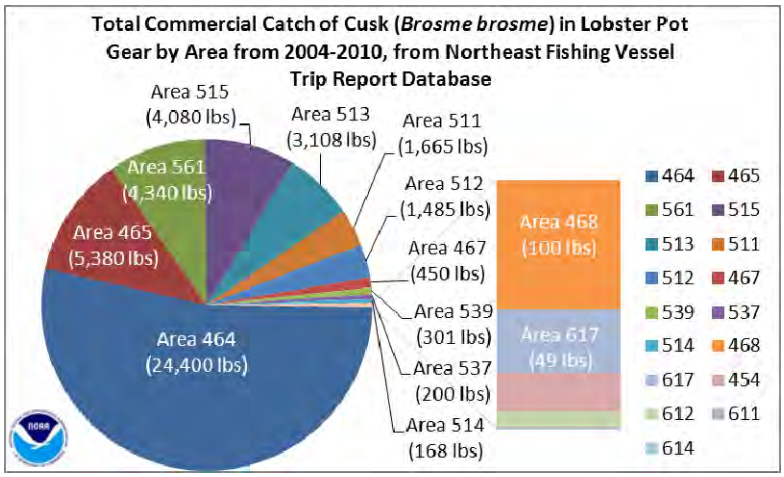


Figure 10. Commercial catch (landings and discards) of cusk in pounds by Lobster Pot (PTL) gear from 2004-2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. For statistical area map see Appendices 2 and 3, or Figures 11-17. Data are preliminary and subject to change. Prepared by NMFS Northeast Region.

Figures 11-18 show average annual cusk catch by area as reported on Northeast Fishing Vessel Trip Reports (VTR) from 2004-2010, from commercial (pounds) and recreational (count) fisheries*. Figure 11 shows landings for all commercial gear types combined, and Figures 12-18 show the primary gear types reporting cusk (including recreational). Figures 19 and 20 show total catch of cusk per year by area for commercial (pounds) and recreational (count).

***Note: It will be helpful to receive feedback from participants on the areas that the VTR data indicate cusk can occur compared to other information and experience provided by participants at the workshop. Participants will be considering all information to discuss whether such "hotspots" can be identified. These graphics provide some preliminary information and an example of some of the information which will be provided and discussed.**

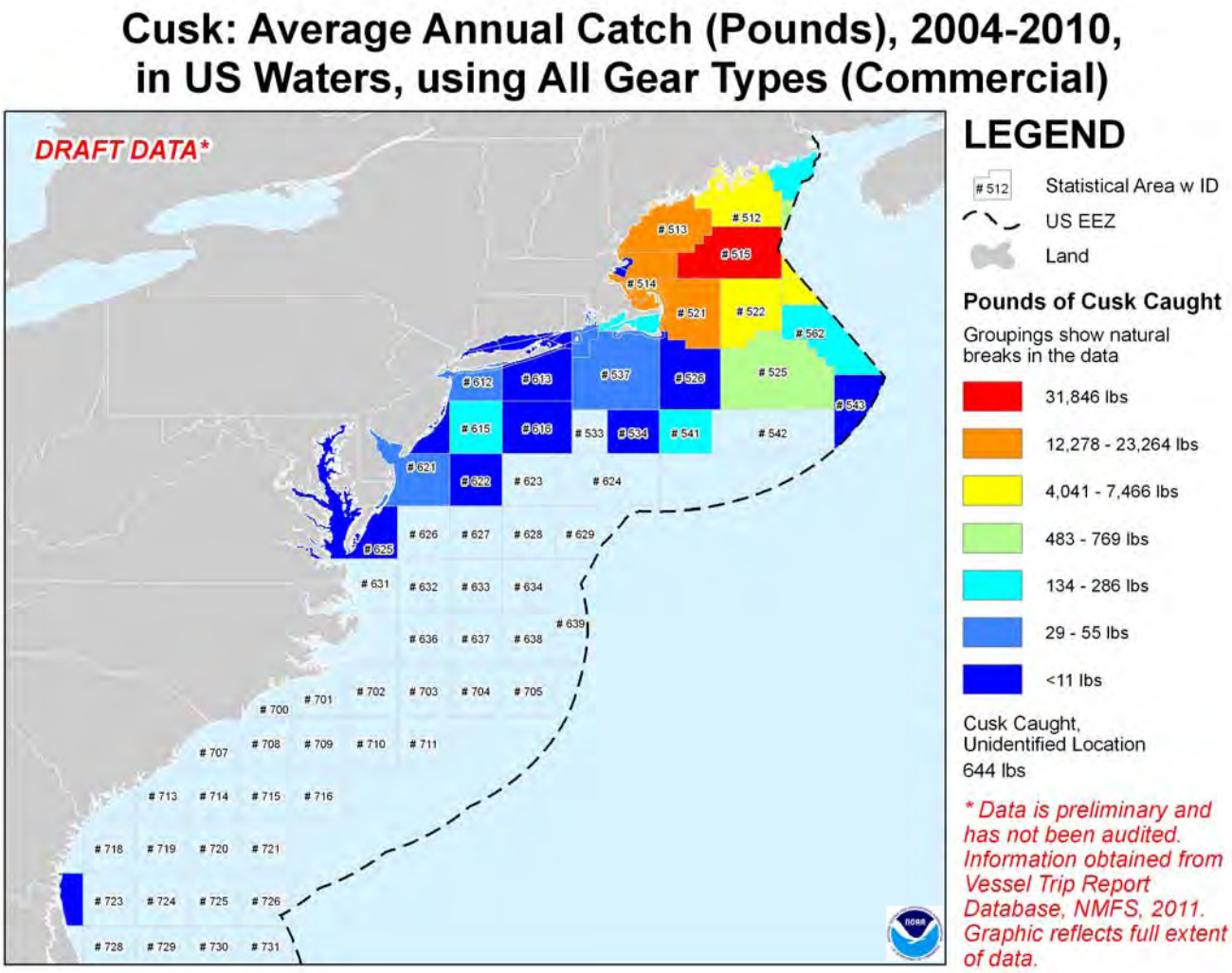


Figure 11. Average annual commercial catch of cusk (Brosme brosme) in US waters by all gear types from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

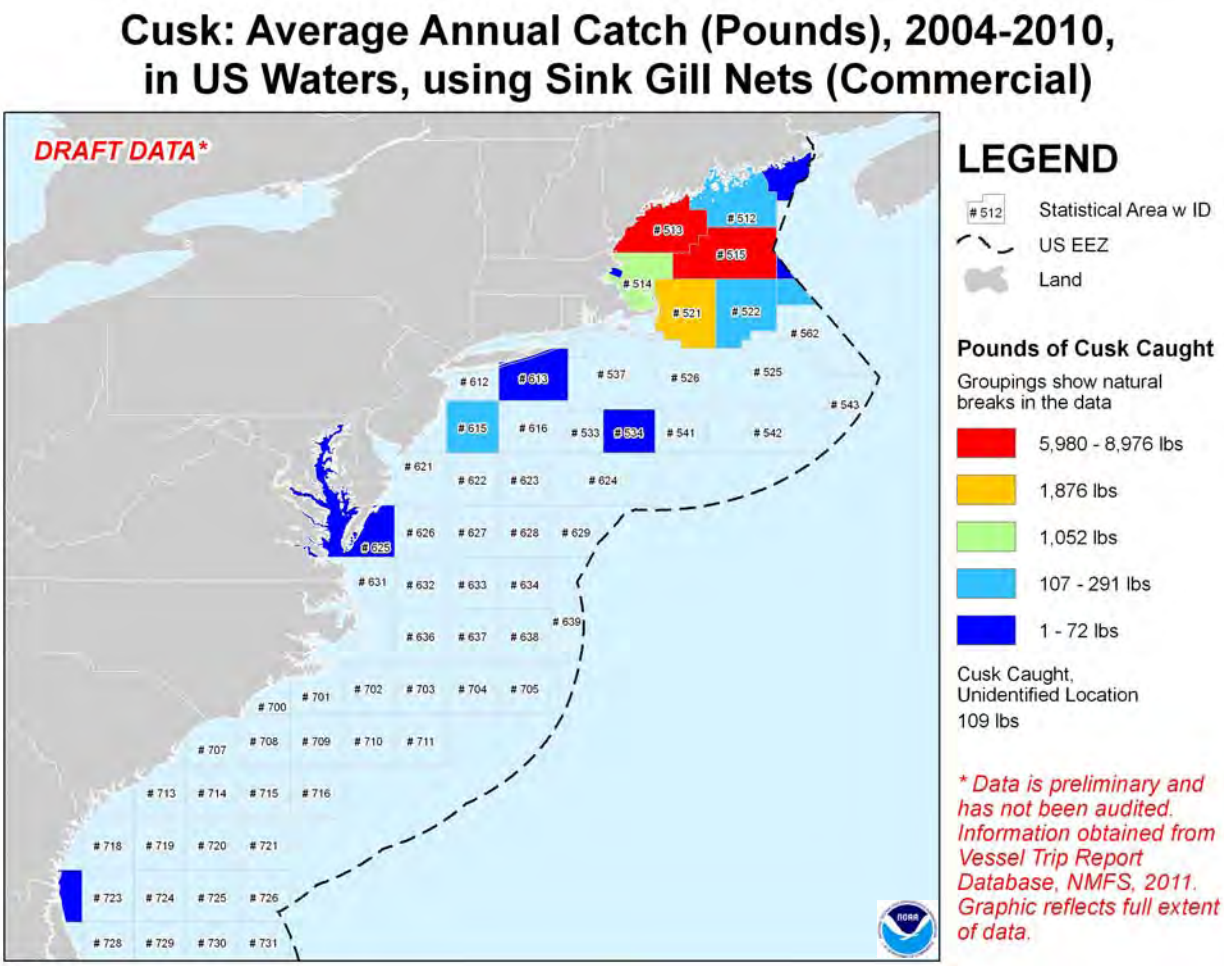


Figure 12. Average annual commercial catch of cusk (Brosme brosme) in US waters by sink gill net gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

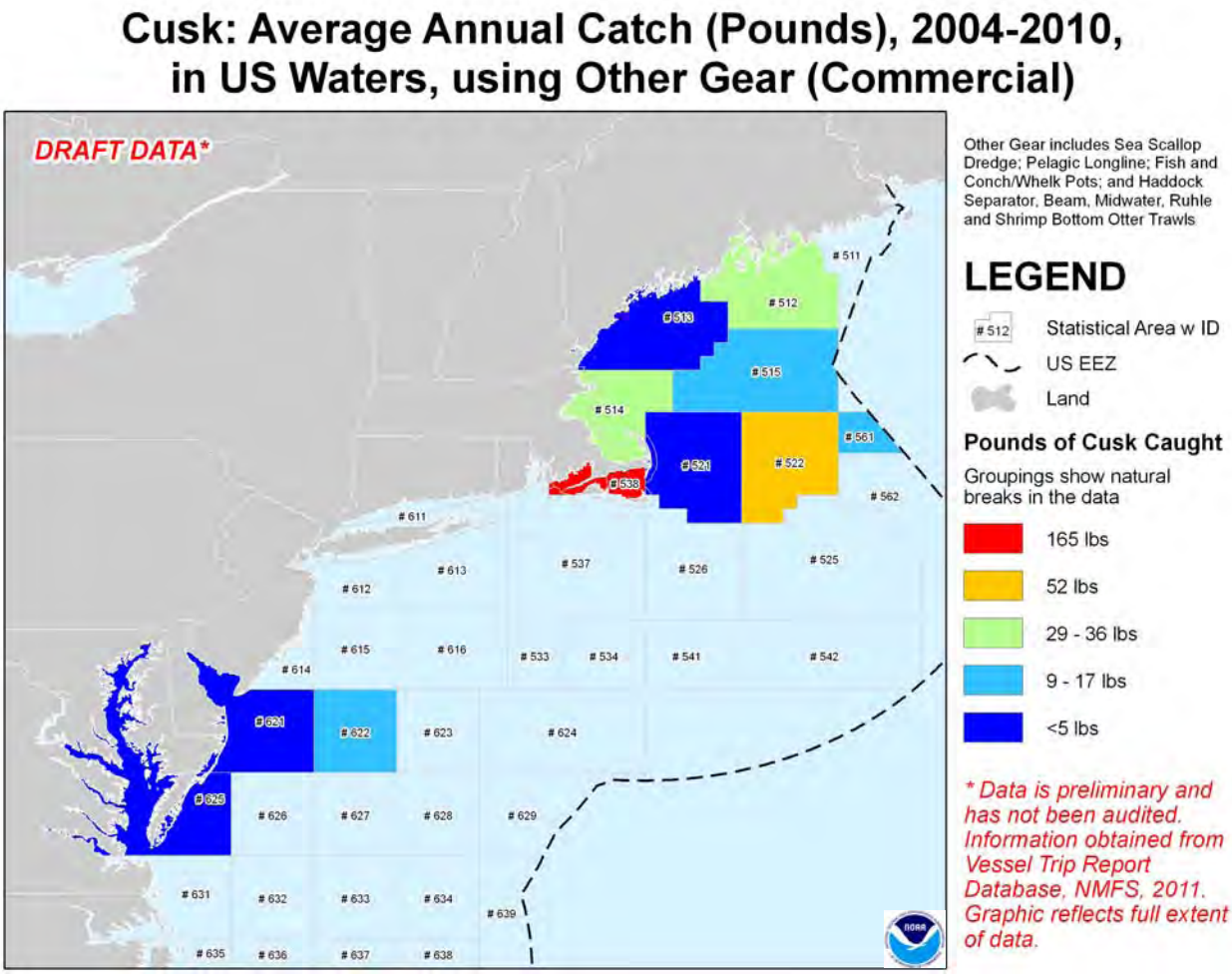


Figure 13. Average annual commercial catch of cusk (Brosme brosme) in US waters by other gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

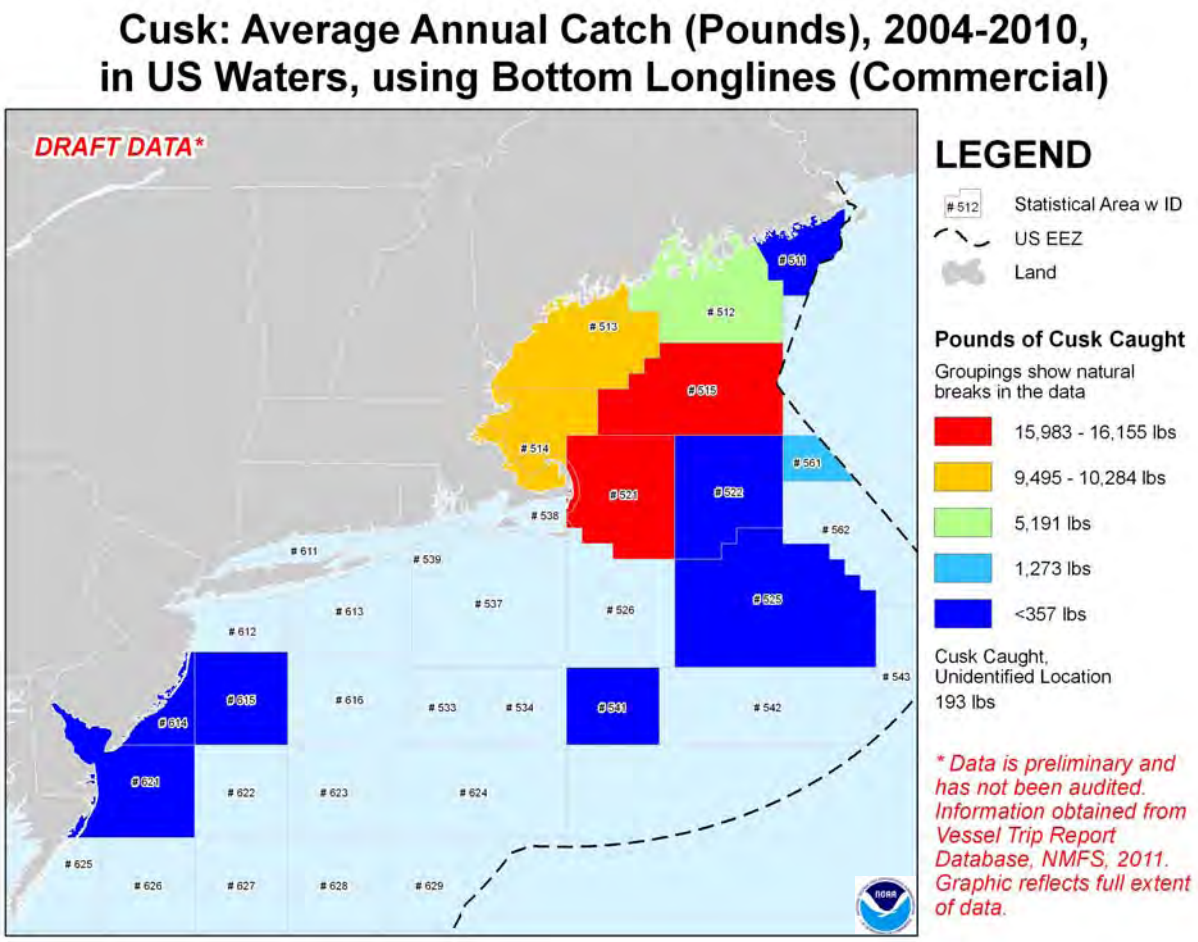


Figure 14. Average annual commercial catch of cusk (Brosme brosme) in US waters by bottom longline gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

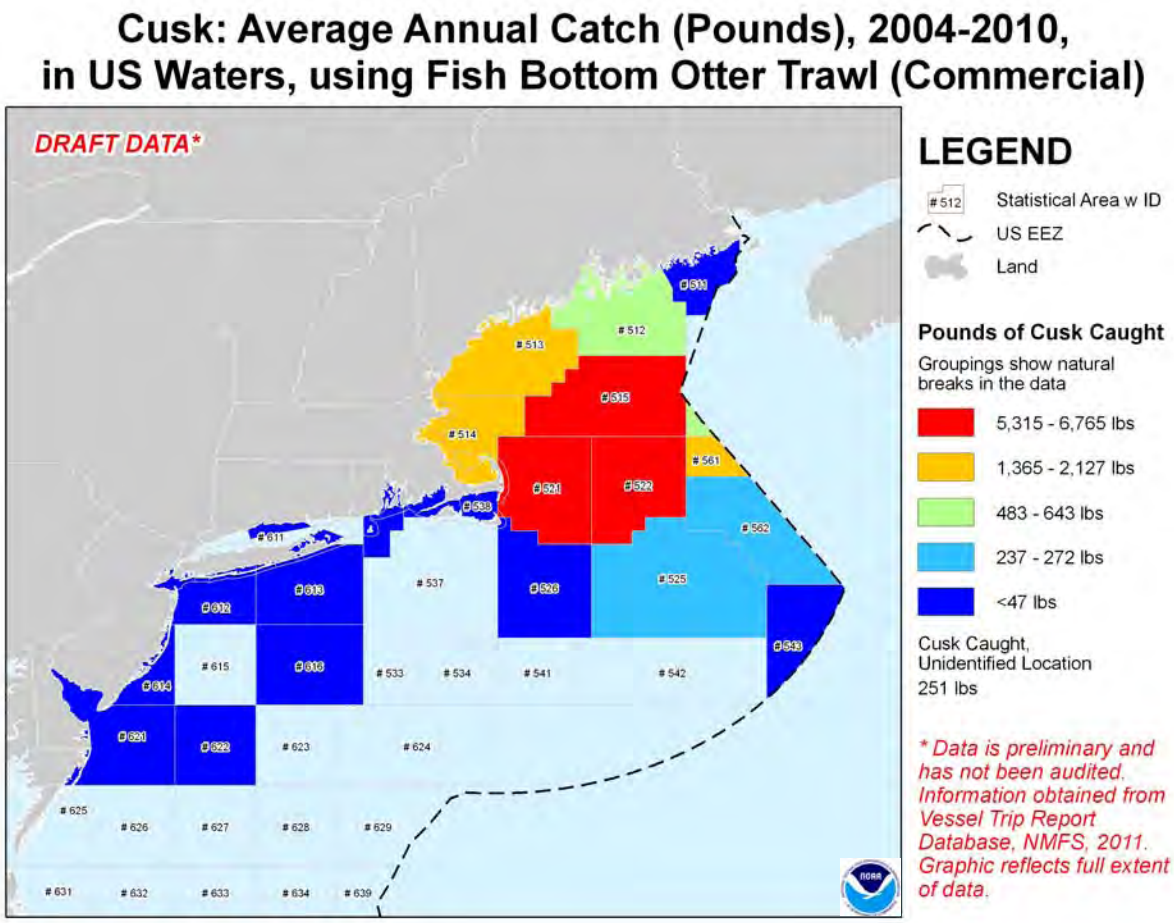


Figure 15. Average annual commercial catch of cusk (Brosme brosme) in US waters by bottom fish otter trawl gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

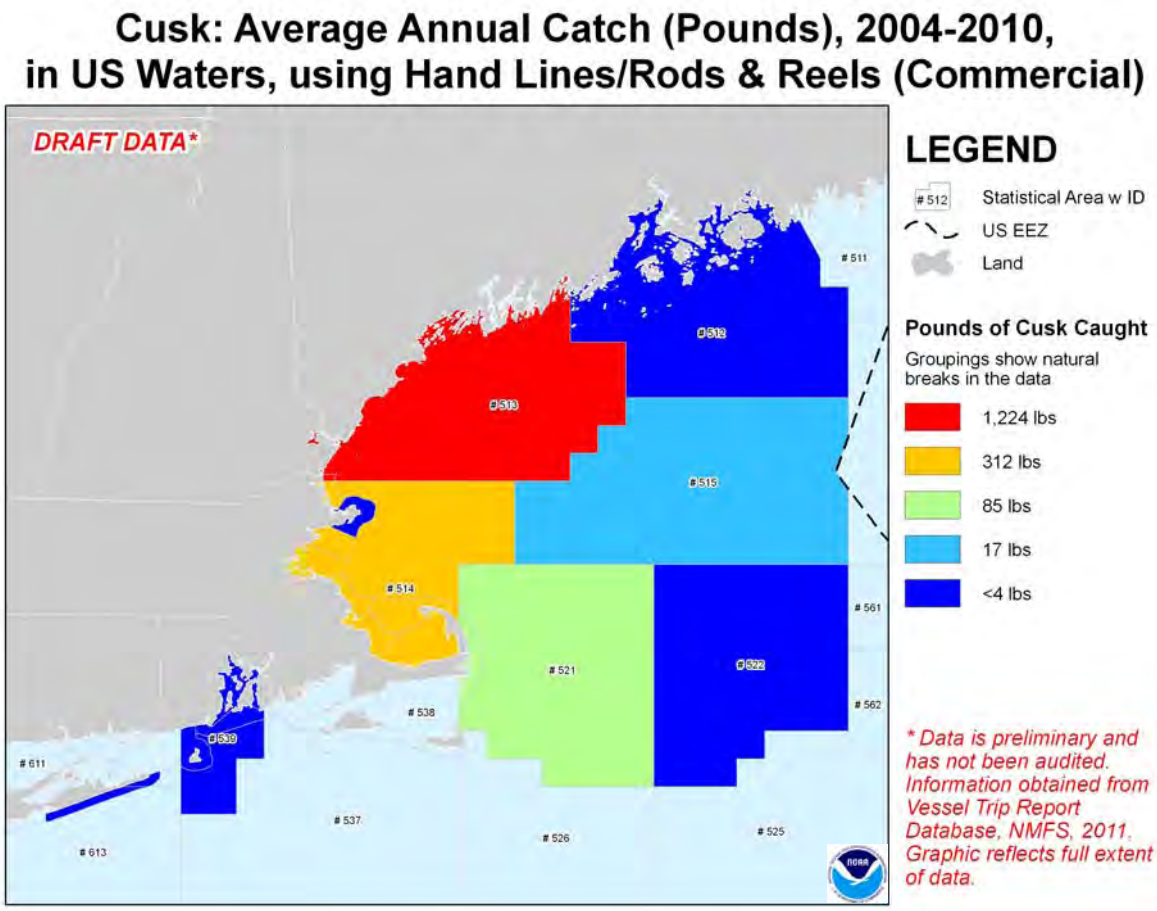


Figure 16. Average annual commercial catch of cusk (Brosme brosme) in US waters by hand lines/rod and reel gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

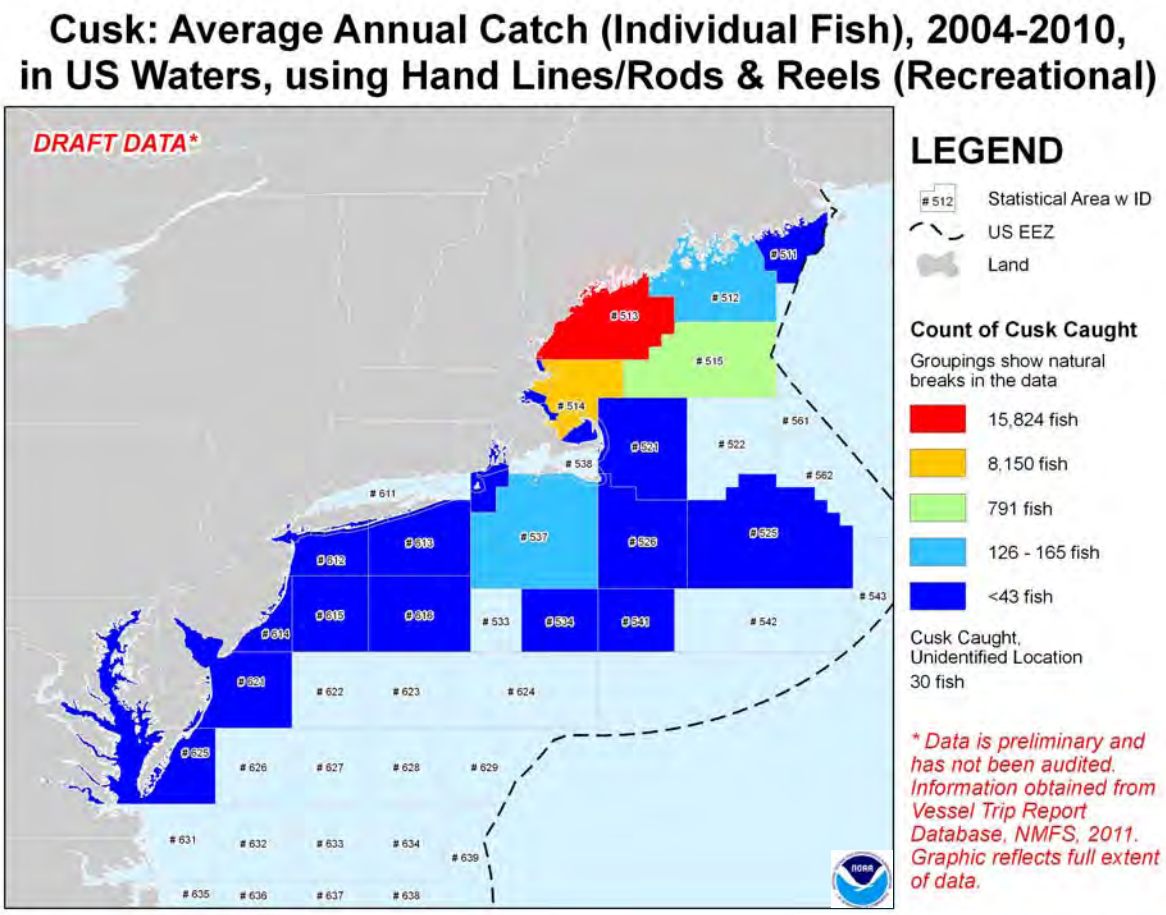


Figure 17. Average annual recreational catch of cusk (Brosme brosme) by individual count in US waters by hand line/rod and reel gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

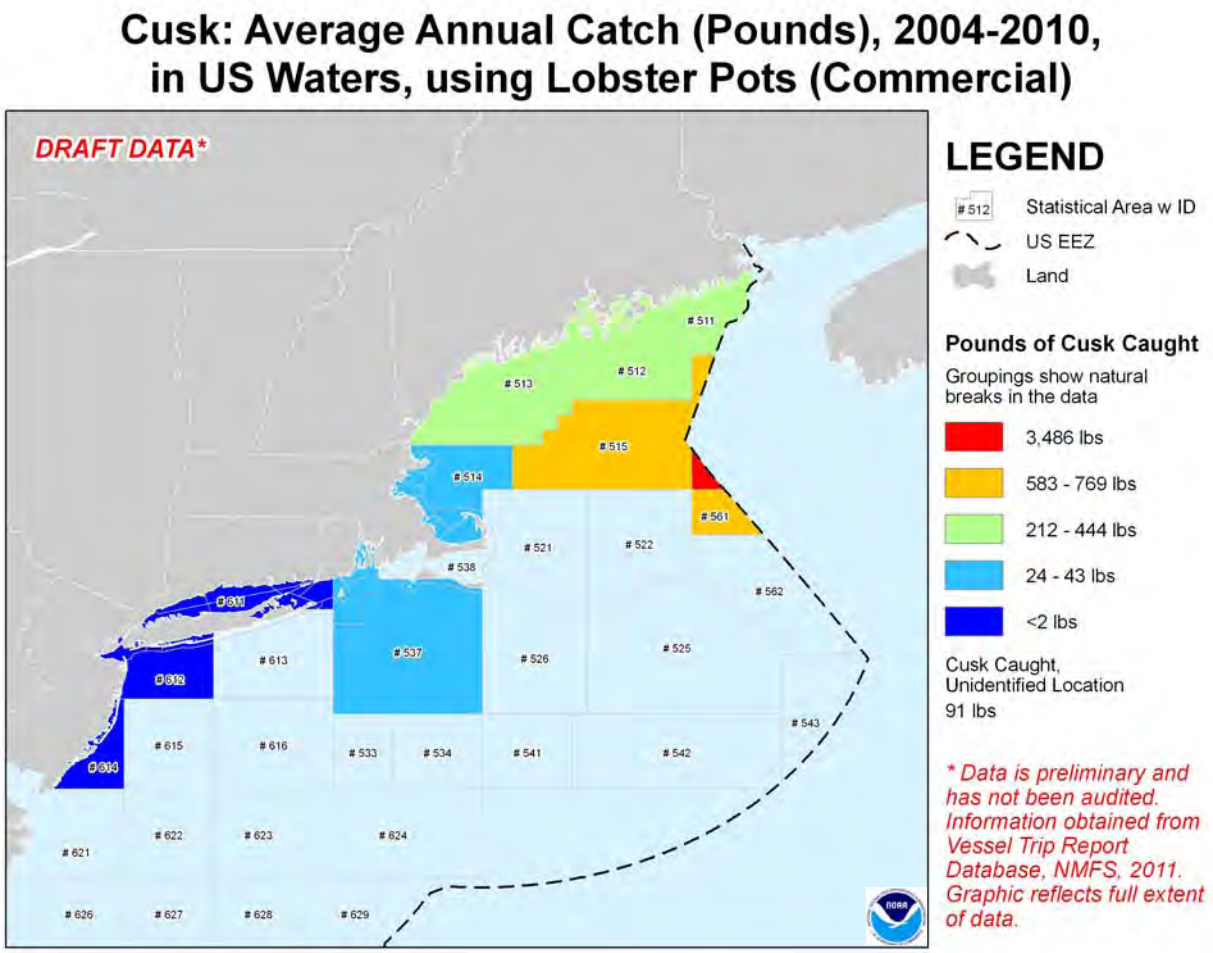


Figure 18. Average annual commercial catch of cusk (Brosme brosme) in pounds in US waters by lobster pot gear from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

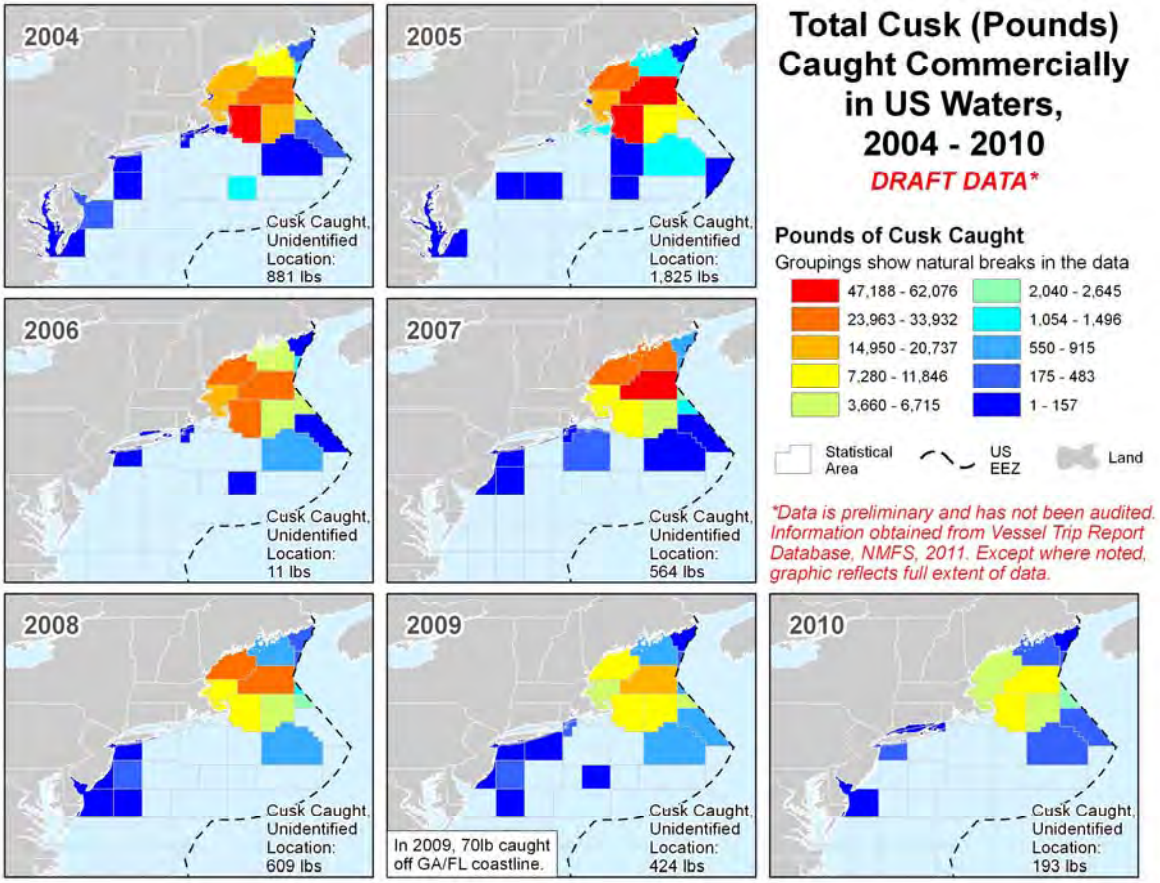


Figure 19. Total pounds of cusk (Brosme brosme) caught commercially in US waters by all commercial gear by year from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

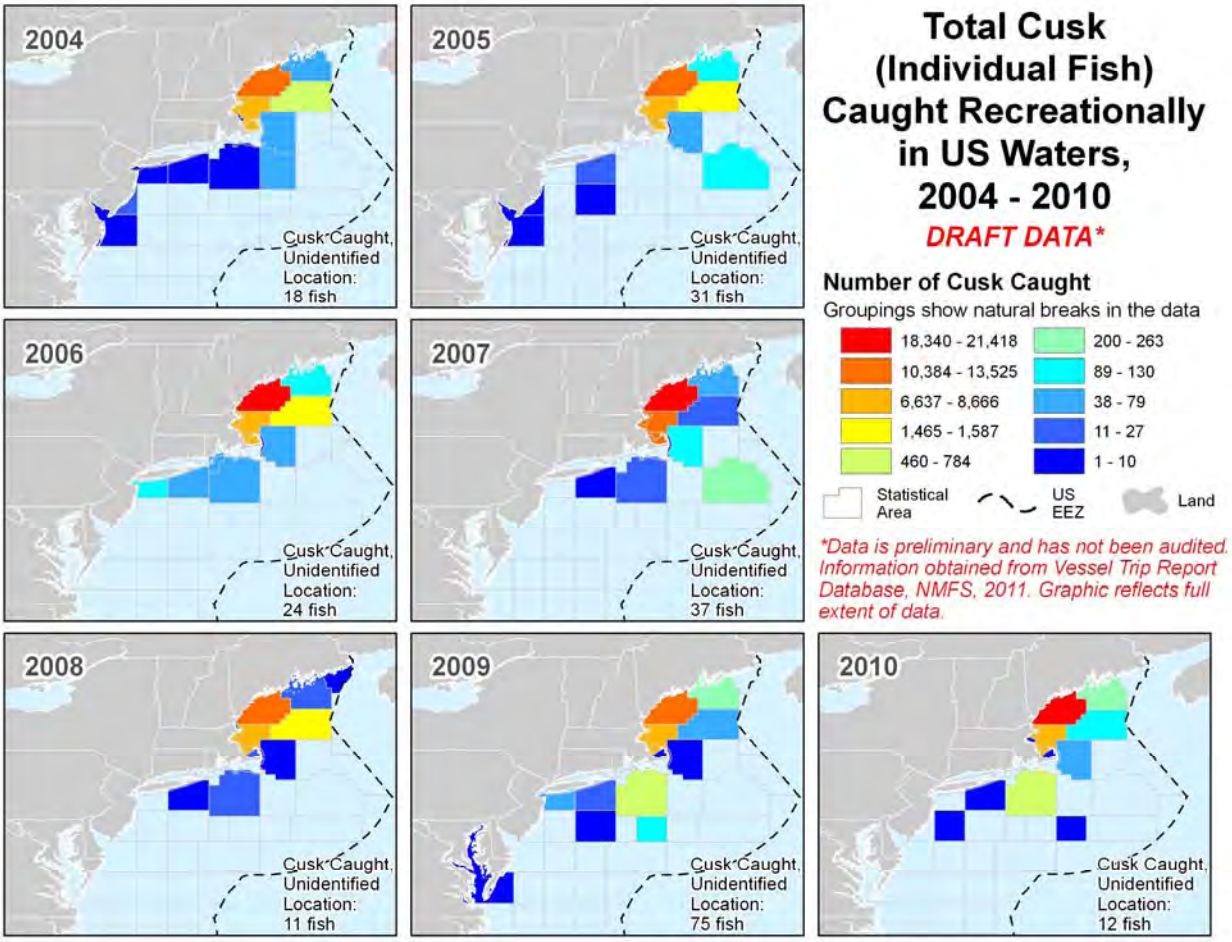


Figure 20. Total pounds of cusk (Brosme brosme) caught recreationally in US waters by year from 2004 through 2010. Information obtained from Northeast Fishing Vessel Trip Report Database, NMFS, 2011. Data is preliminary and subject to change. Prepared by NMFS Northeast Region.

Marine Recreational Fisheries Statistics Survey

Data queried from the Marine Recreational Fisheries Statistics Survey (MRFSS) showed a similar increasing trend in recreational catch of cusk to the VTR data, with both data sets showing a significant drop in total catch in 2008 and 2009 with subsequent increase in 2010 (see Figure 21). States with reported recreational catch from 1996-2010 were Massachusetts, New Hampshire, Maine, and Rhode Island (see Figure 22). Reported catch of cusk has fluctuated in both Maine and New Hampshire from just under 50,000 individual fish caught per year to below 1,000. The greatest reported cusk catch from Rhode Island was in 1999 with 960 individual fish reported; however, no catch has been reported since 2003. Massachusetts exhibited the greatest catch compared with all other states, reaching a high of approximately 140,000 individual fish caught in 2007 with a subsequent drop to just over 83,000 in 2008, and down to approximately 14,000 and 26,000 individual cusk caught in 2009 and 2010 respectively.

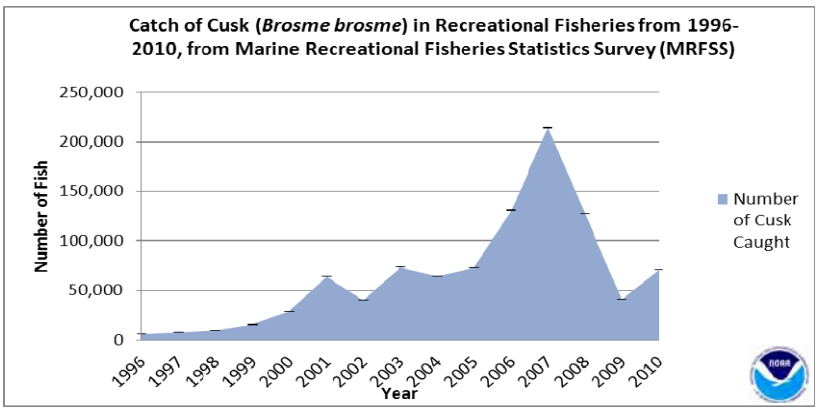


Figure 21. Recreational catch of cusk (Brosme brosme) from 1996-2010. Data obtained from Marine Recreational Fisheries Statistics Survey (MRFSS) database, queried on November 16, 2011. Prepared by NMFS Northeast Region.

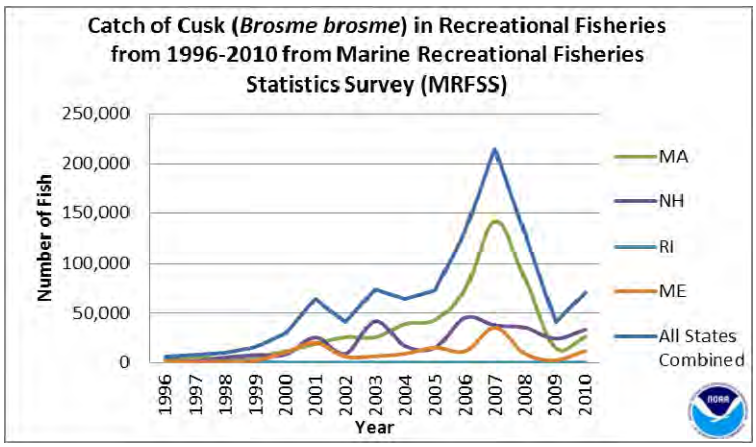


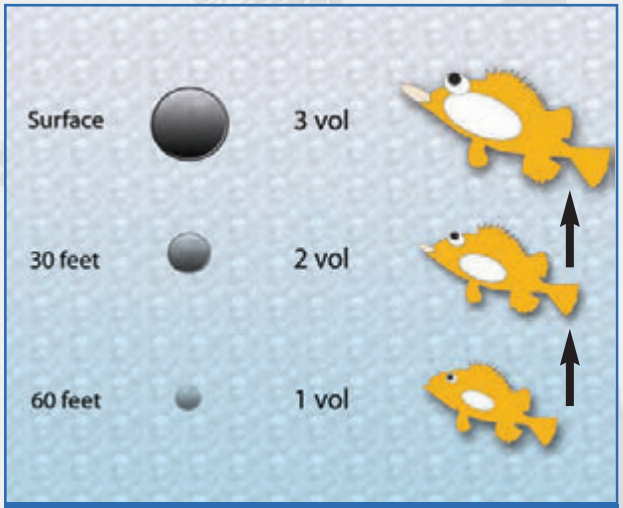
Figure 22. Recreational catch of cusk (Brosme brosme) from 1996-2010, comparing catch in Massachusetts, New Hampshire, Rhode Island, and Maine with the total catch of cusk in all states. Data obtained from Marine Recreational Fisheries Statistics Survey (MRFSS) database, queried on November 16, 2011. Prepared by NMFS Northeast Region.

WHY ARE ROCKFISH PRONE TO PRESSURE-RELATED INJURIES?

Every rockfish has a gas-filled organ called a swim bladder that allows the fish to gently control its buoyancy. By deflating its bladder, a fish can descend more easily. By inflating it, its ascent is assisted. When a fish is caught and reeled in, this mechanism for moving vertically in the water column is thrown out of whack.

Depending on the depth at which the fish was caught, a fish's air bladder may swell so much its stomach is forced out its mouth. The eyes may bulge and other organs can be injured as well. Fish suffering from pressure-related injuries are said to be experiencing barotrauma (pressure shock). Without intervention, a fish with barotrauma may die from the progression of its wounds or succumb to temperature shock or predators.

"Floaters" – overly inflated fish that cannot re-descend on their own – are especially easy targets for sea gulls and sea lions.



The volume of a fish's swim bladder can triple when reeled in from depths as shallow as 60 feet.

Alternate communication formats of this document are available upon request. If reasonable accomodation is needed, call DFG at (916) 322-8911. The California Relay Service for deaf or hearing impaired can be utilized from TDD phones at (800) 735-2929.

ROCKFISH-BAROTRAUMA MYTHS

Myth:	Reeling a fish in slowly prevents barotrauma.
Fact:	Rockfish cannot acclimate to the pressure drop even when reeled in slowly.
Myth:	The organ protruding from a "popped" fish's mouth is the swim bladder.
Fact:	It is the stomach! Never vent the stomach or try to force it back inside the mouth.
Myth:	You can tell by looking whether a fish will survive or die.
Fact:	When properly recompressed, even fish with severe barotrauma can survive.

ROCKFISH-BAROTRAUMA SCIENCE

According to published results of a Sea Grant study led by researchers at Cal State Long Beach:

The degree of barotrauma in a fish is not a reliable predictor of its survival. The most significant predictor of post-release survivorship is the time a fish spends at the surface.

In experiments with several species of common Southern California rockfish, 83 percent of fish caught at depths between 217 feet and 350 feet, survived when returned to depth within 2 minutes. The odds of a fish dying following recompression nearly doubled with every 10-minute increase in time at the surface.

Tagging and recapture studies showed some released fish were still alive 1.5 years later.

For current recreational groundfish fishing regulations, call (831) 649-2801 for recorded information or visit the California Department of Fish and Game website at www.dfg.ca.gov/marine/regulations.asp.

Sea Grant

This brochure was a collaborative effort of California Sea Grant, Oregon Sea Grant and the California Department of Fish and Game.
Printing was funded by the California Department of Fish and Game.

Sea Grant

BRING THAT ROCKFISH DOWN

Compiled by NMFS Northeast Region for the 2011 Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

FISH CAN SURVIVE BAROTRAUMA

Amazingly, rockfish that look dead at the surface can "pop" back to life if quickly returned to a native depth range. Because of this, rockfish that you must, or want to, toss back should be quickly recompressed.

Even fish with bulging eyes and protruding stomach can survive if returned to depth quickly. Note: the organ protruding from the fish's mouth is the stomach, not the swim bladder.

TOP FIVE REASONS TO SEND'EM DOWN

Why should you care about helping a released fish return to depth?

1. Floating fish are a waste of the resource.
2. Some populations of prohibited species, such as canary and yelloweye rockfish, may take decades to rebuild.
3. High-grading is illegal and selects for smaller fish in the gene pool.
4. Venting fish may cause more harm than good.
5. Re-descending fish can increase their chances of survival.

Catch-and-release practices work best when you can help with fish survival. Helping fish get back down is good for the resource and the sport.

PRACTICE THE FOLLOWING TECHNIQUES AND SAVE ROCKFISH LIKE THIS!

There are many ways of returning a fish to a depth at which it can recompress. Your choice may depend on the size of the fish you usually catch, your experience as an angler, sea conditions and cost.

Upside-down crate, weighted and attached to rope

Upside-down milk crate, weighted and attached to a rope: Crate is dropped over the fish and then, with the buoyant fish inside, lowered to a minimum depth of 60 feet and kept down until it can swim out on its own. Caveats: In rough seas, fish can escape prematurely and the crate may bang against a fish's extended eyes. Try lowering the fish down gently or paint crate's inside with a rubberized coating to smooth sharp edges.

Inverted barbless hook with weight

Inverted *barbless* hook with weight: Hook fish through lower lip from inside to outside, to keep hook from puncturing an extruded stomach and to prevent line cuts to eyes. You can also hook a fish through the membrane on its upper lip from outside to inside, which some say makes for easier release. In both cases, the weight must lead the fish into the water and be heavy enough to sink it to the desired depth. Fish is released with a sharp jerk on the line. Caveats: Hook can puncture an extruded stomach. Once a fish reaches a depth at which it regains muscle coordination, it may wrestle free prematurely. Method works best with smaller fish.

Commercial fish descender

Commercial fish descenders: There are a variety of practical, easy-to-use fish descenders on the market. The best one for you may depend on the sizes and species you catch. For more information, visit www.sheltonproducts.com and http://git-r-down.com.

VENTING: A sharp needle or steel cannula is used to puncture a fish's inflated swim bladder. The California Department of Fish and Game does not currently encourage venting as it can cause serious injury to fish and angler. You may accidentally puncture the wrong organ and/or introduce infection. Even when done properly, venting damages a fish's swim bladder.

Appendix 1. Commercial fisheries gear codes for vessel trip report (VTR) data. *Source:* Fishing Vessel Trip Report (VTR) Reporting Instructions downloaded November, 2011, from http://www.nero.noaa.gov/ro/fso/vtr_inst.pdf.

TRAWLS

CODE	GEAR DESCRIPTION
OTB	OTTER TRAWL, BEAM
OTC	OTTER TRAWL,BOTTOM,SCALLOP
OTF	OTTER TRAWL,BOTTOM,FISH
OHS	OTTER TRAWL, HADDOCK SEPARATOR
OTR	OTTER TRAWL, RUHLE
OTM	OTTER TRAWL,MIDWATER
OTS	OTTER TRAWL,BOTTOM,SHRIMP
PTM	PAIR TRAWL,MIDWATER
PTB	PAIR TRAWL,BOTTOM
PUR	SEINE, PURSE
SED	SEINE, DANISH
SEH	SEINE, HAUL
SES	SEINE, SCOTTISH
STS	SEINE, STOP

GILLNETS

CODE	GEAR DESCRIPTION
GND	GILL NET,DRIFT
GNR	GILL NET,RUNAROUND
GNS	GILL NET,SINK

HOOK AND LINE

CODE	GEAR DESCRIPTION
LLB	LONGLINE,BOTTOM
LLP	LONGLINE, PELAGIC
HND	HAND LINE/ROD & REEL

DREDGES

CODE	GEAR DESCRIPTION
DRC	DREDGE,OCEAN QUAHOG/SURF CLAM
DRM	DREDGE,MUSSEL
DRS	DREDGE,SCALLOP,SEA
DSC	DREDGE, SCALLOP-CHAIN MAT
DRU	DREDGE, URCHIN

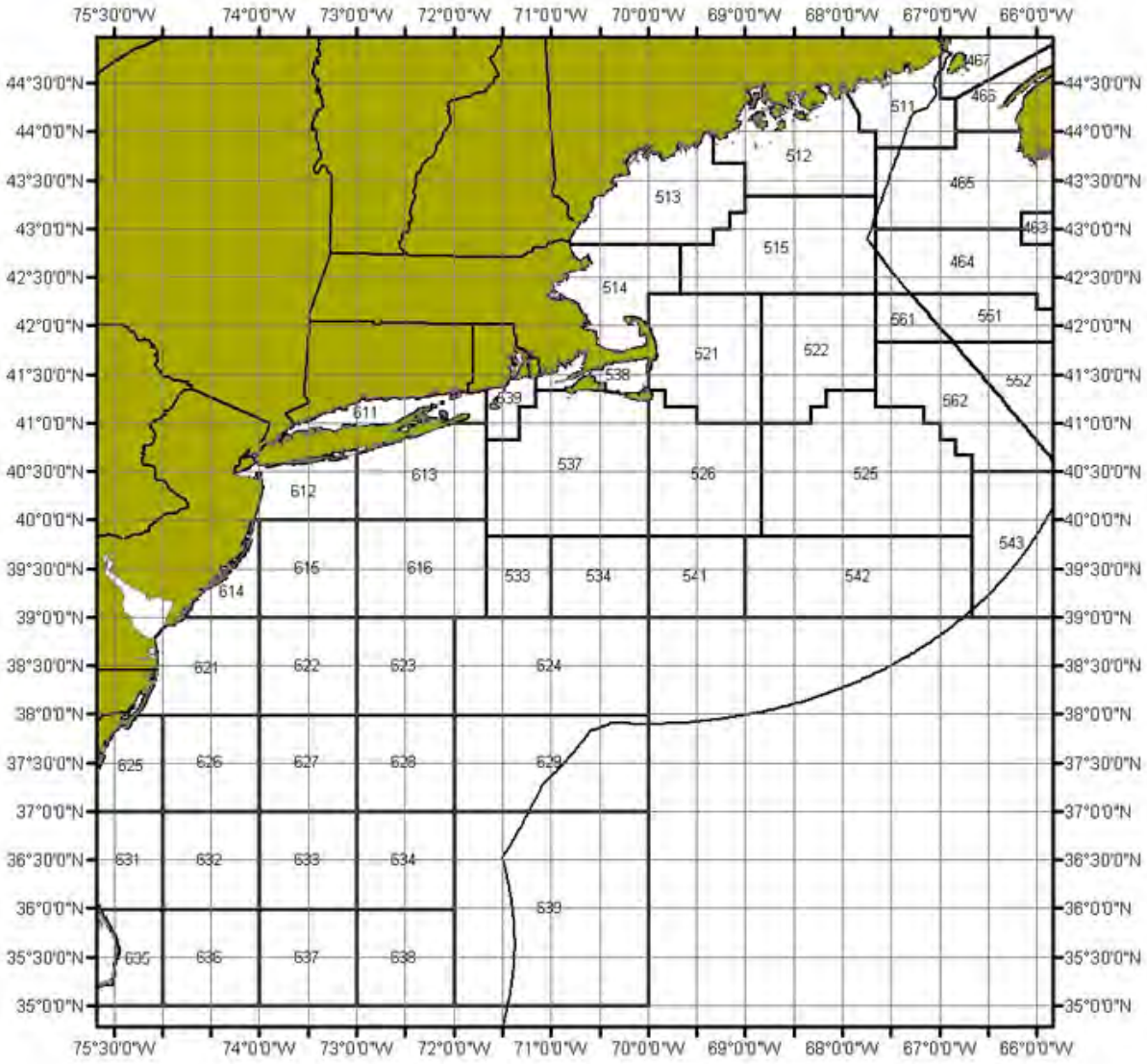
POTS AND TRAPS

CODE	GEAR DESCRIPTION
PTC	POT,CRAB
PTE	POT, EEL
PTF	POT,FISH
PTH	POT, HAG
PTL	POT,LOBSTER
PTS	POT,SHRIMP
PTW	POT, CONCH/WHELK
TRP	TRAP, FISH
WEI	WEIR

OTHER

CODE	GEAR DESCRIPTION
CST	CASTNET
DIV	DIVING GEAR
FYK	FYKE NET
HRP	HARPOON
RAK	HAND RAKE

Appendix 2. NOAA Fisheries Service Northeast Region Statistical Areas. Map downloaded November, 2011, from http://www.nero.noaa.gov/nero/fishermen/charts/stat1.html. These charts are not meant for navigational purposes. They are informational only.



Appendix 3. Charts 1-9 of statistical areas including Gulf of Maine, Georges Bank, Long Island Sound and New York NEMFIS area, Southern New England, Massachusetts Bay and Cape Cod NEMFIS area, Rhode Island Sound, Cape Cod and the Islands NEMFIS areas, East of Nova Scotia, and Mid-Atlantic areas. *Source:* Fishing Vessel Trip Report (VTR) Reporting Instructions downloaded November, 2011, from http://www.nero.noaa.gov/ro/fso/vtr_inst.pdf.

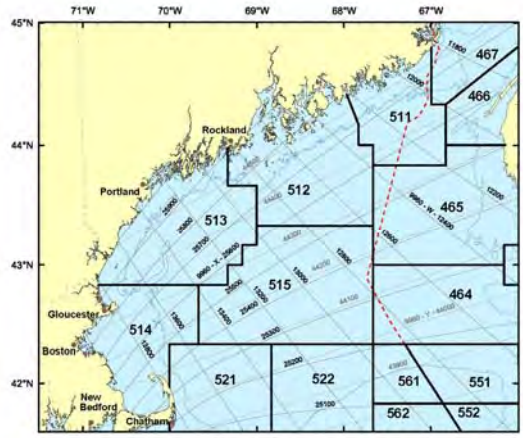


Chart 1. Gulf of Maine

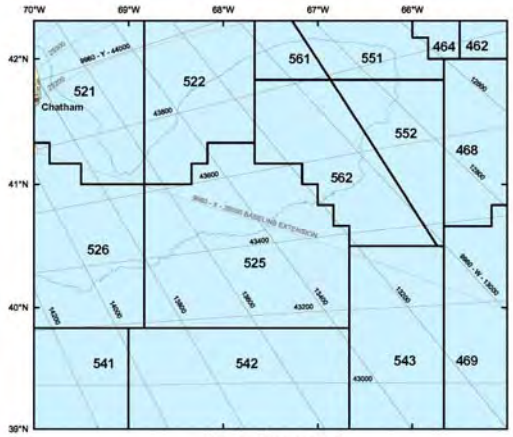


Chart 2. Georges Bank

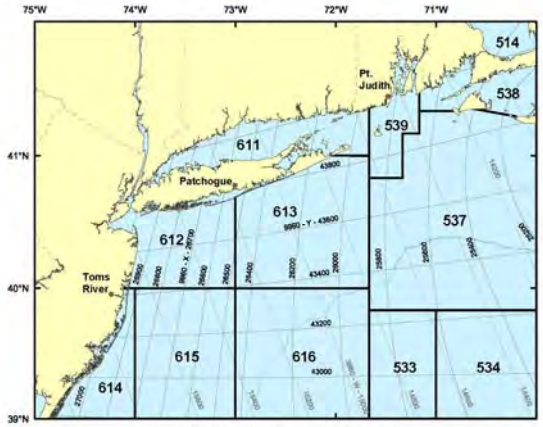


Chart 3. Southern New England

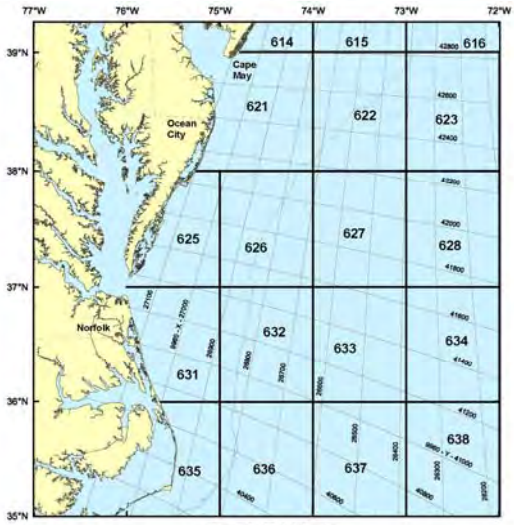


Chart 4. Mid-Atlantic

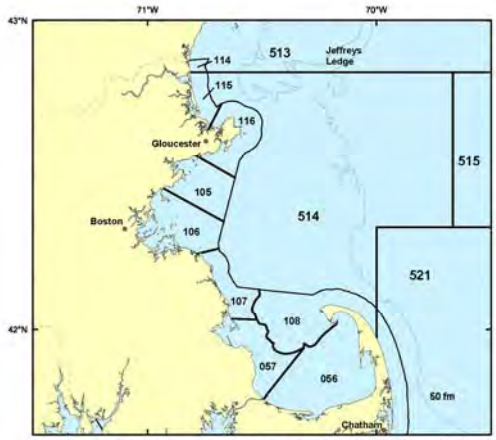


Chart 5. Massachusetts Bay and Cape Cod Bay NEMFIS Area Codes

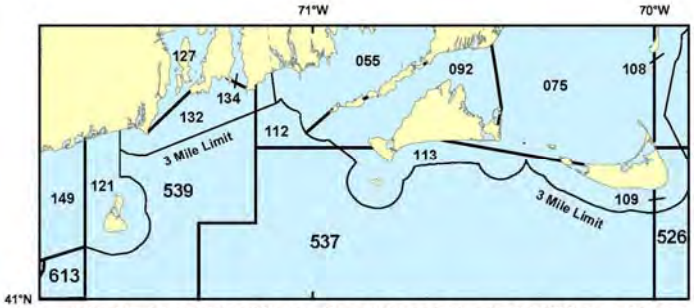


Chart 6. Rhode Island Sound, Cape Cod and Islands NEMFIS Area Codes

Appendix 3. (Continued)

Chart 7. Long Island Sound and New York NEMFIS Area Codes

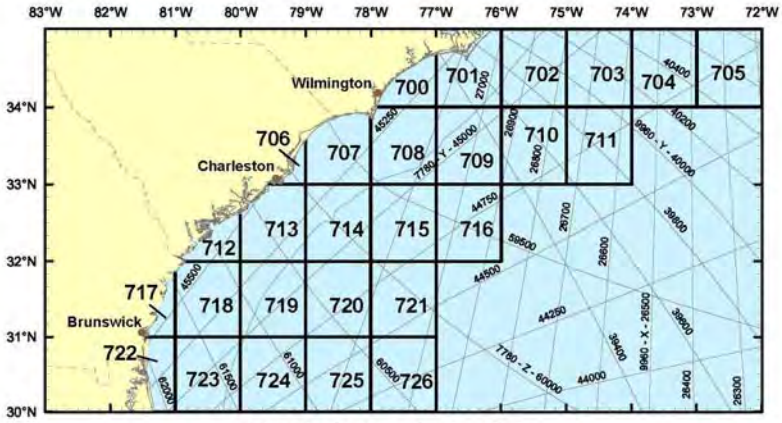


Chart 8. South of Cape Hatteras

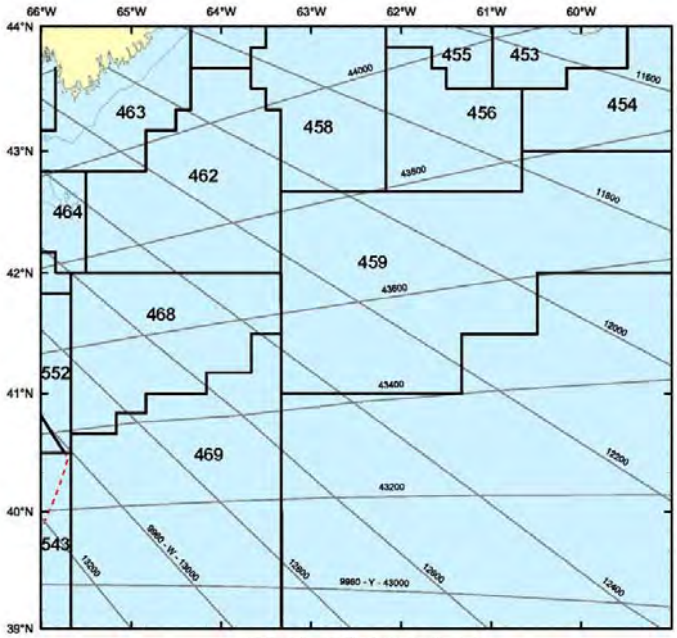


Chart 9. East of Nova Scotia

Appendix 3 – Presentations

What we know in the U.S.: lifecycle, distribution, genetics, stock structure, habitat and climate change

Jon Hare
Northeast Fisheries Science Center
Narragansett Laboratory

Cusk Life Cycle

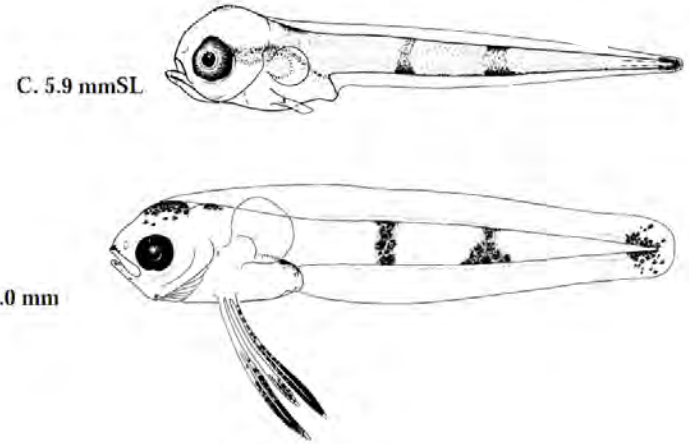
Typical life cycle for marine fish

- Small planktonic (water column) eggs
- Small planktonic (water column) larvae
- Juveniles settle from the plankton to the bottom
- Adults are bottom oriented

Late Juvenile – Benthic

?

Larvae & Early Juveniles - Pelagic



Data sources:

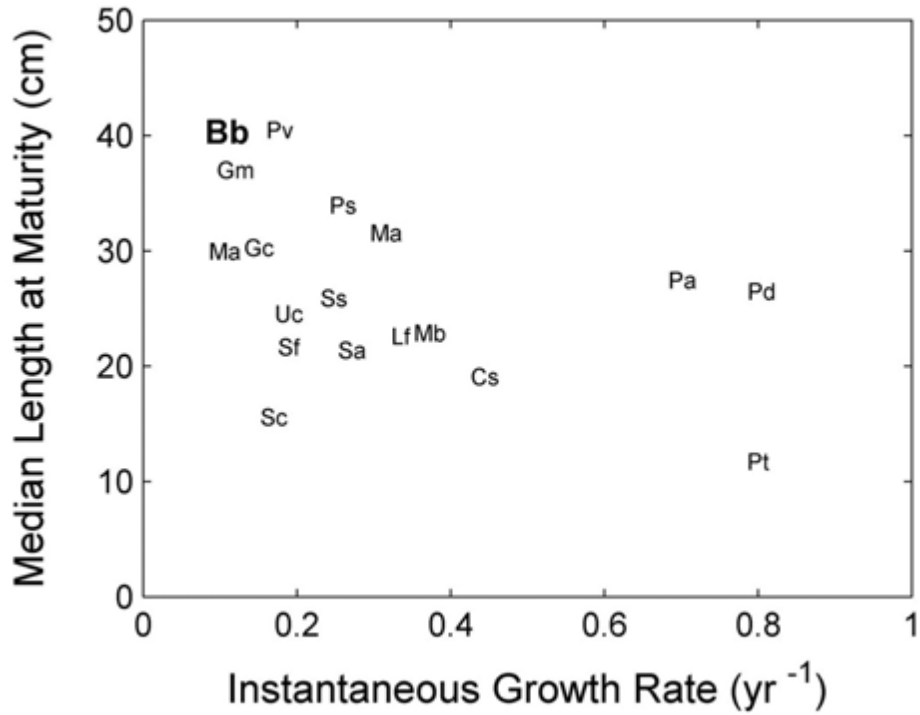
- **Summary of literature and NEFSC survey data**

Cusk Life Cycle

Life cycle is “slow” compared to other species in the region

Cusk (***B**rosme **b**rosme*) have large length-at-maturity and low growth rate

Studies have indicated that ‘slow’ species are slower to respond to change / pertubations



Data sources:

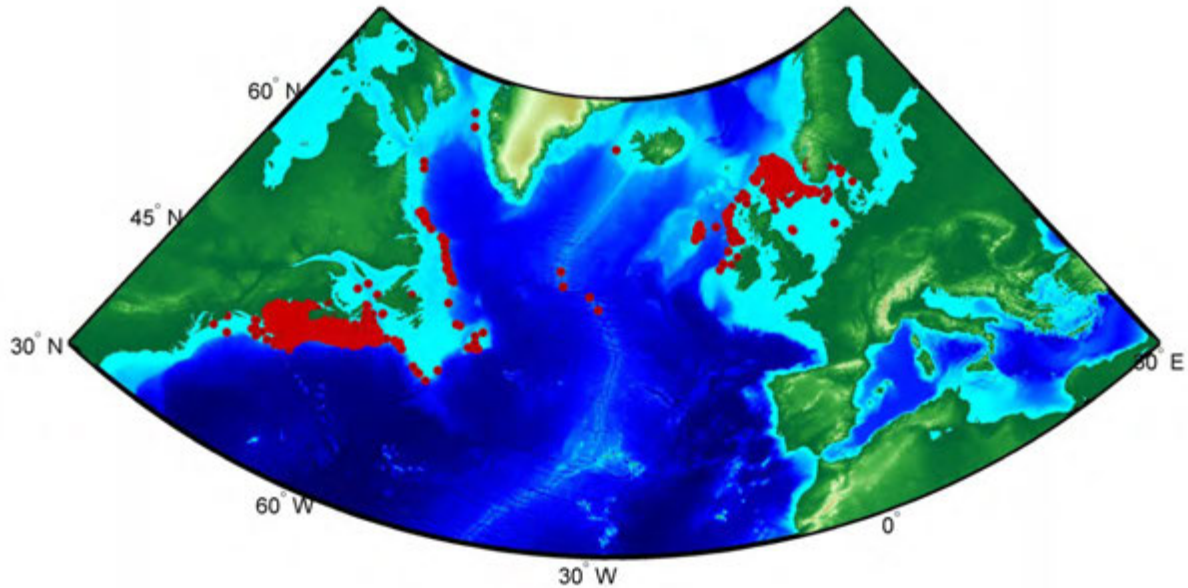
- **Largely based on O'Brien, L., J. Burnett, et al. (1993). Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990NOAA Tech. Report. NMFS 113, 66 p**
- **Other specific sources also included**

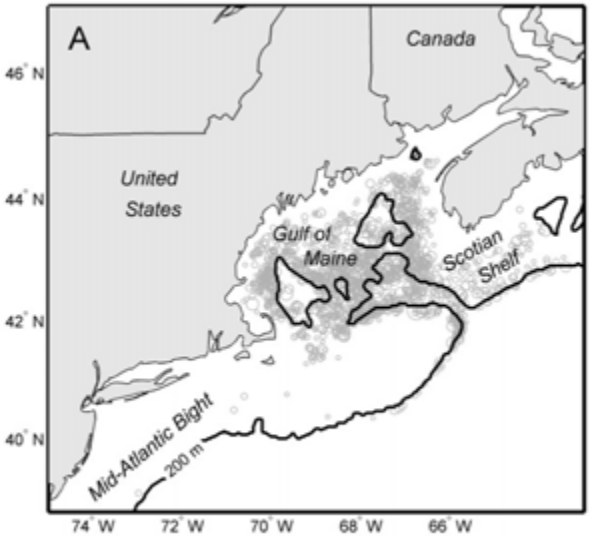
Cusk Distribution

Across North Atlantic

In U.S. waters, most abundant in deeper waters of the Gulf of Maine

Extend northward in Canadian waters along the Scotian Shelf





Data sources:

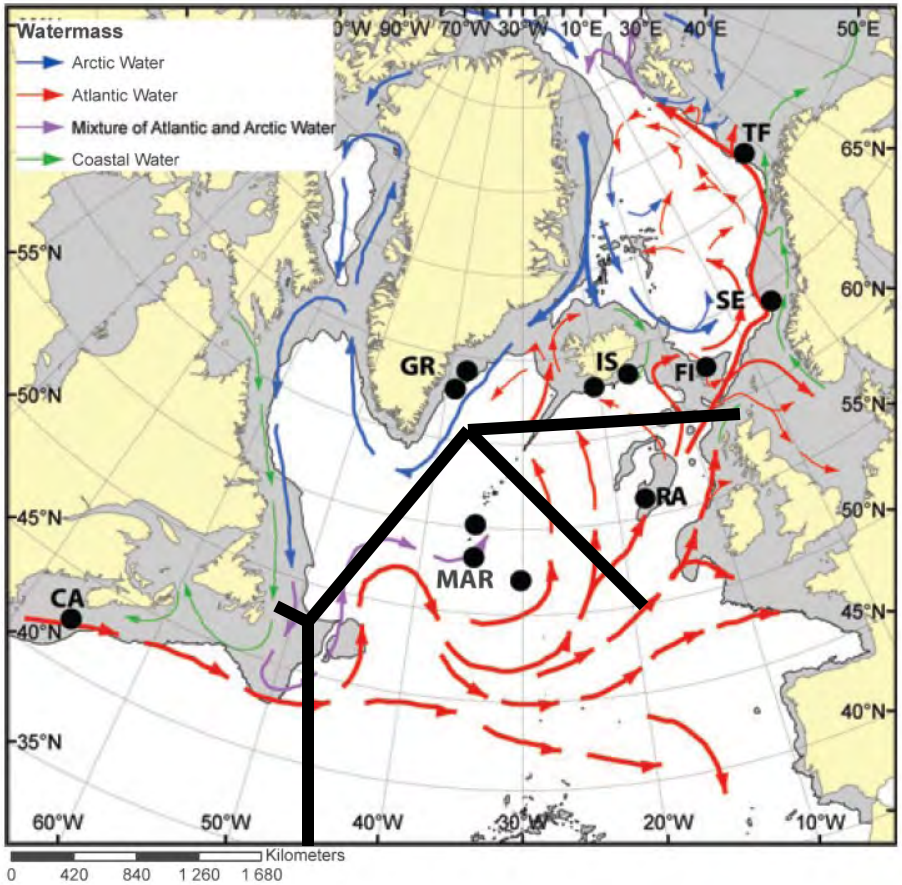
- **Ocean Biogeographic Information System (http://www.iobis.org/)**
- **NEFSC Trawl Survey (http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html)**

Cusk Genetics

Microsatellite analysis defines cusk into discrete genetic groupings

Groupings separated by deepwater and distance

Spatial resolution in Northwest Atlantic Ocean low (n=1)



Data sources:

- **Knutsen, H., P. E. Jorde, et al. (2009). Bathymetric barriers promoting genetic structure in the deepwater demersal fish tusk (*Brosme brosme*). Molecular Ecology 18(15): 3151-3162.**

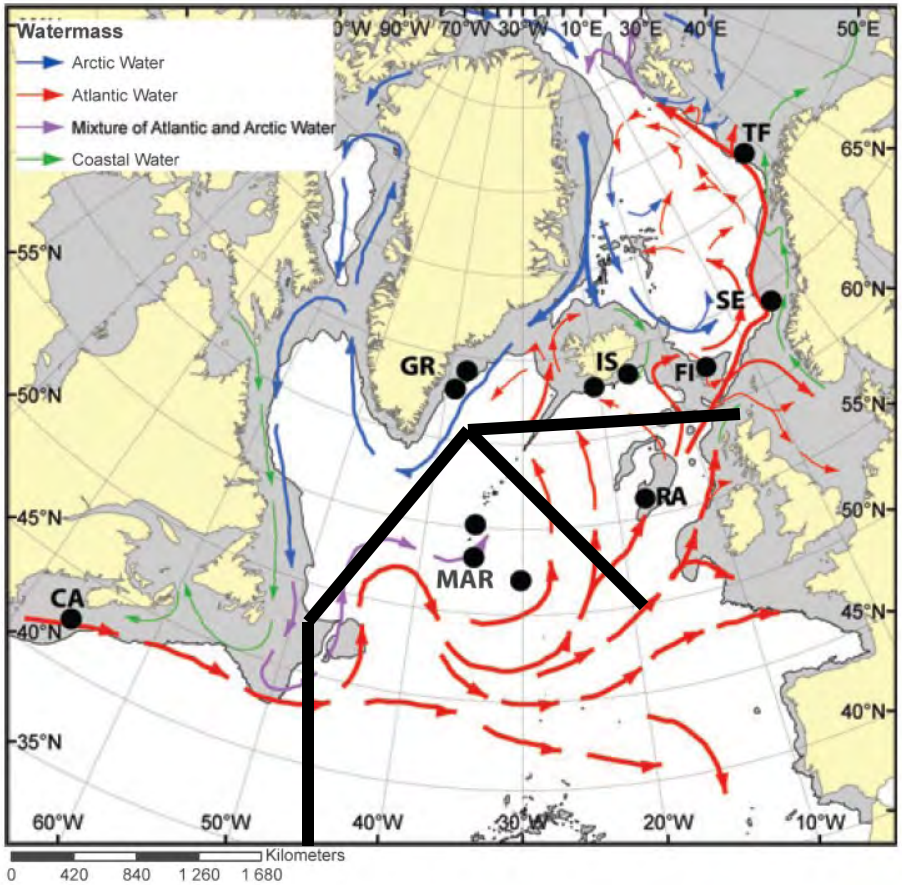
Cusk Stock Structure

No information regarding within the Western North Atlantic

Evidence that cusk move little from bank to bank (promote discrete stocks)

Planktonic eggs and larvae (promotes a unified stock)

One stock in the Northwest Atlantic Ocean, but need to consider linked local populations

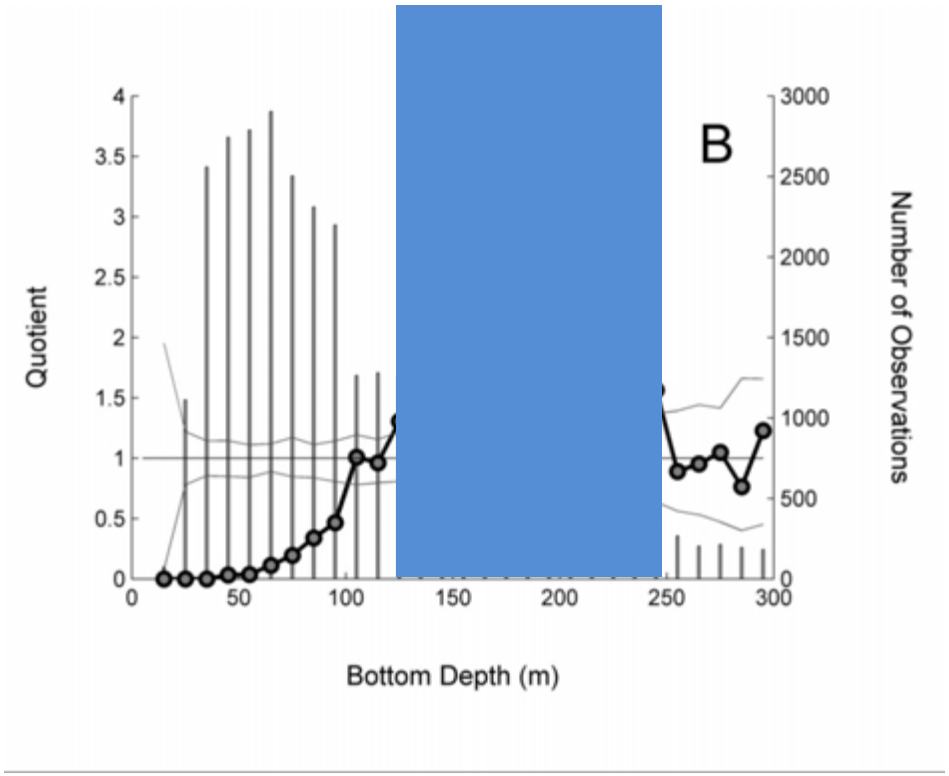


Data sources:

- **Collette, B. B. and G. Klein-MacPhee, Eds. (2002). Bigelow and Schroeder's Fishes of the Gulf of Maine. Washington, D.C. USA, Smithsonian Institution Press.**

Cusk Habitat

Cusk prefer moderately deep water



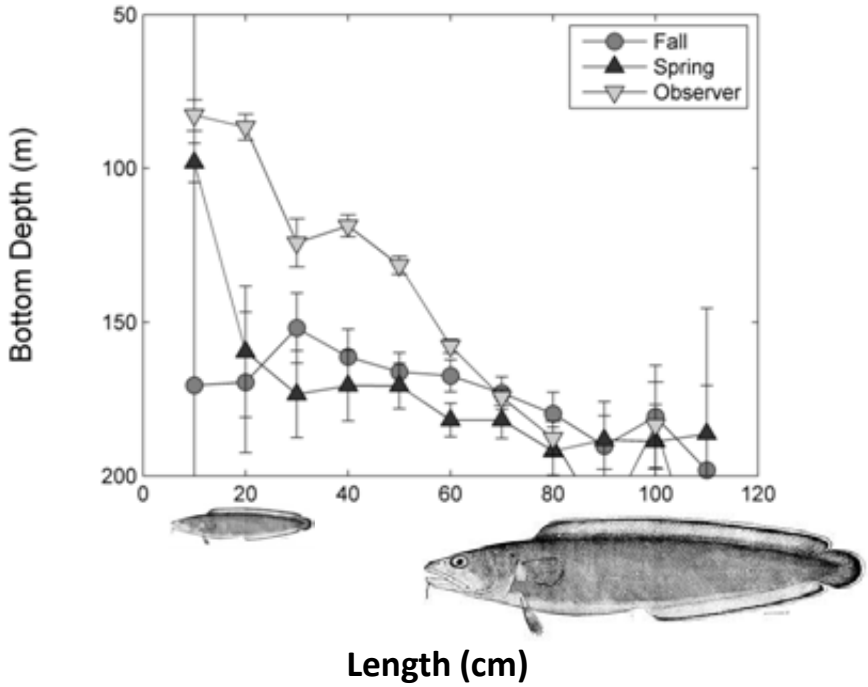
Data sources:

- **NEFSC Trawl Survey (http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html)**

Cusk Habitat

Cusk prefer moderately deep water

Larger cusk are found in deeper water



Data sources:

- **NEFSC Trawl Survey (http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html)**

Cusk Habitat

Cusk prefer moderately deep water

Larger cusk are found in deeper water

Cusk inhabit complex habitats (rocks, corals, ledges, banks)

Data sources:

- **Collette, B. B. and G. Klein-MacPhee, Eds. (2002). Bigelow and Schroeder's Fishes of the Gulf of Maine. Washington, D.C. USA, Smithsonian Institution Press.**

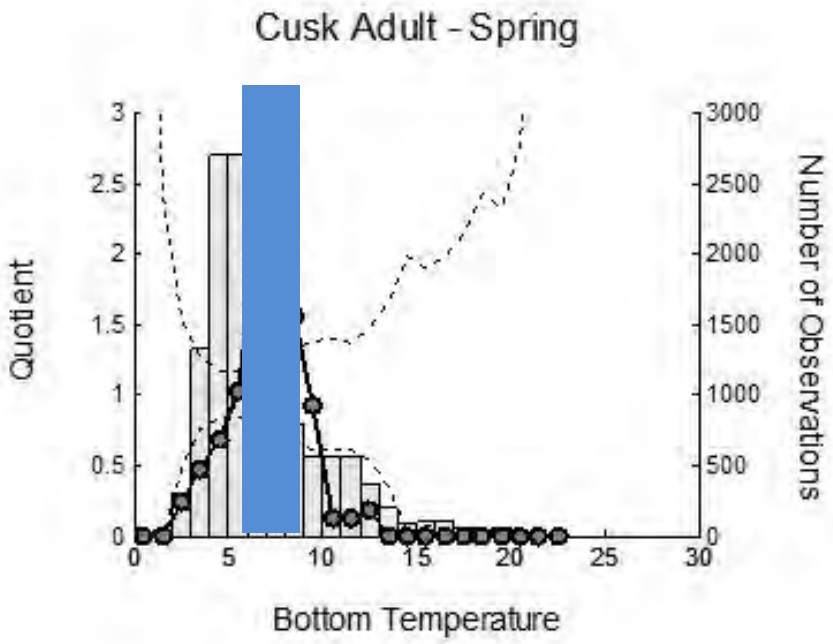
Cusk Habitat

Cusk prefer moderately deep water

Larger cusk are found in deeper water

Cusk inhabit complex habitats (rocks, corals, ledges, banks)

Cusk prefer moderately cold temperatures



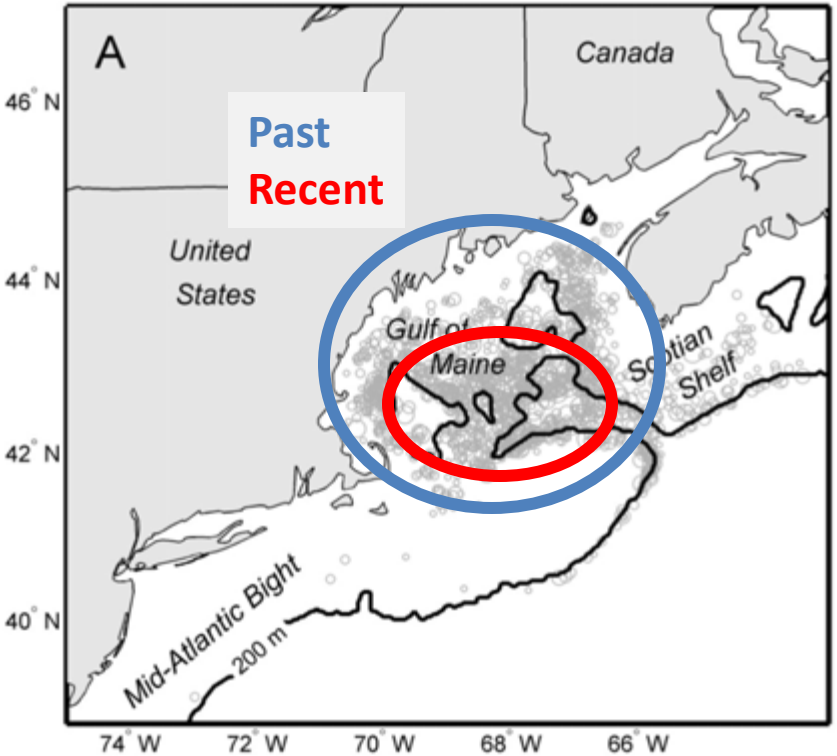
Data sources:

- **NEFSC Trawl Survey (http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html)**

Cusk and Climate Change

Since 1960's the area occupied by cusk has decreased, the distribution has shifted deeper, and the distribution has shifted southward

Conceptual summary of Nye et al.

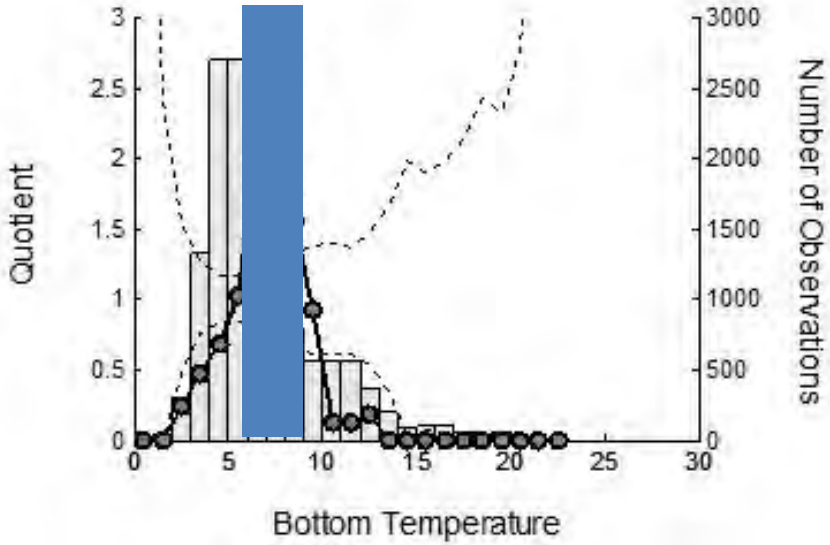


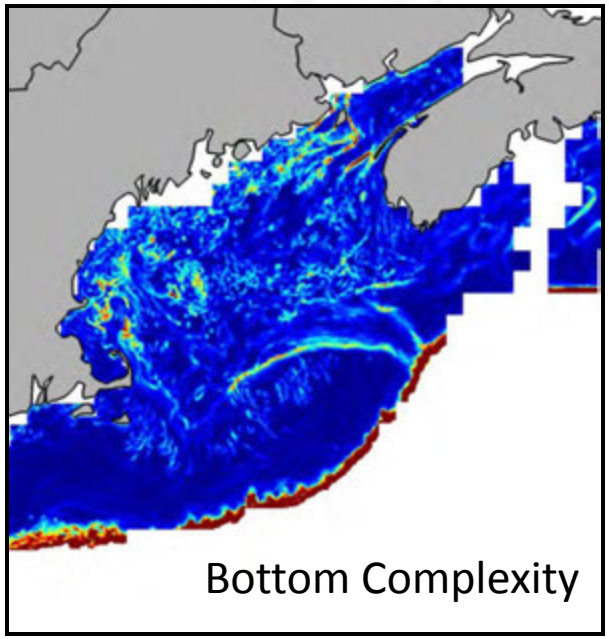
Data sources:

- **Nye, J. A., J. S. Link, et al. (2009). Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. Marine Ecology Progress Series 393: 111-139.**

Cusk and Climate Change

Habitat model including bottom complexity and temperature





Data sources:

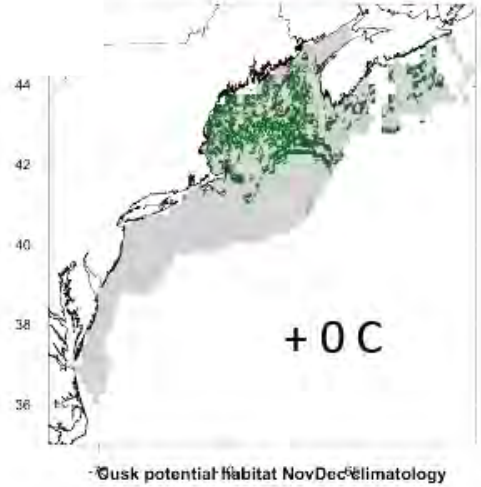
- **Hare, J. A. (in prep) Cusk (*Brosme brosme*) and climate change: assessing the threat to a data poor candidate species under the Endangered Species Act**

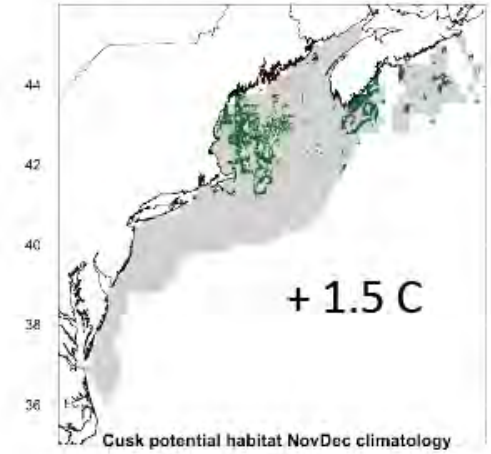
Cusk and Climate Change

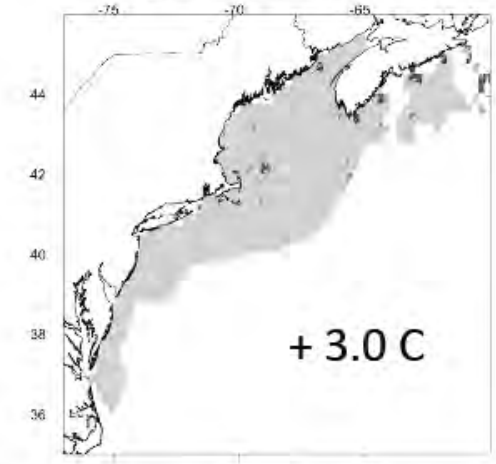
Habitat model including bottom complexity and temperature;

Increase in temperature may decrease cusk habitat in Gulf of Maine

Increase in temperature may fragment cusk habitat in Gulf of Maine







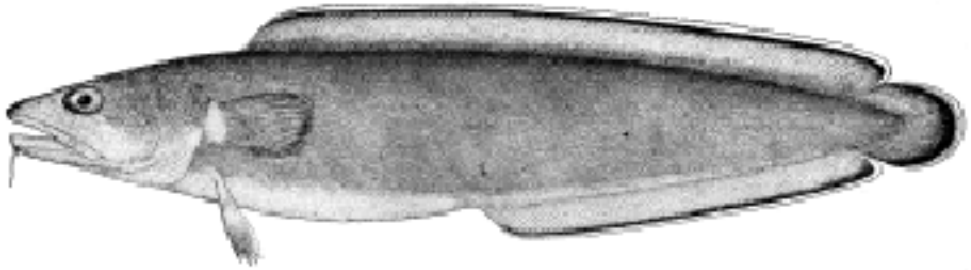
Data sources:

- **Hare, J. A. (in prep) Cusk (*Brosme brosme*) and climate change: assessing the threat to a data poor candidate species under the Endangered Species Act**

Cusk – My list of what is needed from a ecology point-of-view

- An improved understanding of the distribution of seafloor habitats
- Where is juvenile habitat?
- Do fish move deeper as they grow?
- Is there stock structure in the Northwest Atlantic (genetics / movement)?
- How would habitat fragmentation affect cusk?
- Cusk physiology – temperature, acidification & depth effects
- Cusk trophic interactions (have basic data but limited detailed information)

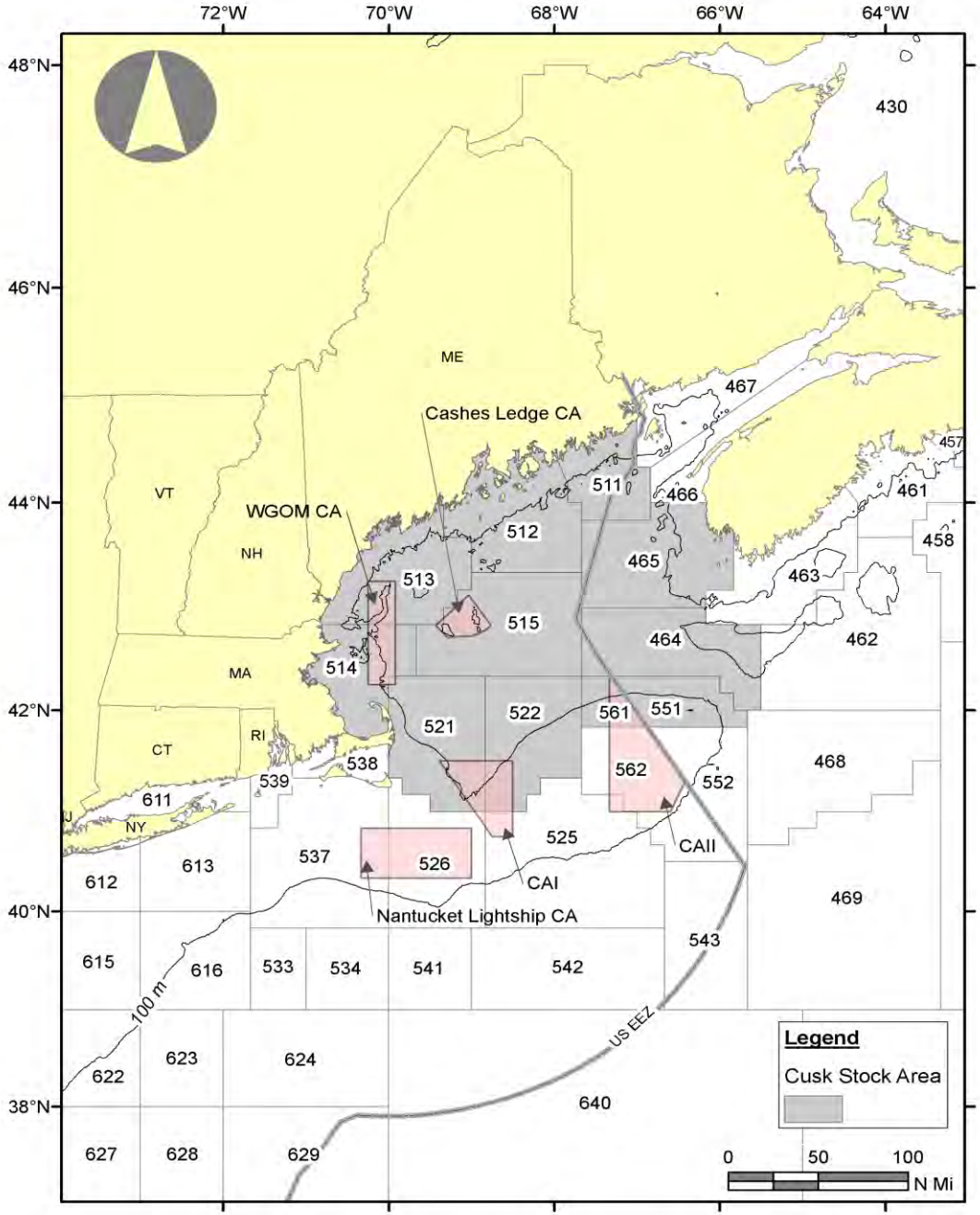
Status of Cusk in USA Waters



Loretta O'Brien

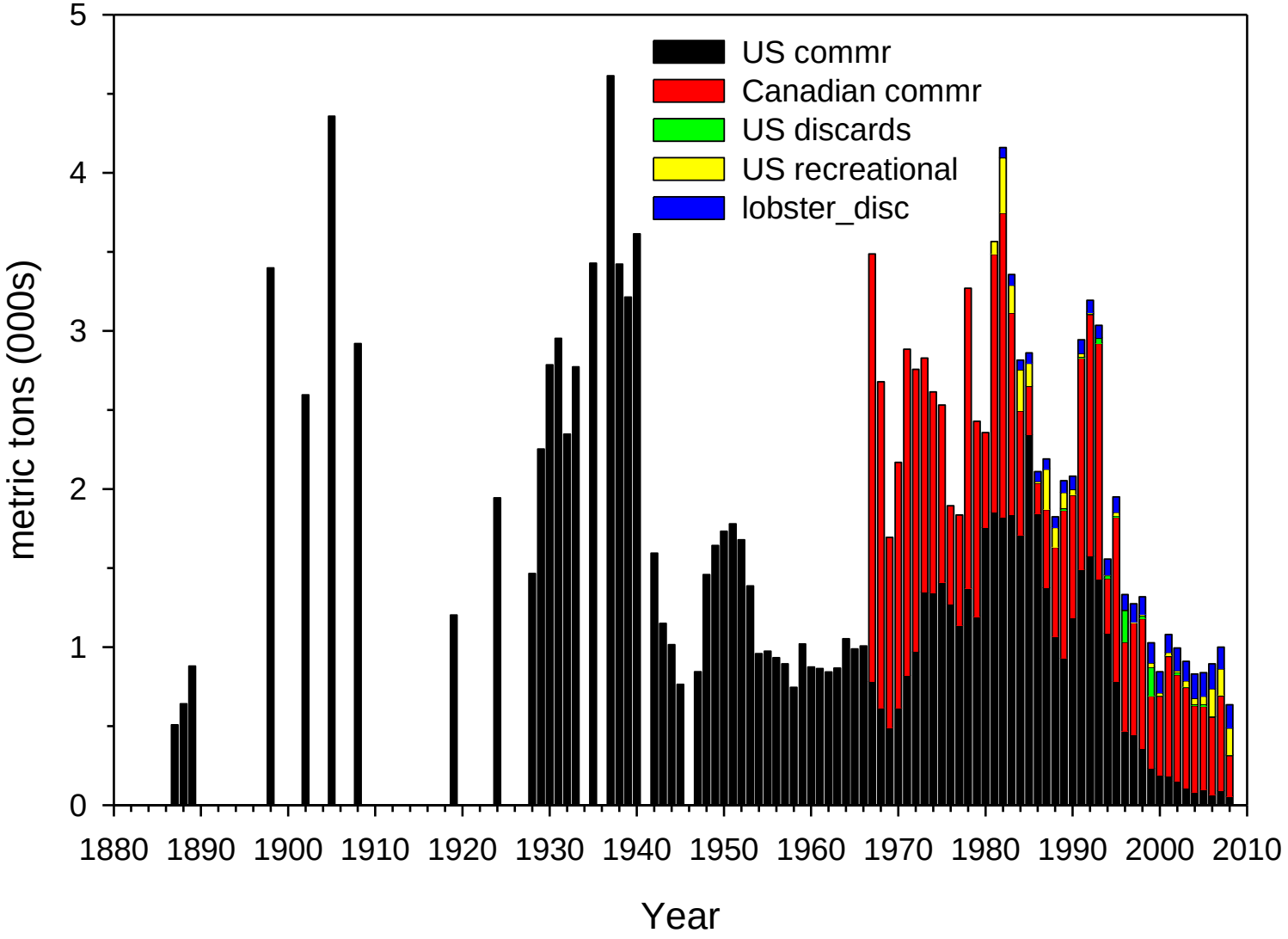
Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk
Gulf of Maine Research Institute
Portland, Maine
December 6, 2011

Stock area

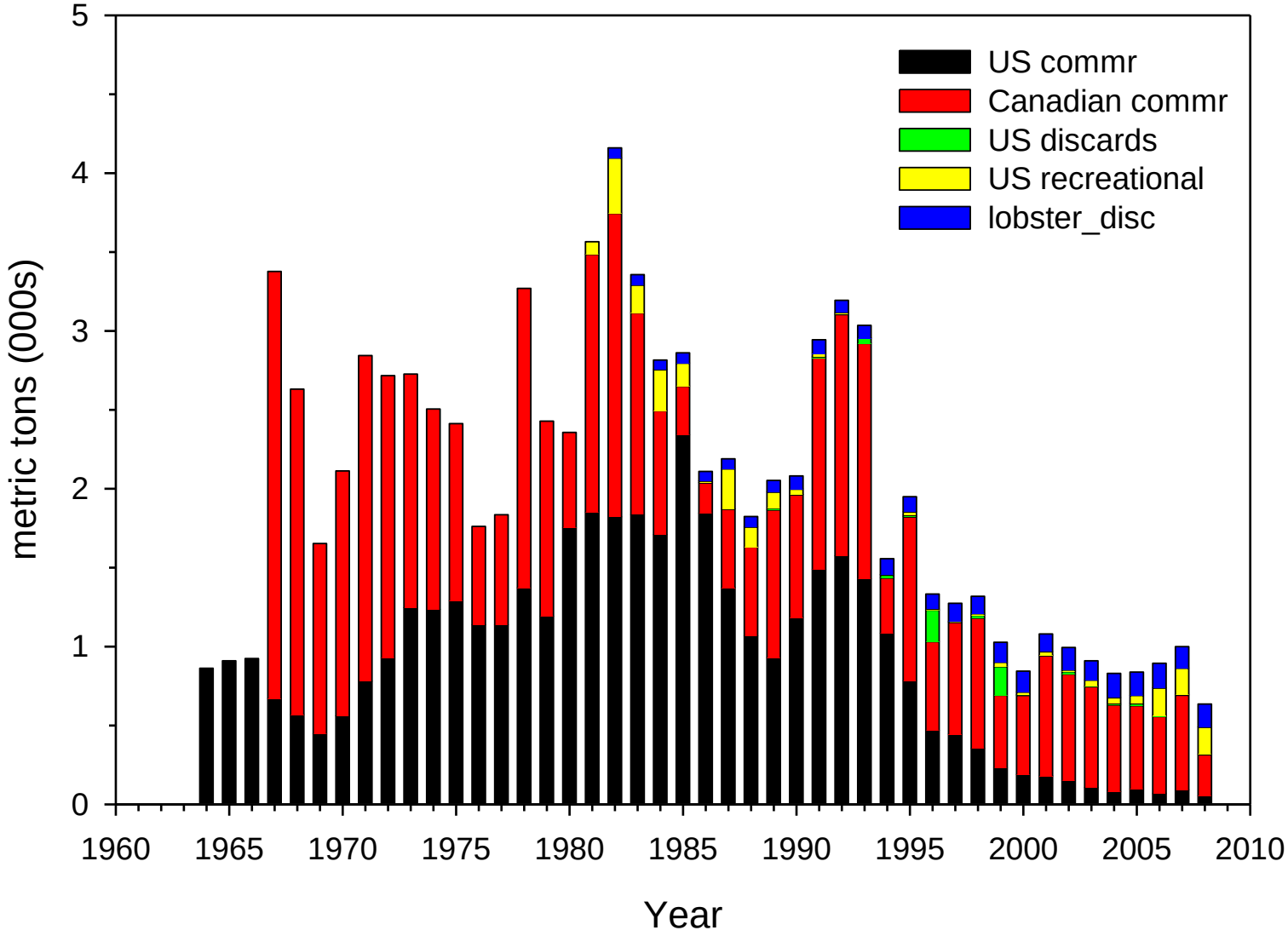


72°W
70°W
68°W
66°W
64°W
48°N
46°N
44°N
42°N
40°N
38°N
430
ME
467
Cashes Ledge CA
457
VT
WGOM CA
511
466
461
512
458
NH
465
463
513
515
464
462
MA
514
522
561
551
521
RI
CT
538
562
468
539
552
611
NY
525
CAII
537
526
613
612
CAI
469
Nantucket Lightship CA
543
615
616
533
534
541
542
100 m
US EEZ
623
624
622
640
627
628
629
Legend
Cusk Stock Area
0
50
100
N Mi

CATCH

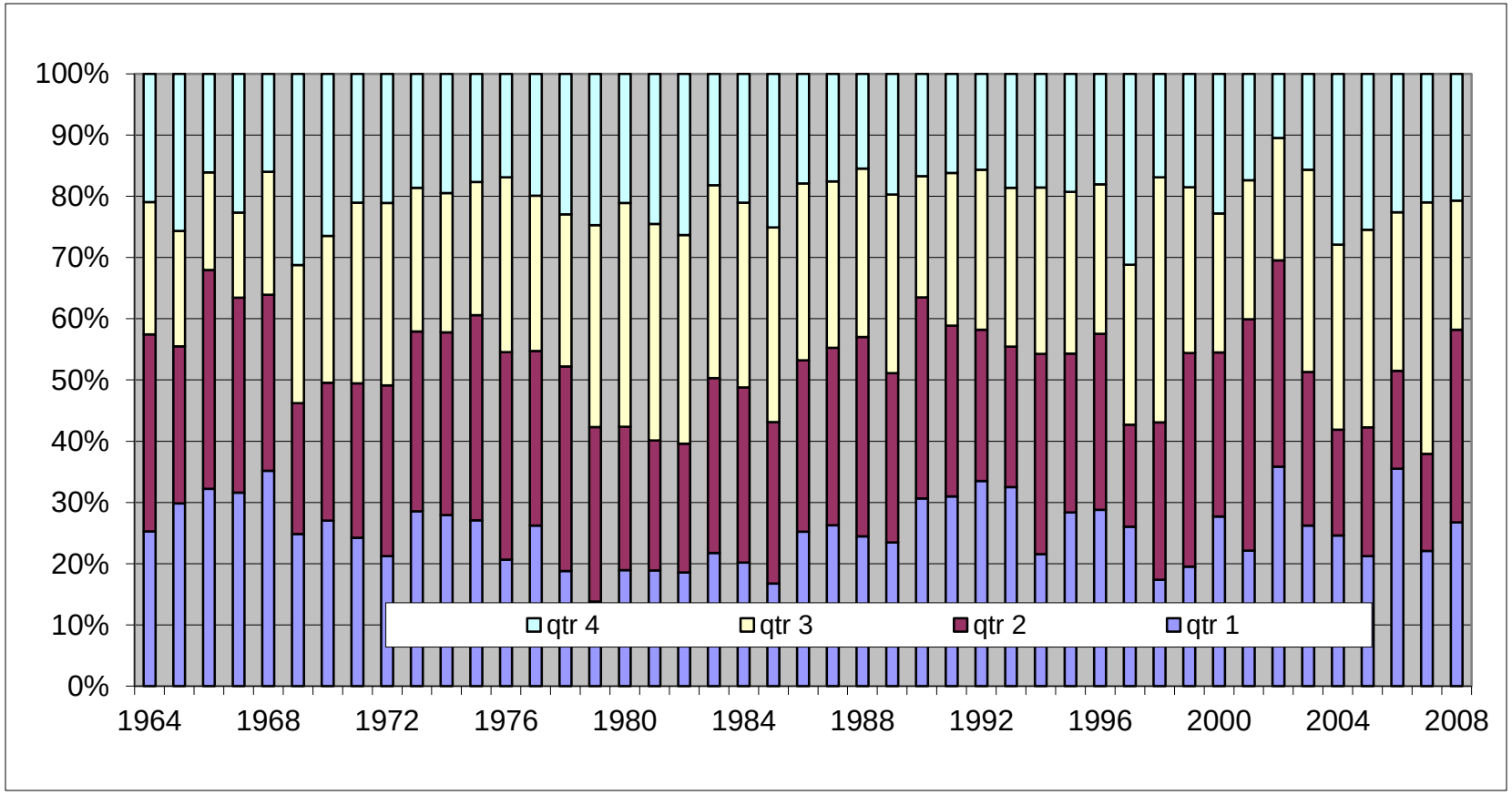

US commr
Canadian commr
US discards
US recreational
lobster_disc
metric tons (000s)
0
1
2
3
4
5
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

CATCH



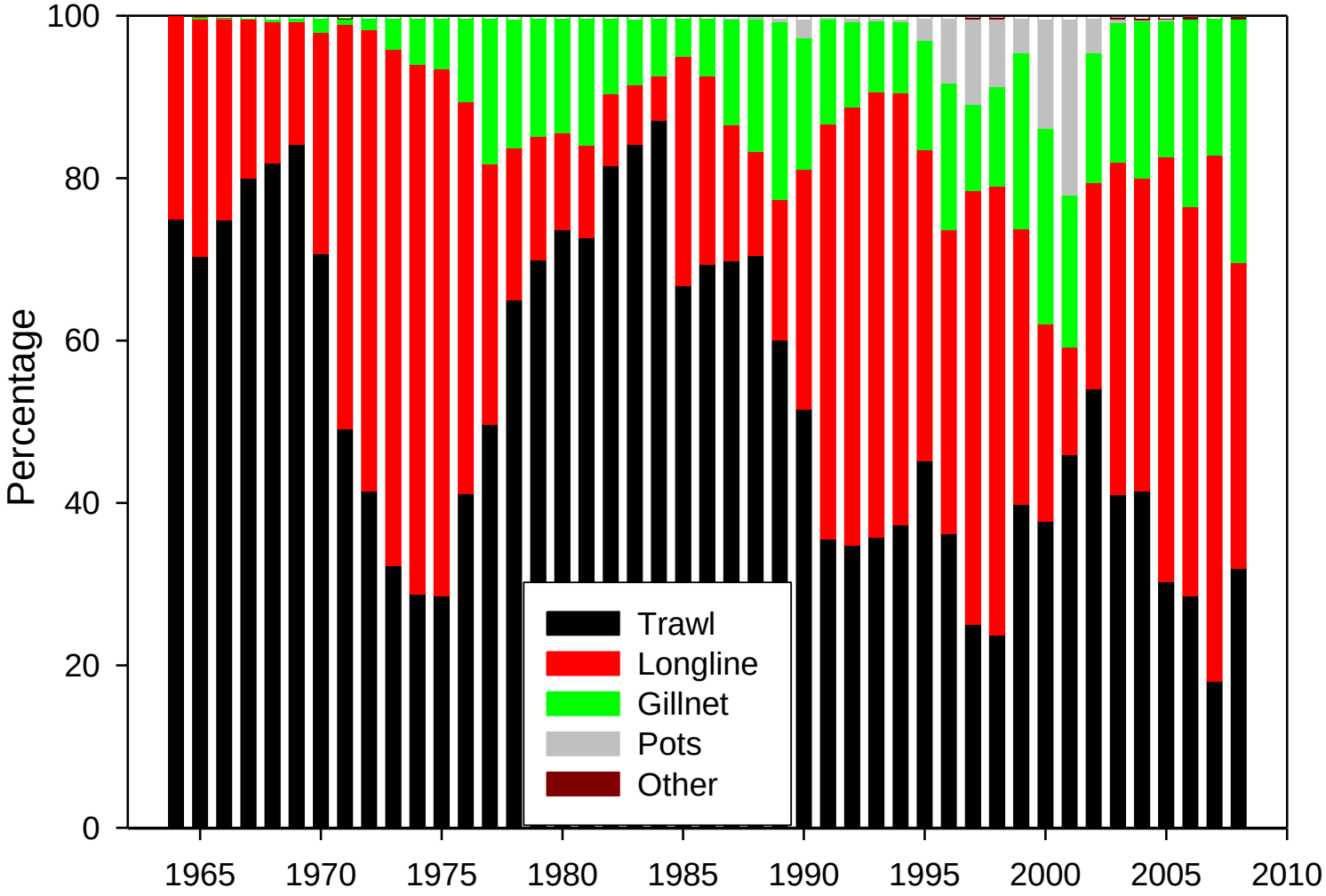
US landings 2010: 34 mt

Catch Seasonal Pattern

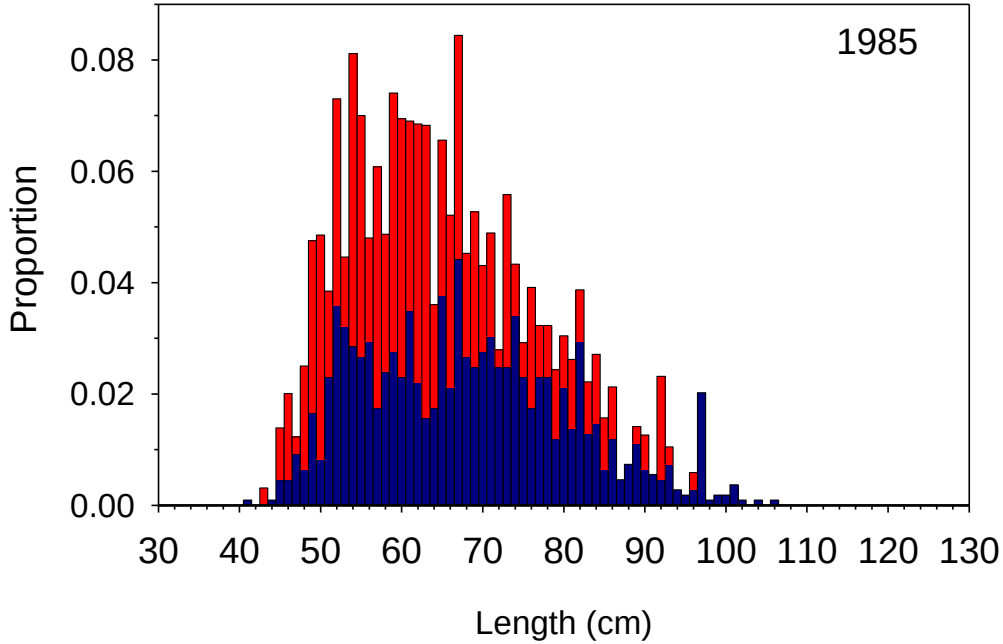


Qtr 1, 2, 3 > 25%, qtr 4 ~ 20 %

GEAR

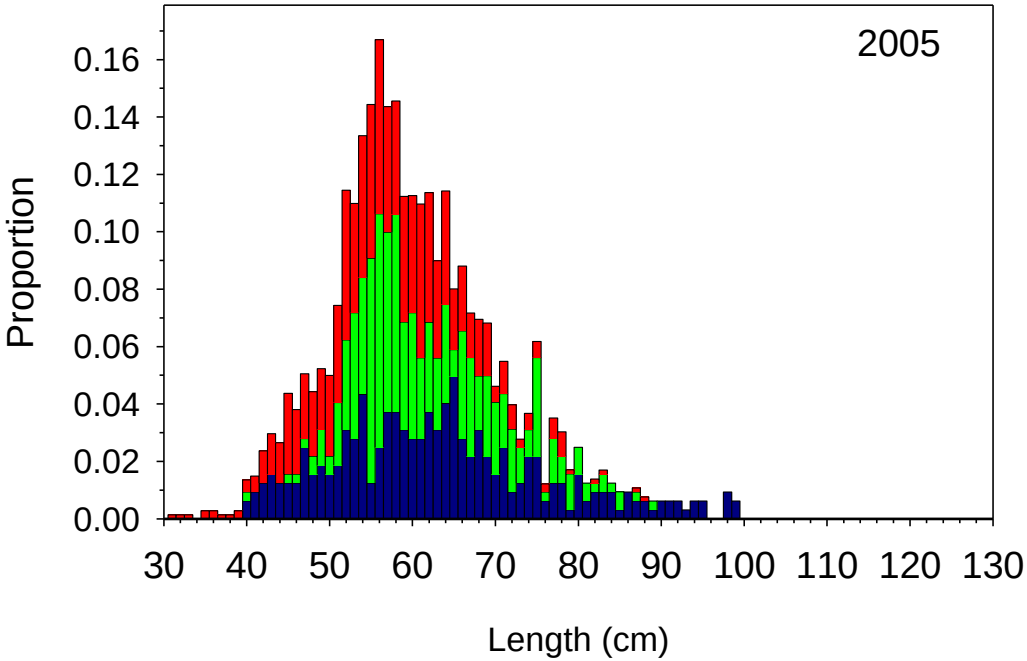

100
80
60
40
20
0
Percentage
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Trawl
Longline
Gillnet
Pots
Other

Length frequency



ot = 1087
ll = 323

otter trawl
gill net
longline



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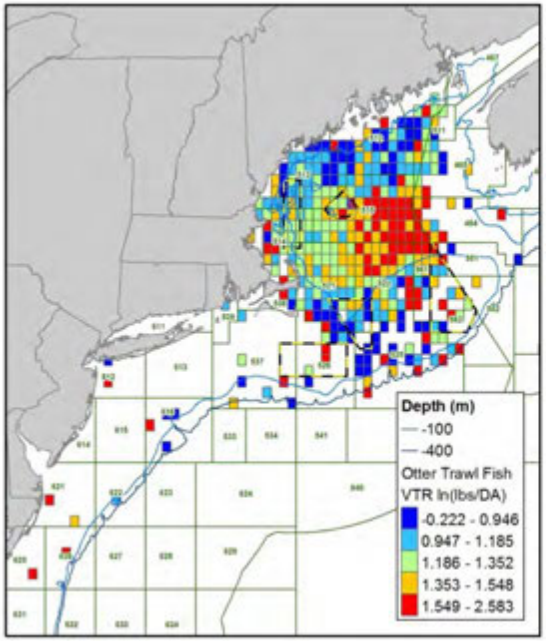
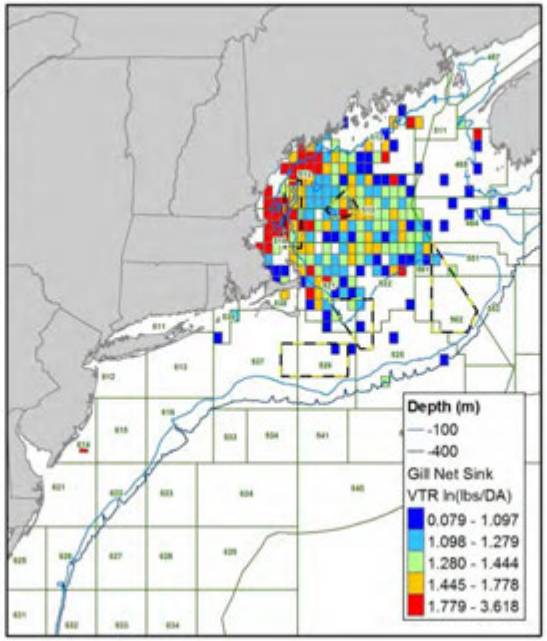
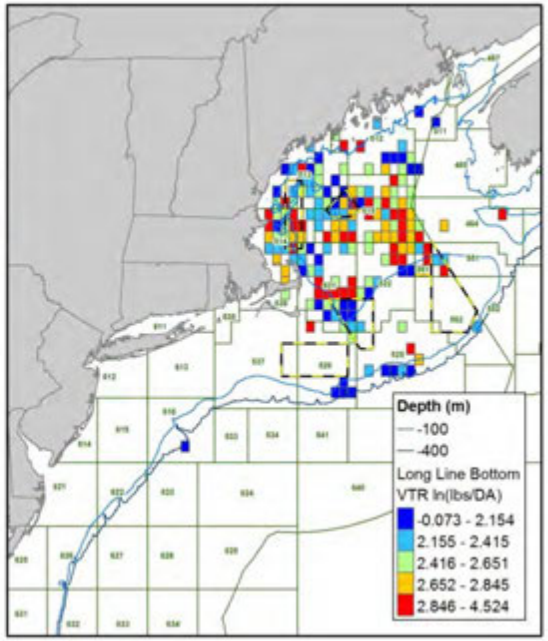
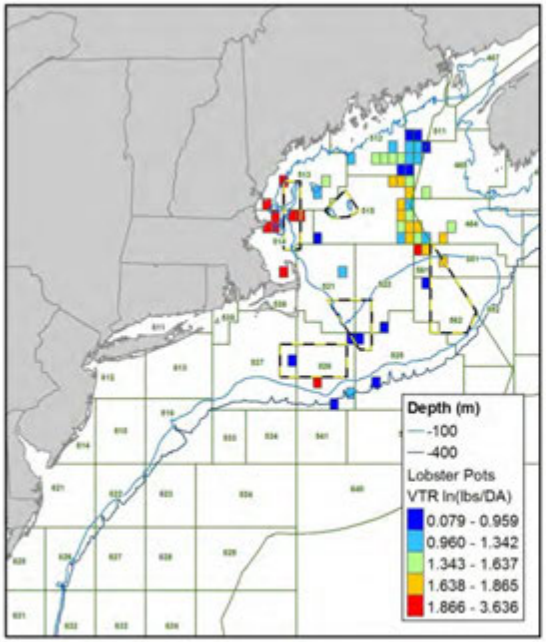
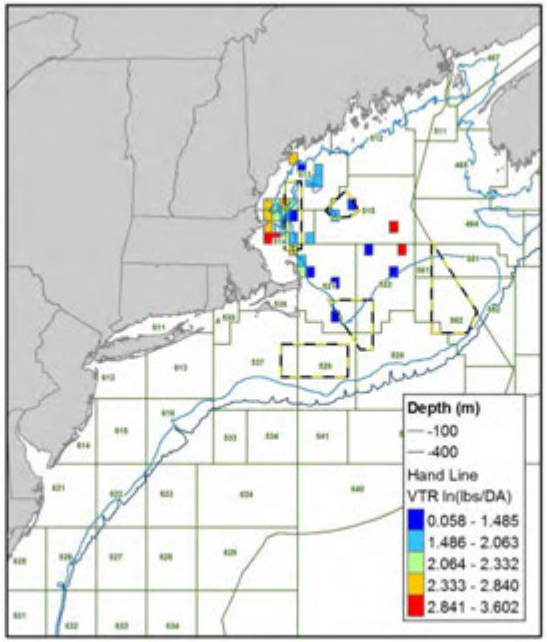
ll = 709











Cusk VTR - 1994-2008

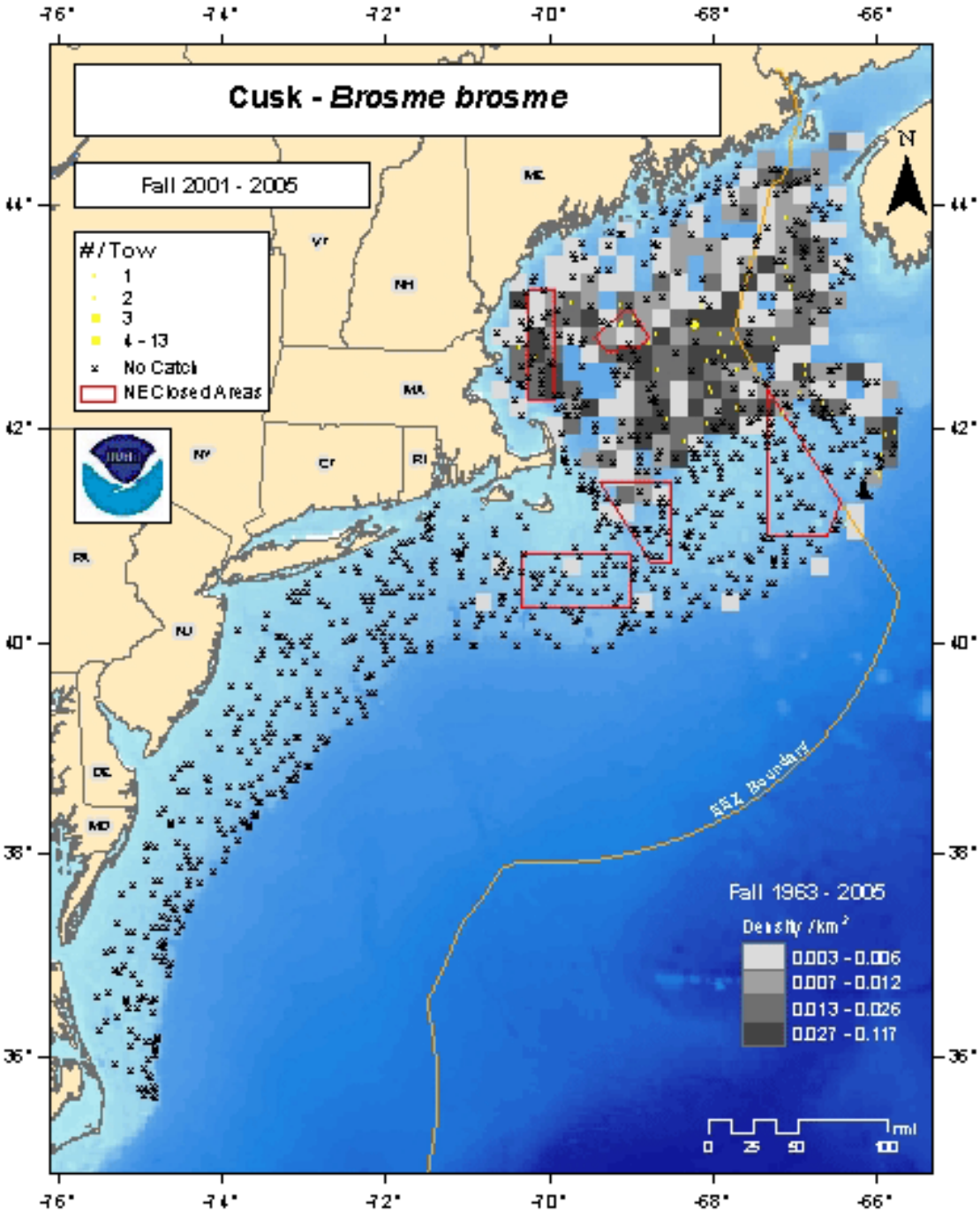
Log (qty kept (lbs) / days absent) by TMS

*commercial trip data only

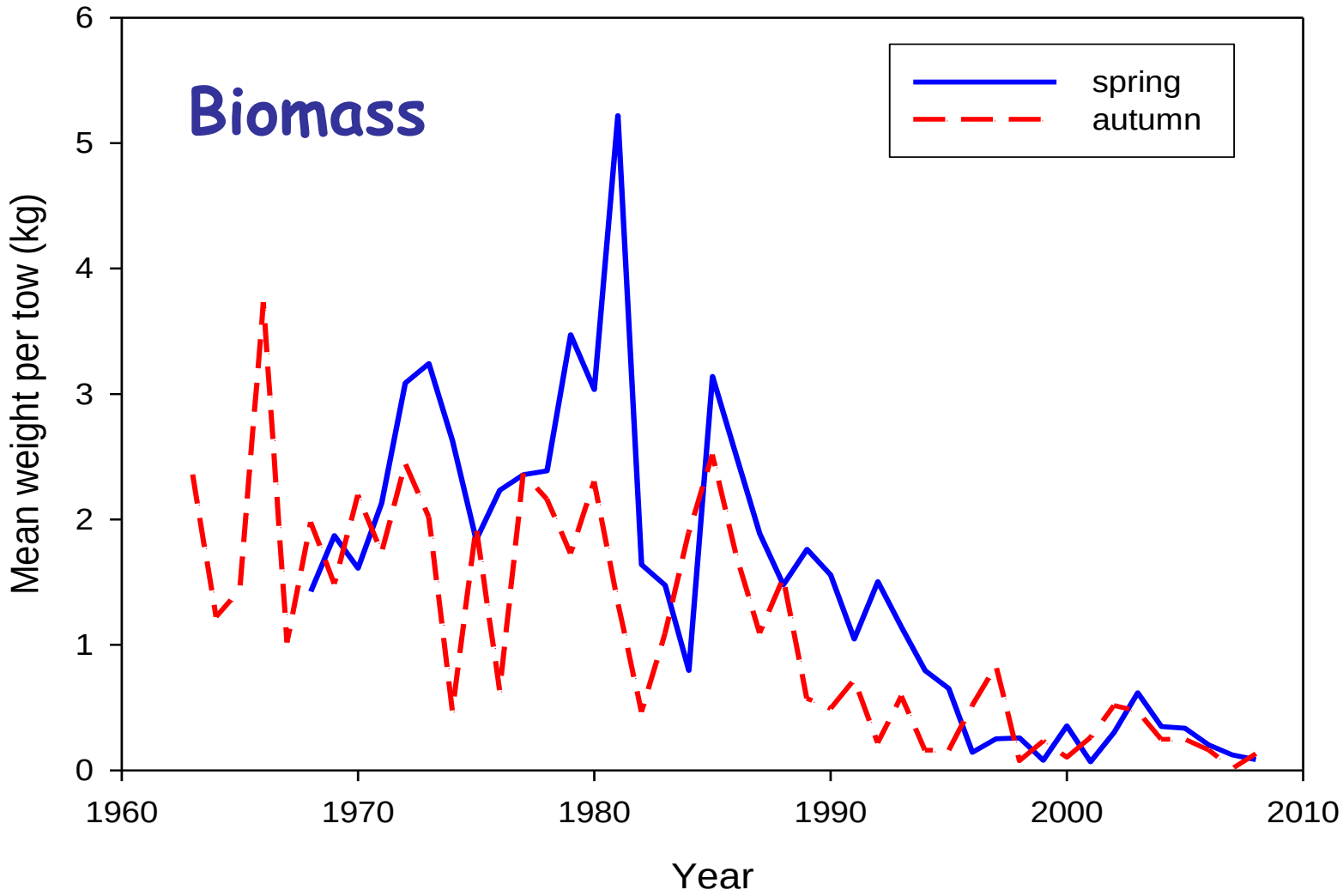
NEFSC Bottom Trawl Research Survey

Autumn: 1963- 2005

Density of Cusk

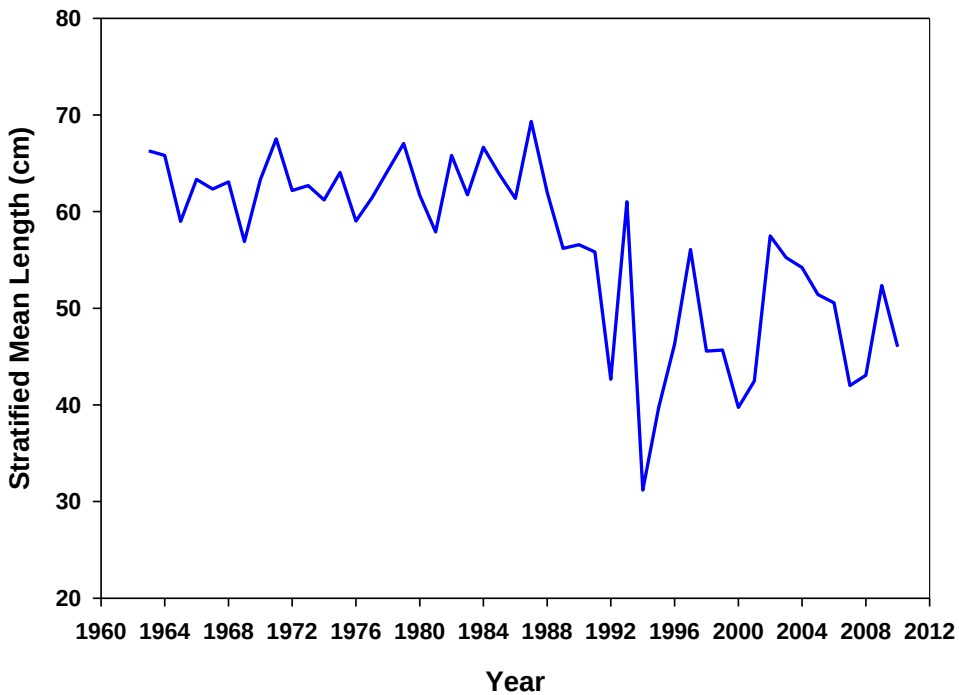


NEFSC Research Bottom Trawl Surveys



Spring: 1968 – 1988 to 1989-2010 → 81% decline
Autumn: 1963 – 1988 to 1989-2010 → 76% decline

Survey Mean Length (cm)



1963 – 1988: 63 cm = 25"
1989 – 2010: 49 cm = 19"

NEFSC age data GM : Age 12 oldest observed

Mature ~ females: 37.1 cm = 14.6" ~ ~ age 4
males: 43.5 cm = 17.1" ~ ~ age 4

2009 Cusk Stock Assessment:

Survey method
Production Model
Statistical Catch at Length Model

} **Not Accepted**

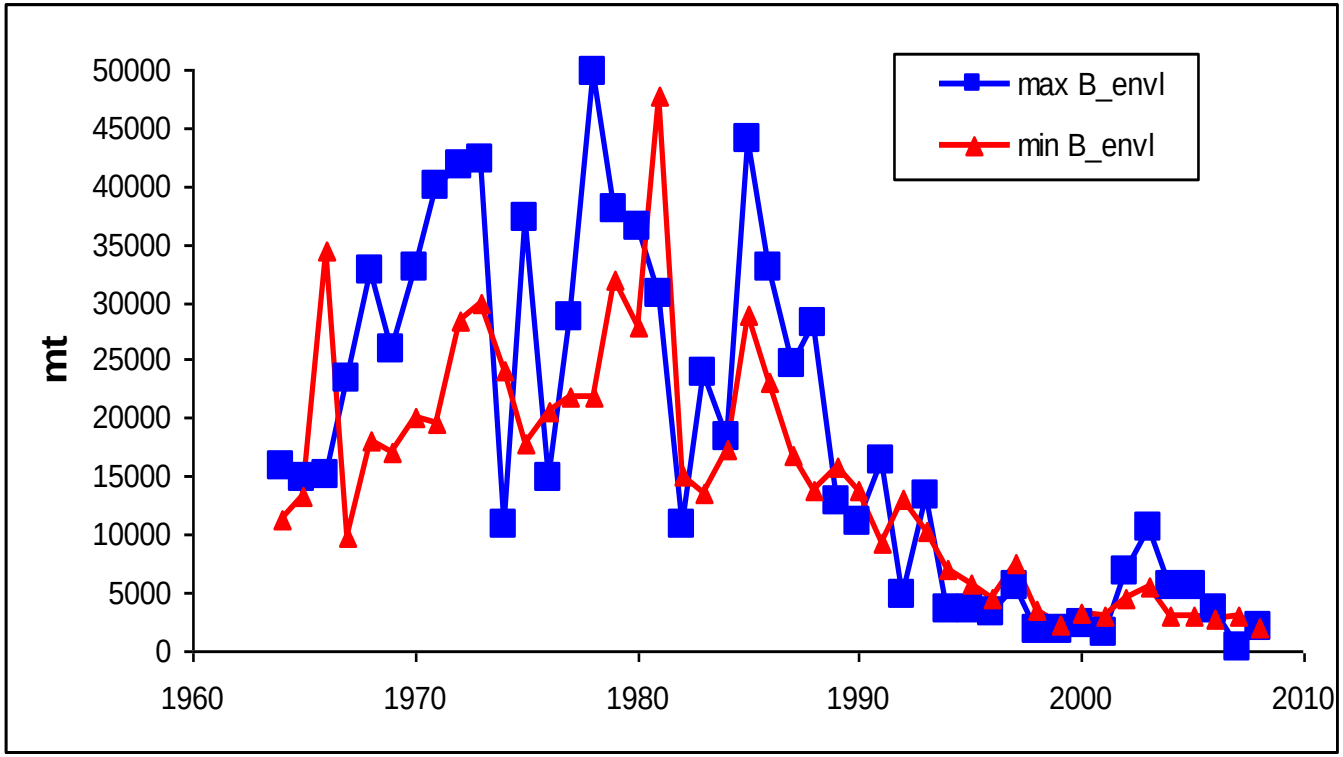
* one way trip in biomass; declining catch but mean length remains low/declines

Heuristic : 'Envelope' method

Determines feasible bounds on population biomass using:

- Use survey mean weight per tow:
  assuming lowest and highest survey catchability (q)

- Catch data: assuming lowest & highest fishing mortality



Take minimum of high biomass estimates & maximum of low biomass estimates to determine the 'envelope' of possible population biomass

1968 - 1990 avg : 22,289 mt

1991 - 2008 avg : 5,171 mt

biomass declined about 75%

Summary

- Cusk is mostly a by-catch fishery
- US discards higher then landings
- Trawl survey likely underestimates abundance
- Current analytical modeling: results not feasible
- 'Envelope' avg. population : 22,000 - 5,000 mt

Cusk Ecology in Canadian Waters

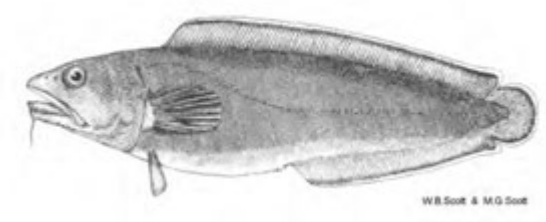
Lei Harris
St. Andrews Biological Station

Fisheries and Oceans Canada
Pêches et Océans Canada

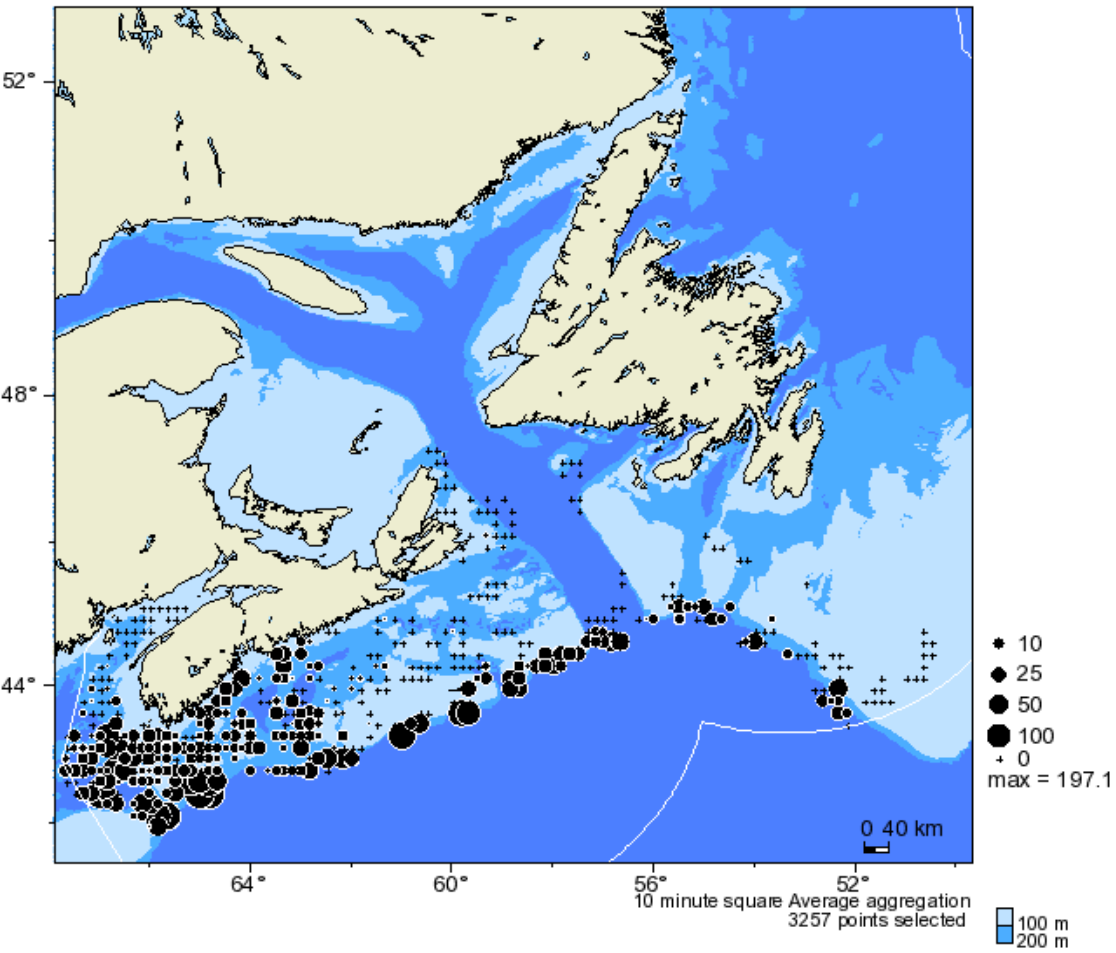
Canada

Outline

- Distribution
- Habitat
- Diet
- Growth
- Ageing
- Spawning
- Stock structure



Distribution in Canada



ador to Georges Bank
, Western Scotian
and slope
mmon off NL
in Gulf of St.
nce and inner Bay of
,

Halibut Industry survey data

Habitat

- Adult cusk prefer structured, hard bottom habitat, including boulders, rocks or pebbles and coral. They are occasionally found on mud, but rarely on sand.
- Hide in crevices
- Caught from depths of 20 m to 1185 m (deepest set in HS), may occur deeper
- Preferred depth range 400 to 600 m based on high CPUE in the halibut industry survey
- Preferred habitat of juvenile cusk is not known
- Habitat requirements for spawning are also unknown.

Cusk Biology

- Slow moving, sedentary and solitary
- Diet not well known as their stomachs generally evert when fish brought to the surface
- Feed on invertebrates (**crab**, shrimp, squid) and fish (silver hake, redfish, herring)
- Cusk have been found in the diets of cod and halibut

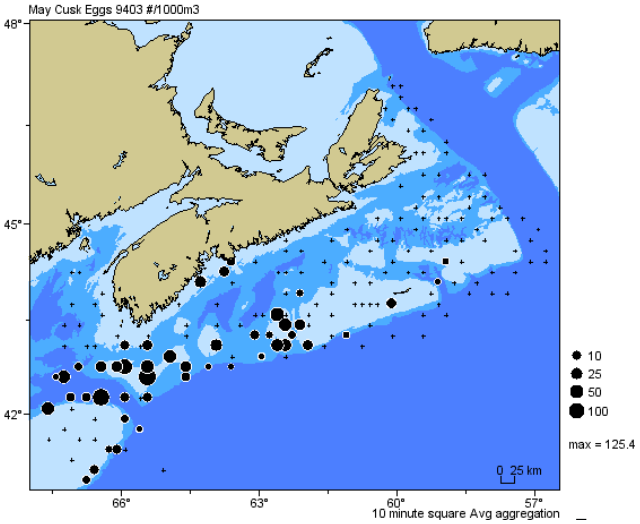
Growth and Ageing

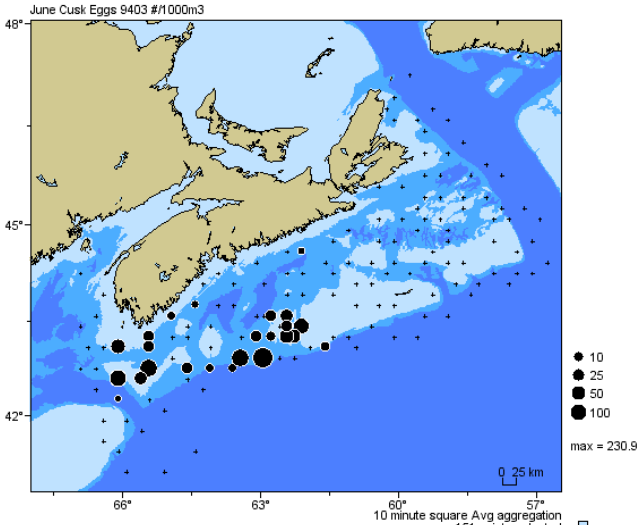
- Cusk otoliths, particularly of larger specimens, difficult to read
- Preliminary radiocarbon bomb dating suggests an 82 cm fish aged at 39 years
- These new ageing data also suggest that cusk may reach maturity at 10 years
- Cusk considered slow growing and long lived

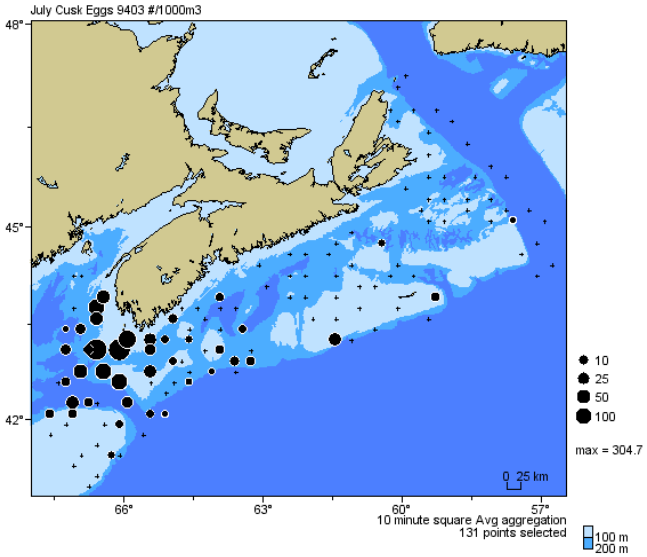
Reproduction

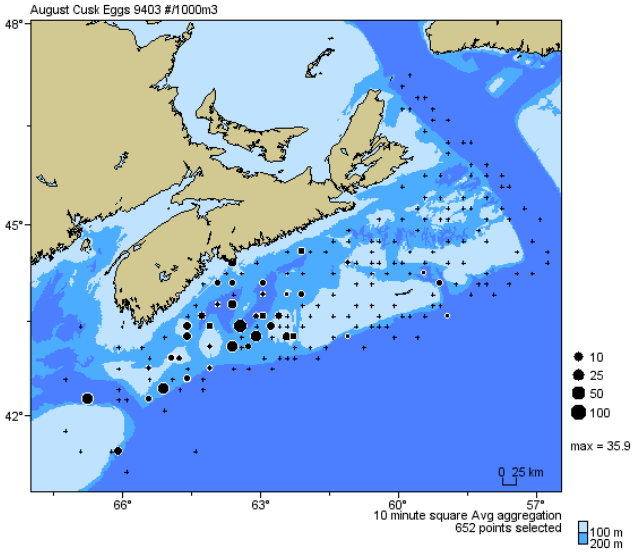
- 50% maturity around 41 cm
  - Males 44 cm and females 39
  - Fecund – 4 million eggs for an 80-cm fish
- Maximum length observed in Canada of 118 cm
- Ichthyoplankton data and maturity studies indicate spawning on Scotian Shelf May to August and peaks in June
- Port samplers observed cusk in spawning condition as early as March

Eggs in SSIP May-August 1976-1982









Early Life History

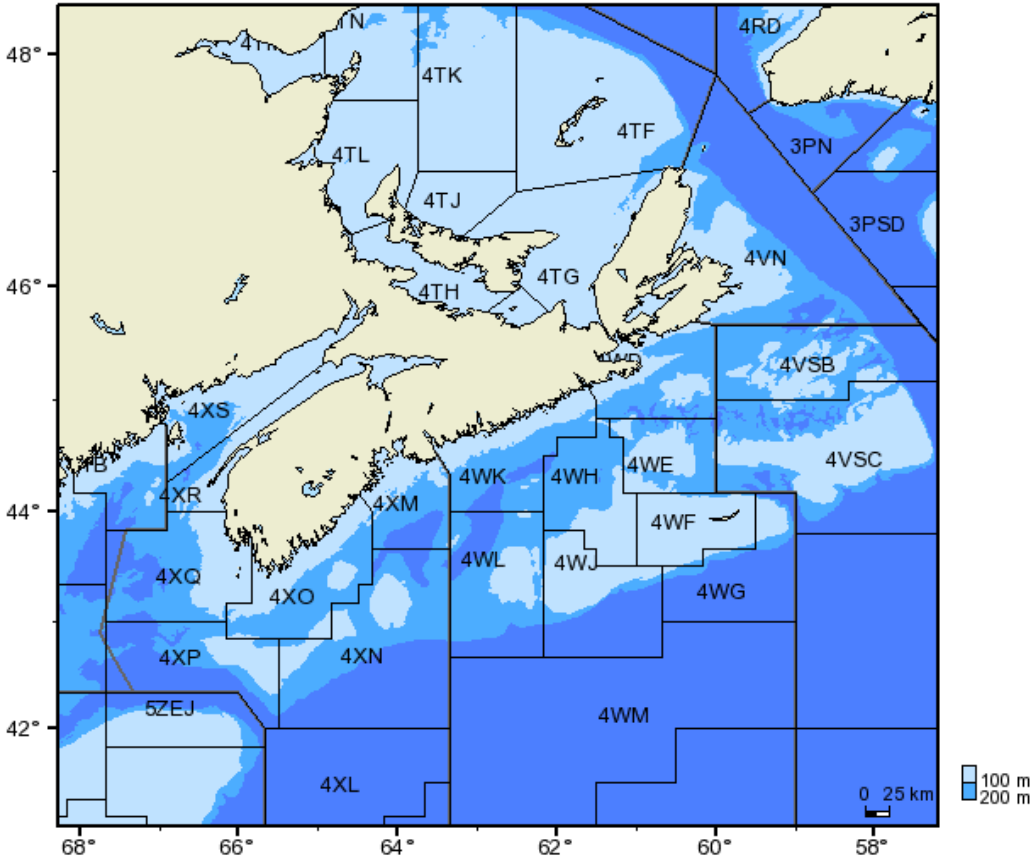
- The buoyant eggs are 1.3-1.5 mm in diameter with a pinkish oil globule.
- Pelagic larvae ~4 mm when hatched
- Migrate to bottom when ~ 50 mm in length

Stock Structure and Genetics

- Phylogenetic study of cusk was carried out using mitochondrial DNA.
  - samples from Georges Bank and Scotian Shelf (majority), Newfoundland, Greenland, Norway, and Mid-Atlantic ridge
  - No obvious geographic pattern in distribution of the mitochondrial diversity
- Considered single stock

Fisheries and Survey Trends

- Considered single stock (4VWX5Z)

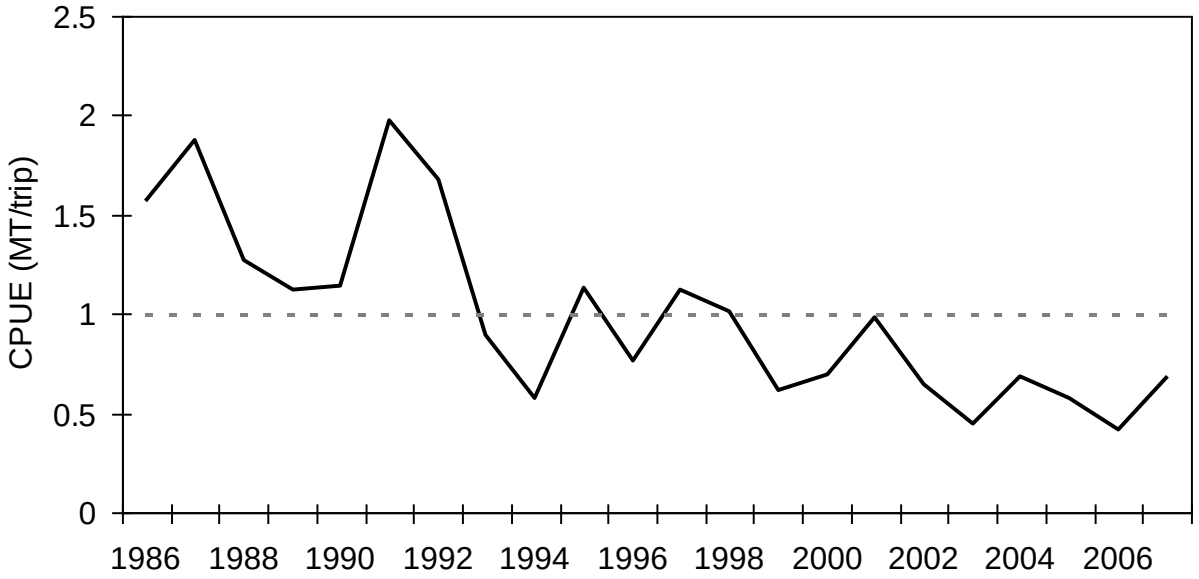


Challenges in Assessing Status

- Earlier fisheries data less reliable
- Changes in management for quota species and for bycatch species
- Unreported fishing mortality
- No dedicated survey
- No ageing
- No quantitative assessment

Trends in Abundance – Commercial CPUE

- Longline 4Xnopqu, tc 2,3
- Cusk abundance appears to have declined (~40%) since the 1980s
- CPUE may stable or declining slightly in recent years



July-September

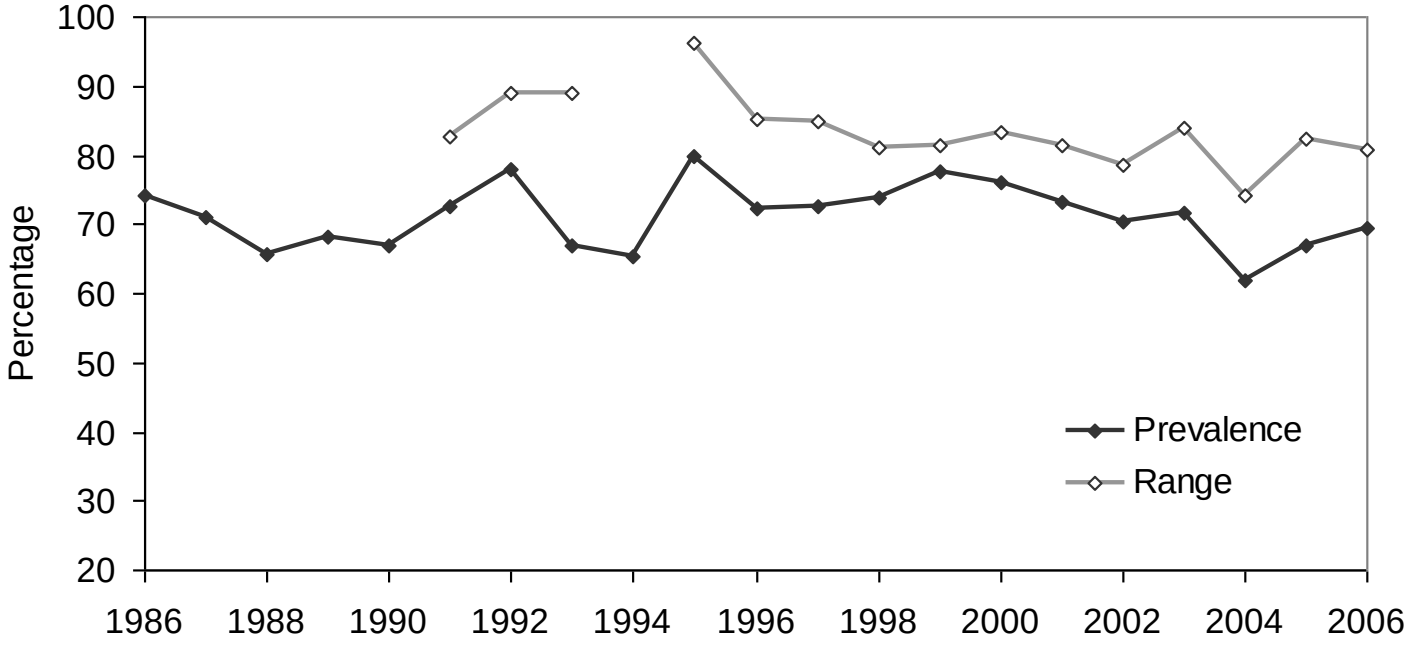
Trends in Distribution – Commercial Landings

Longliners in 4X

Range: % of 5-minute blocks with cusk

Prevalence: % trips with cusk

- No trend
- Cusk widespread and common

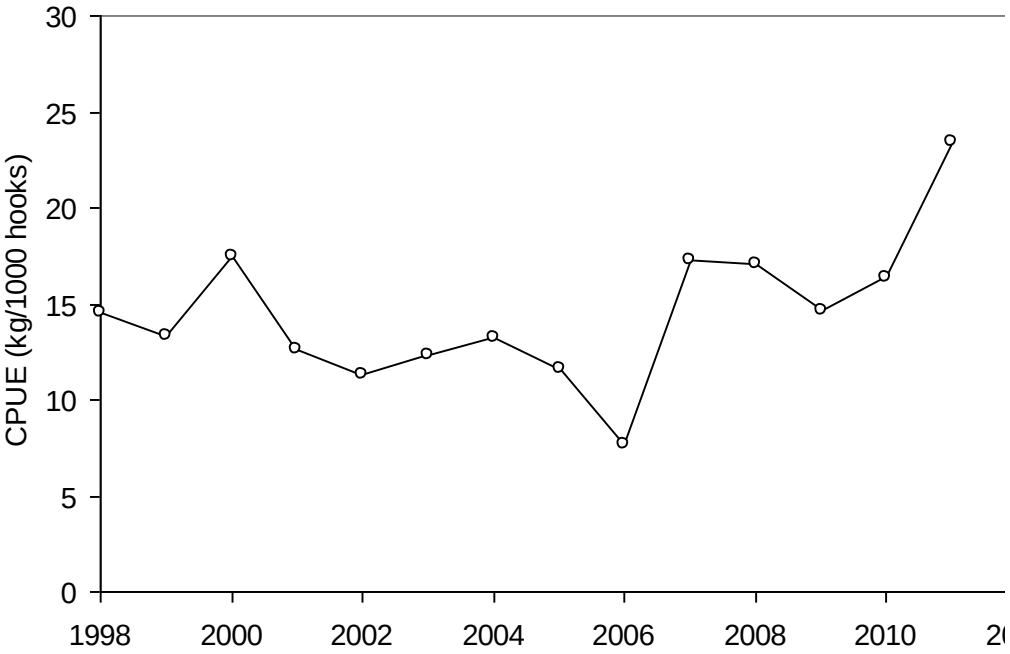


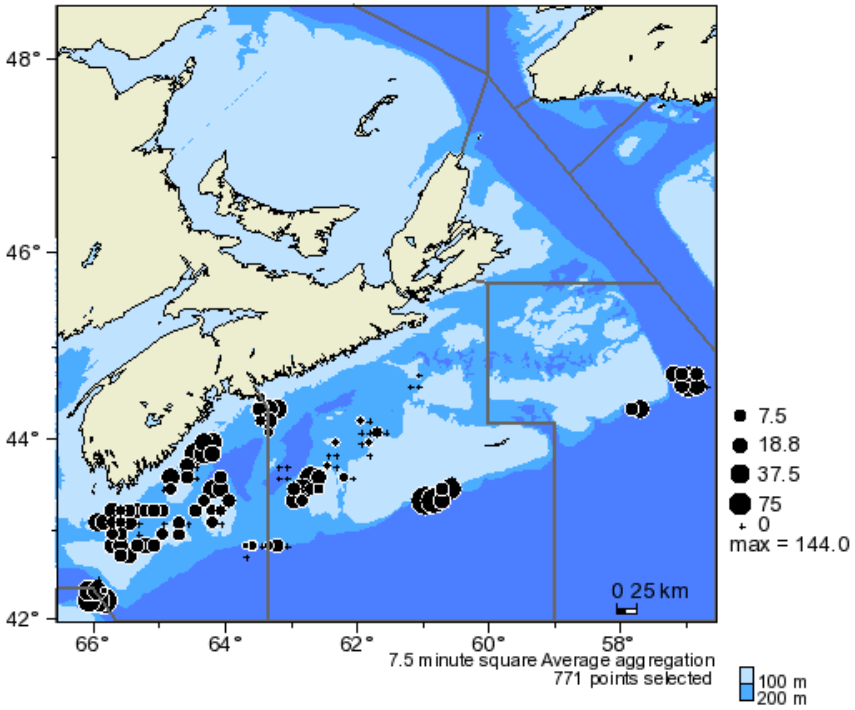
Survey Data

- No dedicated survey
- RV survey not considered good source of data (gear type, bottom type, depth)
- Industry surveys short time series
- However Halibut Industry Survey considered most useful

Trends in Abundance – Halibut Industry Survey

- Longline Industry survey
- Fixed station design
- Starts after decline seen in commercial CPUE





- Fluctuates without trend, 2011 highest in series

Status

- Abundance less than in 1970s and 1980s
- Still widespread and commonly caught
- Some indicators of status but
  - No estimate of abundance
  - Magnitude of decline not known

Cusk Management in Canadian Waters

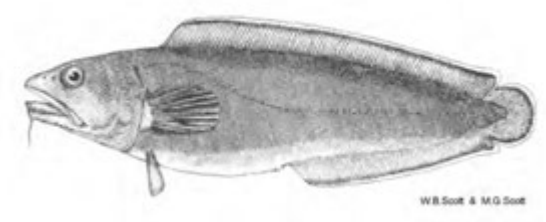
Lei Harris
St. Andrews Biological Station

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

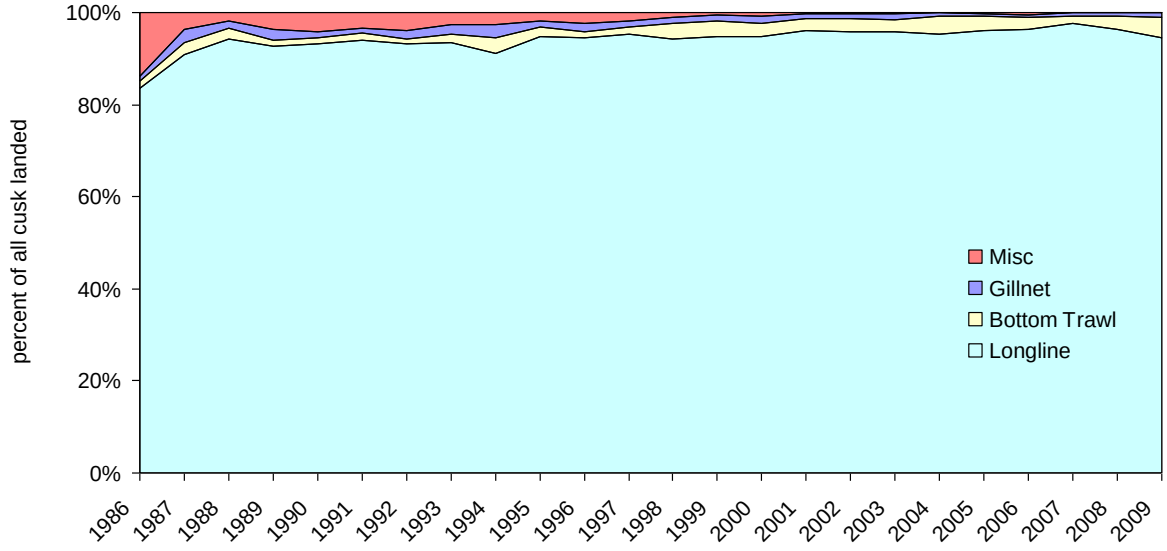
Outline

- Fishery
- Management measures
- Cusk and *Species at Risk Act*



Commercial Fishing

- Caught as bycatch
- Landed in groundfish fisheries
  - Mostly longline targeting cod and haddock
- Discarded in other fisheries since 1999
  - Mostly invertebrate trap



Cusk Management

- Cusk bycatch landings controlled through fleet ‘caps’ since 1999
- Allow for regulation of fishery’s impacts on cusk while allowing directed fishing for other groundfish species.
- Cap allocated to each fleet though a share arrangement and landings against this cap monitored during the year
- Once cap reached, cusk are not allowed to be landed and must be discarded.

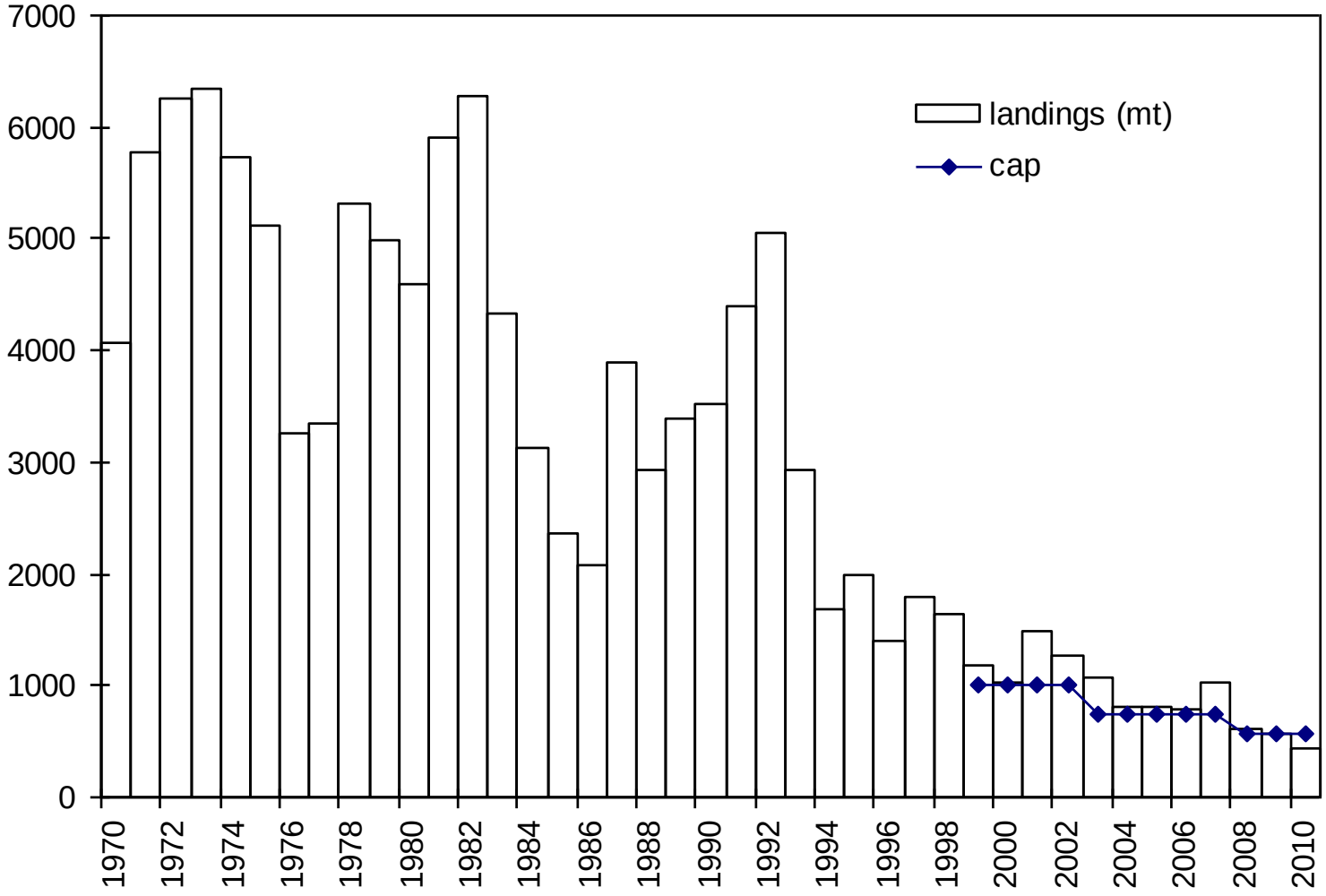
Cusk Caps 2011

Fleet	NAFO division	Cap
FG <45'	4X5	500 mt
FG <45'	4VW	70 mt
FG 45-65	4X5	35 mt
FG 45-65	4VW	13 mt
MG <65'	4VWX5	20 mt

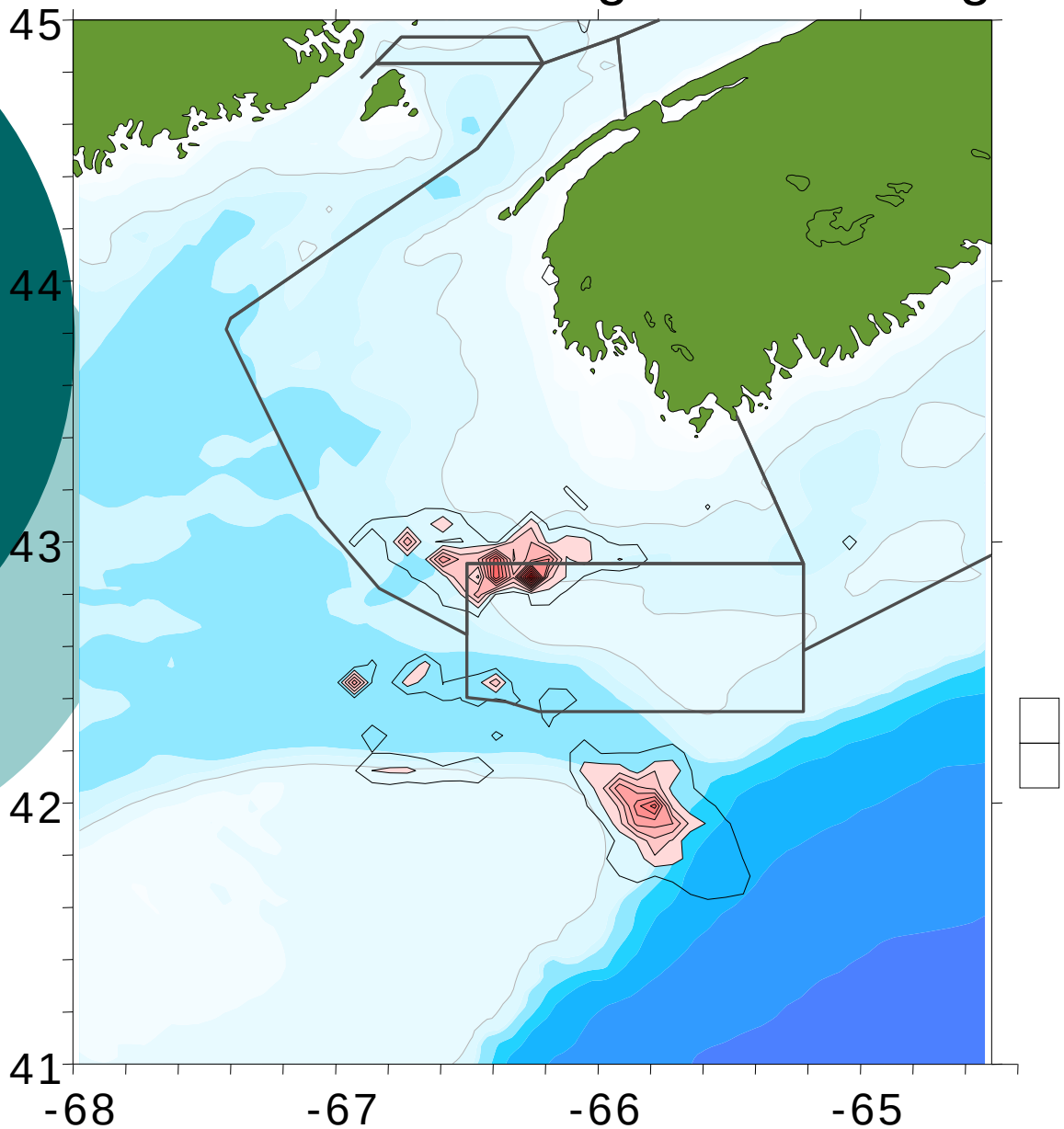
Other Conditions 2011

- 4VWX fixed gear, cusk not to exceed 25% of the round weight of the directed species and the trips' landings should not exceed 4,000 lbs round at any time
- 5Z fixed gear, cusk not to exceed the lesser of 15% of the amount of cod, haddock and pollock combined onboard the vessel or 3000 pounds round weight.
- Any licence holder found to be deliberately or consistently exceeding limit is required to have additional observer coverage at their expense
- DFO may close the fleet's fishery if this occurs.
- All gears (except <45' FG) are subject to 100 % dockside monitoring (DMP) of landings. The <45' FG vessels are subject to a minimum of 25% DMP and the actual level is closer to 50% (100% for FG<45' in 5Z)

Longline Landings and Effort



Areas of highest landings



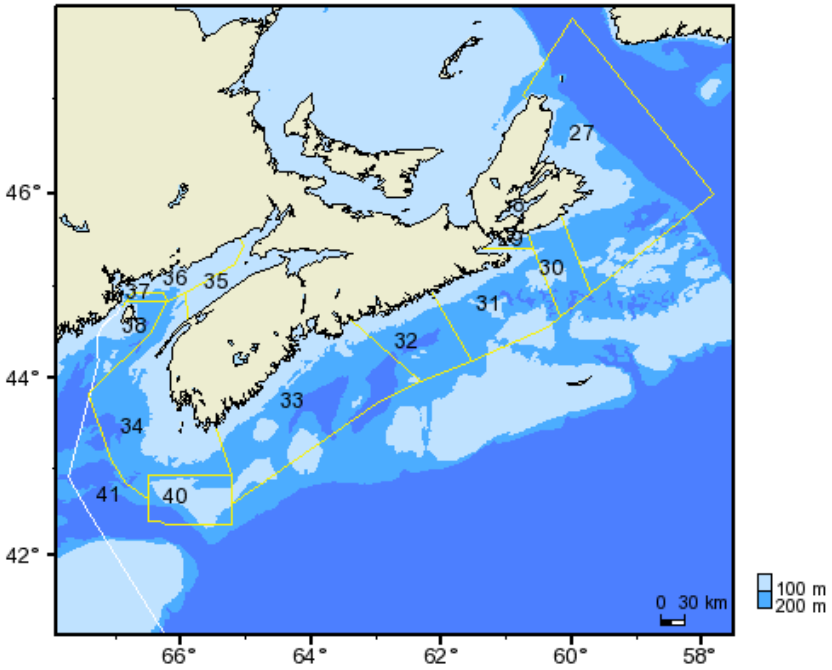
2003-2008 Landings summed within 2 minute grid cell

Distribution of highest landings from groundfish longline fishery

Between German Bank and Browns Bank, off NE peak of Georges, in Fundian Channel

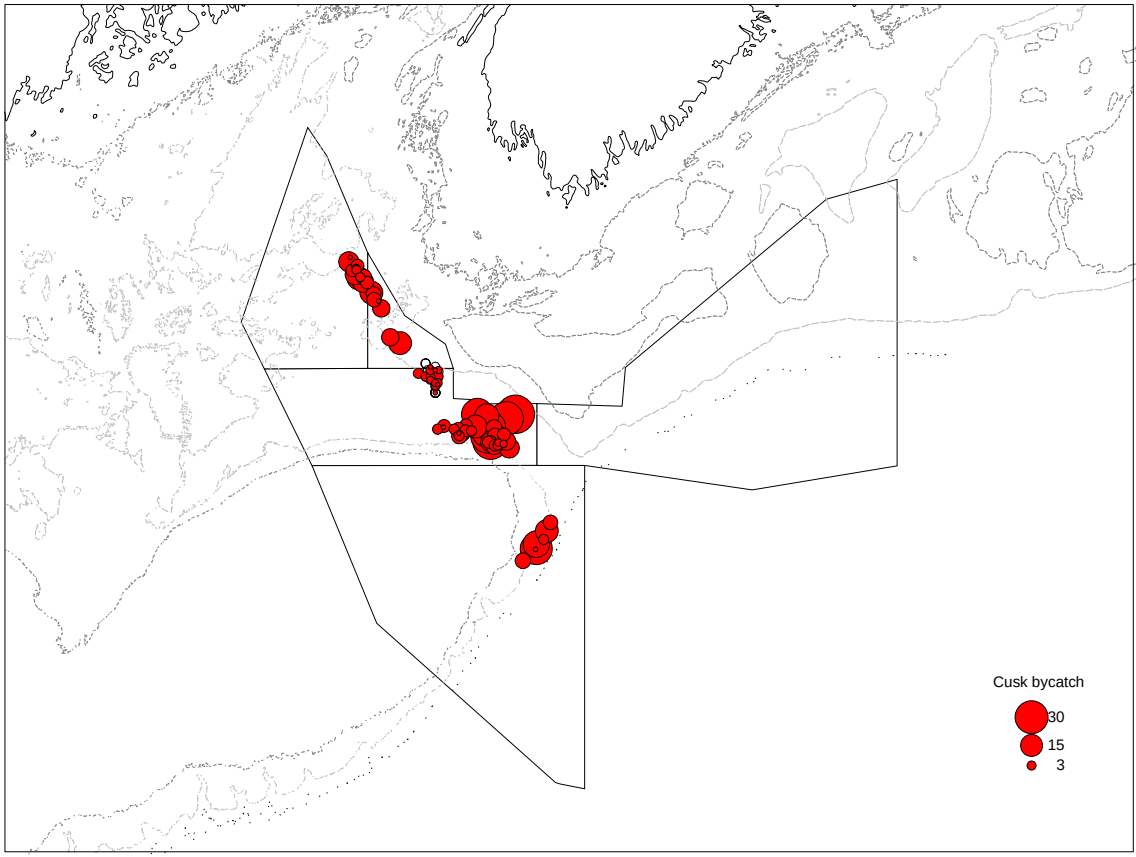
Special Sampling: Lobster Bycatch

- Targeted sampling program between 2005-2007
- LFAs 34 and 41 areas of highest landings
- Cusk (and other spp) landed legally until 1999
- Anecdotal information suggested bycatch may be high

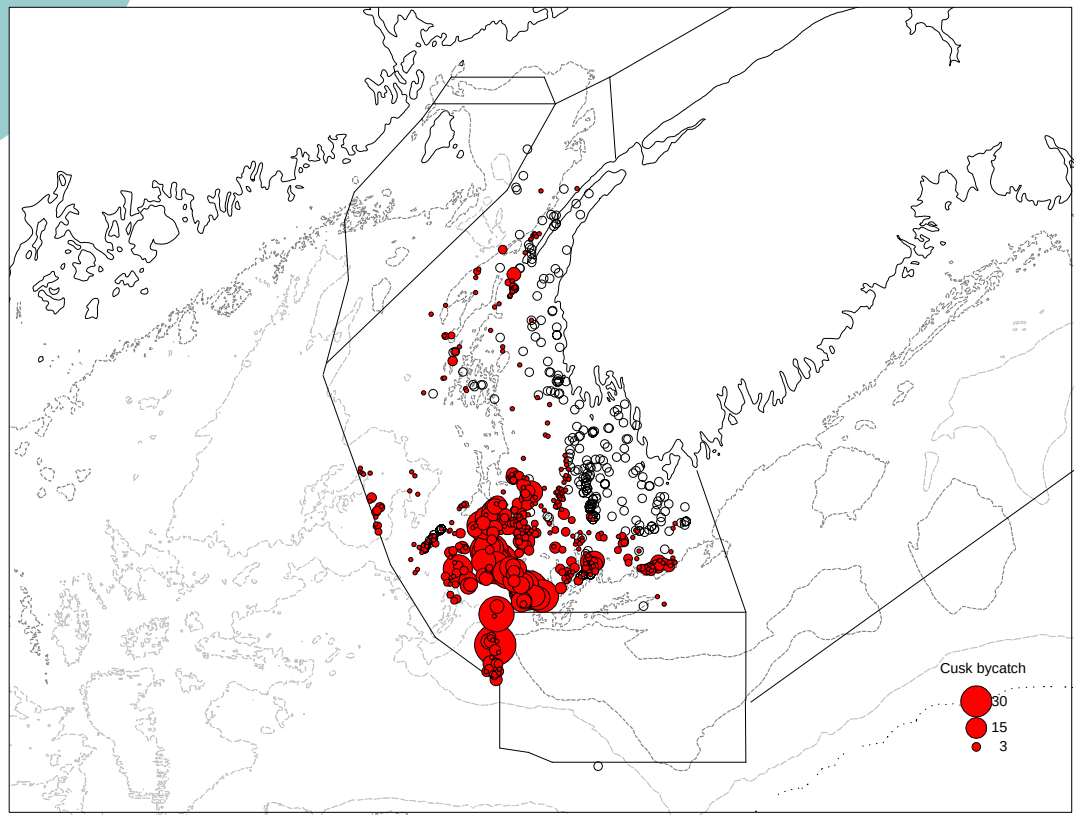


Lobster Fishing Area 41

- LFA 41 7 trips, over 14 000 traps
- 8 licenses



Lobster Fishing Area 34



- Over 1000 license holders
- LFA 34 201 trips, over 70 000 traps

Lobster Fishery Bycatch

	LFA 34		LFA 41	
	Bycatch	Mortality	Bycatch	Mortality
2005/2006	461	226	25	22
2006/2007	344	169	-	-

Mortality rate LFA 34 49%, LFA 41 86% (Mortality rates do not include cusk used as bait, cusk mortality after return to water)

- No estimates for other LFAs
- No estimates for other fisheries (crabs?)

Cusk and Species at Risk Act

Species at Risk Act

- Wildlife status assessed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada)
- Federal government decides whether to list under *Species at Risk Act*
  - *List (as designated)*
  - *Do not list*
  - *Refer back to COSEWIC*

Cusk and SARA

- COSEWIC Assessment May 2003
- The main population ... has been in decline since 1970. Over three generations, the decline rate is over 90%, and the fish occurs in fewer and fewer survey trawls over time. Fishing, unrestricted until 1999, is now capped but remains a source of mortality.
- Designation: Threatened
- Cusk was being considered for legal listing under *SARA*

Cusk and *SARA*

- April 2006 GiC referred the assessment back to COSEWIC for further information and consideration since all available information was not used in the assessment
- December 2006, COSEWIC reaffirmed the original assessment without reassessing the species, citing an absence of new information that would lead to a change in the status of this species
- Regional listing recommendation completed
- Listing decision 2012?

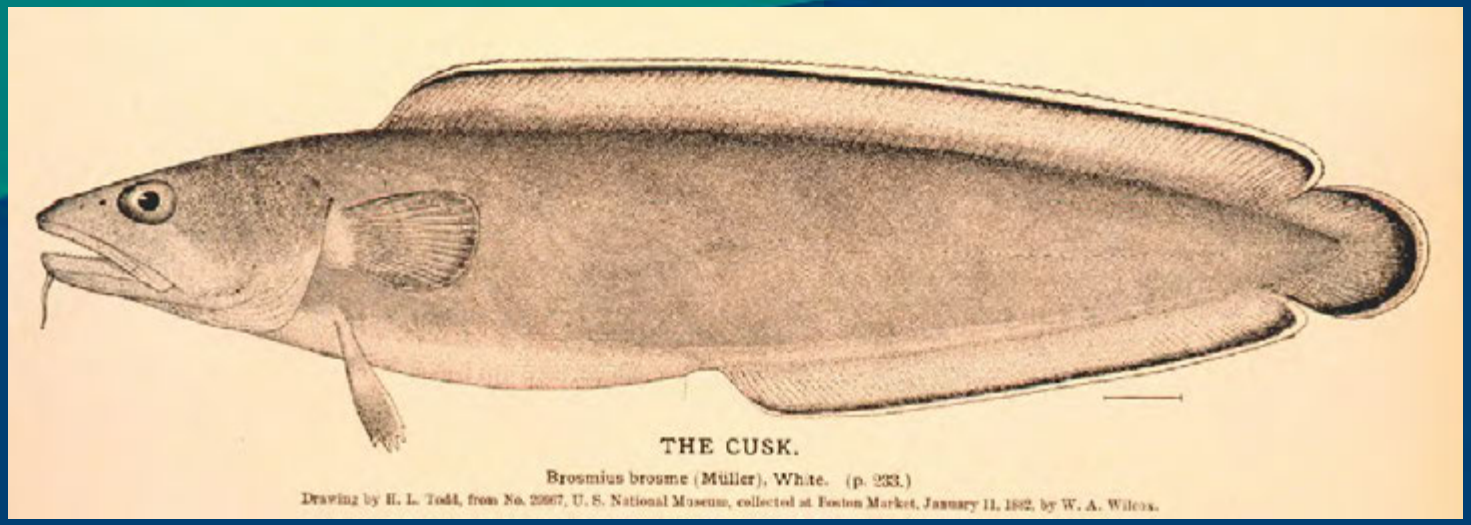
Summary of Status

- No estimate of abundance
- Magnitude of decline in abundance not known (current commercial CPUE around 40% of 1980s)
- Some evidence suggests decline ceased
- Currently under consideration for legal listing under *SARA*

Reported Landings

	Longline	Bottom Trawl	Gillnet	Misc	Total
1995	1896	42	25	38	2001
1996	1326	17	27	31	1401
1997	1716	26	23	34	1799
1998	1540	56	21	15	1633
1999	1117	39	16	5	1177
2000	977	29	16	9	1031
2001	1431	39	17	4	1490
2002	1225	38	13	3	1279
2003	1019	28	13	3	1063
2004	779	32	6	1	818
2005	773	24	6	1	804
2006	761	22	5	3	790
2007	994	16	7	0	1018
2008	586	17	5		608
2009	533	25	7		564
2010	410	13	15		438

Science, Service, Stewardship



Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

Cusk and the Endangered Species Act (ESA)

NOAA FISHERIES SERVICE

NOAA
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SERVICE

Cusk & the Endangered Species Act (ESA)

Norwegian Seafood Export Council

Species of Concern (2004)

- Species for which there are concerns regarding the danger of extinction or risk of becoming endangered, but for which insufficient information is available to indicate a need to list under the ESA.
- NOT protected under the ESA.
- Identified through the Proactive Species Conservation Program which encourages proactive conservation efforts in order to preclude the need for listing in the future.

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Cusk & the Endangered Species Act (ESA) (cont.)

Candidate Species (2007)

—Species of Concern can also be “candidate species” if they have been petitioned for ESA listing or if a status review has been initiated by NMFS.

—NMFS decision based on:

- 2003 Committee on the Status of Endangered Wildlife in Canada’s (COSEWIC) determination that the Canadian stock should be designated as threatened.
- Concern over declines in abundance of cusk recognized in both Canadian and U.S. waters.

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ESA Status Review

Timeline

- March 2007 - NMFS initiated status review
- August 2008 - Completed draft peer reviewed
- Late 2008 - Peer review indicated need to consider additional information (particularly, recreational landings)
- 2009 - NEFSC initiated modeling effort to develop population trajectories
- 2010 - NEFSC determined not feasible to develop reliable population trajectories
- February 2010 - Qualitative Threats Assessment Workshop
- April 2010 - Initiated climate change pilot project

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ESA Overview

What can be listed under the ESA?

—Species

—Subspecies

—Distinct population segment of a vertebrate

- Discrete - markedly separated based on physical, physiological, ecological and behavioral factors (genetic or morphological differences can be used)
- Significant – occupies a unique ecological setting, loss would result in significant gap in the range, evidence that pop. is only surviving natural occurrence, pop. differs markedly from others in genetic characteristics

DPS Info	Northwest Atlantic population	Northeast Atlantic Population
Longevity	40 yrs	20 yrs
Age/Length at maturity	41-60 cm (5-10 years)	40-50 cm (8-10 years)
Avg minimum length	46 cm	30 cm
Avg length at age 6	49 cm	22 cm
Most common length range	46-80 cm	30-70 cm
Most common age/length range of commercial catch	55-65 cm (7-10 years)	45-60 cm (10-12 years)
Spawning Season	April-August	April-July
Spawning Aggregations	unknown	major grounds between Scotland, the Faeroe Islands and Iceland
Spawning depth	18-183 m	50-500 m
Largest recorded length	118 cm	112 cm
Preferred temperature	6-10ºC	4-10ºC
Habitats	piled boulders	coral reefs
Preferred depth	18-550 m	150-450 m
Diet	crustaceans and fish	crustaceans and mollusks

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ESA Overview (cont.)

The ESA specifies 5 factors that must be considered to determine whether a "species" is Threatened or Endangered

- —Present or threatened destruction, modification, or curtailment of its habitat or range;
- —Overutilization for commercial, recreational, scientific, or educational purposes;
- —Disease or predation;
- —Inadequacy of existing regulatory mechanisms;
- —Other natural or manmade factors affecting its continued existence

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Primary Threats

- Incidental catch in commercial fisheries
- Recreational catch
- Inadequacy of existing regulatory mechanisms for fisheries
- Habitat loss and degradation, increasing distance between habitat patches

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Qualitative Threats Assessment

- Held in February 2010.
- Convened to provide information for the status review of cusk based on its data poor nature.
- Cusk experts ranked habitat fragmentation and recreational & commercial bycatch as threats that posed a moderate or high risk to the continued existence of cusk.

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Climate Change & Cusk

- Preliminary results indicate that there is potential for: 1) a decrease in habitat, but not an extirpation from the Gulf of Maine, and 2) increased fragmentation of habitat.
- The final results will be incorporated in the ongoing status review on this species under the ESA.

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Next Steps for Cusk Conservation

- Complete cusk climate change project winter 2011/2012.
- Complete status review and associated listing determination in 2012.
- Proactive conservation efforts are needed & important
  - —Options/measures to reduce commercial & recreational fisheries bycatch
  - —Important consideration for NMFS when determining whether listing cusk under the ESA is warranted.
    - Policy for Evaluation of Conservation Efforts (PECE) analysis.

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Potential Funding Through Protected Resources

- Proactive Species Conservation Program Grant
- Species of Concern Internal Grant Funding
- Species Recovery Grants to States

MAREANO/Institute of Marine Research, Norway

Cusk Research
Maine Department of Marine Resources

J. Kohl Kanwit

Trisha DeGraaf

Timothy Bennett

Amanda Harden

Rodney Lowery

Dan Lowery

Jason Alley*

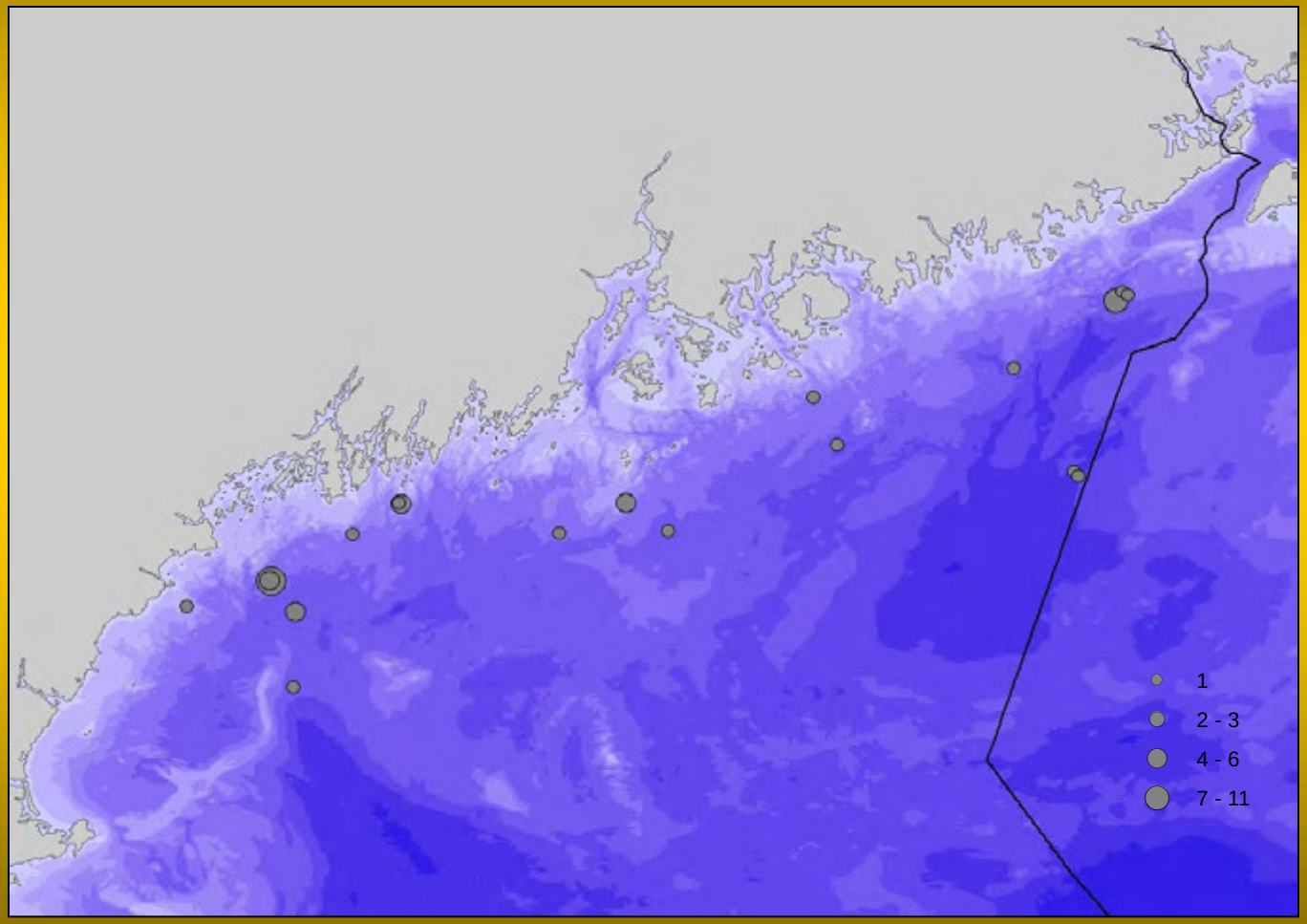
Projects

- Longline survey – 2007 & 2008
- Otolith reference collection
- Cusk mortality study

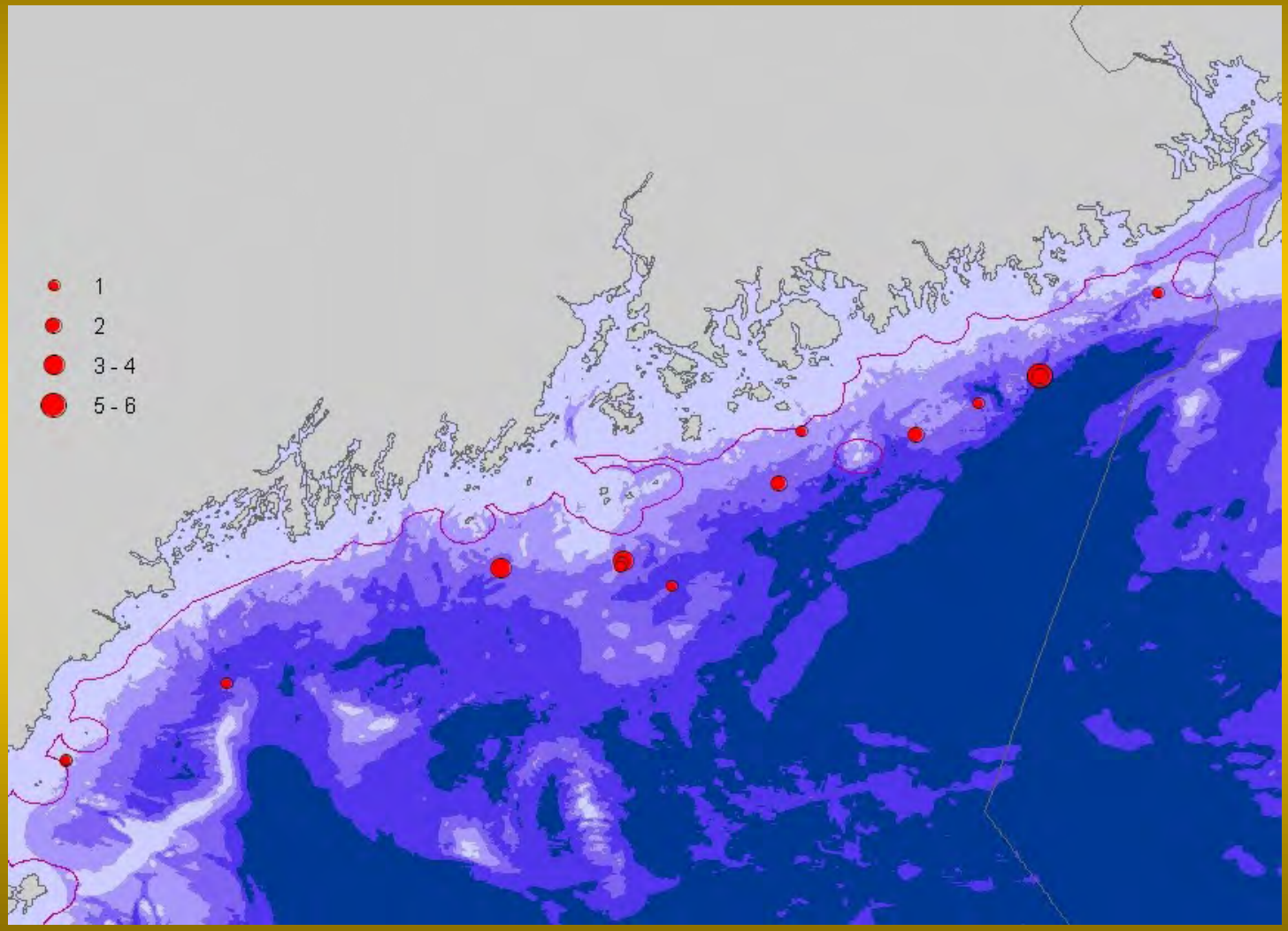
Longline Survey

- Began as a halibut survey but as many cusk were caught as halibut
- Fish were sacrificed and biological samples collected (otoliths, gonads)

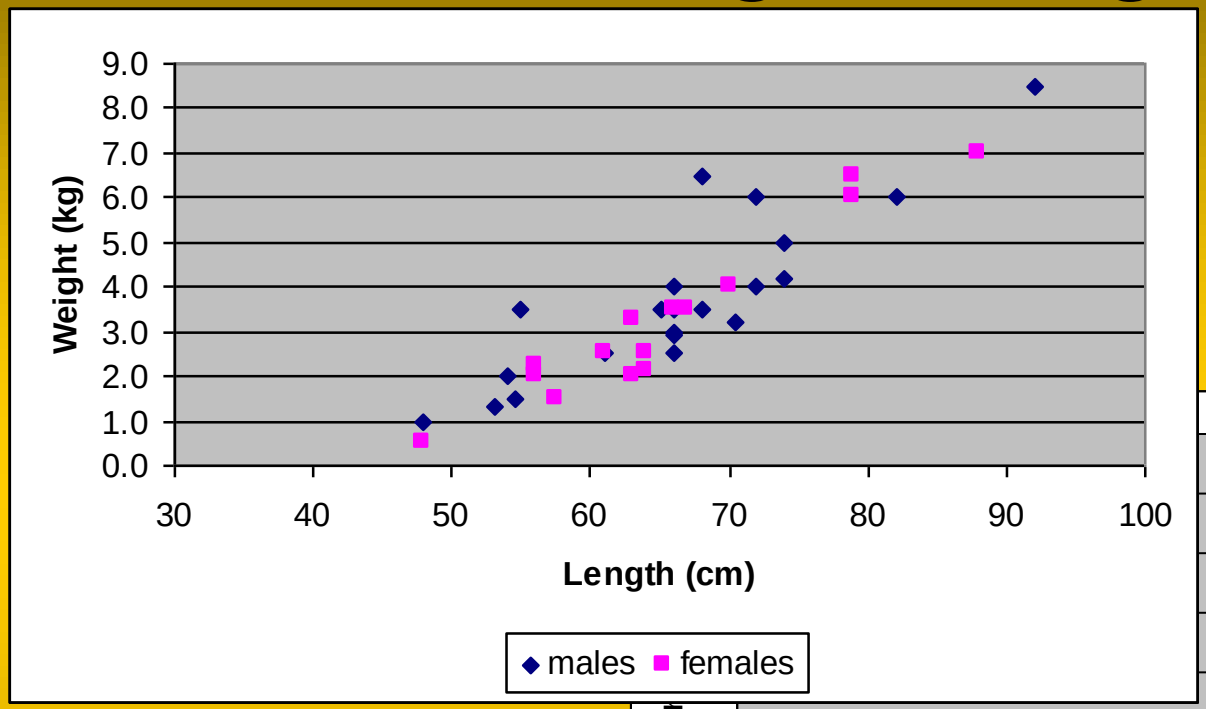
2007

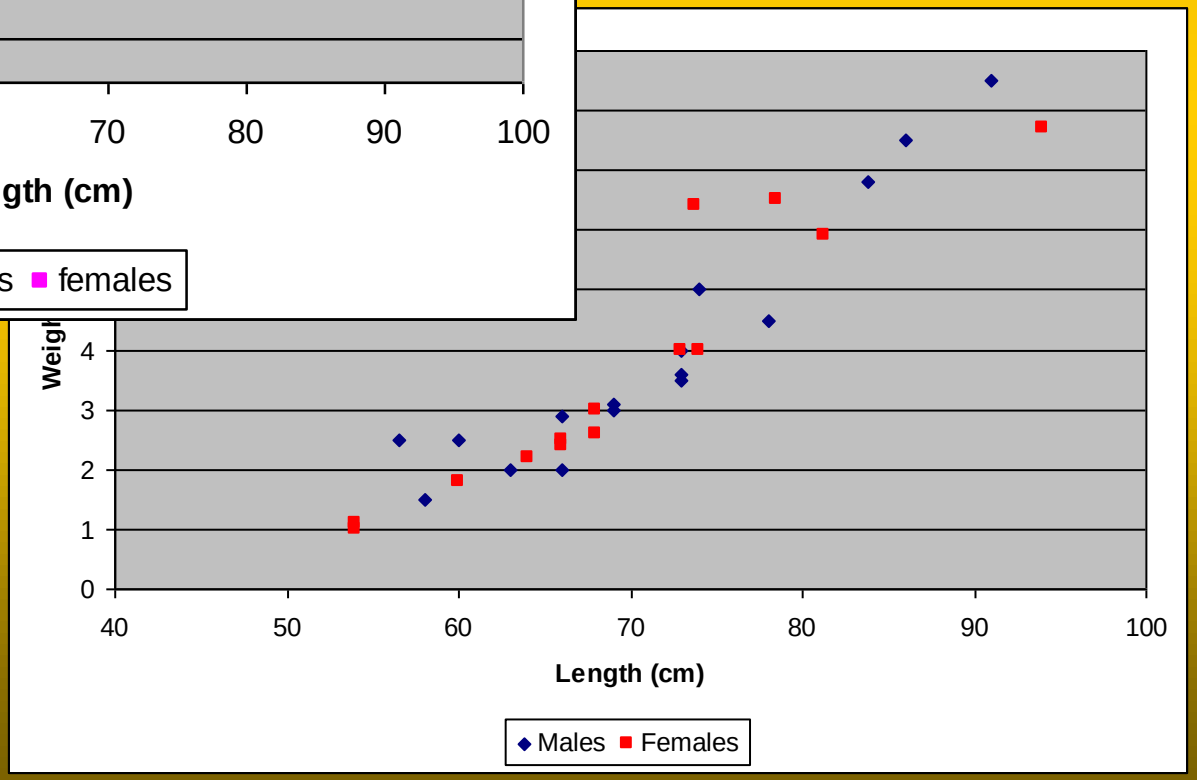


2008



Length-weight



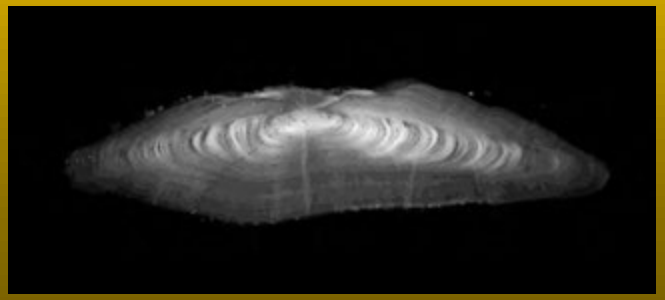


Analysis

- Data from the longline survey were analyzed using a generalized linear model (GLM) and a generalized additive model (GAM) to model the relationship between fish density and spatial/environmental variables (location, depth, hook size and bottom type). The GLM performed better than the GAM and results from this analysis showed that bottom type and depth are the first and second most important factors for cusk distribution.

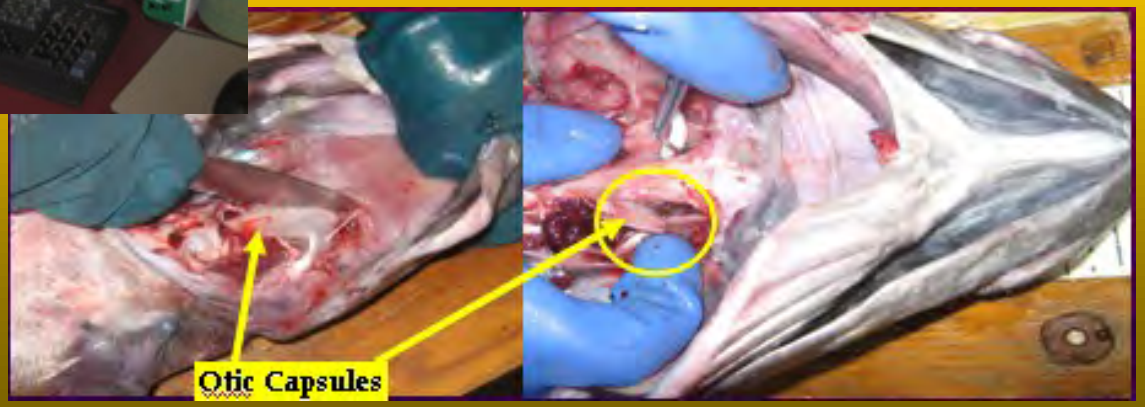
Otolith Reference Collection

- Tim Bennett or Trisha DeGraaf
- Confusion over max age (14 v. 40)
- Tried to compare structures (vertebrae, fin rays, otoliths)
- Section and digitized 451 otoliths
- Looked at other methods of otolith preparation (break and burn)



Follow-up work

- Radio carbon bomb analysis?
- More lab collaboration: NMFS, DFO, DMF



Mortality Study

- Funding from SK in 2009 – money not received until 2010 and fieldwork done in the spring of 2011
- 12 trips fishing trap and longline gear – NO CUSK, of course
- Volunteer fisherman from Jonesport stepped in and saved the project

PSATs and mortality

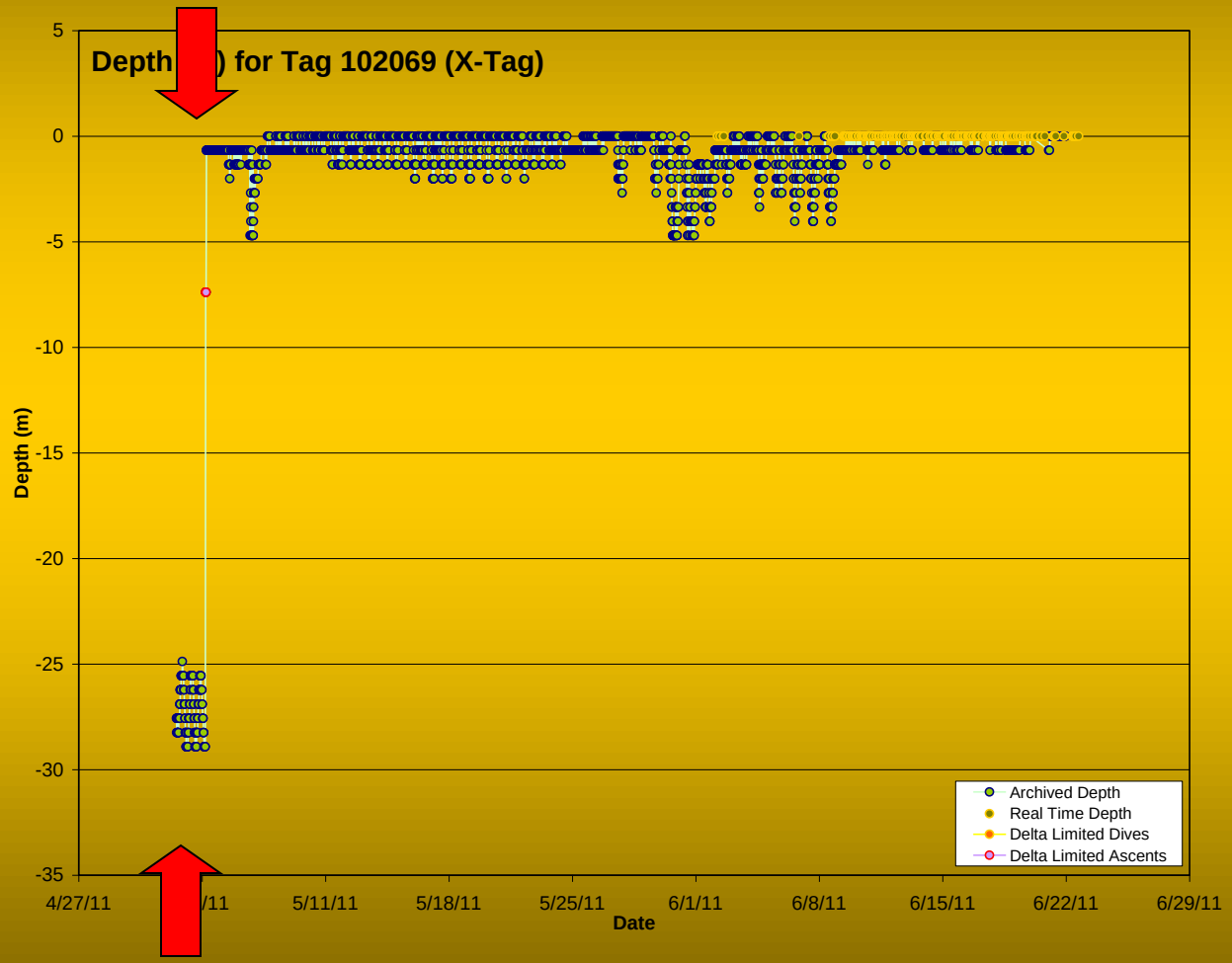
- Draw-backs with regular mortality studies – elimination of predation, confinement, gear damage, etc
- PSATs provide a “picture” of fish’s fate

POP-OFF DATE REACHED

102069

1 MONTH

Surface date 5/4/11



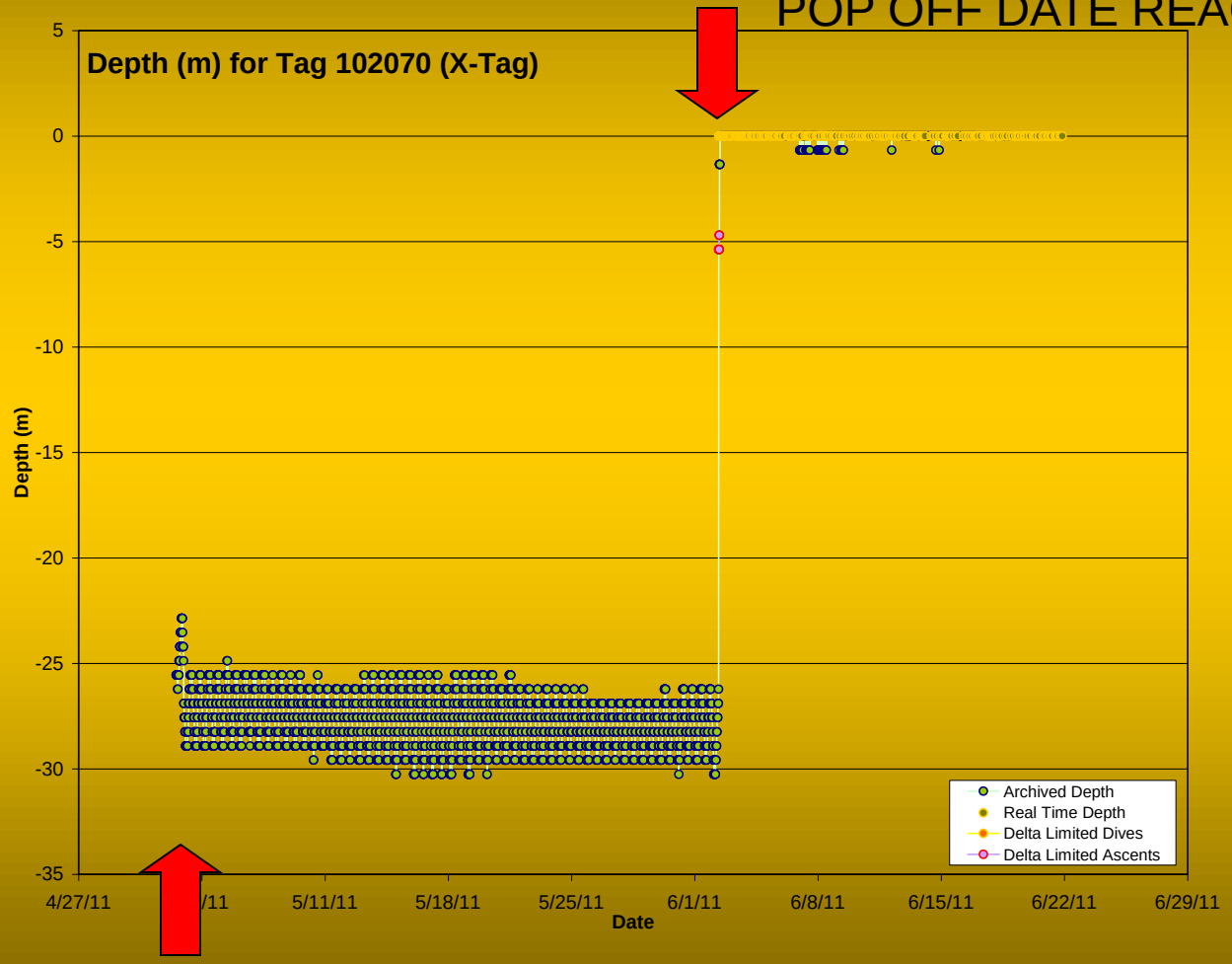
Release date 5/2/11

POP-OFF DATE REACHED

102070

1 MONTH

Surface date 6/2/11
POP OFF DATE REACHED



Release date 5/2/11

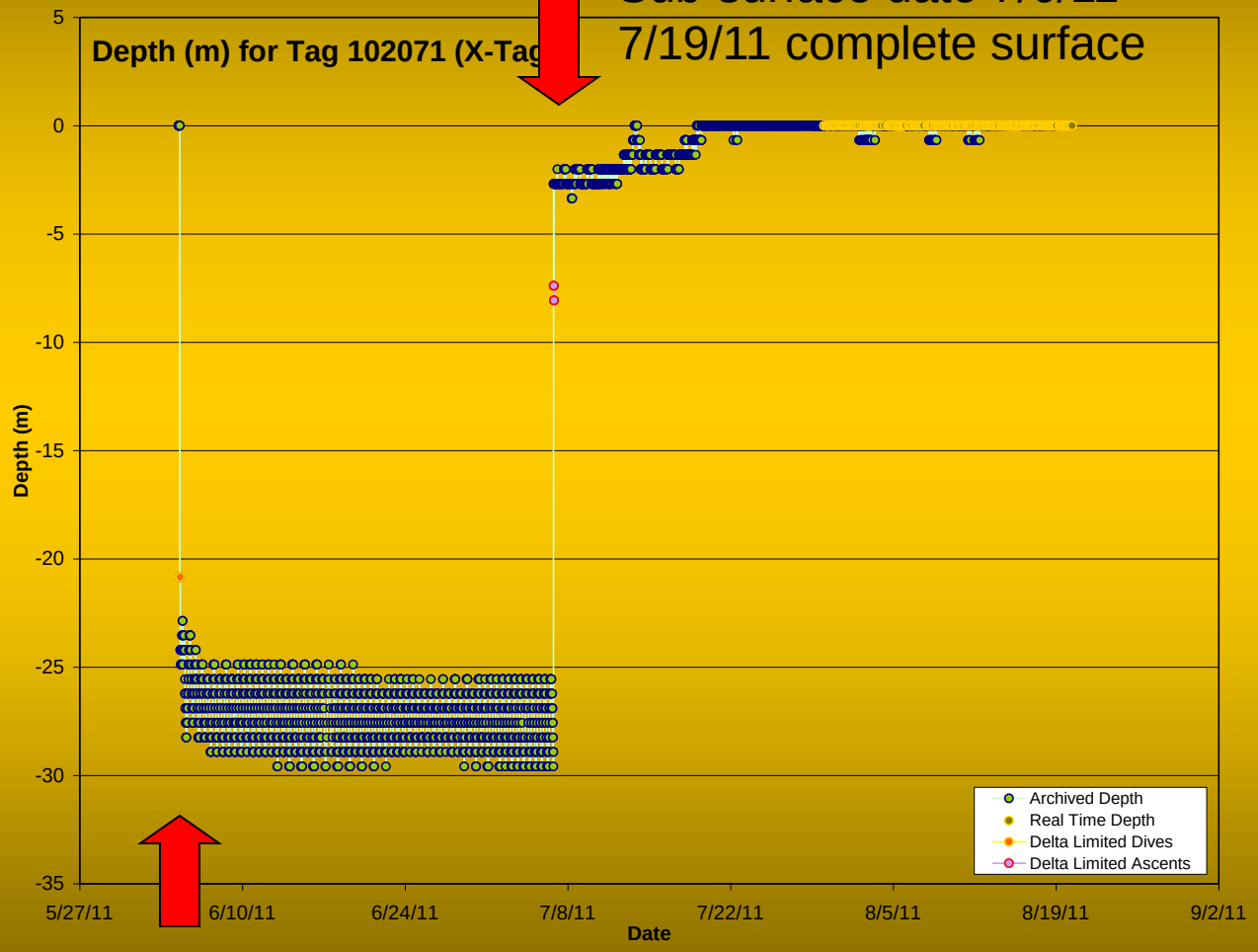
CONSTANT PRESSURE

102071

3 MONTH

Sub-surface date 7/6/11

7/19/11 complete surface



Release date 6/4/11

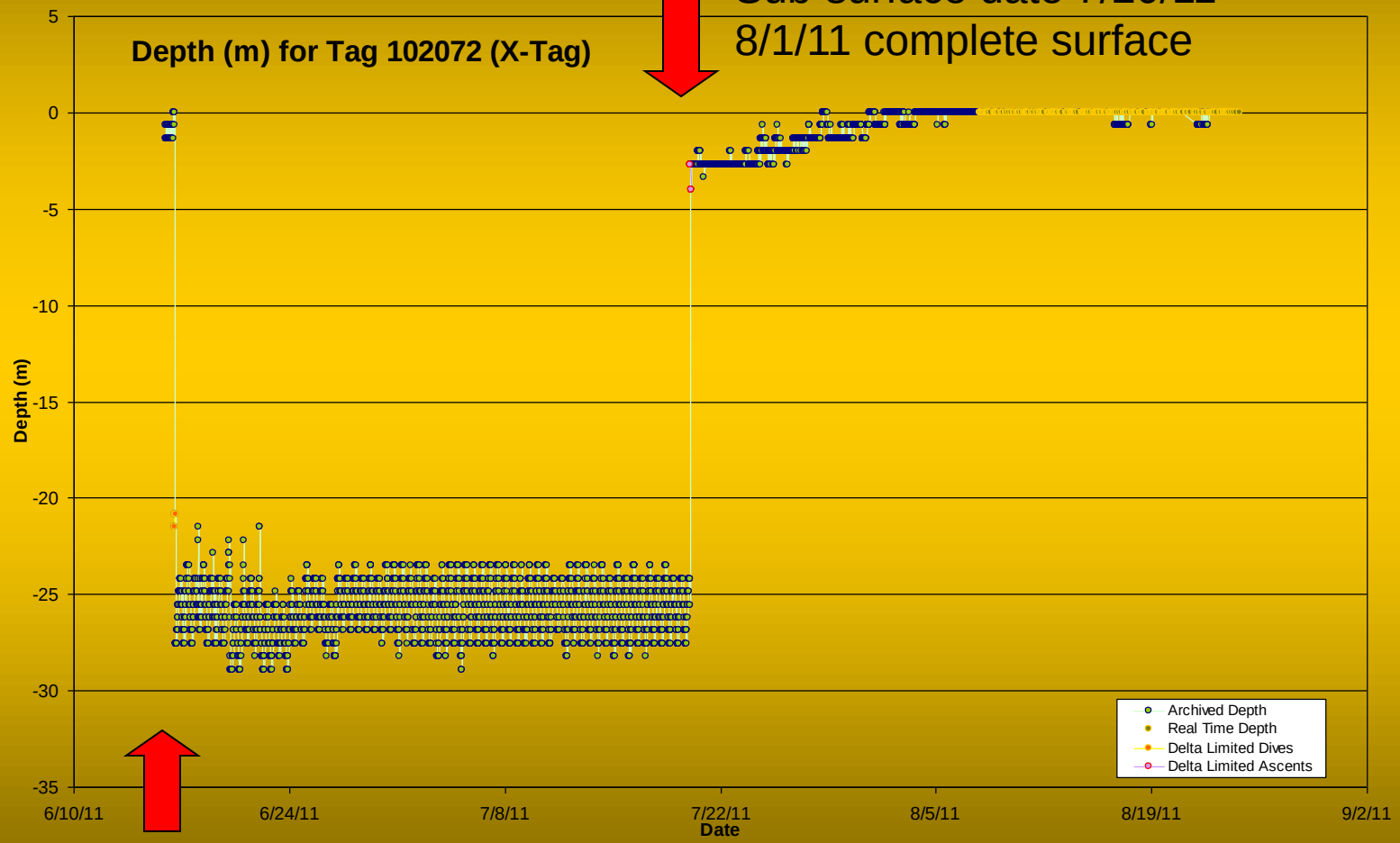
CONSTANT PRESSURE

102072

6 MONTH

Sub-surface date 7/20/11

8/1/11 complete surface



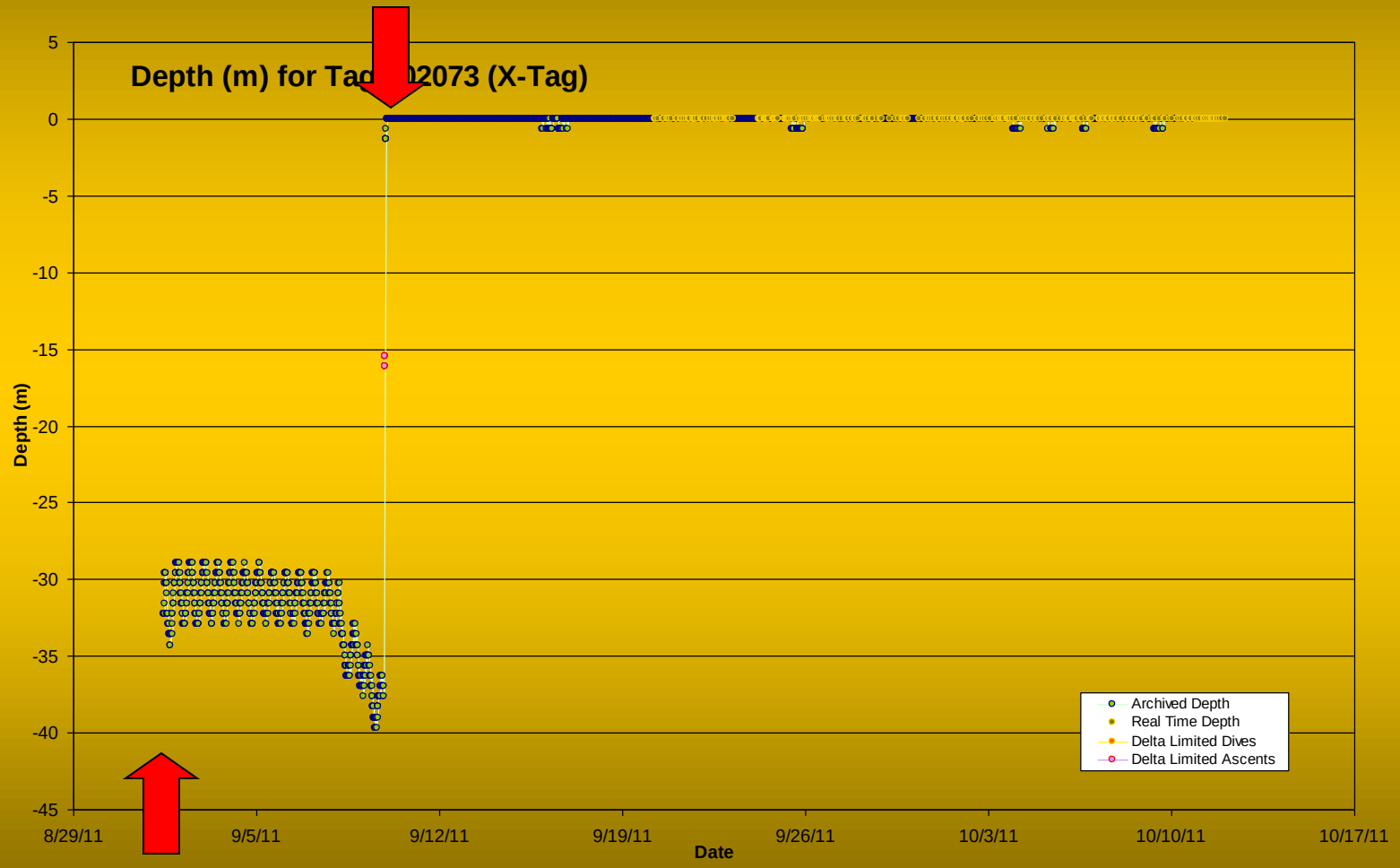
Release date 6/15/11

CONSTANT PRESSURE

102073

12 MONTH

Surface date 9/19/11



Release date 9/1/11

Future

- Yong Chen at UMaine – looking at fishery dependant fixed gear survey
- SOC no longer a priority for DMR
- Currently no groundfish scientist
- No funding to pursue aging resolution

Video and hook-and-line survey to further knowledge of cusk distribution and habitat preferences

Marc Stettner, F/V Too Far
Graham Sherwood, GMRI
Jonathan Grabowski, Northeastern University

Cashed Ledge cusk, J. Grabowski

Gulf of Maine Research Institute
Science. Education. Community.

The issue

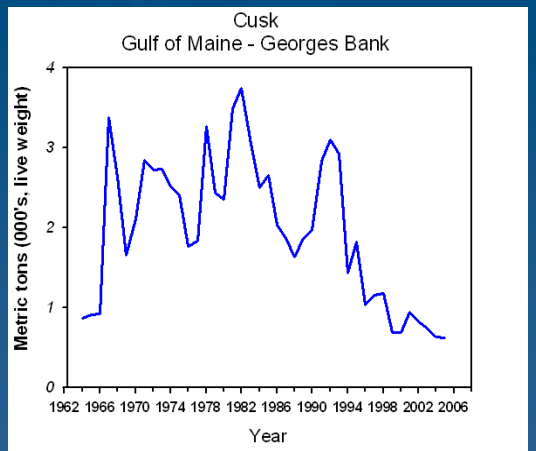


Figure 19.2. Total commercial landings of cusk from the Gulf of Maine-Georges Bank region, 1964-2005.

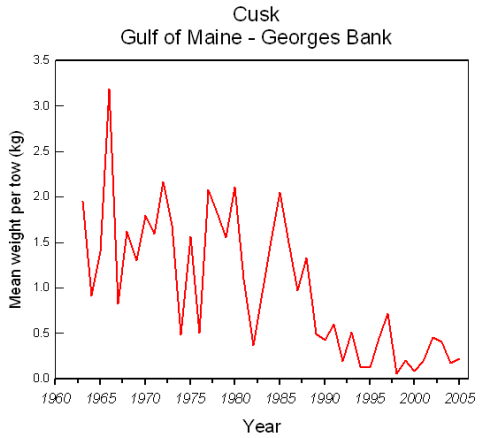


Figure 19.3. Biomass indices (stratified mean weight per tow) of cusk in NEFSC autumn bottom trawl research vessel surveys, 1963-2005.

O'Brien 2006

How much of this is effort controls?

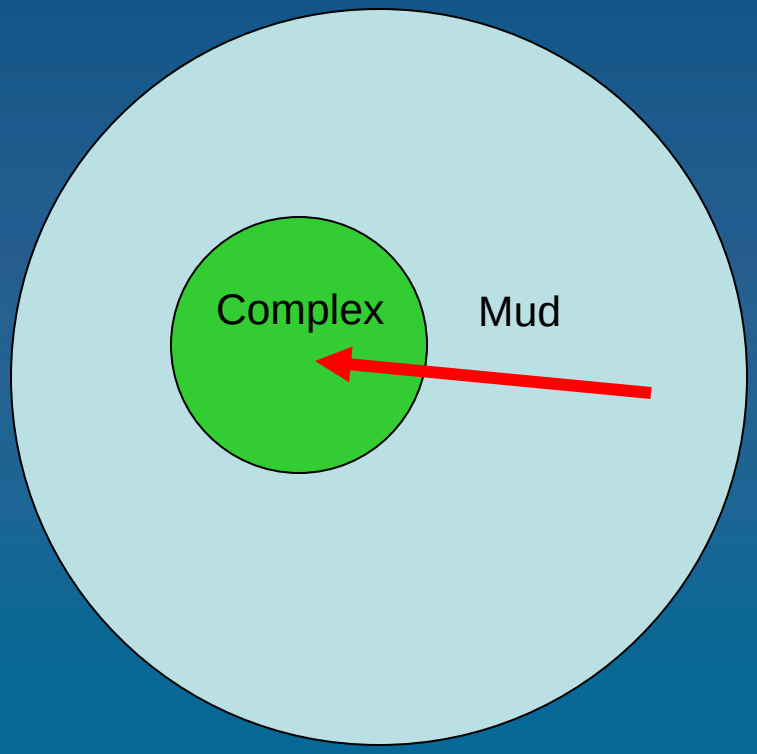
How much of this is sampling bias (i.e., habitat)?

Definite decline in index but are we near bottom? Have we overestimated % decline?

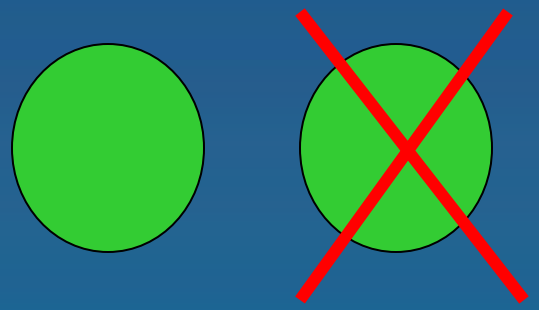
Gulf of Maine Research Institute

The issue

Contraction of range: retreat to optimal (complex habitats)



Loss of one type of complex habitat



Rocky Coral

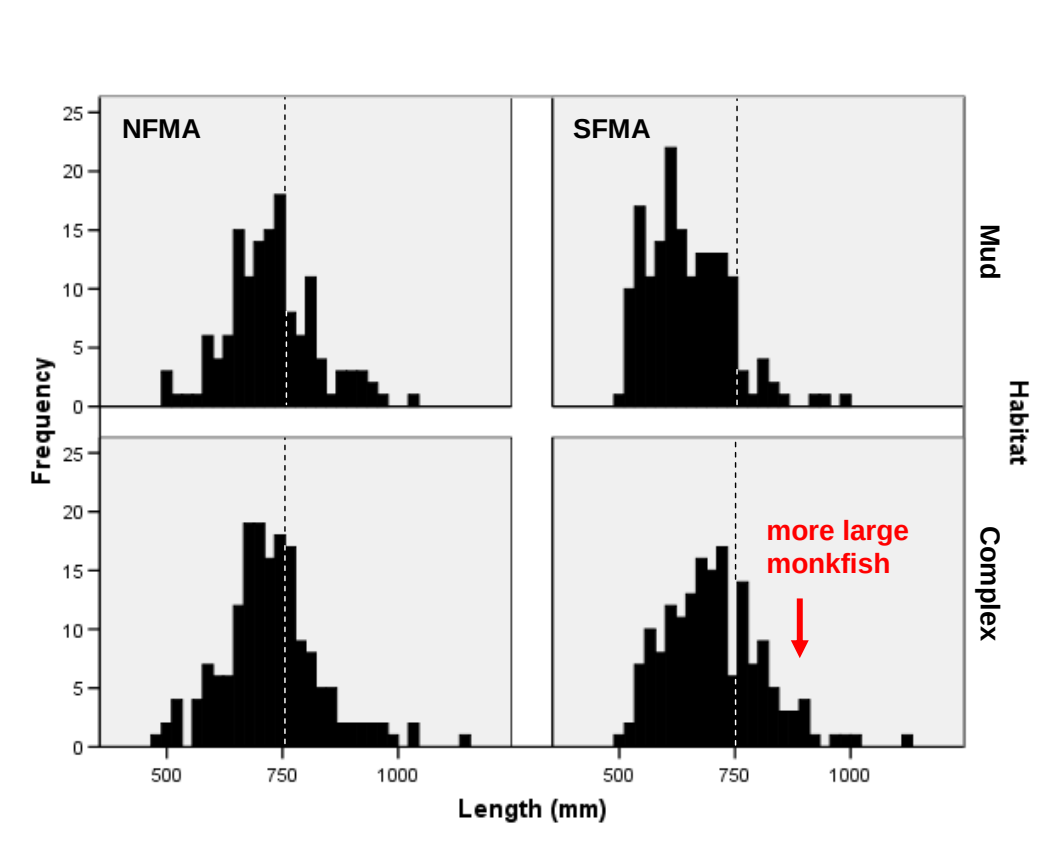
Or both

Gulf of Maine Research Institute

A question of habitat

Plenty of species prefer hard/complex bottom

e.g., Monkfish



Gulf of Maine Research Institute

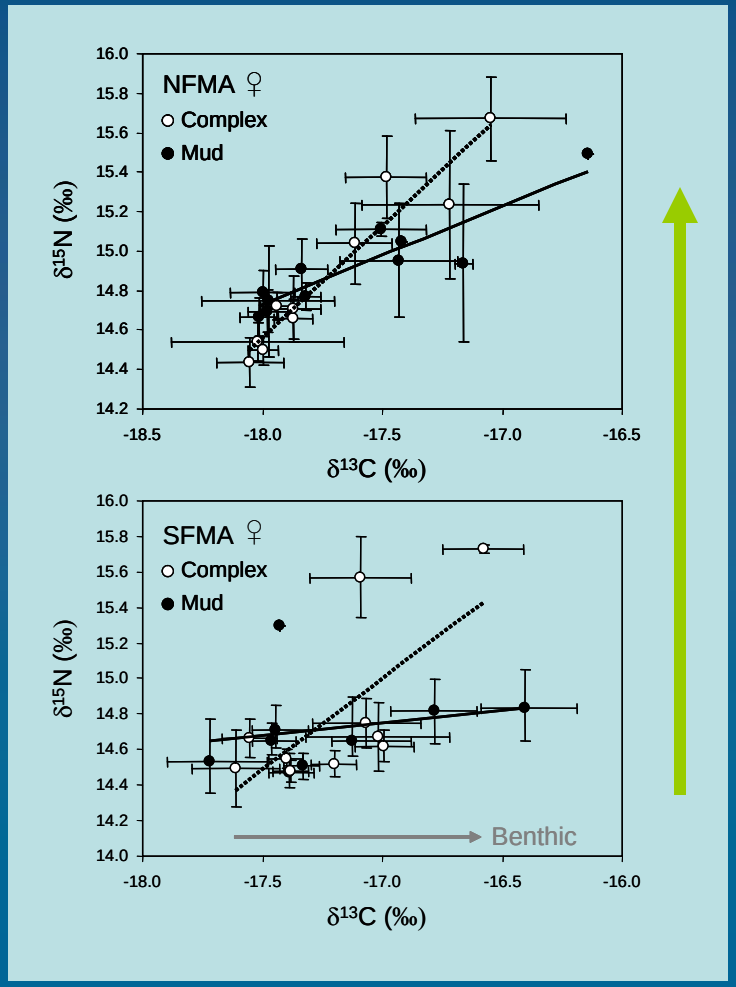
Sherwood 2007

A question of habitat

Plenty of species prefer hard/complex bottom

e.g., Monkfish

Large monkfish get some kind of trophic benefit from living in more complex habitats (better foraging for larger prey)



Sherwood 2007

Gulf of Maine Research Institute

A question of habitat

Do cusk prefer complex (rocky) habitats?

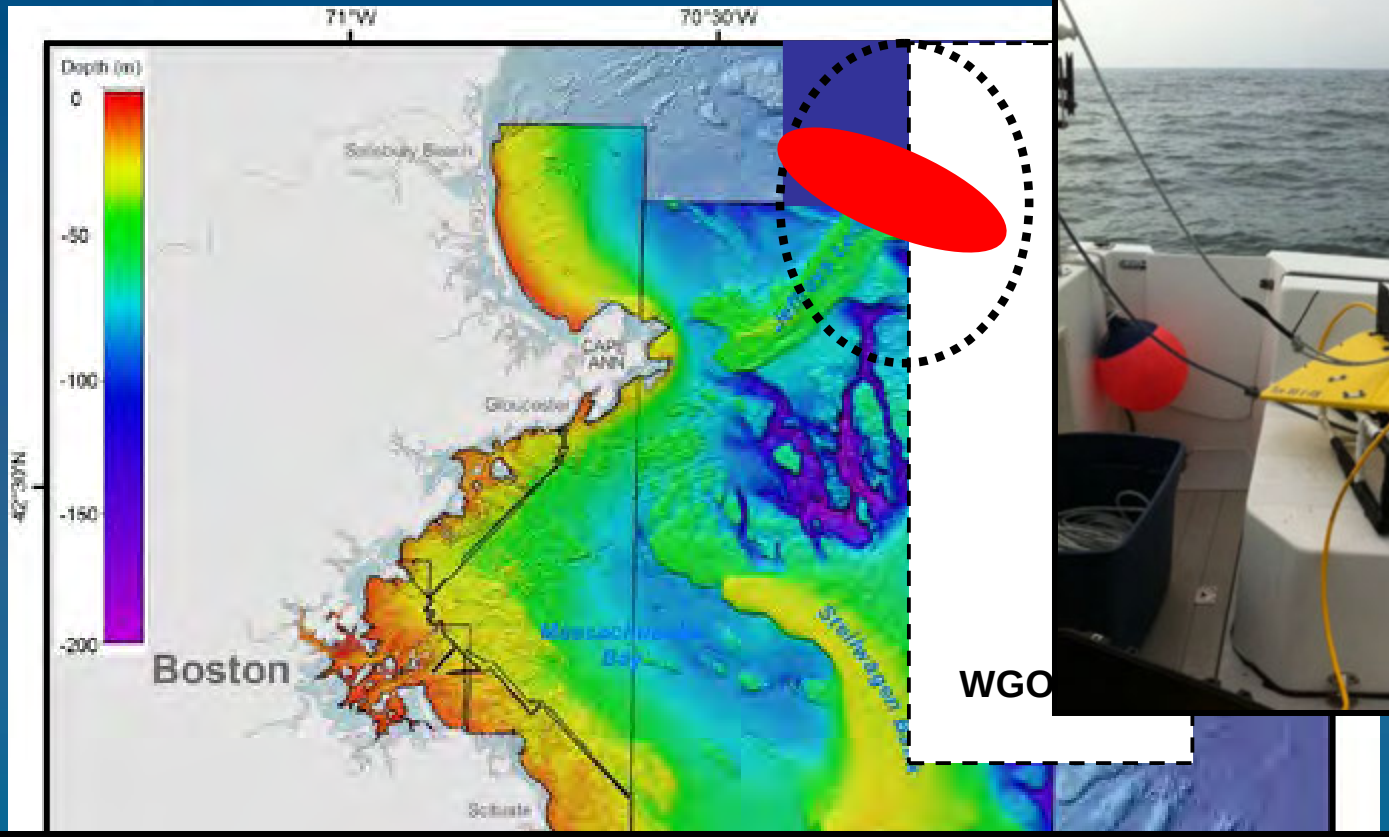
Approach:

- Conduct fine-scale sampling over a range of habitats (WGOM)
- Quantify habitat using drop video system
- Quantify cusk using video system (visitation rates) and CPUE (hook-and-line)

Hypothesis:

- Cusk visitations/sightings and CPUE higher in complex/rocky habitats; diet/growth differences?

Preliminary results



4 days completed: affirmative cusk sightings; 12 cusk captured; intriguing behavior observed

Gulf of Maine Research Institute

Say cheese!

Gulf of Maine
Research Institute

So far…

This project is an NEC development award

Method looks feasible for collecting fine-scale data on cusk habitat preferences and behavior

Early data support hypothesis: Cusk only found and captured so far in complex habitats

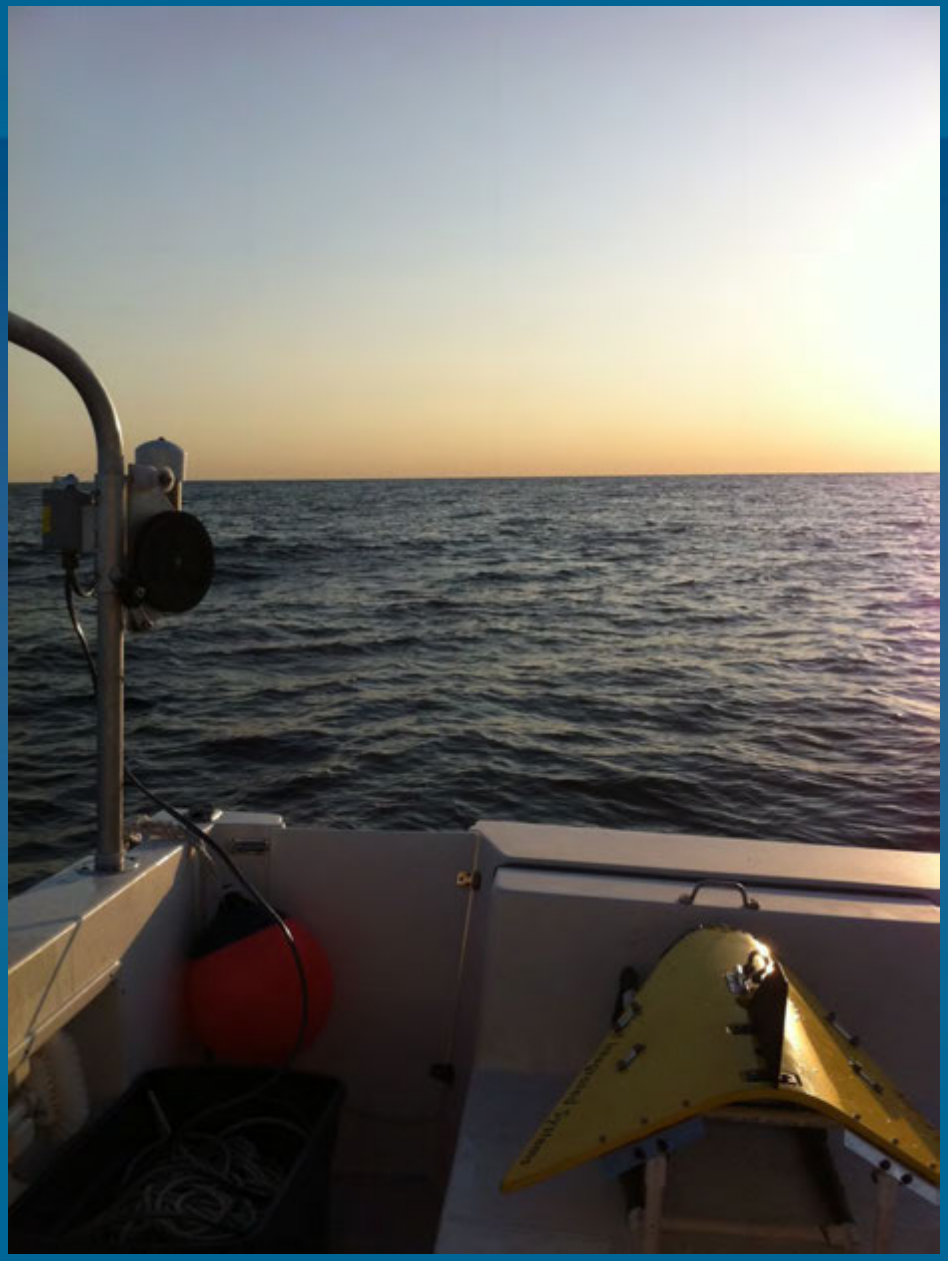
Evidence of disturbance avoidance behavior (hiding under rock)

What does this mean for catchability?

Thank you

Funding:

The Northeast Consortium



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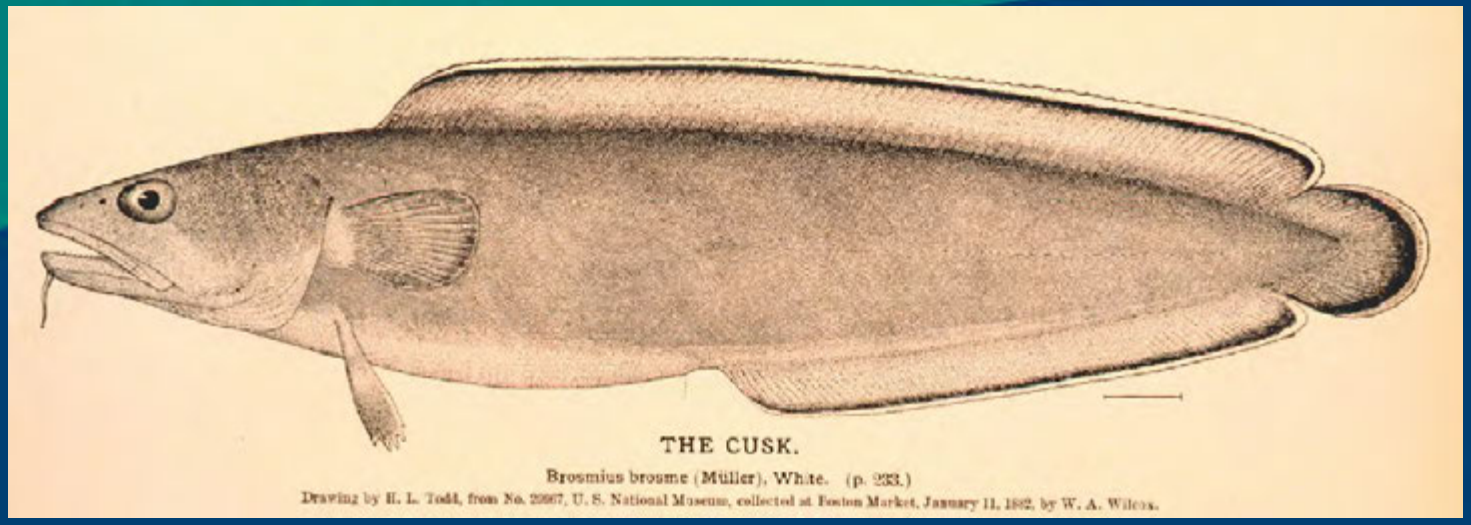
Science, Service, Stewardship



Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

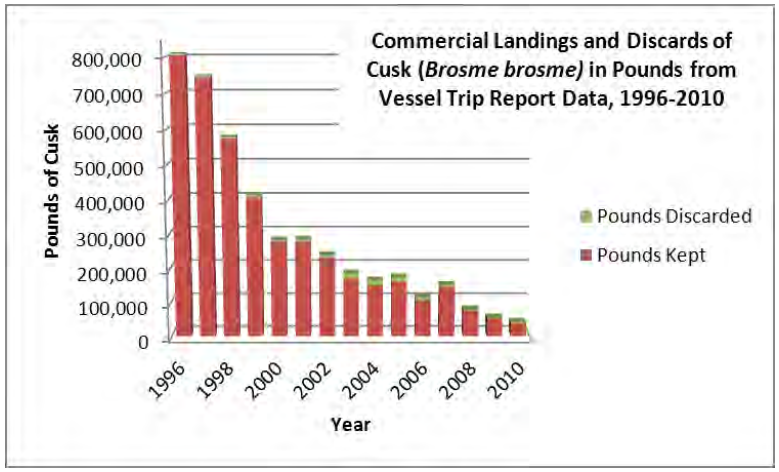
Data from NMFS
Commercial & Recreational Databases

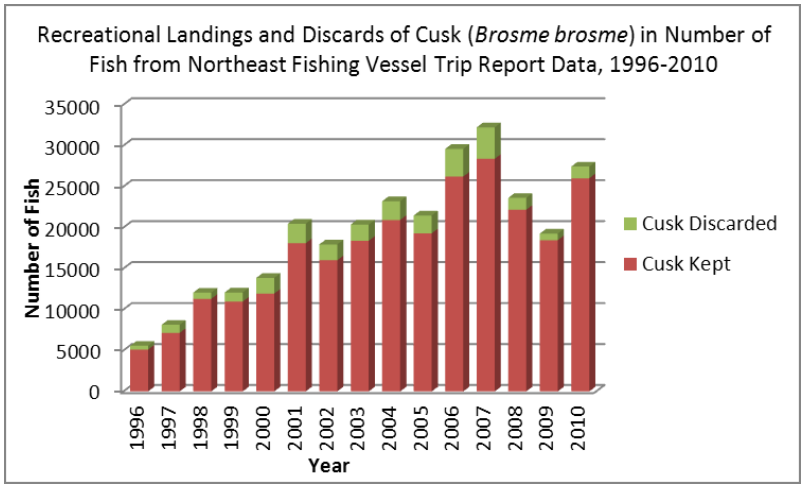
NOAA FISHERIES SERVICE

NOAA FISHERIES SERVICE

NMFS Northeast Vessel Trip Report (VTR) 1996-2010 Data

- Cusk landings & discards (i.e., catch)
  - Decrease in commercial (pounds)
  - Increase in recreational (individual fish)
    - Marine Recreational Fisheries Statistics Survey (MRFSS) shows a similar trend
- Cusk typically kept versus discarded





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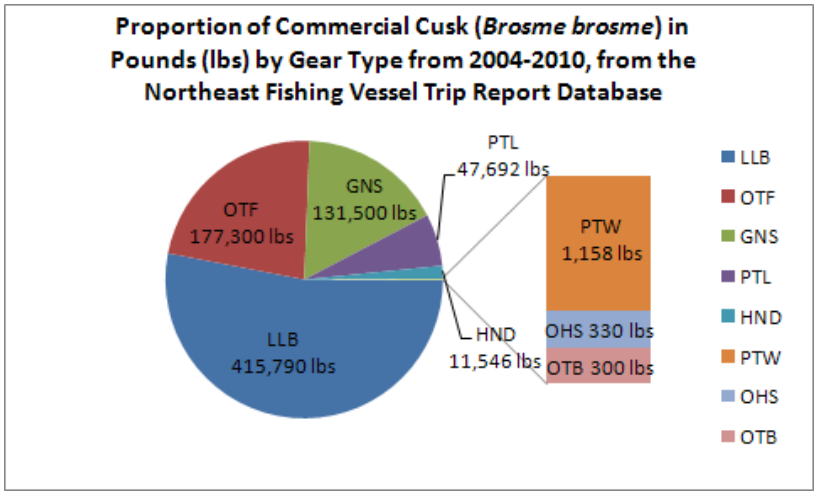
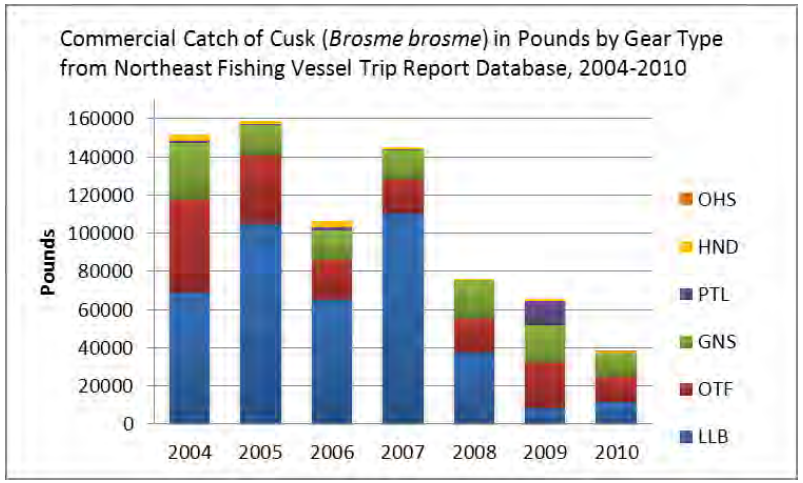
NMFS Northeast Vessel Trip Report (VTR) 2004-2010 Data

- Majority of cusk catch
  - Bottom longline (53%)
  - Otter trawl (bottom fish) (23%)
  - Sink gillnet (17%)
  - Lobster pot (6%)
  - Hand line (1%)
- Fisheries accounting for majority of cusk catch change over time





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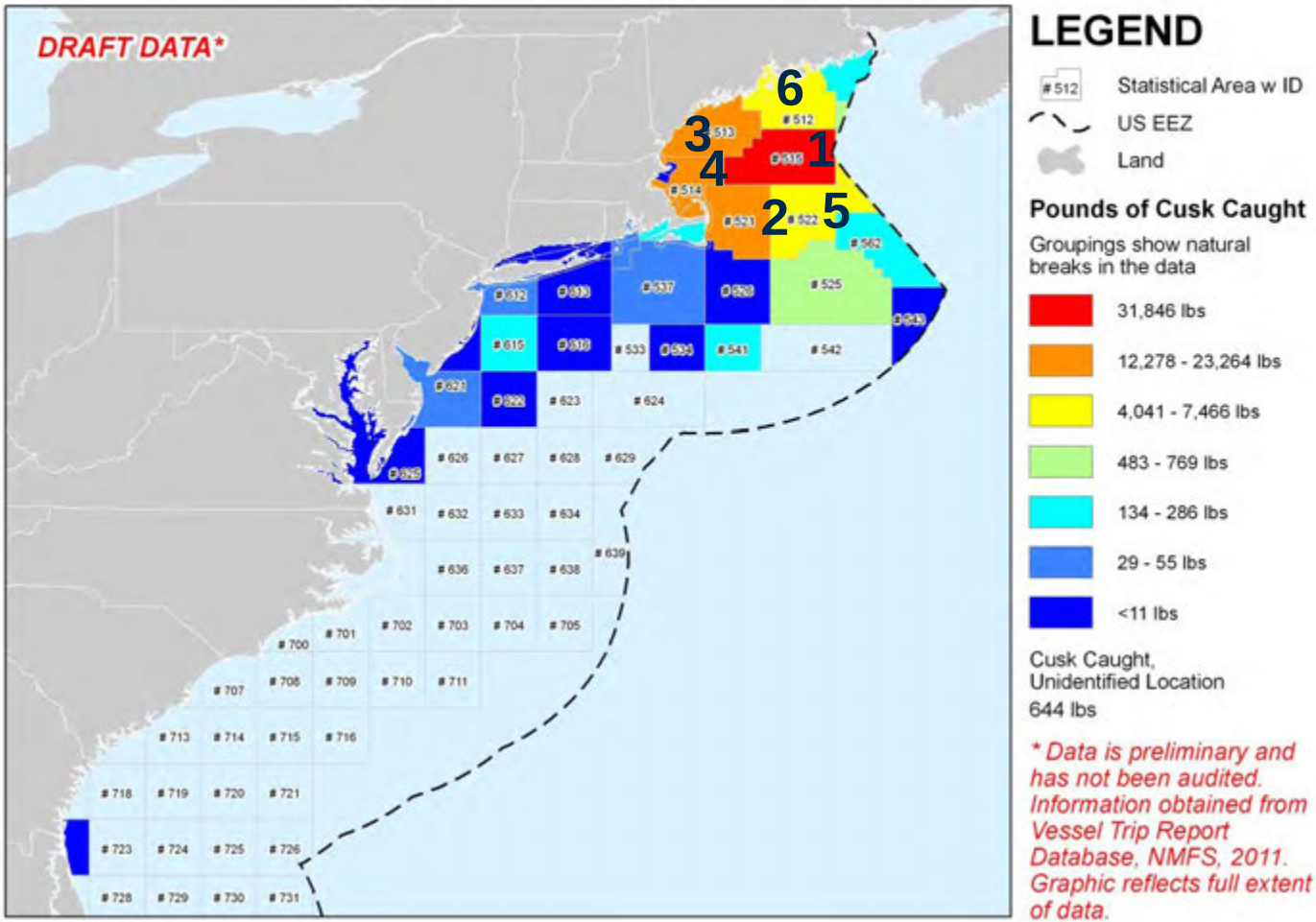
NMFS Northeast Vessel Trip Report (VTR) 2004-2010 Data

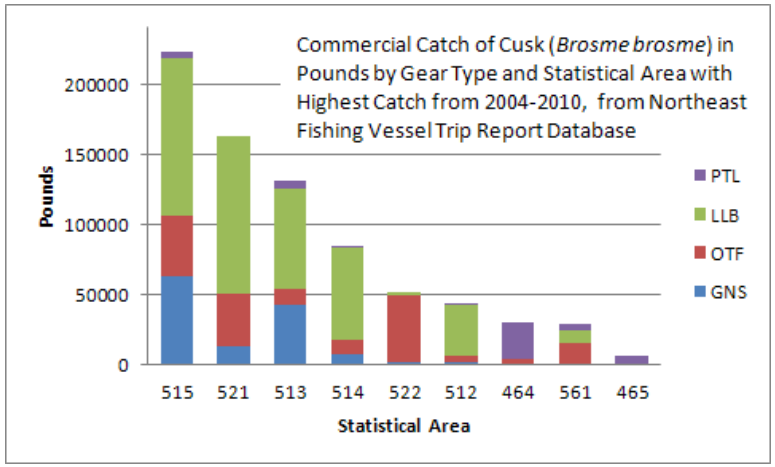
Cusk: Average Annual Catch (Pounds), 2004-2010, in US Waters, using All Gear Types (Commercial)

- Shading indicates average annual catch
- Numbers indicate rankings of total catch of cusk (>50,000 lb only) from 2004-2010

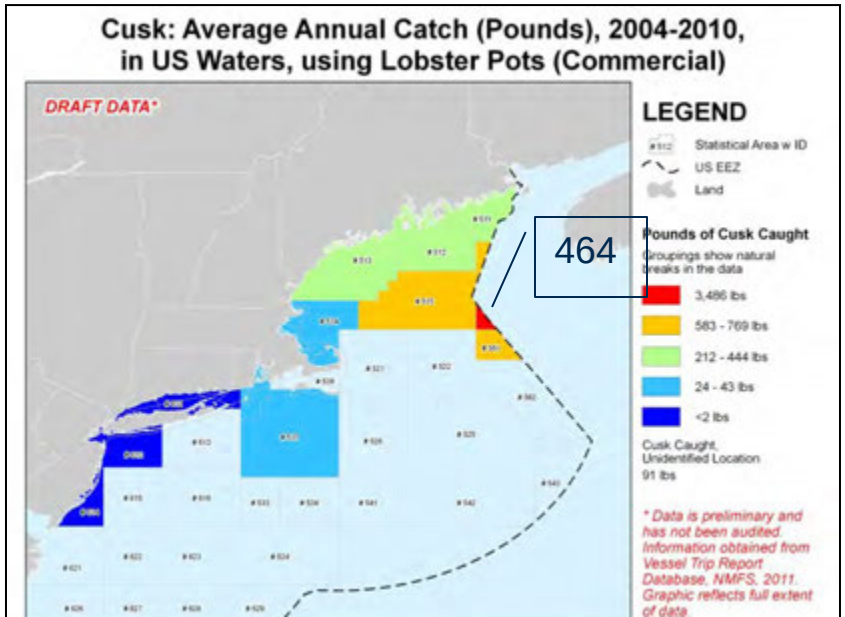


NOAA FISHERIES SERVICE

NMFS Northeast Vessel Trip Report (VTR) 2004-2010 Data



- Area 515 is a common "hot spot" for cusk catch in bottom longline, sink gillnet & otter trawl
  - Bottom longline & otter trawl show other similar "hot spots"(e.g., 521)
- Area 464 is a "hot spot" for cusk catch in lobster trap



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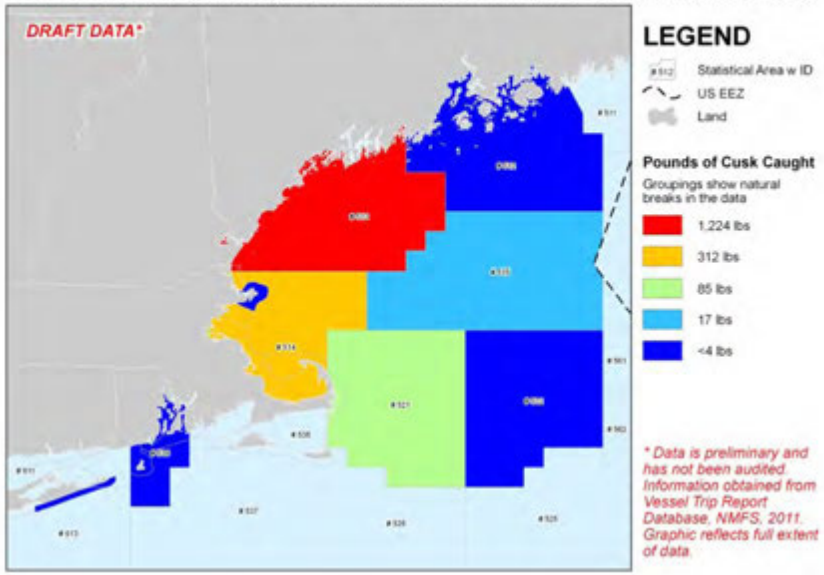
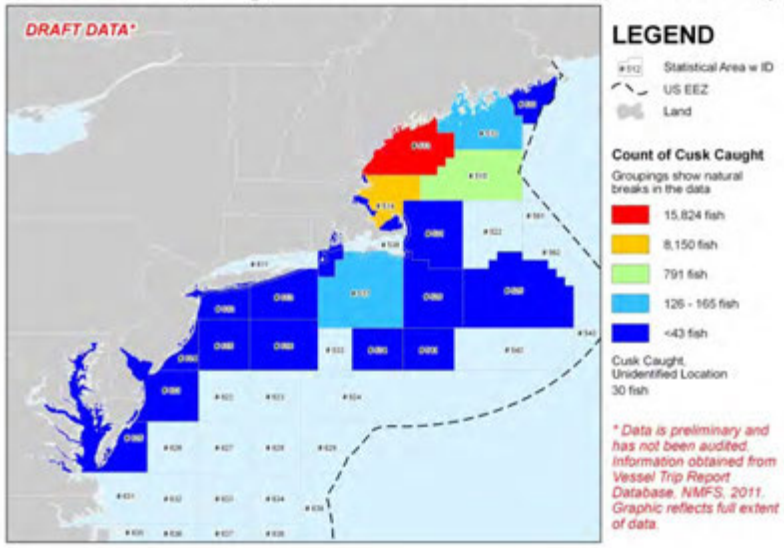
NMFS Northeast Vessel Trip Report (VTR) 2004-2010 Data

- Similar trends in “hot spots” for commercial & recreational hand lines/rods & reels
  - Areas 513 & 514

Cusk: Average Annual Catch (Pounds), 2004-2010, in US Waters, using Hand Lines/Rods & Reels (Commercial)

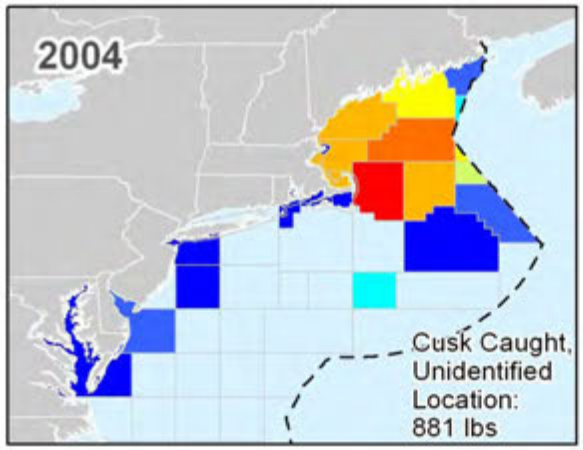


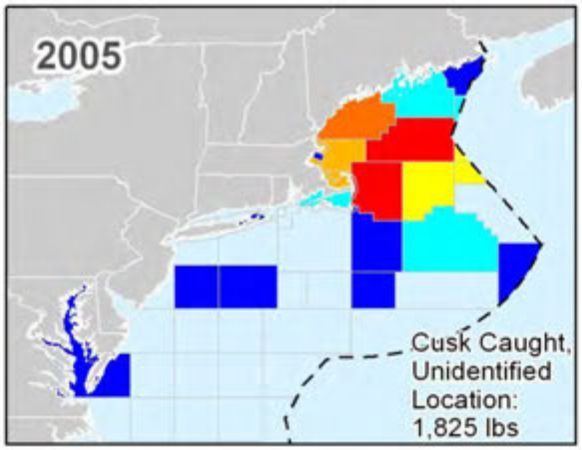
Cusk: Average Annual Catch (Individual Fish), 2004-2010, in US Waters, using Hand Lines/Rods & Reels (Recreational)

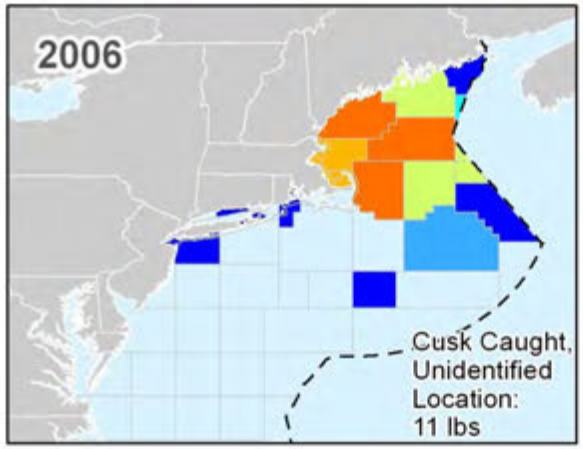


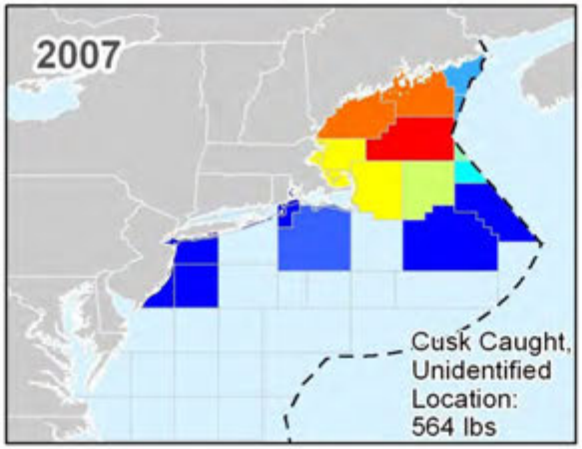
Total Cusk (Pounds) Caught Commercially in US Waters, 2004 - 2010

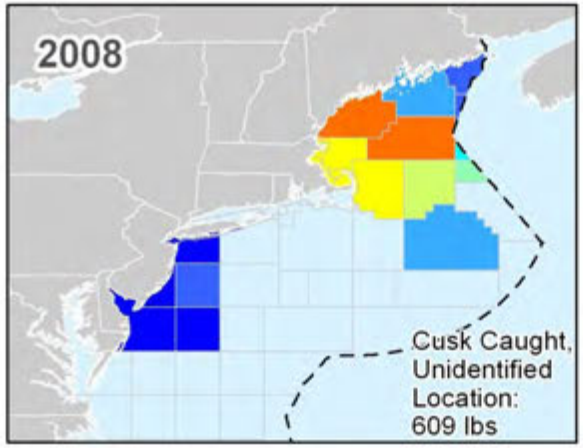
DRAFT DATA*

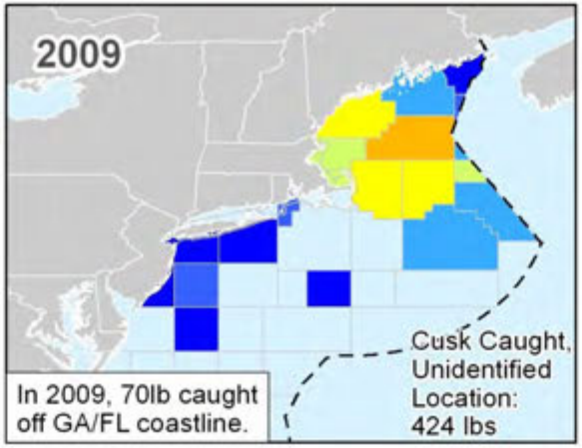


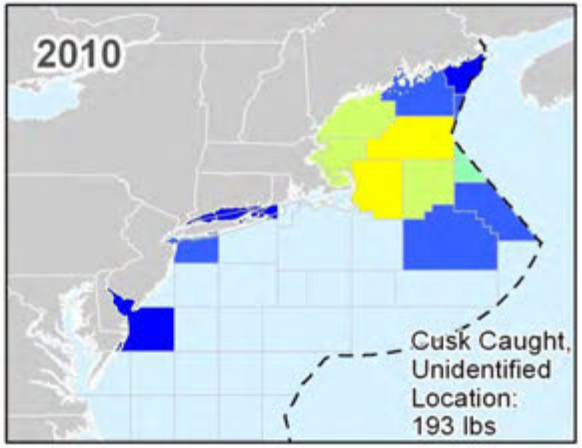












Pounds of Cusk Caught

Groupings show natural breaks in the data

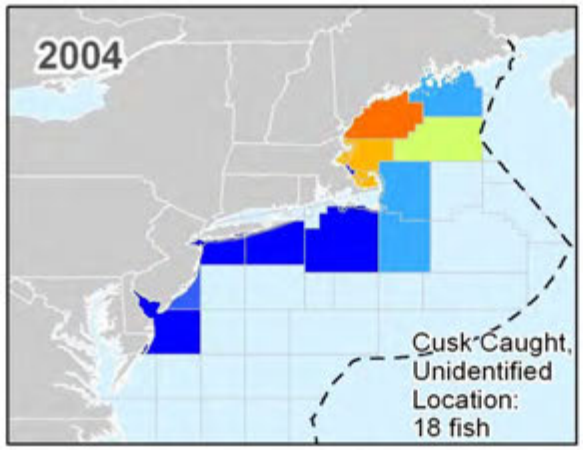
- 47,188 - 62,076
- 23,963 - 33,932
- 14,950 - 20,737
- 7,280 - 11,846
- 3,660 - 6,715
- 2,040 - 2,645
- 1,054 - 1,496
- 550 - 915
- 175 - 483
- 1 - 157

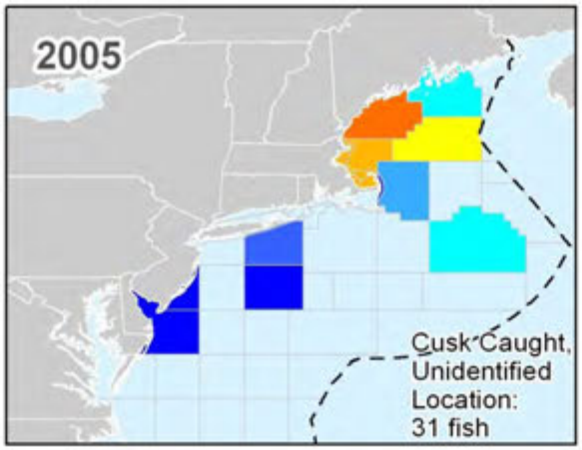
Statistical Area | US EEZ | Land

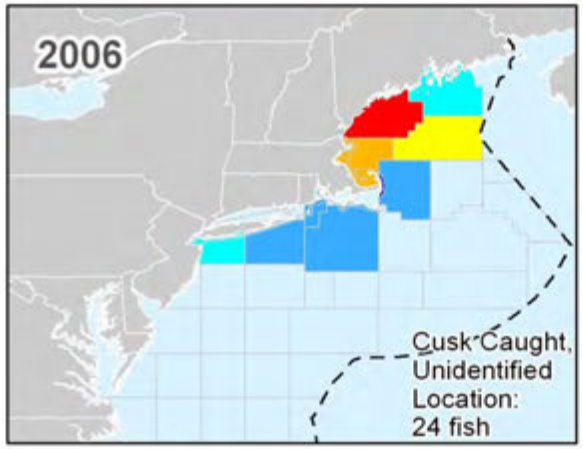
**Data is preliminary and has not been audited. Information obtained from Vessel Trip Report Database, NMFS, 2011. Except where noted, graphic reflects full extent of data.*

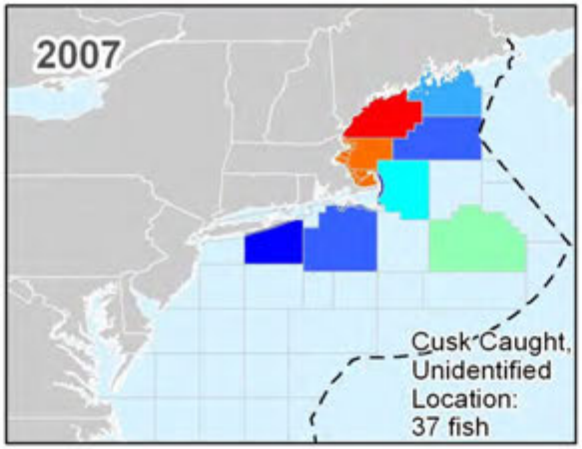
Total Cusk (Individual Fish) Caught Recreationally in US Waters, 2004 - 2010

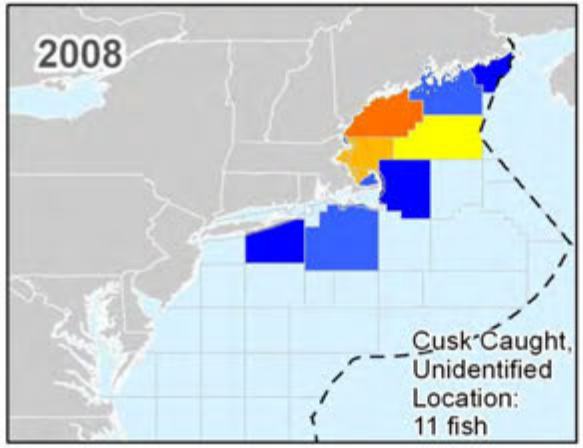
DRAFT DATA*

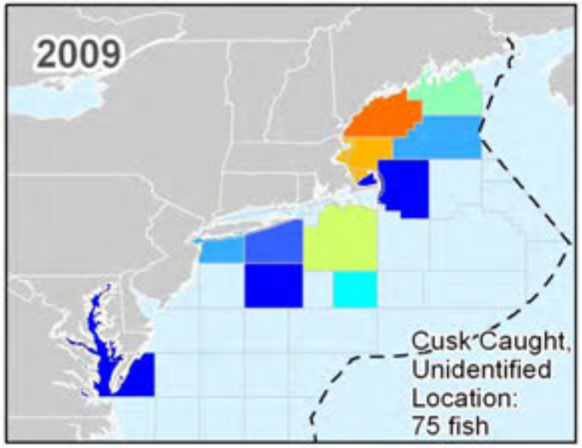


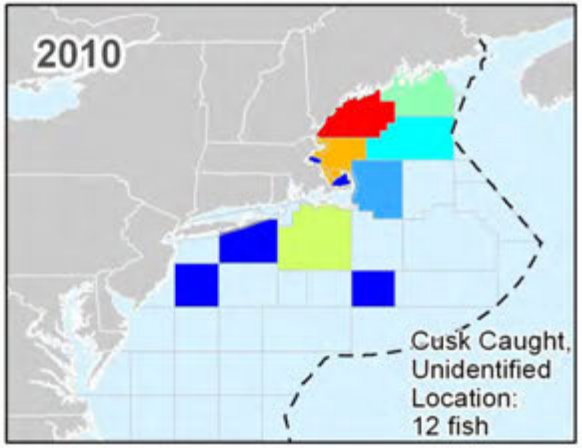












Number of Cusk Caught

Groupings show natural breaks in the data

- 18,340 - 21,418
- 10,384 - 13,525
- 6,637 - 8,666
- 1,465 - 1,587
- 460 - 784
- 200 - 263
- 89 - 130
- 38 - 79
- 11 - 27
- 1 - 10

Statistical Area | US EEZ | Land

**Data is preliminary and has not been audited. Information obtained from Vessel Trip Report Database, NMFS, 2011. Graphic reflects full extent of data.*

Science, Service, Stewardship

Observed Cusk Records 2000-2010

Northeast Fisheries Observer Program

GMRI Cusk Workshop

December 7-8, 2011, Portland, Maine

NOAA FISHERIES SERVICE

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SERVICE

Northeast Fisheries Observer Program

14,879 seadays in Fiscal Year 2011

201 Observers/At-Sea Monitors

Coverage from Maine through North Carolina

Training/Data Processing Facility in Falmouth, MA

- About 50 support personnel (data editors/debriefers, data auditors, trainers, area leads, etc)

Primary gear types covered:

- Bottom trawl, gillnet, bottom longline, scallop dredge

NOAA
FISHERIES
SERVICE

Caveats to Observer Data

Haven't addressed all factors/co-factors

Trends might not be generalized over all records

Dependent on fishing effort, regulations, variable observer coverage rate, etc.

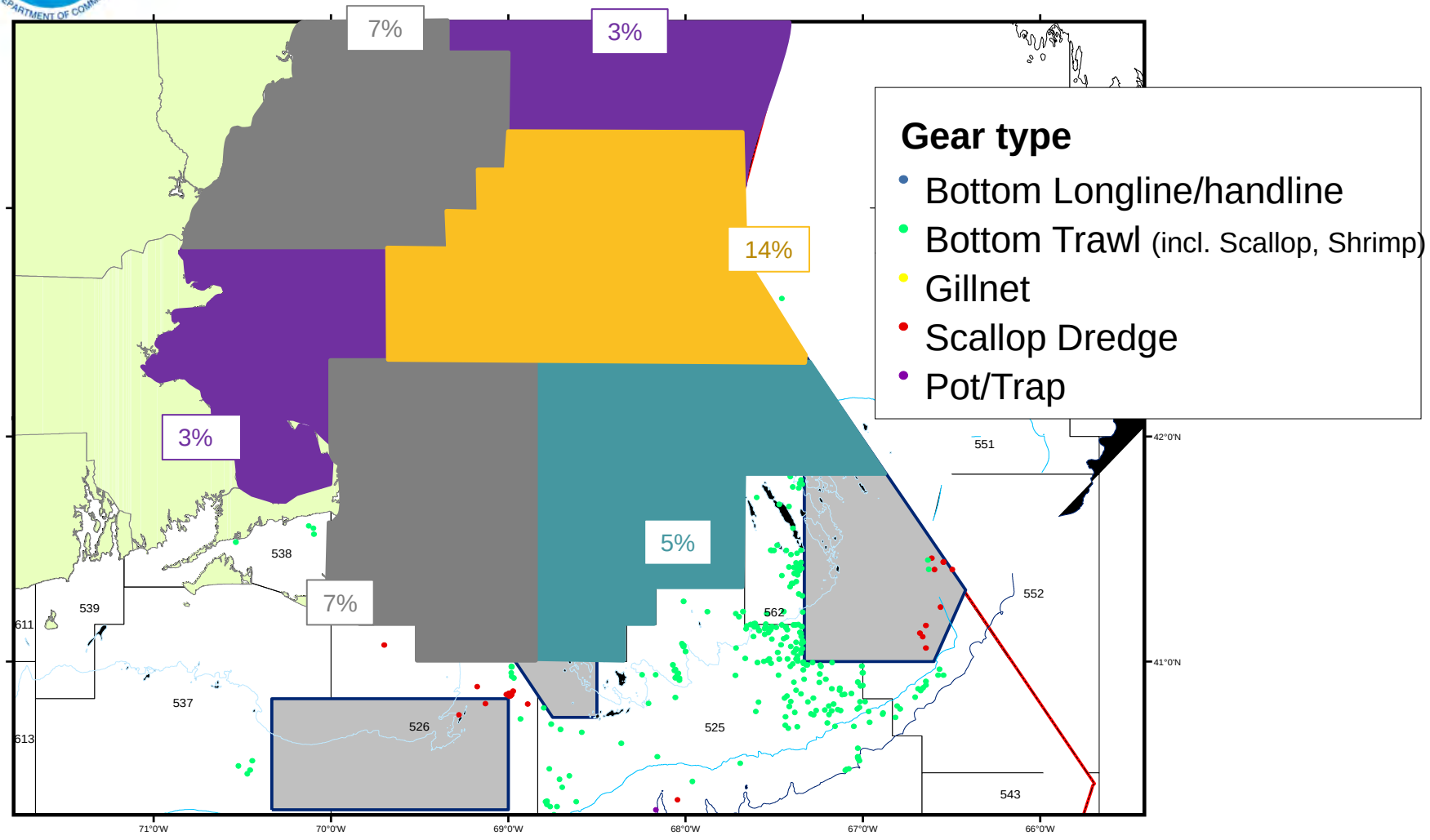
Cannot extrapolate these numbers to entire fleet

Not standardized for effort (soak duration, haul duration, string length, etc.)

More complex analysis is needed to tease apart interrelated factors

NOAA FISHERIES SERVICE

All Observed Cusk Records, by gear



Boxes indicate percent of observed hauls with cusk

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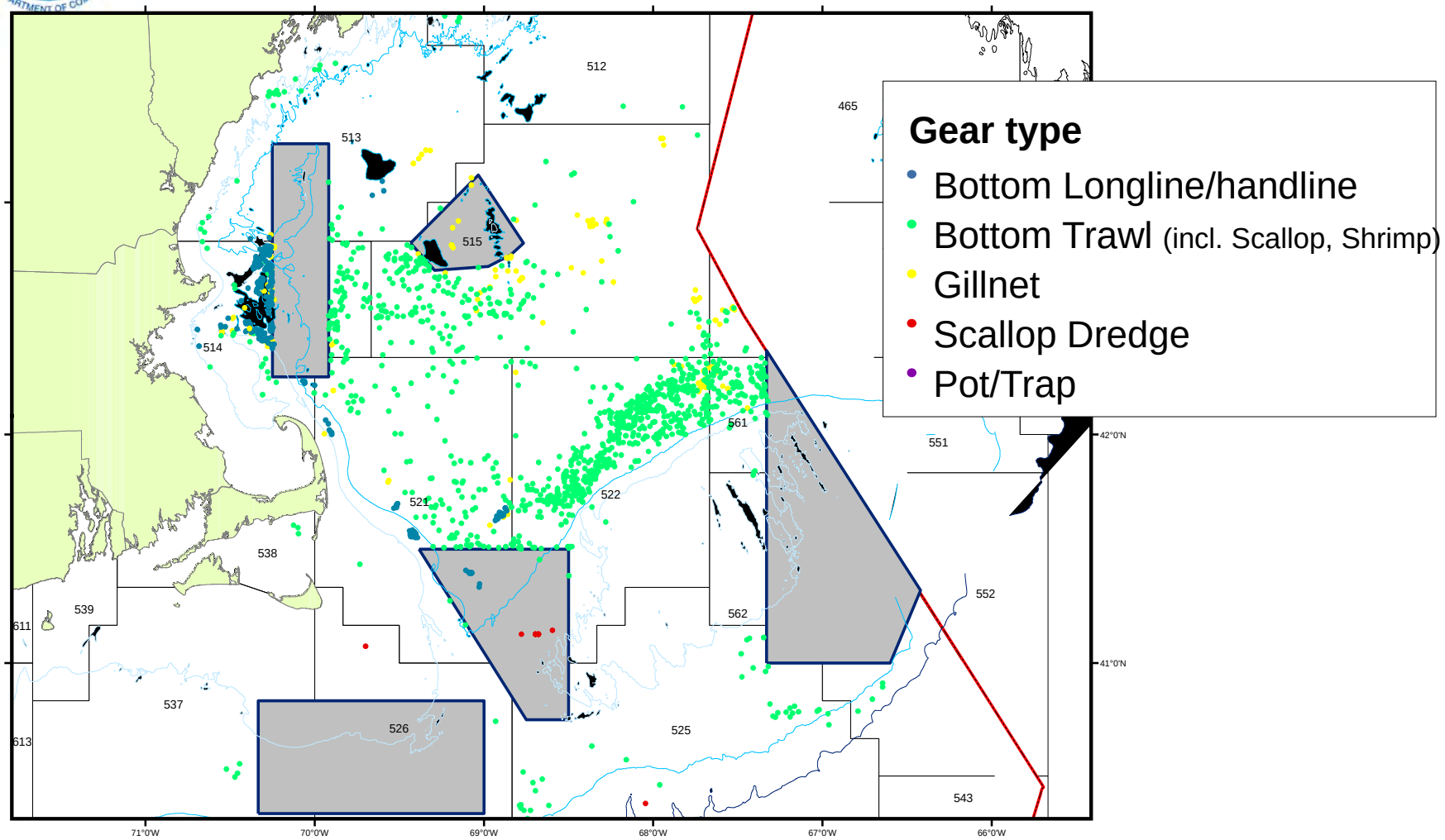
Winter (Jan-Mar)



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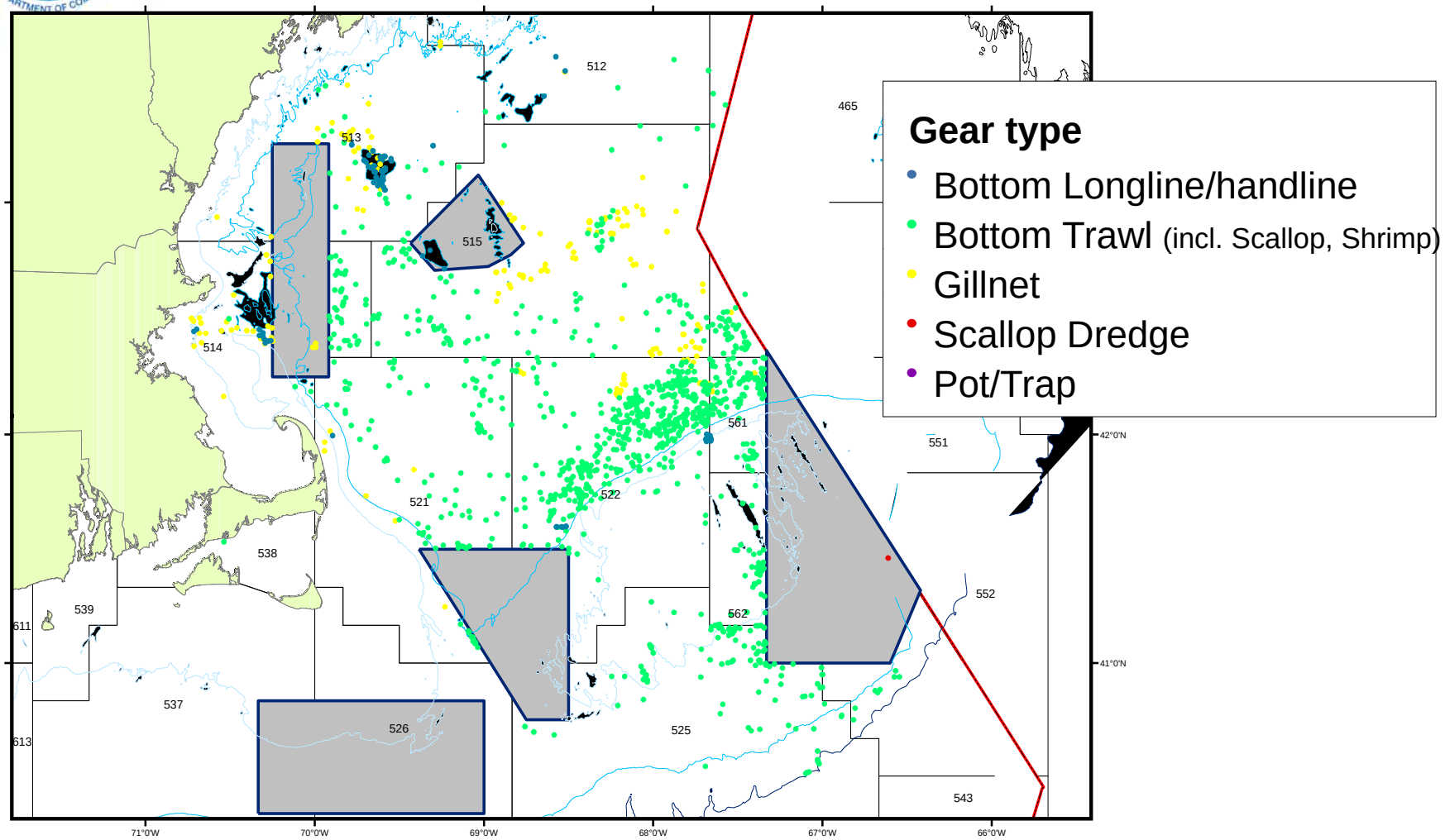
Spring (Apr-Jun)



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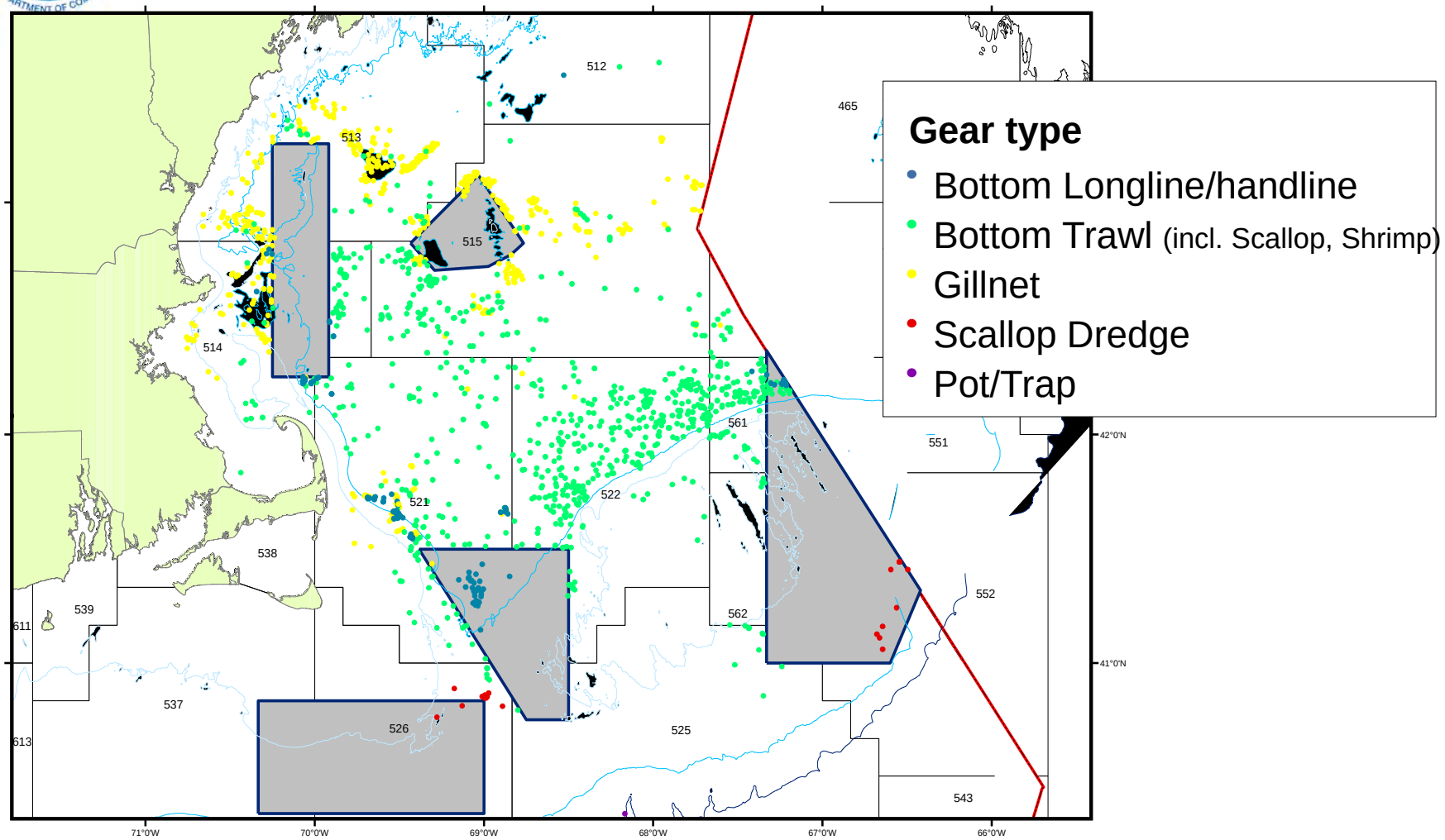
Summer (Jul-Sep)



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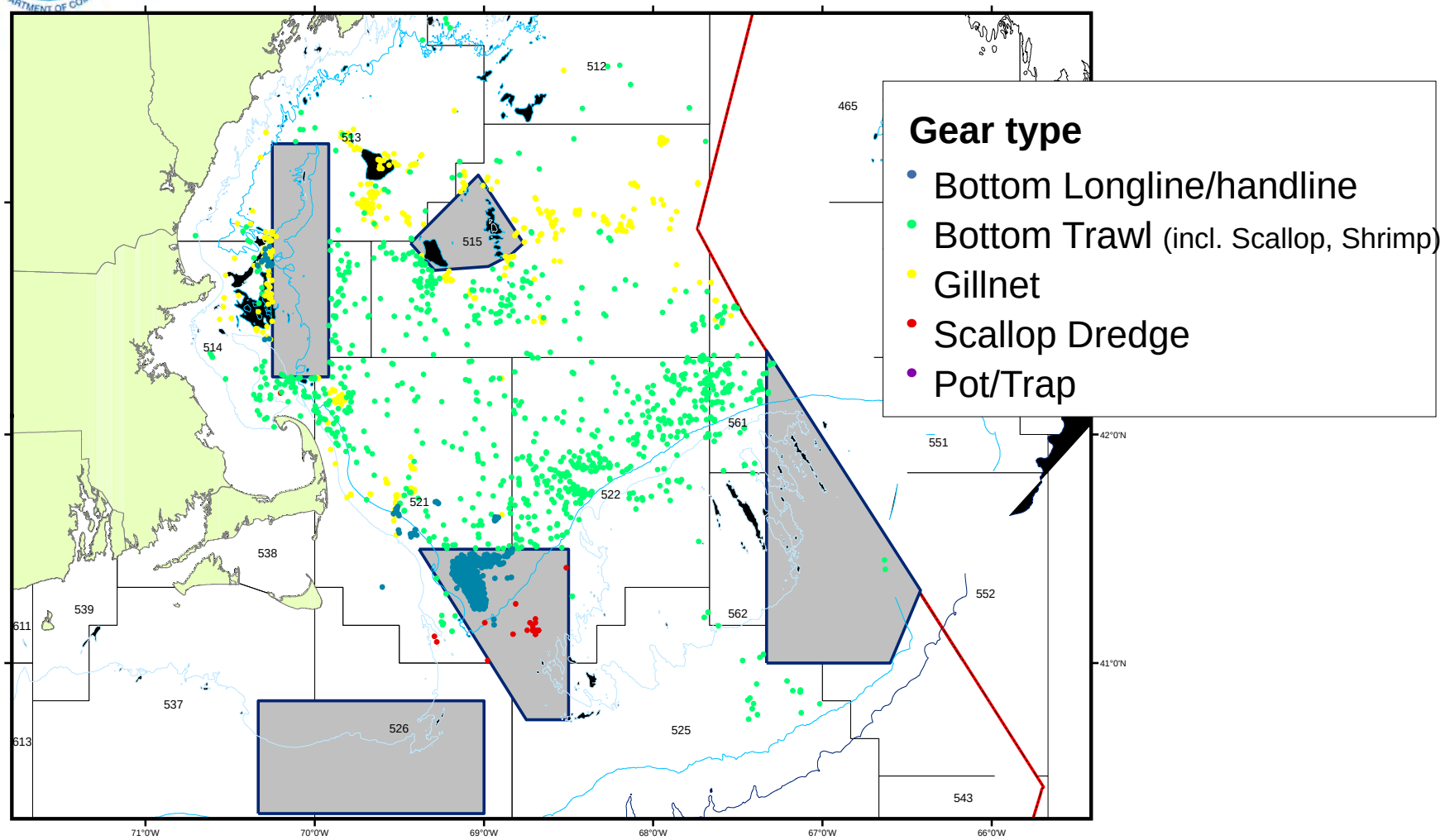
Fall (Oct-Dec)



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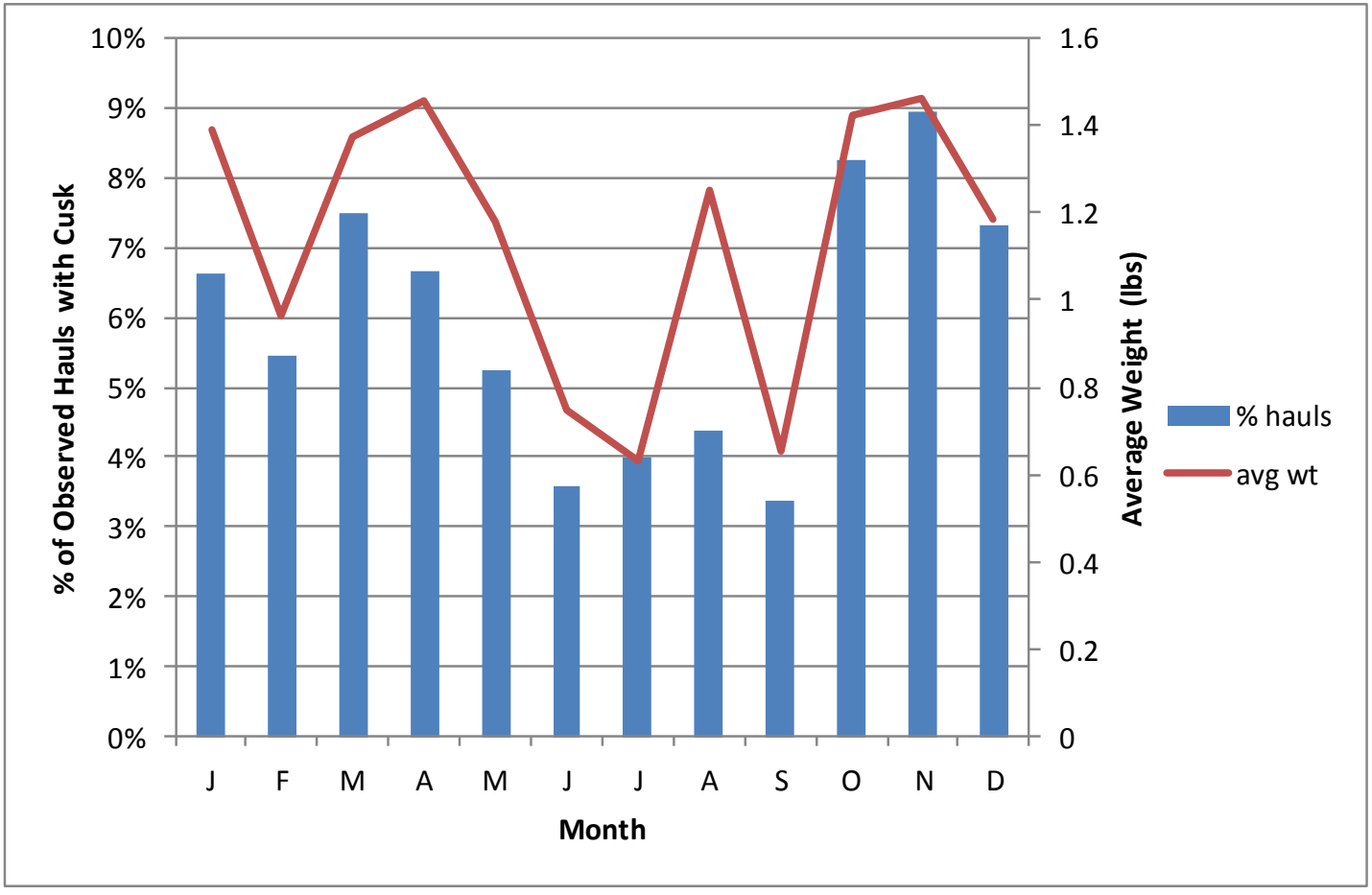
Catch by Month

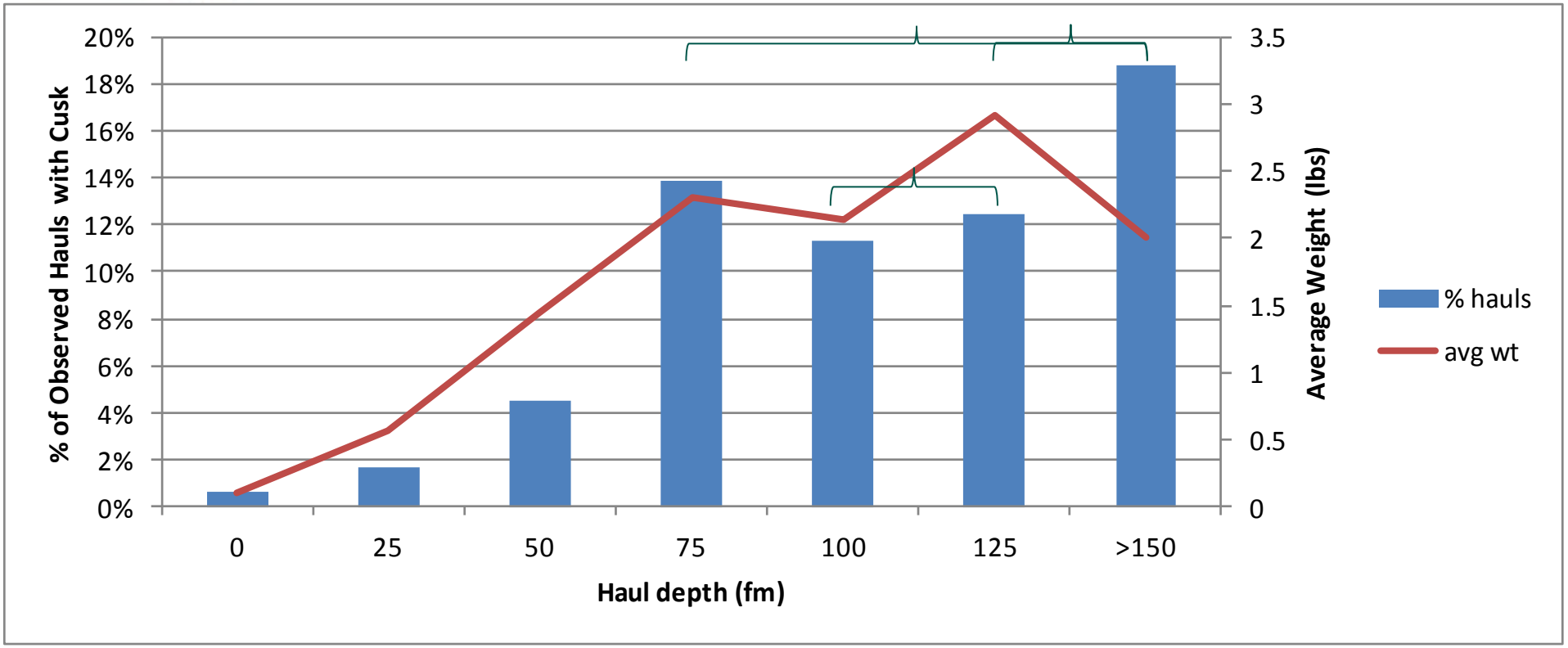


Highest % occurrence Oct-Dec (Haddock Hook SAP?)

Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

NOAA FISHERIES SERVICE

Catch by Depth



Most frequently encountered in deep water (>75 fm)

Brackets indicate groups with no significant difference in % occurrence (pairwise χ^2 at $\alpha = 0.95$)
Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

NOAA FISHERIES SERVICE

Catch Disposition

	# of records	total pounds
Kept	6,214	118,136
Undesired	884	9,240
Too small	738	8,388
Fell from Gear	44	439
Regulations	30	107
Poor Quality	19	87
Other	39	350

- 78% of cusk records are kept (86% by weight)
- No significant changes in overall kept/discard behavior in last 10 years
- “Other” = unknown reason, sample retained by observer, upgraded, consumed, or accidentially discarded

NOAA FISHERIES SERVICE

ID Verification

- Observers trained and tested on species ID
- 2007 – implemented ID Verification Program
  - Required to send in samples/photos
  - 59 samples* correctly ID'd as cusk
  - 5 samples* incorrectly ID'd as cusk
    - Hake, Ocean Pout
    - 3 observers – all contacted and explained correct ID
- Take what we learn from this project to create new tests to catch errors going forward

*2009-2011

NOAA
FISHERIES
SERVICE

Pot/Trap

No observed cusk in Pot/Trap trips

Lower coverage rate than other fisheries

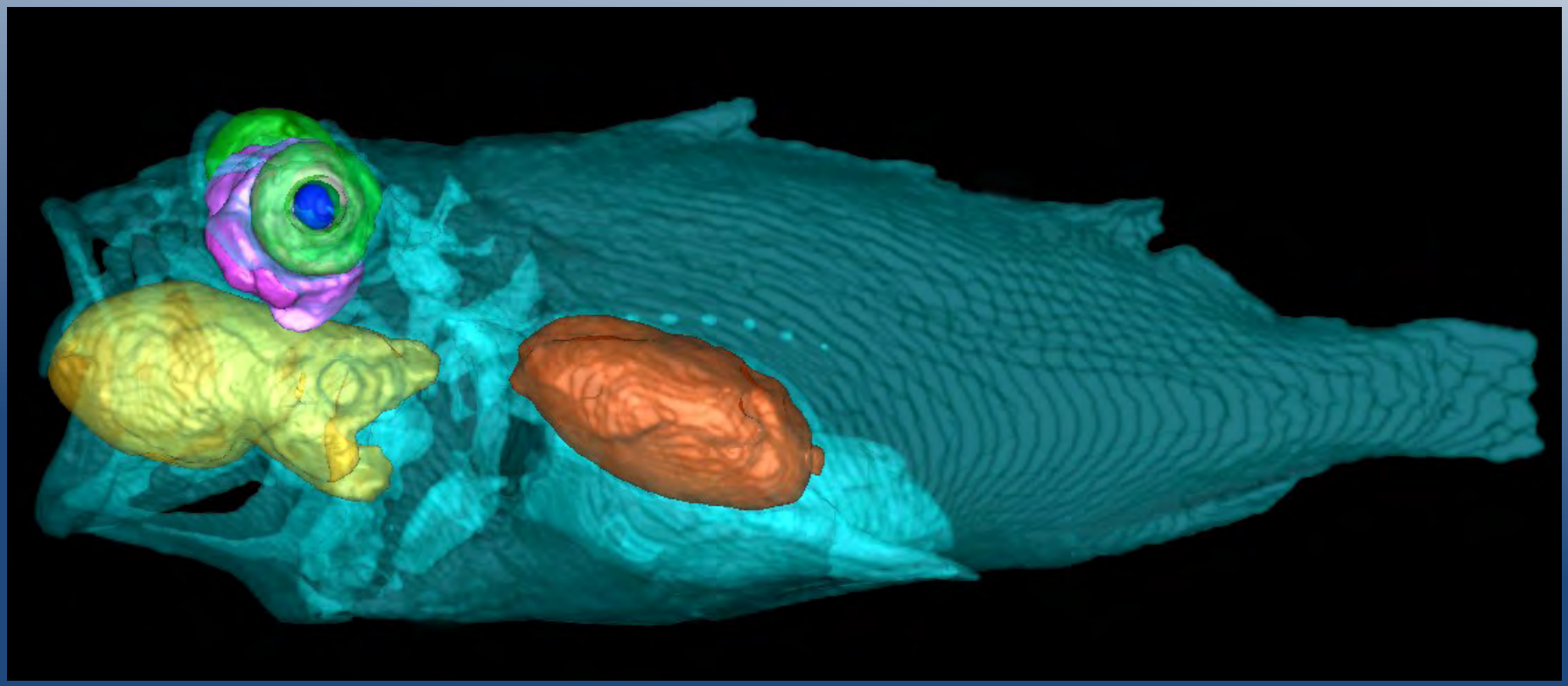
2000-2010:

- Fish Pots = 12 hauls
- Hagfish Pots = 448 hauls
- Lobster Traps = 61 hauls

Some coverage in early/mid-1990's

- Most trips had similar gear/bait usage, so difficult to tease out factors
- May not be applicable to today's fleet

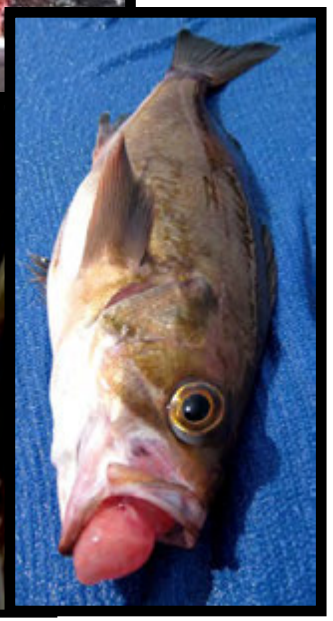
Recovery in Rockfish After Barotrauma and Recompression



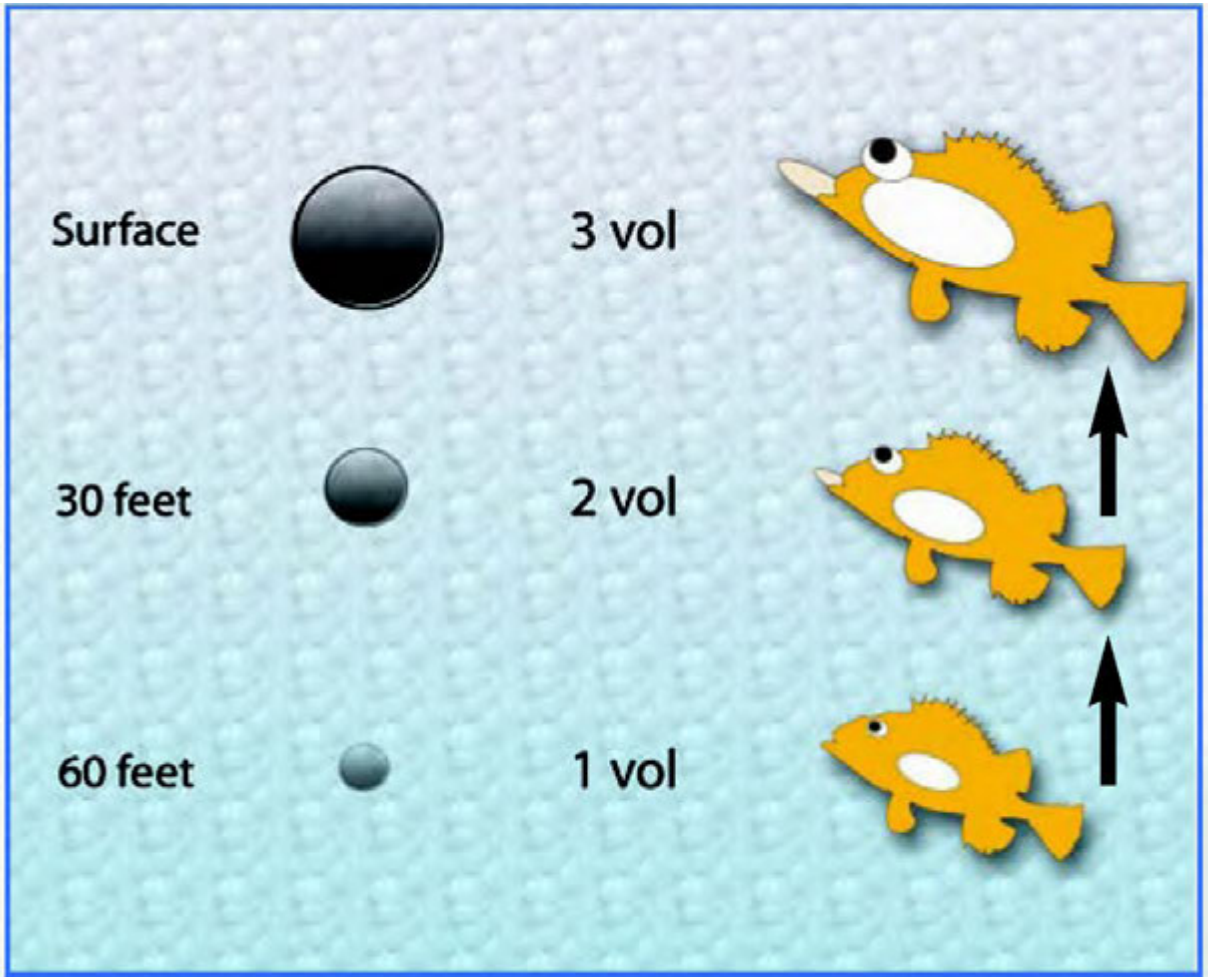
Bonnie L. Rogers
CSU Long Beach, Ocean Associates/NMFS

The Discard-Mortality Problem

- Gas bladder over-inflates/leaks/ruptures, stomach everts, eye extends (exophthalmia), etc.
- Undesired fish are thrown overboard (discarded) and remain floating
- Discard mortality **magnifies** population decline (Davis 2002)



Gas expansion & buoyancy



The volume of a fish's swim bladder can triple when reeled in from depths as shallow as 60 feet. SeaGrant; Erica Jarvis 2007

0 meters, 1 atm
Higher %Nitrogen

10 meters, 2 atm,
Volume increase 100%

20 meters, 3 atm,
Volume increase 200%
Higher %Oxygen

If at neutral buoyancy when captured, volume could increase upwards of 500%.....gas bladder could tear/leak/rupture.

Factors affecting injury

- Depth/ gas bladder volume at time of capture (Hannah and Matteson 2007, Parker et al. 2006, Wilson and Burns 2002)
- Species/body shape (Hannah et al. 2008, Jarvis et al. 2008)
- SA-volume ratio, permeability thickness, healing rate, prior trauma (Pribyl 2010)
- Water temperature differences (Jarvis et al. 2008, Feathers and Knable 1983)
- ‘Fast’ or ‘slow’ tissue transport

Signs of barotrauma in 8 spp.

		Occurrence of barotrauma (%)								
		External signs					Internal signs[a]			
Common name	*n*	EX	CB	SE	PC	*n*	ST	HE	OT	AE
Bocaccio	66	33	29	*92*	0	12	0	*100*	33	25
Flag rockfish	32	*63*	*59*	*84*	13	5	0	*80*	0	40
Halfbanded rockfish	41	12	7	*93*	12	0	—	—	—	—
Honeycomb rockfish	28	*57*	46	*82*	4	2	—	—	—	—
Speckled rockfish	13	8	15	*85*	23	0	—	—	—	—
Squarespot rockfish	40	25	15	*88*	15	7	43	*100*	29	29
Starry rockfish	11	*82*	*64*	*91*	0	4	25	*100*	0	*50*
Vermilion rockfish	75	*81*	*52*	*92*	0	13	8	*85*	15	*69*

Note: Values in italics indicate signs of barotrauma occurring in at least 50% of individuals. EX, exophthalmia; CB, corneal gas bubbles; SE, stomach eversion; PC, prolapsed cloaca; ST, swim bladder tear; HE, hemorrhage; OT, organ torsion; AE, arterial embolism.

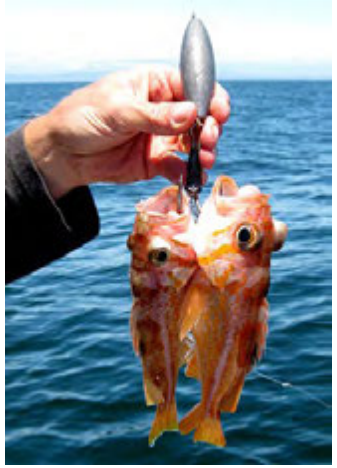
EX: Exophthalmia

SE: Stomach Eversion

ST: Swim bladder Tear

(Jarvis & Lowe 2008)

Recompression methods & survival



- Many studies show recompression works well

(Pribyl dissertation 2010, Hannah and Matteson 2007, Parker et al. 2006, Wilson and Burns 1996)

- High 2-day survival (75%) for rockfish recompressed within 10 minutes (Jarvis & Lowe 2008)

Photos: E. Jarvis, R. Hupp, B. Rogers, SFD

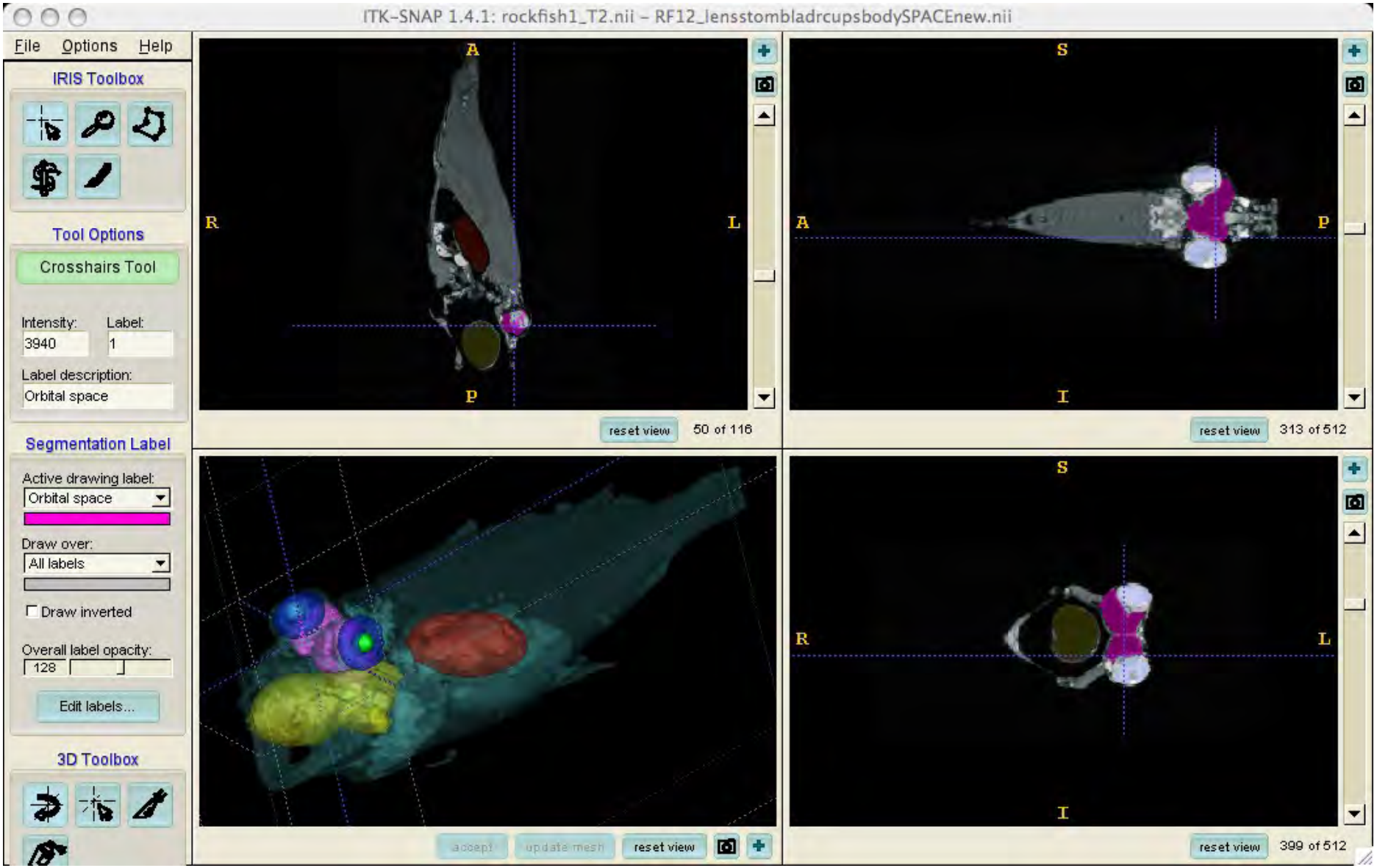
Questions

1. What causes exophthalmia ‘pop-eye’?

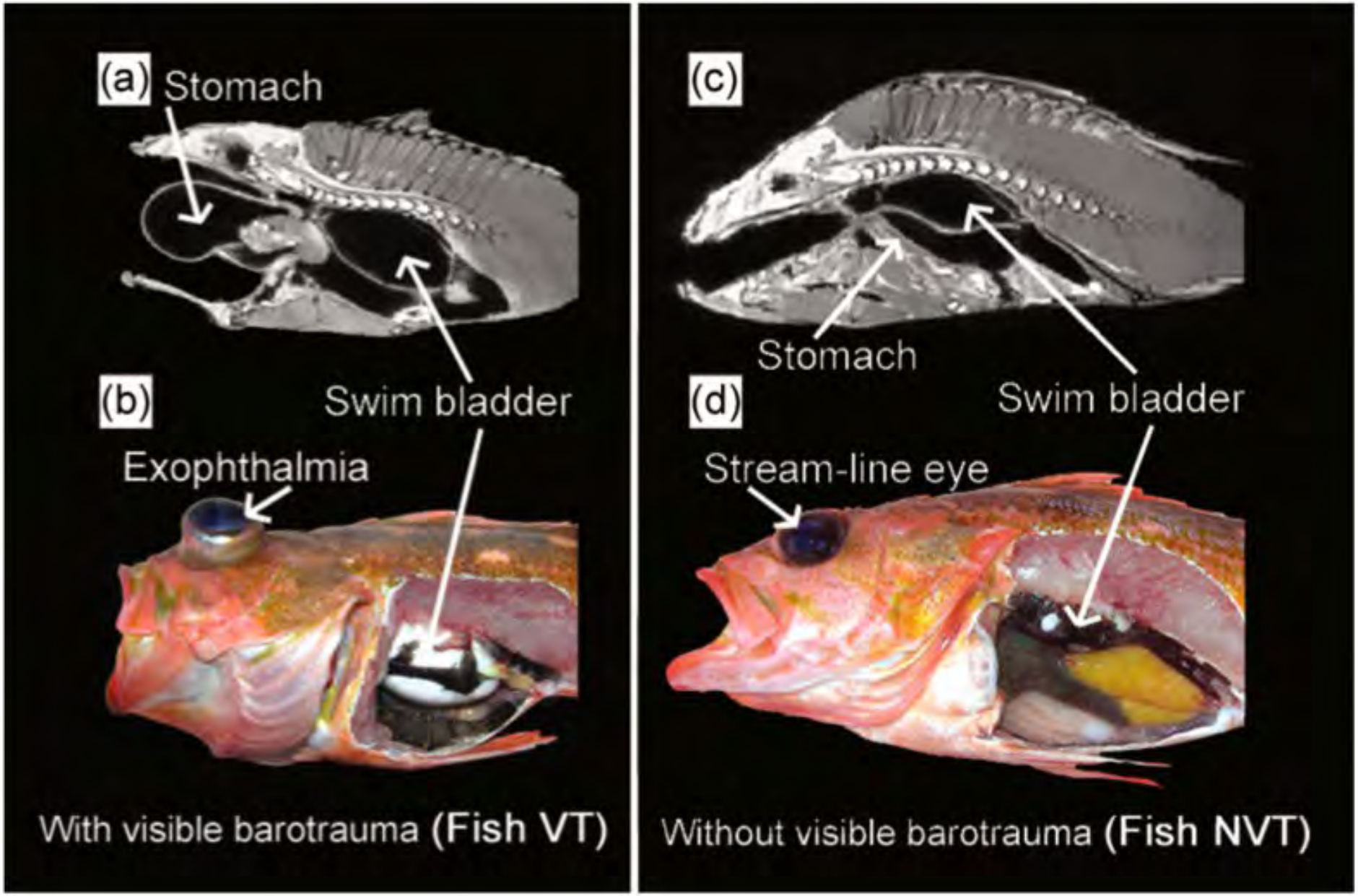
2. Does eye trauma result in permanent damage to vision?

3. How can this information be applied?

Study #1: Magnetic Resonance Imaging & gas expansion volumes



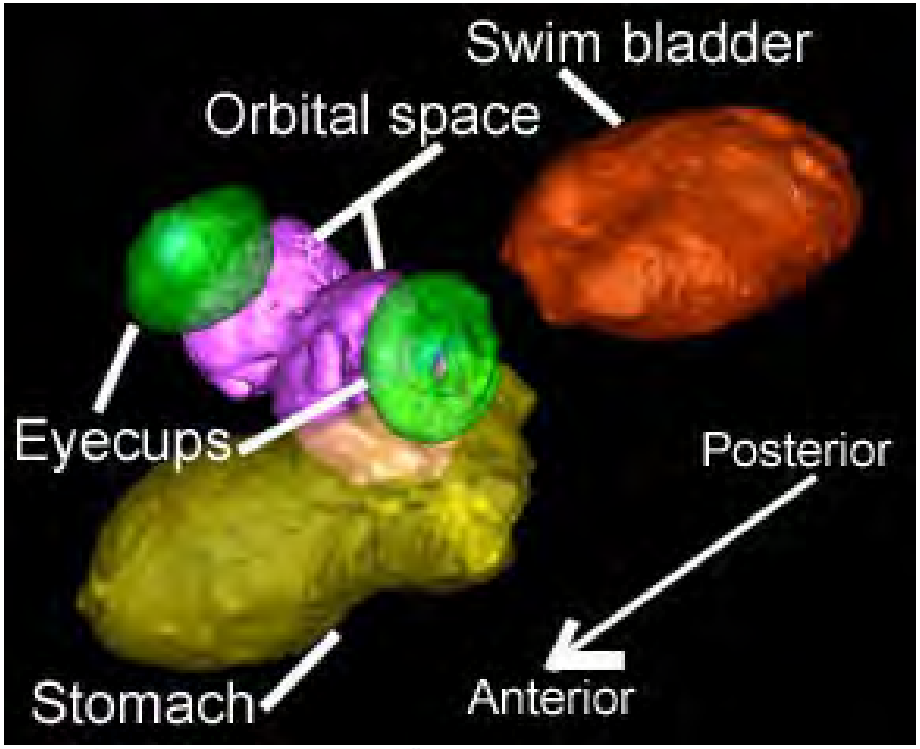
Dissections confirm MRI results



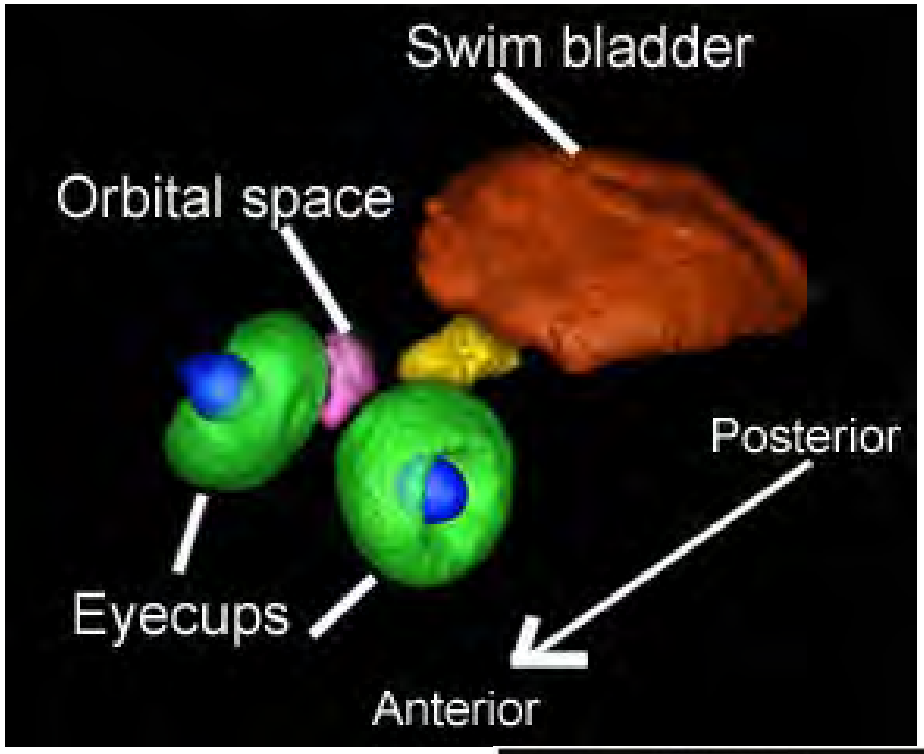
(Rogers et al. 2008)

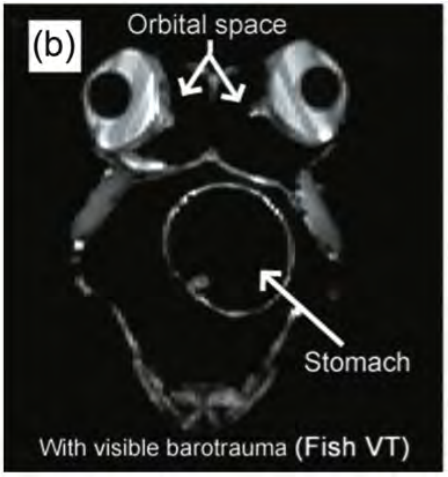
Organ Segmentation

Severe trauma

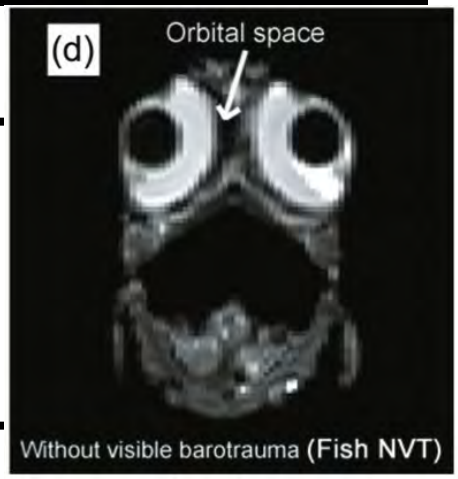


Minor trauma





9.6%	Stomach	0.6%
8.7%	Swim bladder	4.1%
3.5%	Eye space	0.02%



Rogers et al. 2008

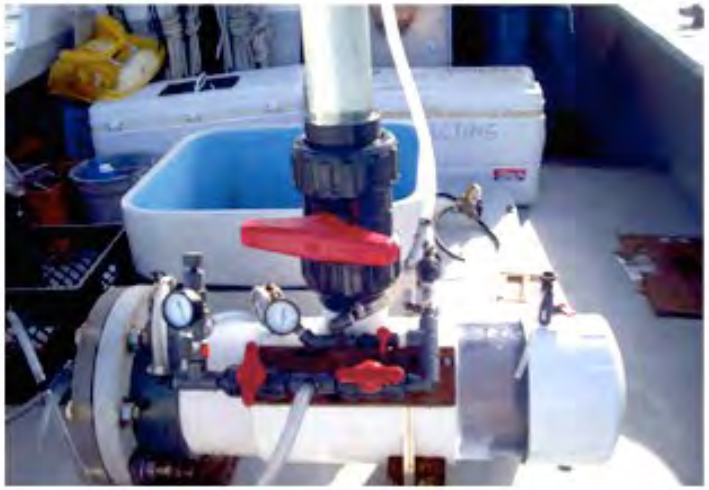
Study #2: Assessing vision after barotrauma

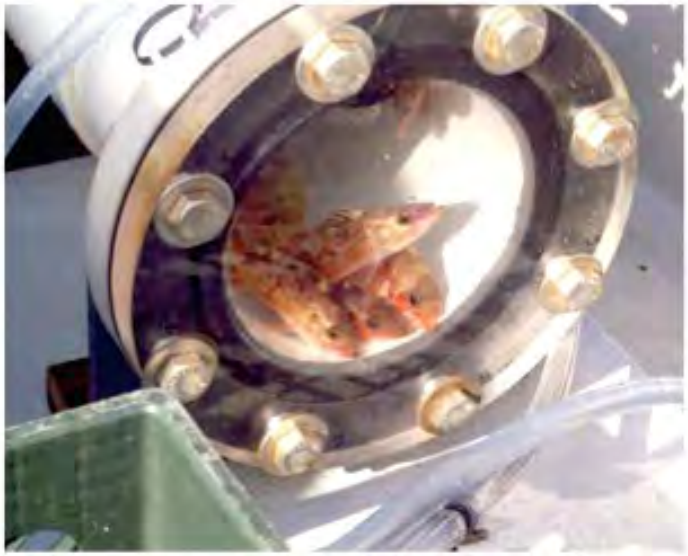
1. Captured from 63-110 m (200-300 ft.)

2. Pressurized to 65 psi = 35 m /105 ft.

3. Slowly decompressed over 4 days

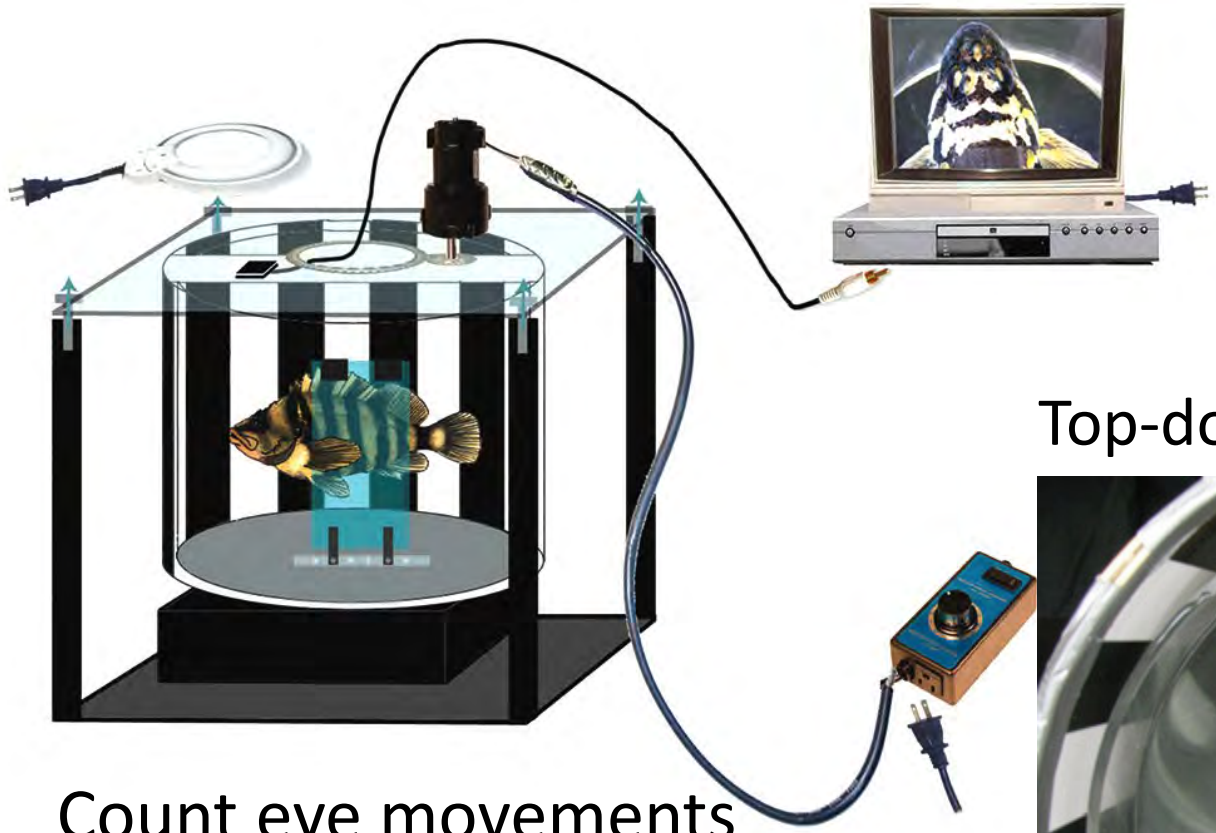
4. Removed from chamber to measure vision



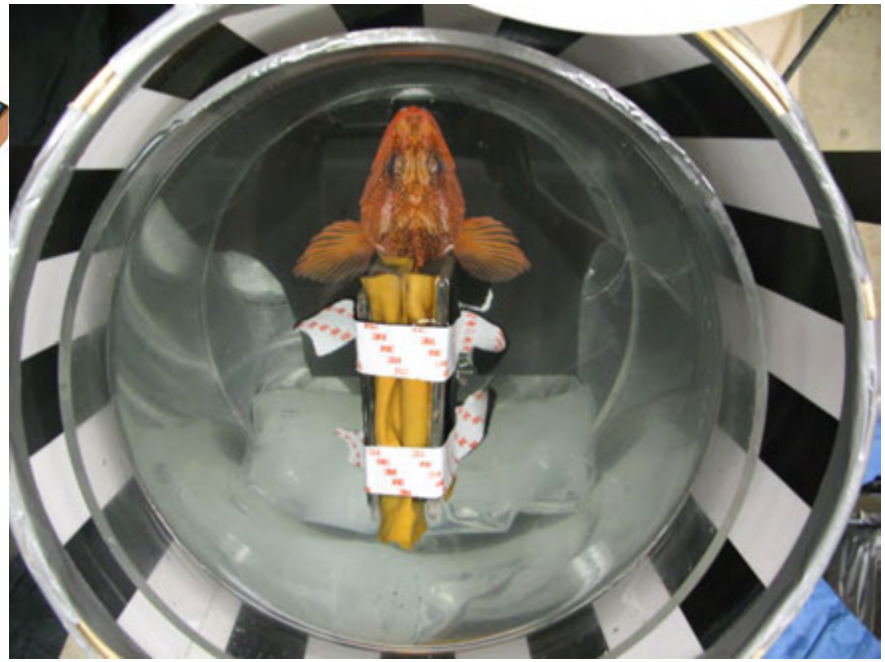


Optokinetic behavioral eye test

- fish involuntarily track moving gratings (Carvalho et al. 2002)



Top-down view of fish in cradle

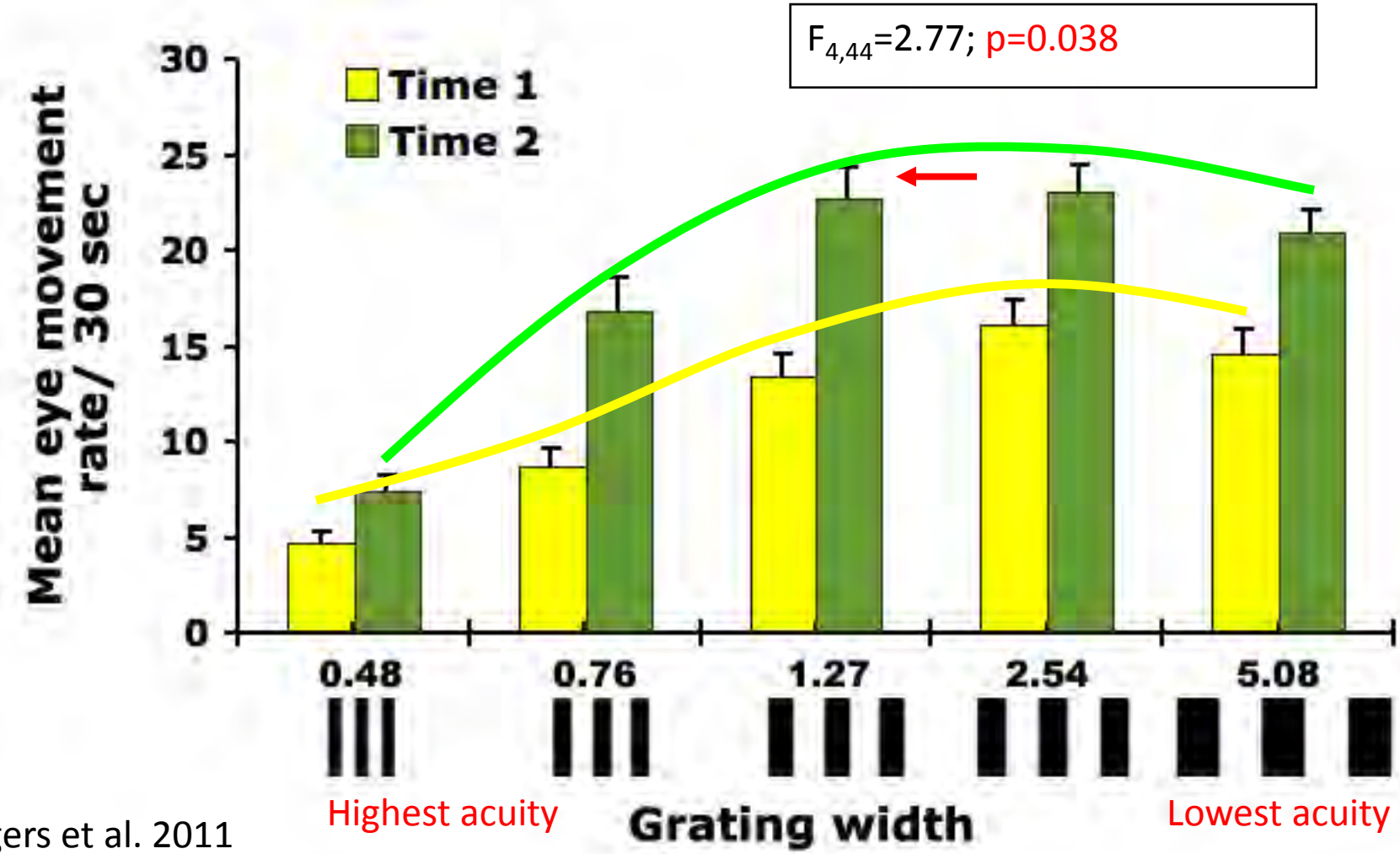


Count eye movements as bars rotate

-5 bar widths

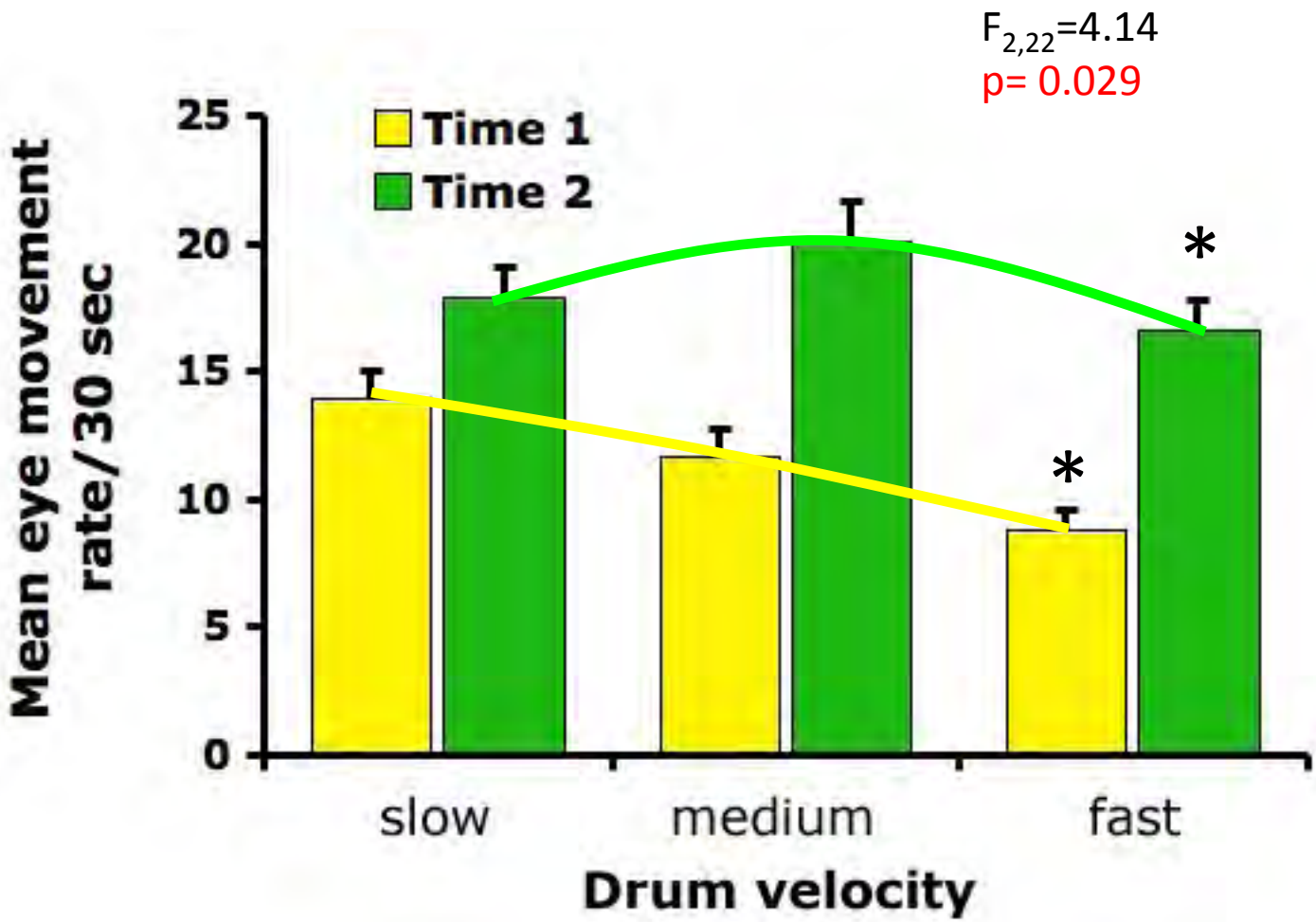
-3 speeds

Vision was functional after recompression (4 days) & improved over time (30 days)



Rogers et al. 2011

Response to stimuli velocity improved over time



Rogers et al. 2011

[illegible] from barotrauma [illegible] rockfish species

1. Low visual impairment (Brill et al. 2008, Rogers et al. 2011)

2. High post-release survival (Parker et al. 2006, Hannah and Matteson 2007, Jarvis and Lowe 2008, etc.)

3. No histological damage in various tissues, except rare rete mirable hemorrhage ([illegible] 2010 dissertation)

4. Swim bladder healing (Pribyl 2010 dissertation)

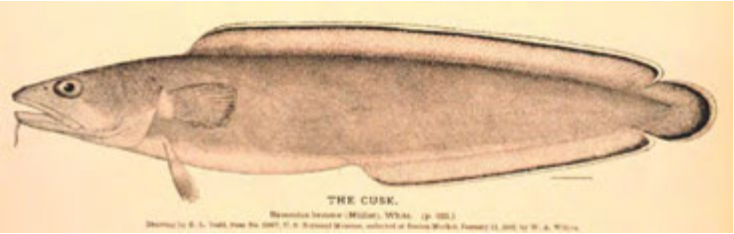
5. Tagged fish detected after [illegible] yrs (Lowe et al. 2009, [illegible] in lab)

Evidence for long-term survival

- Similar to other barotrauma injuries… vision is recoverable if fish recompressed within 10 minutes

- Forced recompression for unwanted catch

Application to recreational Cusk



- **Is catch-and-release an option for cusk?**
  - Are internal injuries lethal upon rapid ascent?
  - Prevention of stomach hooking –circle hooks?
  - Does gas escape the body through cloacae, tears, etc?
  - What is the post-release survival rate?
  - Which method is best: venting, recompression etc.?
- **Cusk advantages for barotrauma research:**
  - Monotypic species: differences always intraspecific
  - Sedentary/benthic species –could recover on bottom
  - Cod barotrauma studies show 24-hr bladder healing (Nichol and Chilton 2006)

Thank you

- Chris Lowe & Esteban Fernandez-Juricic
- Joe Welsh & Todd Love (Monterey Bay Aquarium)
- Greg Kajszo & Issa Mirmehdi
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Lowe Lab: Erica Jarvis-Mason, Kim Anthony, Carlos Mireles, Chris Martin, Kerri Loke, Thomas Farrugia, Mario Espinoza, Megan McKinzie, Carrie Espasandin, Tom Mason, Yvette Ralph

Volunteers: Jimmy Cvitanovich, Tami Gonzales, Chris Gialketsis, Calvin Won, Cody Larsen, Morgan O-Reilly, Elizabeth Garibay, Laurel Fink

Hubbs SeaWorld, Jeff Landsmen, Lance Adams, FMRI Facility

Funding: Southern California Tuna Club Scholarship, Reish Grant, CSULB Graduate Research Fellowship & Summer stipend, AAUS Kevin Gurr scholarship, Minerals Management Service, SCMI;

* IACUC Protocol #250

Resources

My rockfish info. website

http://rockcodfishing.wordpress.com

Bonnie.Rogers@noaa.gov

The one-stop ROCKFISH spot

fishing * barotrauma * release techniques

FishSmart.org & NOAA regional workshops on barotrauma coming up 2012

Fishing gear research and mitigation

Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk

December 7 - 8, 2011

Steve Eayrs
Fishing Technologist

Gulf of Maine Research Institute
Science. Education. Community.

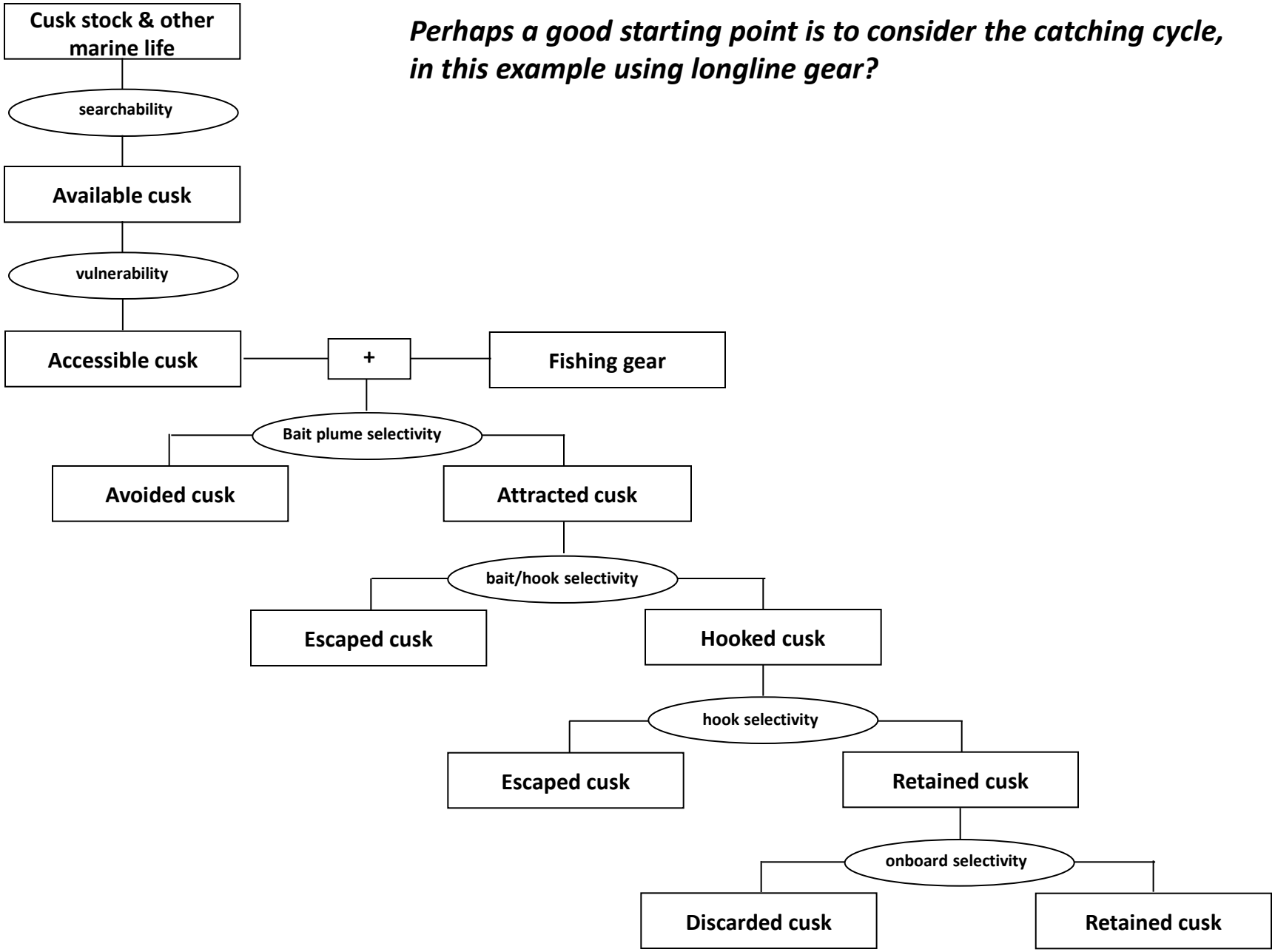
350 Commercial Street, Portland, ME 04101 · tel: 207-772-2321 · fax: 207-772-6855 · www.gmri.org

What do we know about how & where cusk are caught?

- Preference for rocky or pebbly locales, rarely smooth bottom
- Variety of fishing depths, waters > 100 – 600+ ft
- Catch data by gear type
- Bottom longline
- Accept a variety of baits, jigs
- Gillnets
- Bycatch in lobster traps; impact of derelict traps?
- Trawl gear

….so how do we decide where and how to apply gear conservation measures?

Perhaps a good starting point is to consider the catching cycle, in this example using longline gear?



So how is this useful?

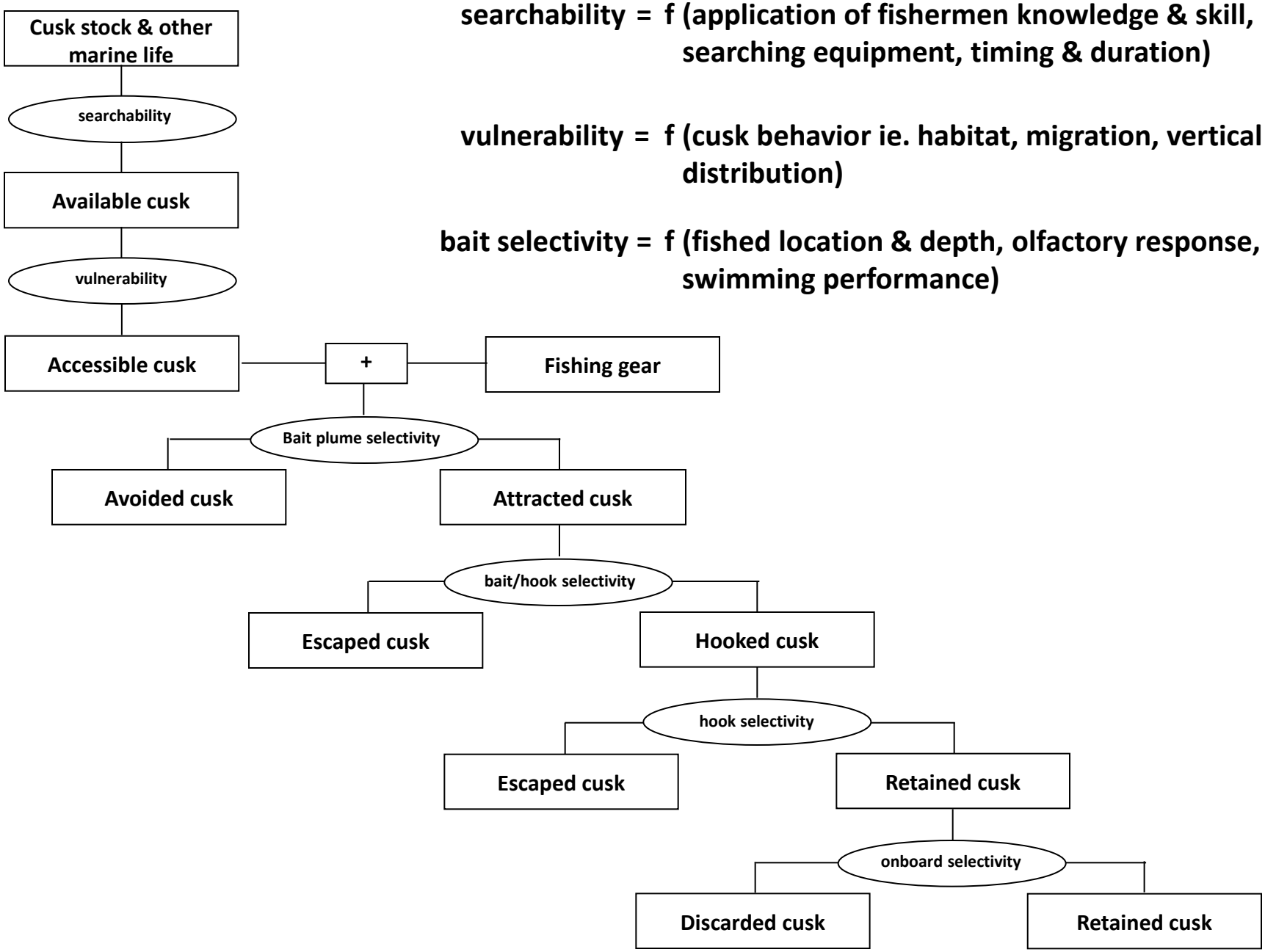
The framework highlights:

- **The complexity of the *entire* fishing operation**
- **A systematic (more in-depth?) way of thinking about the fishing operation**
- **A greater understanding of factors that influence selectivity and efficiency**
- **That selectivity occurs throughout the catching cycle, from the time fishermen leave the dock**
- **How little knowledge we have of the relative impact/importance of these factors**
- **Where the knowledge gaps lie…….prioritizing future research**

searchability = f (application of fishermen knowledge & skill, searching equipment, timing & duration)

vulnerability = f (cusk behavior ie. habitat, migration, vertical distribution)

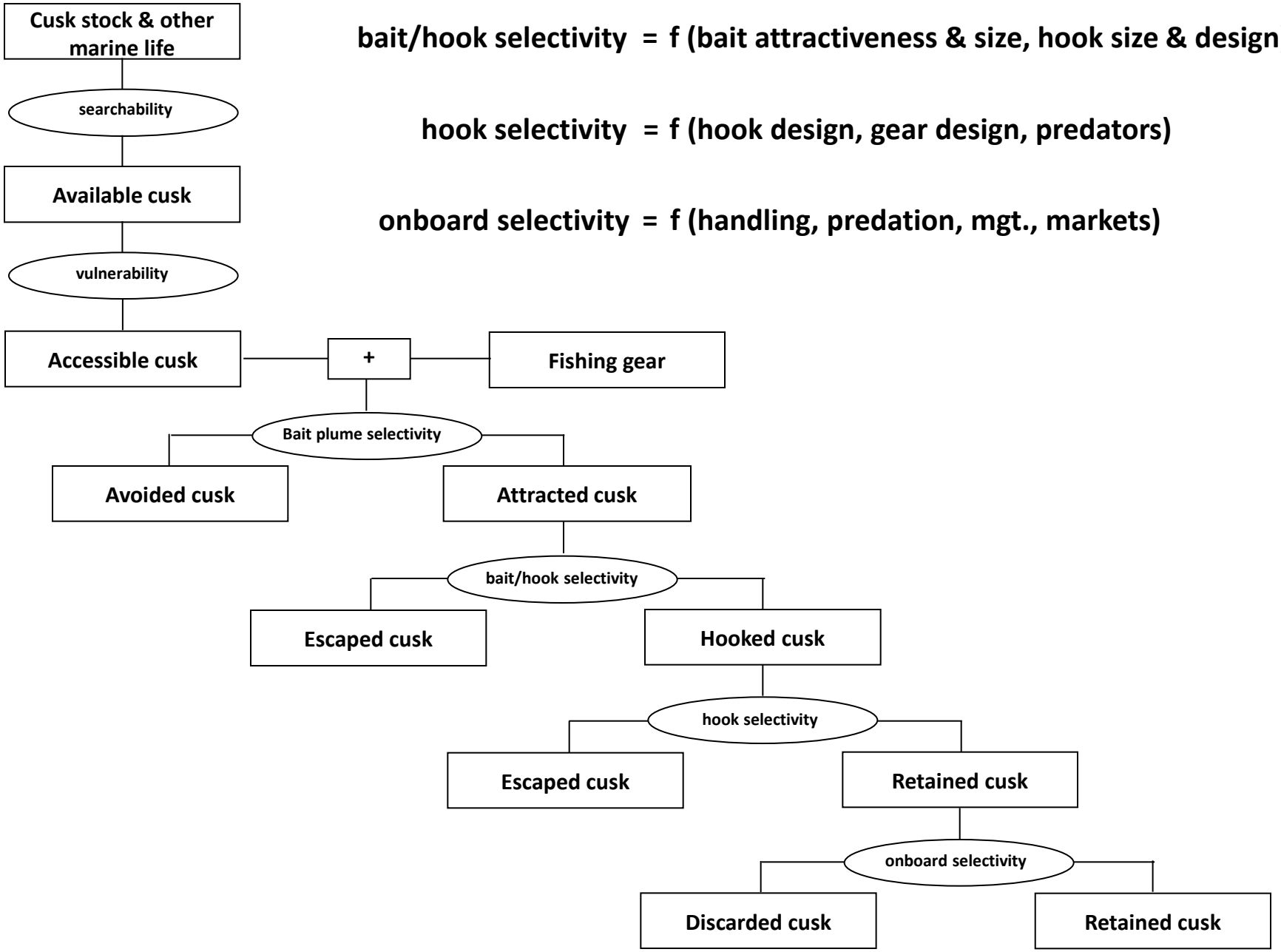
bait selectivity = f (fished location & depth, olfactory response, swimming performance)



bait/hook selectivity = f (bait attractiveness & size, hook size & design)

hook selectivity = f (hook design, gear design, predators)

onboard selectivity = f (handling, predation, mgt., markets)



And so where do we start?

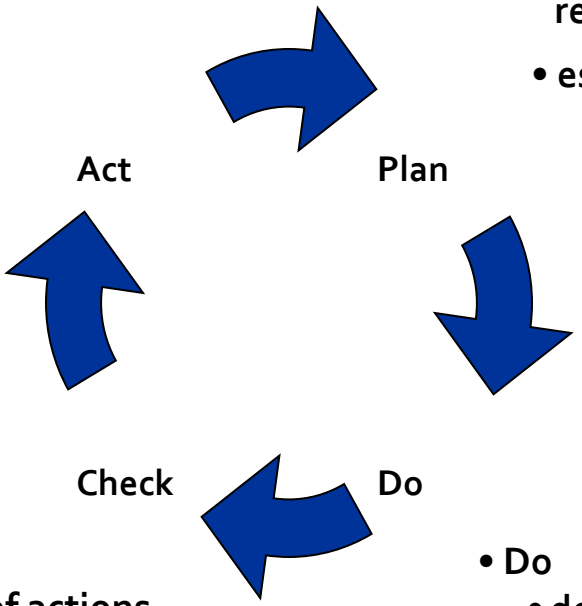
To take proactive steps to conserve cusk, we could:

- **Nail down when, where, and how cusk are caught (published and anecdotal information on fishing mortality)**
- **Identify threats to fishing mortality (retention, discards, predation, drop-out mortality etc.)**
- **Identify data gaps & opportunities to reduce mortality based on the flowchart**
- **Prioritize next steps**

Environmental Management System (EMS)

- Act
  - document performance & outcomes
  - provide evidence of steps to improve performance
  - serve as a platform for future corrective action

- Plan
  - identify project scope
  - assess environmental impacts & related legislation (context)
  - establish goals & priorities for action



- Check
  - performance measurement of actions

- Do
  - develop environmental policy & management program (objectives, targets, roles & responsibilities, & implementation of prioritized actions)

Fishing Gear Research and Mitigation (continued), or Where Do We Start?

U.S.S. Cusk

World's First Missile Submarine

Panko-crusted Cusk

Billy Bob with Cusk

Michael Pol
Conservation Engineering Project
Massachusetts Division of Marine Fisheries

Presented to the Workshop on Proactive Conservation Planning for Northwest Atlantic Cusk • Portland, ME • 7-8 December 2011

So where do we start?

- **To take proactive steps to conserve cusk, we could:**
  - **Collate published and anecdotal data on fishing mortality (when, where, and how)**
  - **Identify key threats to stock mortality**
  - **Identify data gaps**
  - **Prioritize next steps**

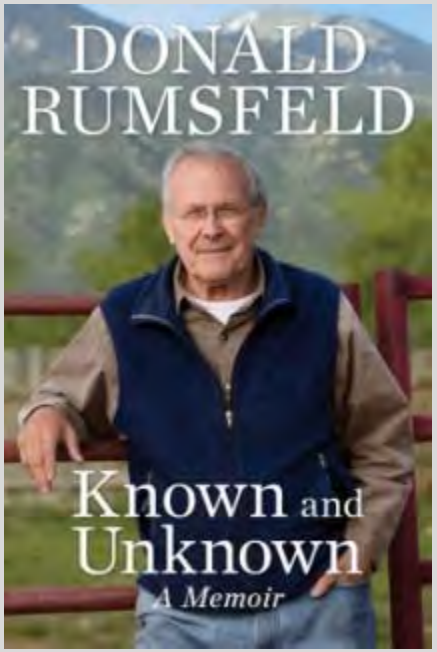
Conservation Engineering Approach

- Understand the capture process in all its detail
  - **searchability, time = f (application of fishermen knowledge & skill, searching equipment, timing & duration,…)**
    - **vulnerability = f (cusk behavior ie. habitat, migration, vertical distribution,…)**
      - **encounters = f (fished location & depth, olfactory response, swimming performance,…)**
        - » **bait, hook selectivity = f (bait type & attractiveness, hook size & design,…)**
          - **hook retention = f (hook design, gear design, predators,…)**
            - **onboard selectivity = f (handling, predation, mgt., markets,…)**

Conservation Engineering Approach

Find all data – “known knowns”

- Types
  - Behavior, distribution, catch records, physiology, habitat, life history, feeding habits, food preferences
  - Typically, many gaps
- Sources
  - Fishermen’s experience and practice
  - Databases – VTR, catch reports, etc
  - Scientific libraries – focus on success
  - Reports – often less-successful but useful
  - Personal libraries – overlooked tidbits
  - Networks – local, national, international
- Similar species: other snaky demersal things?
  - Wolffish, ocean pout, white hake, tilefish,…



Conservation Engineering Approach

Develop a “common knowledge”

Boulder bottom, mud bottom

Soft bodied; small mouthed

“Benthic and sluggish fish not known to undertake migrations”

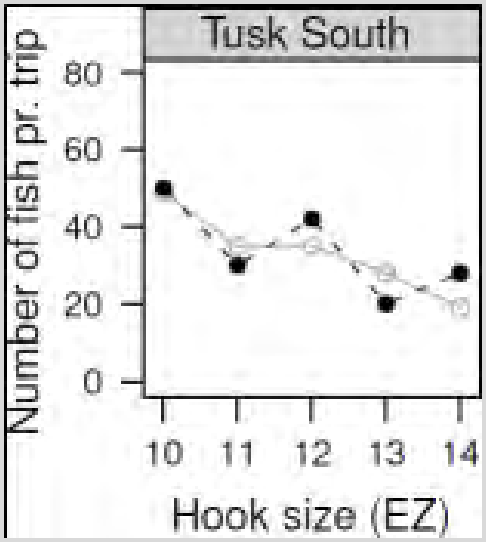
Sound producing

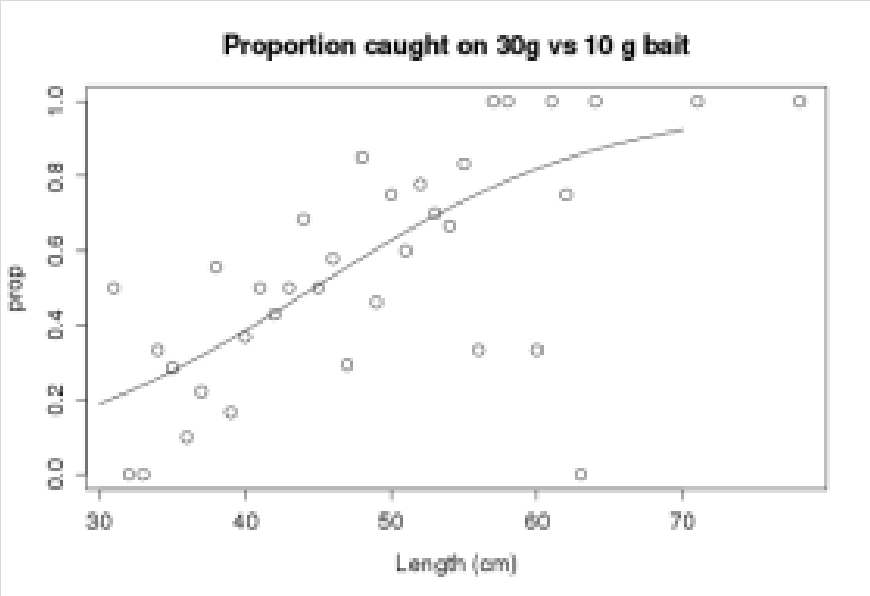
Aggressive toward bait and species; tolerant of conspecifics (Rountree & Juanes, 2010)

Gear and size selectivity

- Norwegian bait experiments
  In fish pots, squid had higher catch rates of cusk than herring or mackerel
  Squid bait caught 9% more cusk than mackerel bait on longlines

- Icelandic tests (2009) with two bait sizes and five hook sizes
  Bigger hooks caught fewer fish
  Larger baits (1 oz) caught larger cusk (>19 in)





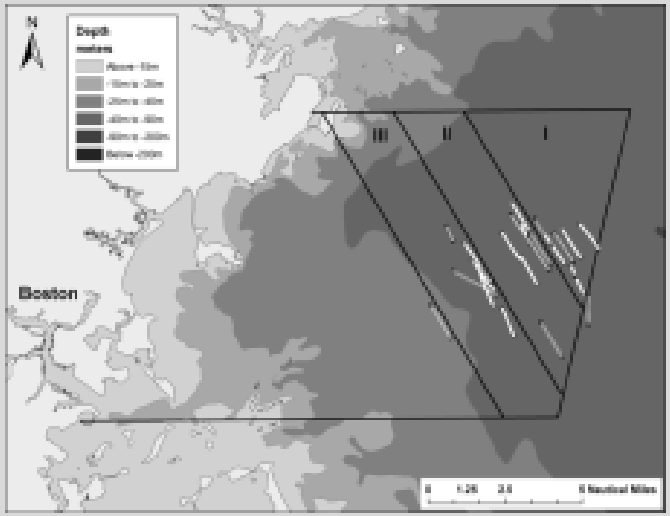
Gear and size selectivity

- DMF tests with some cusk catch

Only caught with herring (v. clams or Norbait 700E) in a longline bait test using 11/0 circle hooks in 8 overnight sets in Mass. Bay in 2007.

Cusk were only caught in flatfish gillnets (not in cod gillnets, dual leadline, or lead-added floatline gillnets) in 35 overnight soaks in Mass. Bay in 2000-2002.

Cusk were second-most common bycatch in a haddock gillnet selectivity trial in WGOM in 2004 (4.5 – 6.5 in mesh)

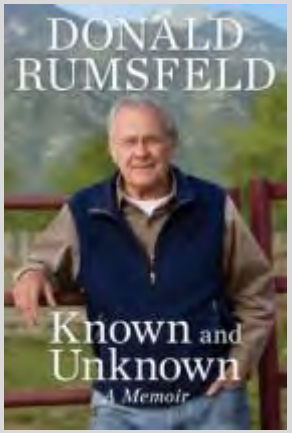


Only one caught in cod pots

Conservation Engineering Approach

What are the data gaps? What do we need to know?

- Continue searching information sources
- Design experimental approach to provide answers
- Prioritize efforts



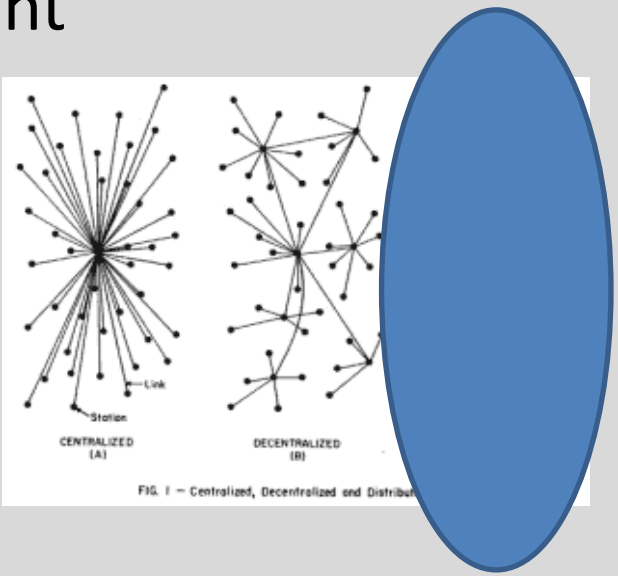
Network v. Competitive Approach

Networks are:

- Outcome oriented
- Inclusive
- People-based
- Efficient

REDNET – 40+ people working toward sustainable redfish fishery

GEARNET – Technology transfer and small-scale gear experiments with 10+ groundfish sectors



Thank you!

I NEVER DREAMED THAT TWO DAYS OF TALKING ABOUT CUSK COULD BE SO ROMANTIC!
THERE WAS A REAL EXCITEMENT TO IT.
KIDS, YOU DON'T KNOW THE HALF OF IT!

European Gear

Targetted with fish pots

- Squid resulted in higher catch rates of cusk than herring or mackerel

Furevik, D.M. & Løkkeborg, S., 1994. Fishing trials in Norway for torsk (Brosme brosme) and cod (Gadus morhua) using baited commercial pots. *Fisheries Research*, 19: 219-229.

Norwegian Research

Targetted with fish pots

- Squid resulted in higher catch rates of cusk than herring or mackerel

Bjordal (1983a) found that squid bait caught twice as many ling (Molva molva) as mackerel bait, but only 9% more torsk (Brosme brosme). Compre-

Løkkeborg, S. & Bjordal, Å., 1992. Species and size selectivity in longline fishing : a review. *Fisheries Research*, 13, pp.311-322.

Norwegian Research

Torsk (Brosme brosme) is a benthic and sluggish fish not known to undertake migrations (Svetovidov, 1986; Bergstad, i 989 j. in

Løkkeborg, S. & Johannessen, T., 1992. The importance of chemical stimuli in bait fishing - fishing trials with presoaked bait. *Fisheries Research*, 14, pp.21-29.

Icelandic Experiment

The effect of hook and bait sizes on size selection in longline fisheries

The effects of hook and bait sizes on fishing efficiency and size composition of cod (Gadus morhua), haddock (Melanogrammus aeglefinus), wolffish (Anarhichas lupus), ling (Molva molva) and tusk (Brosme brosme) were investigated in a designed experiment in the Icelandic longline fishery. Five hook sizes, EZ 10–14, and two bait sizes, ~10 and 30g, were compared. The bait was Saury (Cololabis saira). In general, bait sizes affect catch rates and size selection in longline fishery, while smaller hooks result in higher catches. The proportion of catch of juvenile fish appeared to be inversely related to fish abundance.

ICES, 2011

ROV info

Cusk were common in boulder habitat (SBNMS) but absent from sand and gravel habitats and were seen noon, sunset, and midnight.

Cusk were sometimes startled by ROV bumps.

Appeared to be unaffected by turning lights on.

Approached ROV and attempted to feed on bait, for extended periods. Cusk approached chopped fish, clam bait, not chopped crab bait.

Cusk appeared indifferent to the presence of con- specifics even when feeding, with individuals often bumping into each other and swimming over each other without obvious reactions (Fig. 2). However, cusk were highly aggressive to other species and were observed to chase away pollock, Atlantic cod, and haddock on one or more occasions. Living cusk exhibited a striking pattern of alternating dark and golden yellow bars (Fig. 2). Yellow streaks also appeared on the head through the

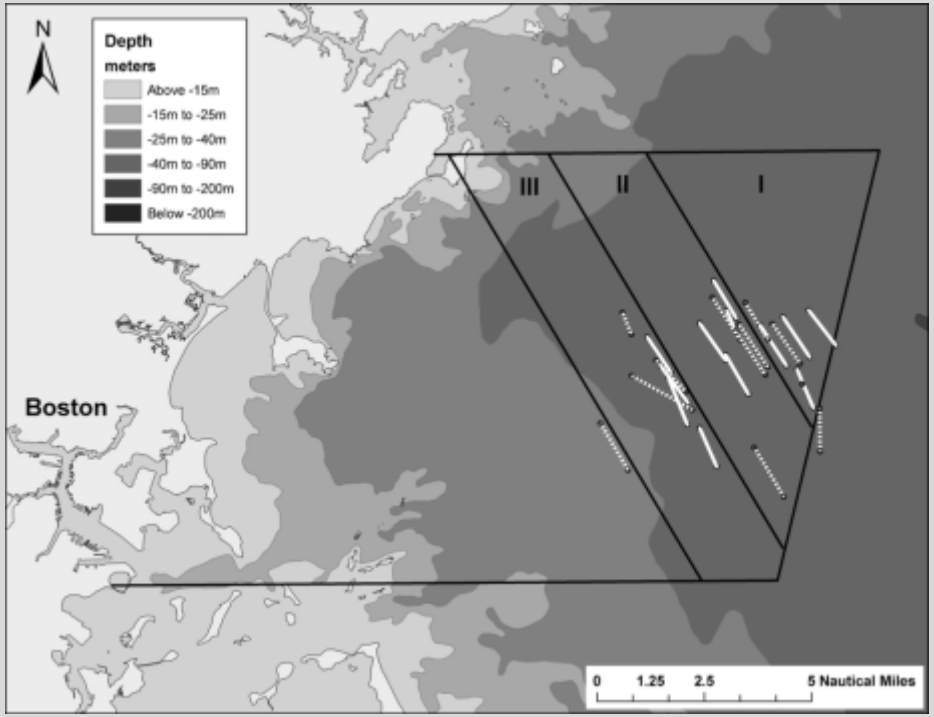
Cusk may have produced sounds.

. First attempt to use a remotely operat vior in the Gulf of Maine, Western Atlantic Ocean. *Current Zoology*, 56(1), pp.90-99.

Odds and Ends

Cusk were only caught with herring (v. clams or Norbait 700E) in a longline bait test using 11/0 circle hooks in 8 overnight sets in Mass. Bay in 2007

		Bait Type		
Common Name		Clams	Herring	Norbait©
Haddock	kg	1087.2	486.5	522.1
	count	615	271	327
Legal-sized haddock	count	585	257	309
Atlantic cod	kg	640.1	461.0	172.3
	count	442	264	111
Spiny dogfish	kg	345.7	1028.2	910.2
Red hake	kg	39.3	51.9	41.7
Thorny skate	kg		62.0	45.0
Winter skate	kg		19.8	
Cusk	kg		17.7	
Ocean pout	kg	11.9		
Little skate	kg		10.1	



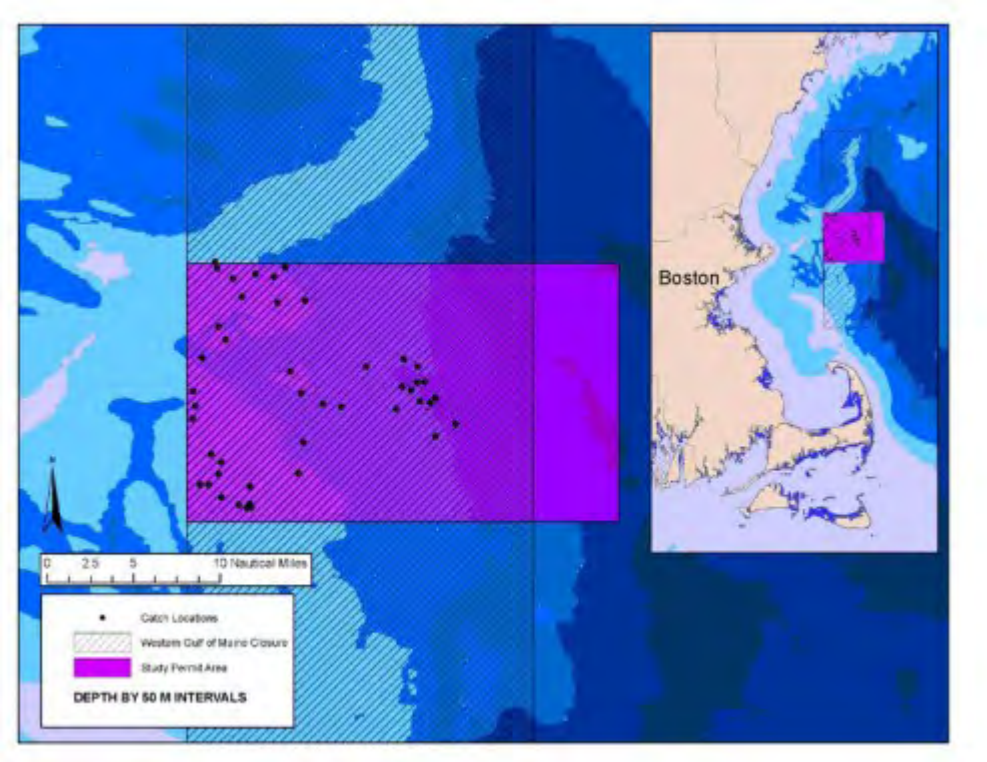
Pol, M.V. et al., 2008. Longlining haddock with manufactured bait to reduce catch of Atlantic cod in a conservation zone. *Fisheries Research*, 94(2): 199-205.

Odds and Ends

Cusk were second-most common bycatch in a haddock gillnet selectivity trial in WGOM in 2004 (4.5 – 6.5 in mesh)

Spiny Dogfish	**1928.0 lb**
Cusk	**36.0 lb**

14 days of fishing; 30 panels



Marciano, D. et al., 2006. *Testing the Selectivity of Gillnets to Target Haddock in the Gulf of Maine*, Gulf of Maine Research Institute.

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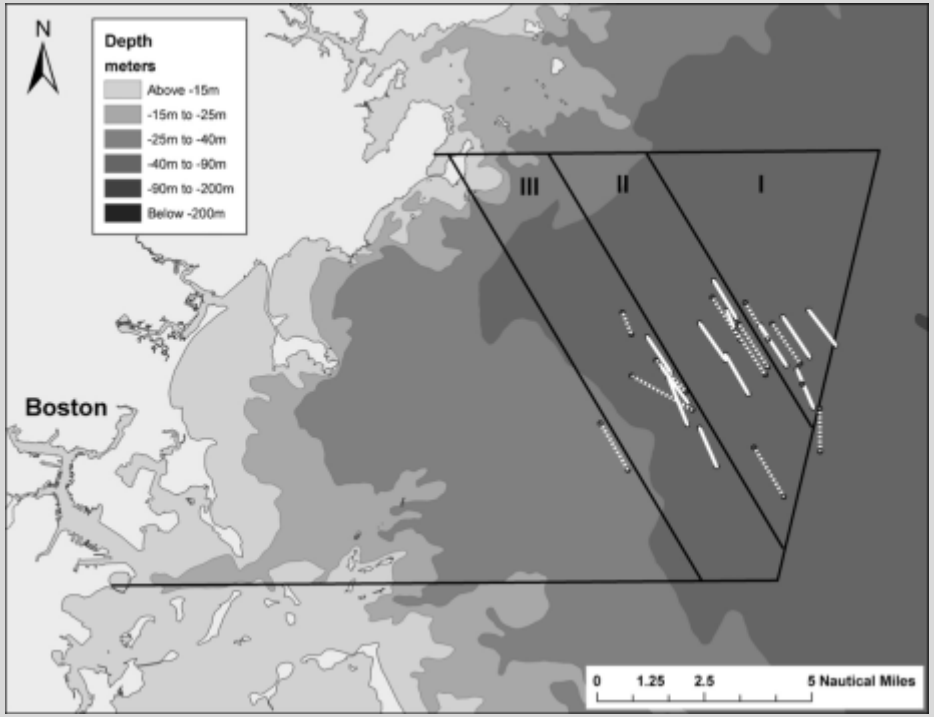
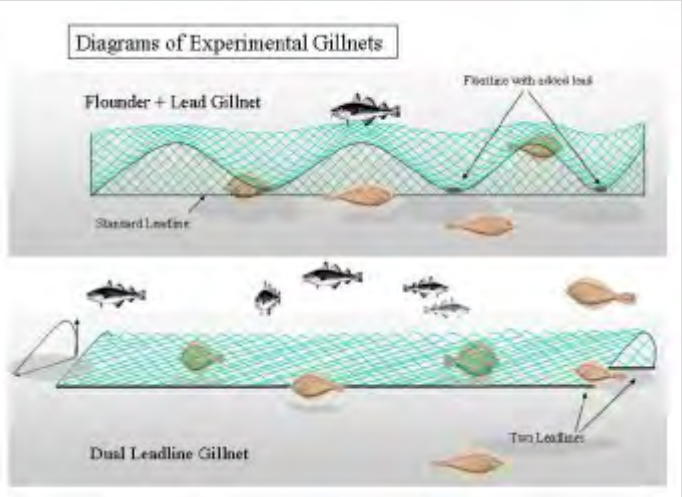
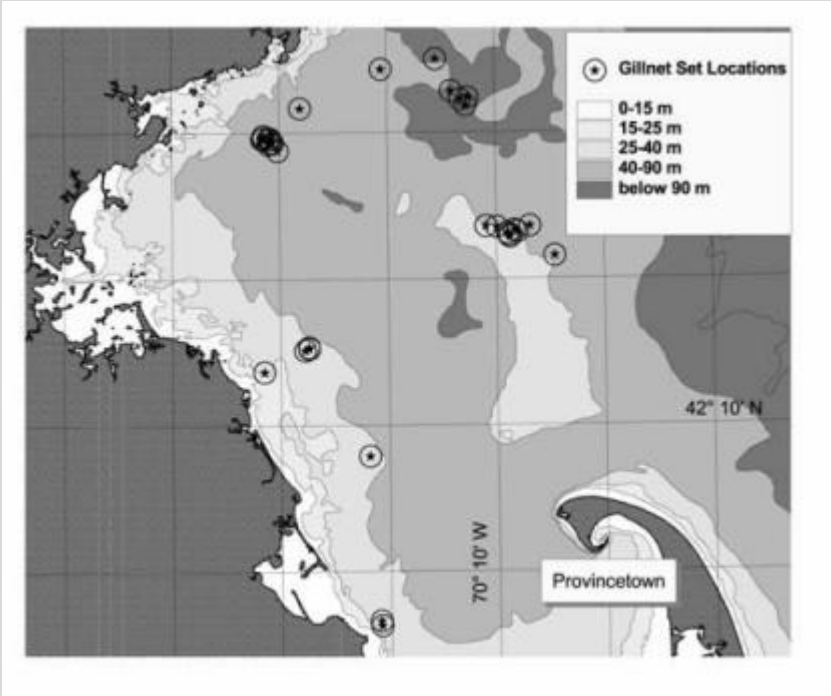


Pol, M.V. et al., 2008. Longlining haddock with manufactured bait to reduce catch of Atlantic cod in a conservation zone. *Fisheries Research*, 94(2): 199-205.

Odds and Ends

Cusk were only caught in flatfish gillnets (not in cod gillnets, dual leadline, or lead-added floatline gillnets) in 35 overnight soaks in Mass. Bay in 2000-2002.





Pol, M.V., 2006. *Testing of Low-Profile, Low Cod-Bycatch Gillnets: Phases I and II*. Final Report to the Northeast Consortium. Massachusetts Division of Marine Fisheries.

Caught one somewhere in one of these tows.

Chosid, D.M. et al., 2008. *Further Testing of Cod-Avoiding Trawl Net Designs*, Massachusetts Division of Marine Fisheries.

Science, Service, Stewardship

Gear Analysis from Observer Data 2000-2010

Northeast Fisheries Observer Program

GMRI Cusk Workshop

December 7-8, 2011, Portland, Maine

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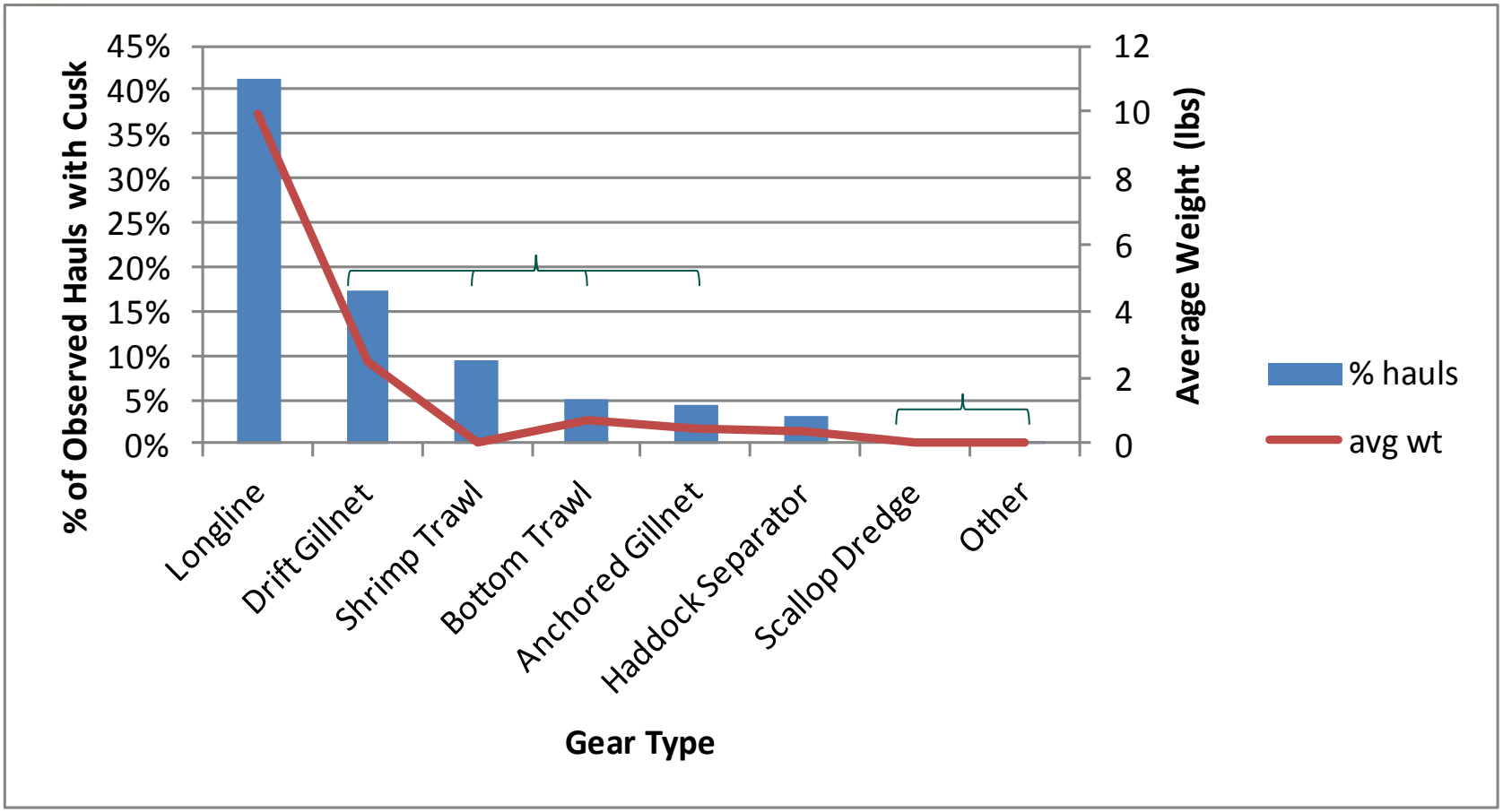
Catch by Gear



Brackets indicate groups with no significant difference in % occurrence (pairwise χ^2 at $\alpha = 0.95$)
Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

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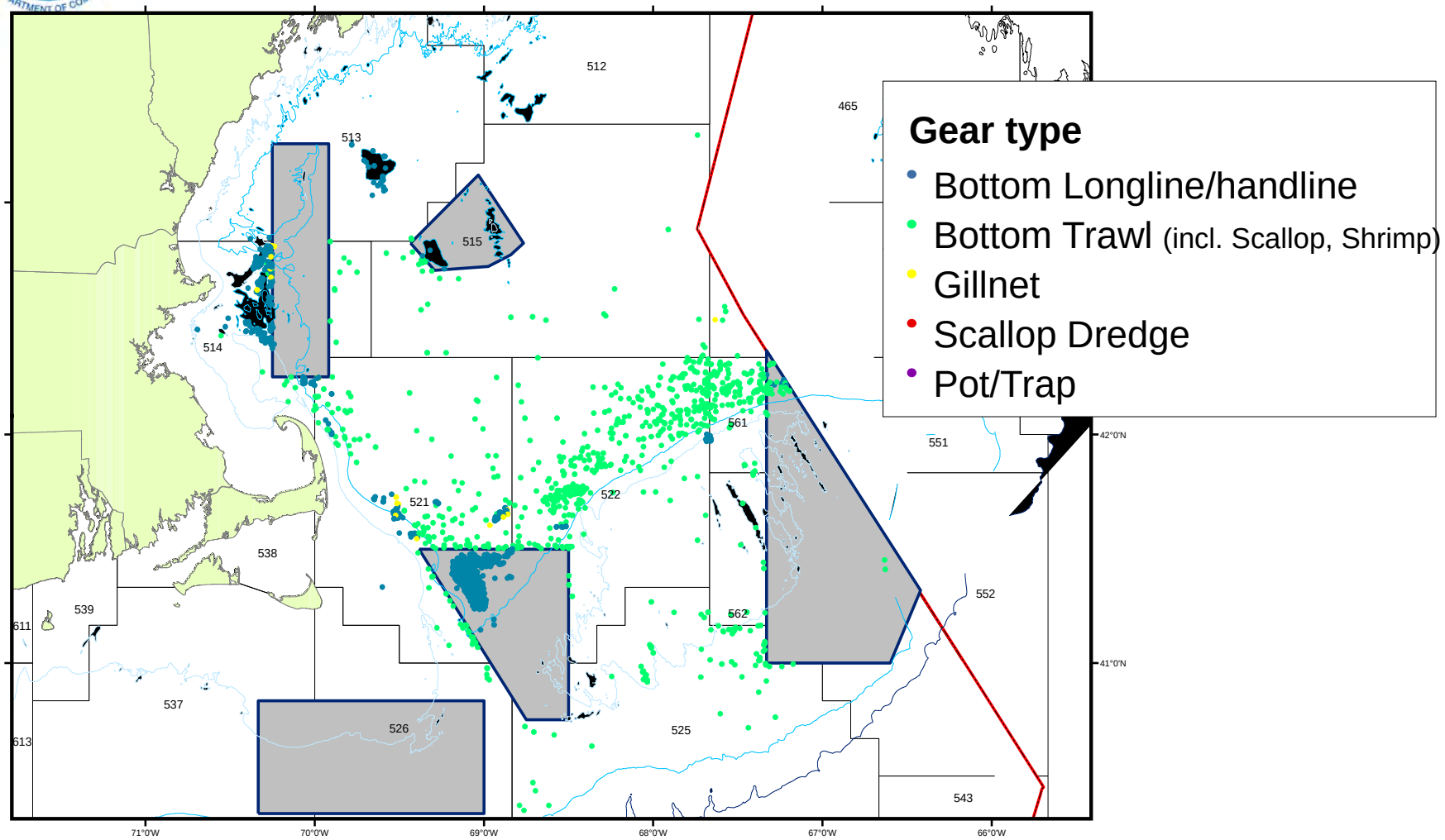
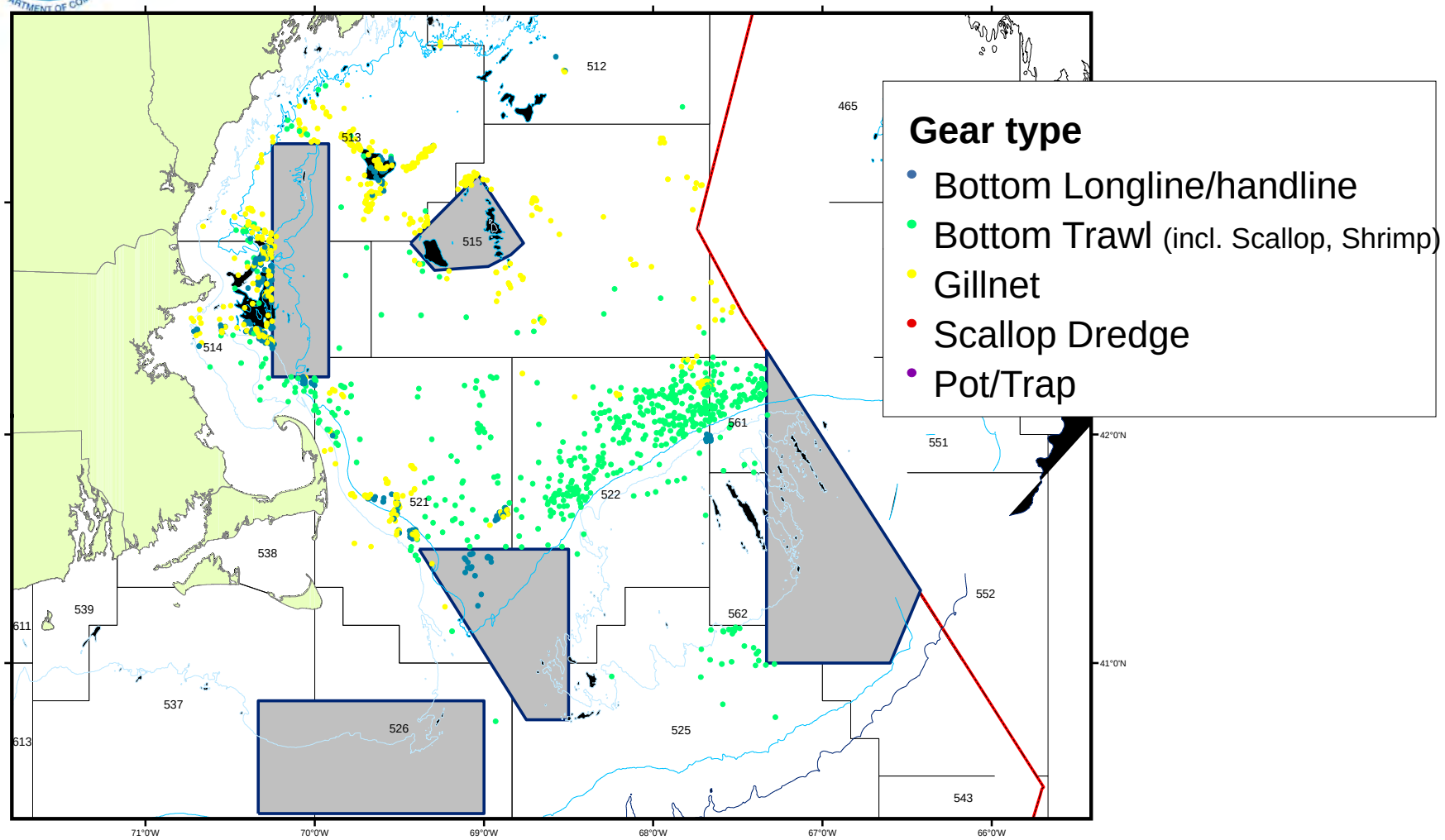
Hauls Targeting Haddock



NOAA FISHERIES SERVICE

Hauls Targeting Cod



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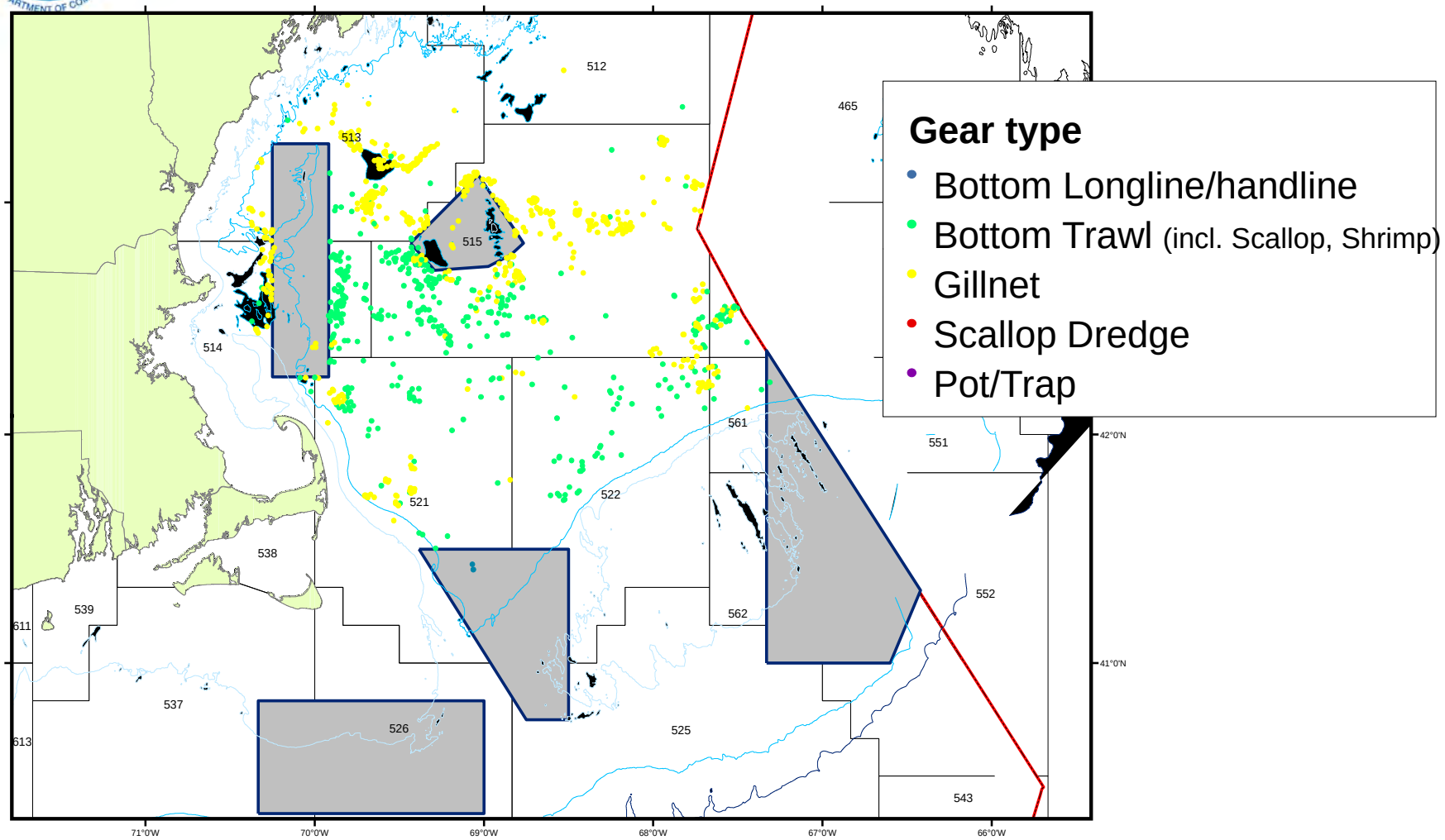
Hauls Targeting Pollock



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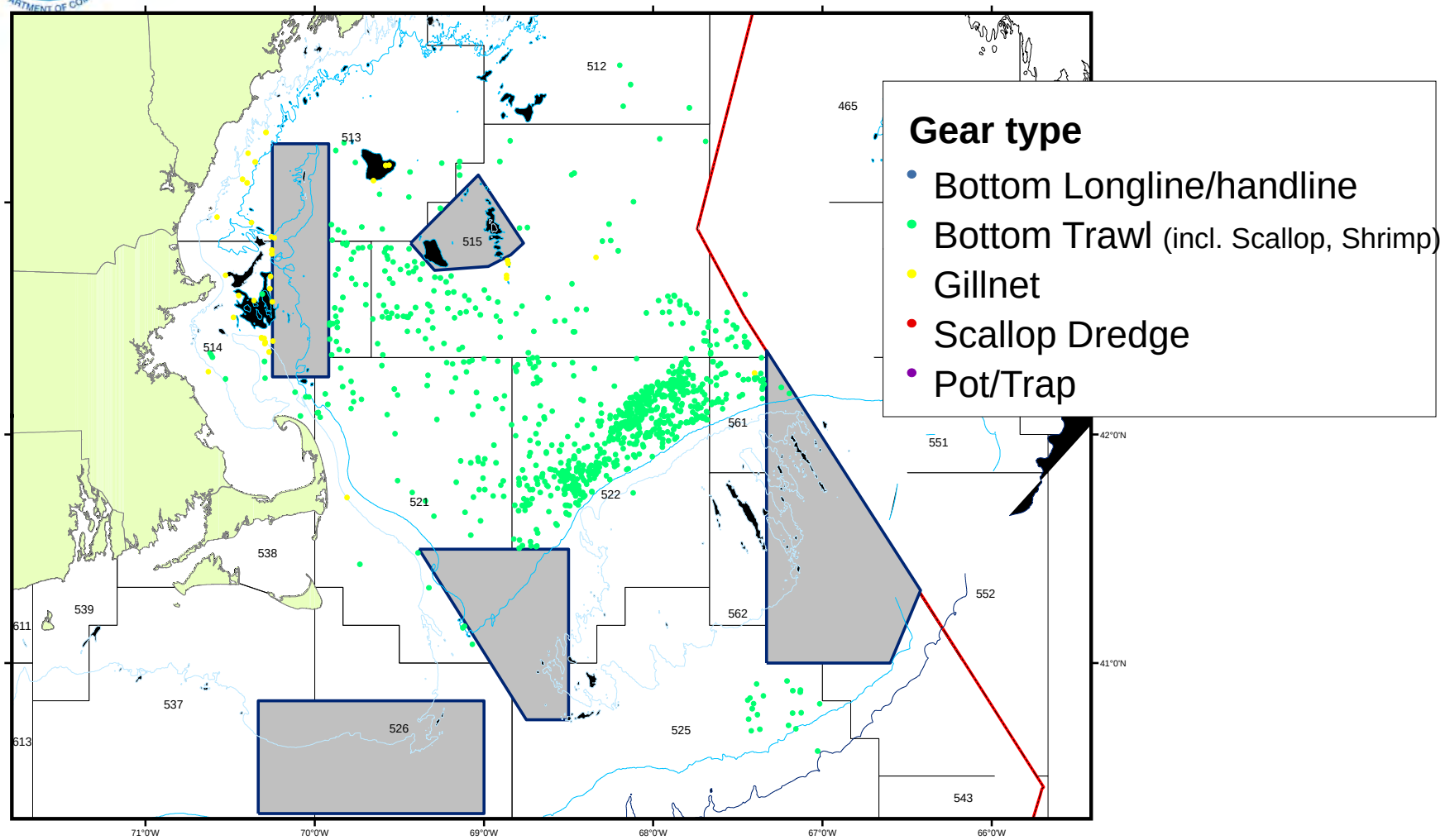
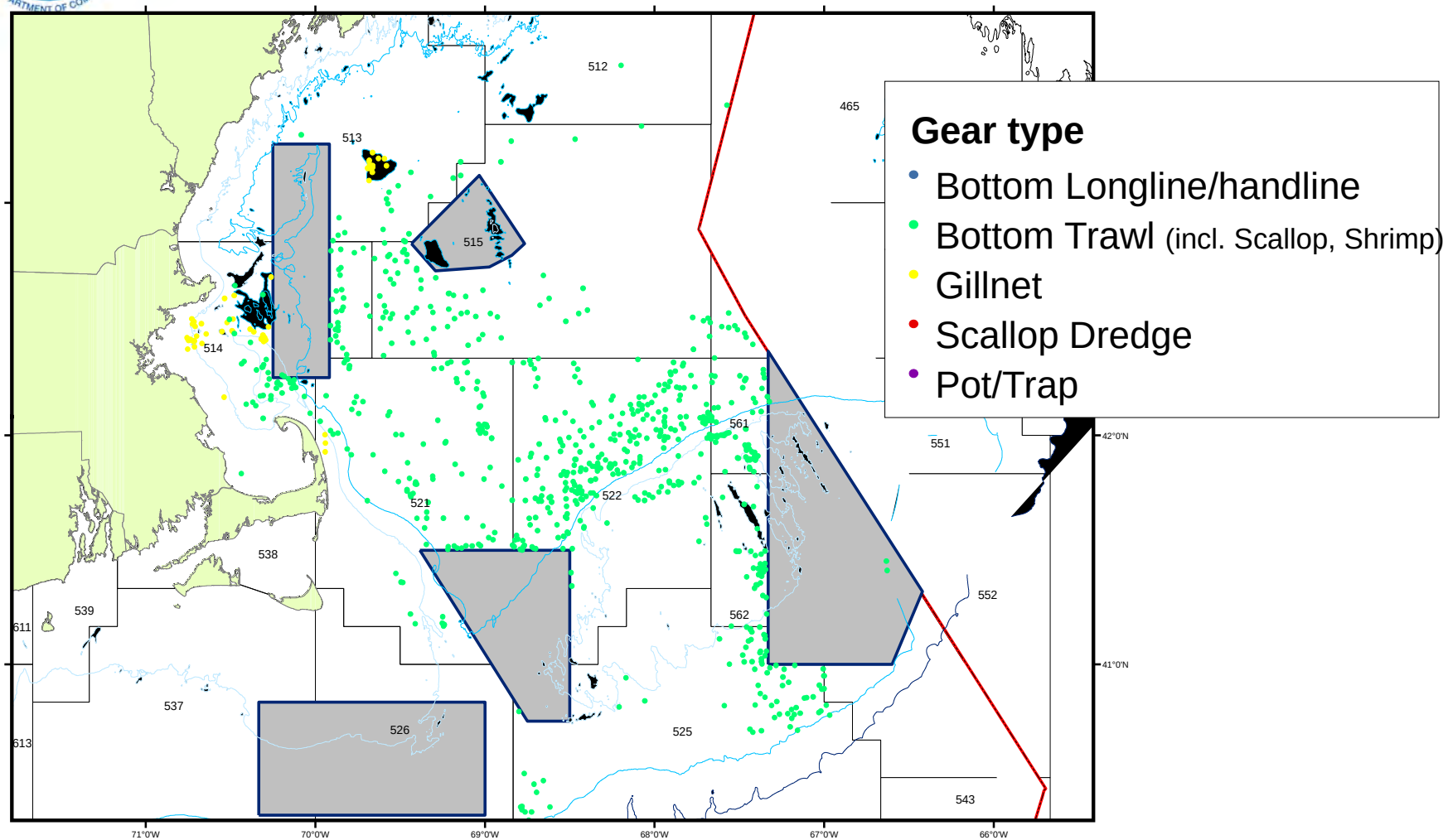
Hauls Targeting Monkfish



NOAA FISHERIES SERVICE

Hauls Targeting Flounders

Winter, Witch, Am. Plaice, Yellowtail



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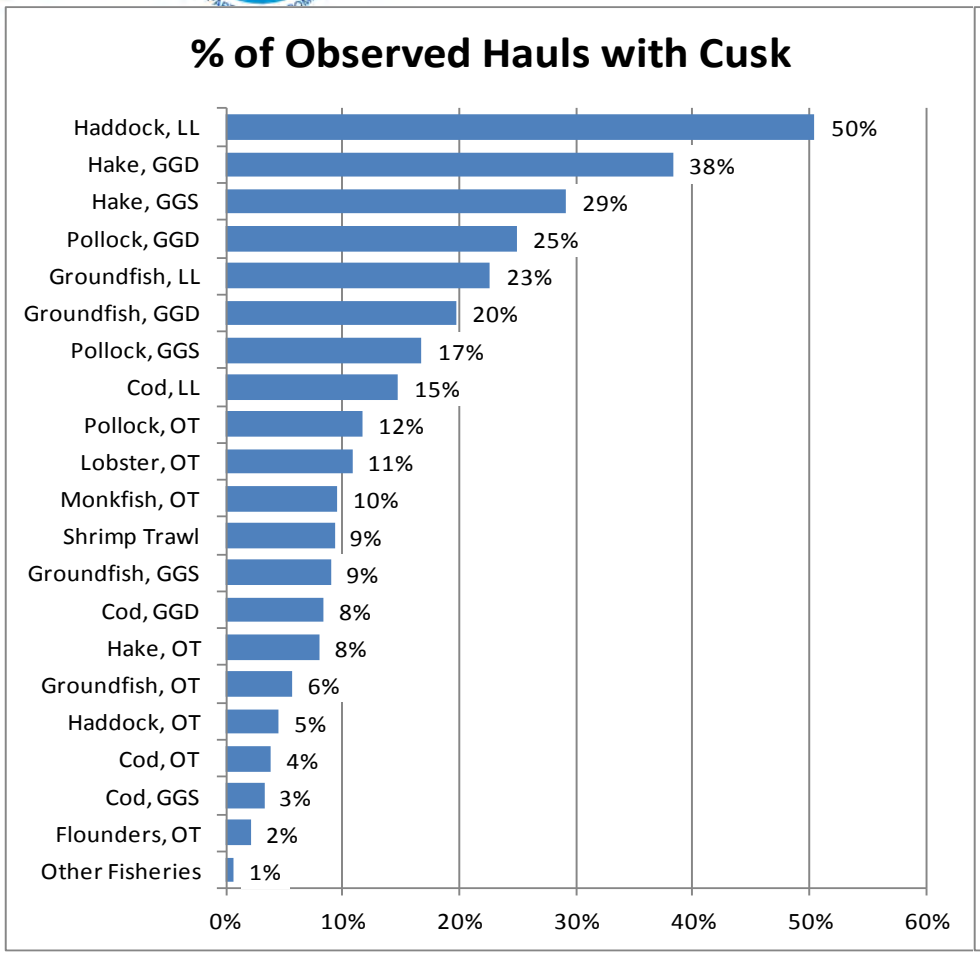
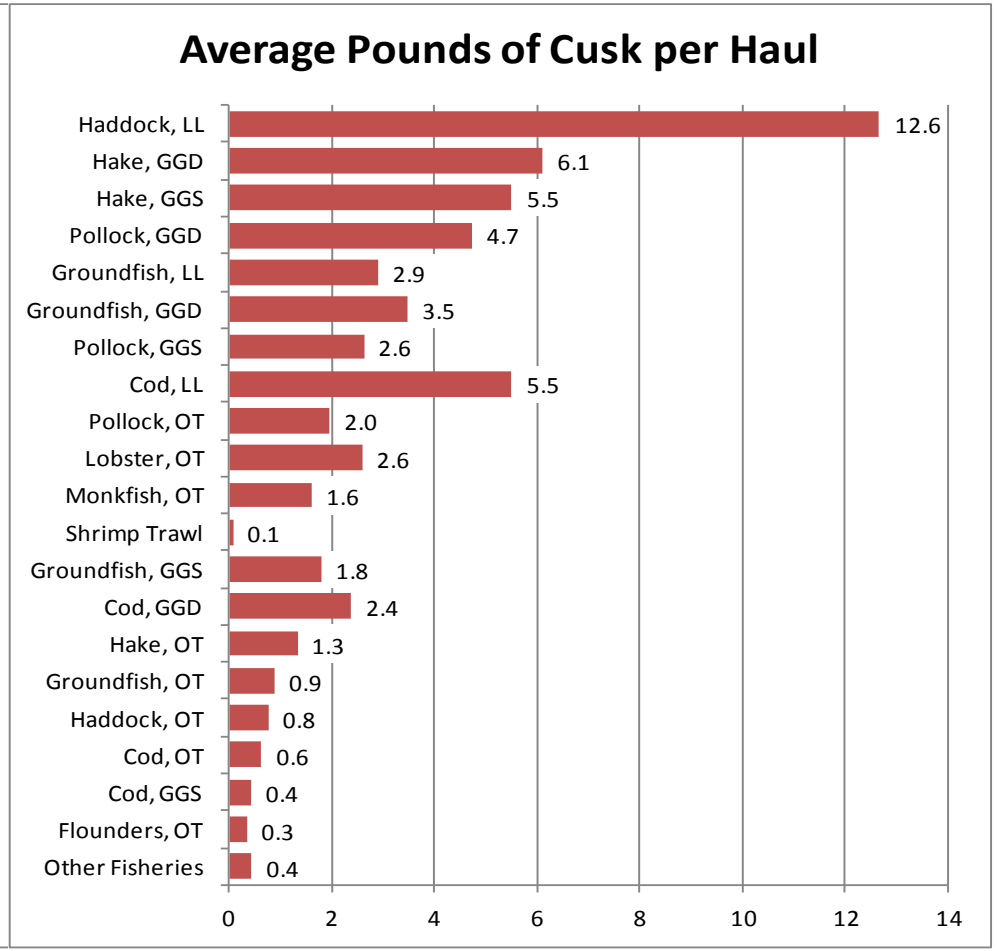
Catch by Target, Gear





3 trips targeting Cusk not included

Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

NOAA FISHERIES SERVICE

Longline Trends

2024 of 4911 observed bottom longline hauls had cusk (41%); total 63,388 lbs

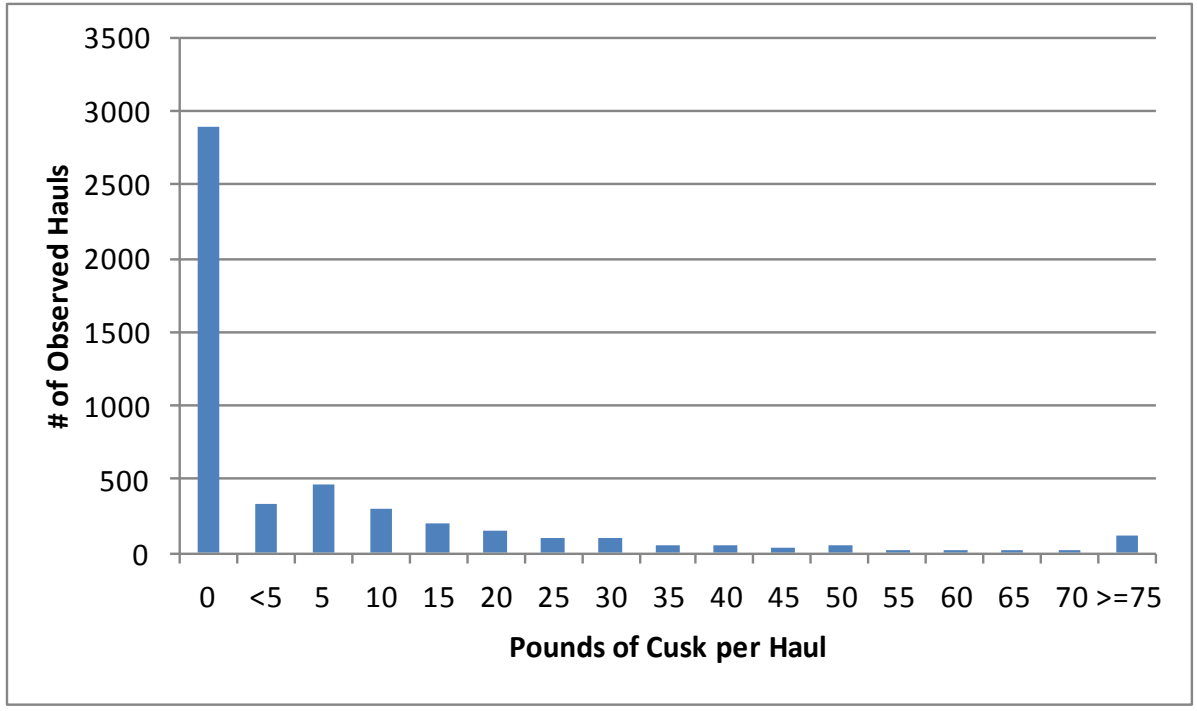
Average = 11.6 lbs per haul

Handline

1 of 562 observed hauls had cusk

Autojig

no observed cusk on 74 hauls



Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

NOAA FISHERIES SERVICE

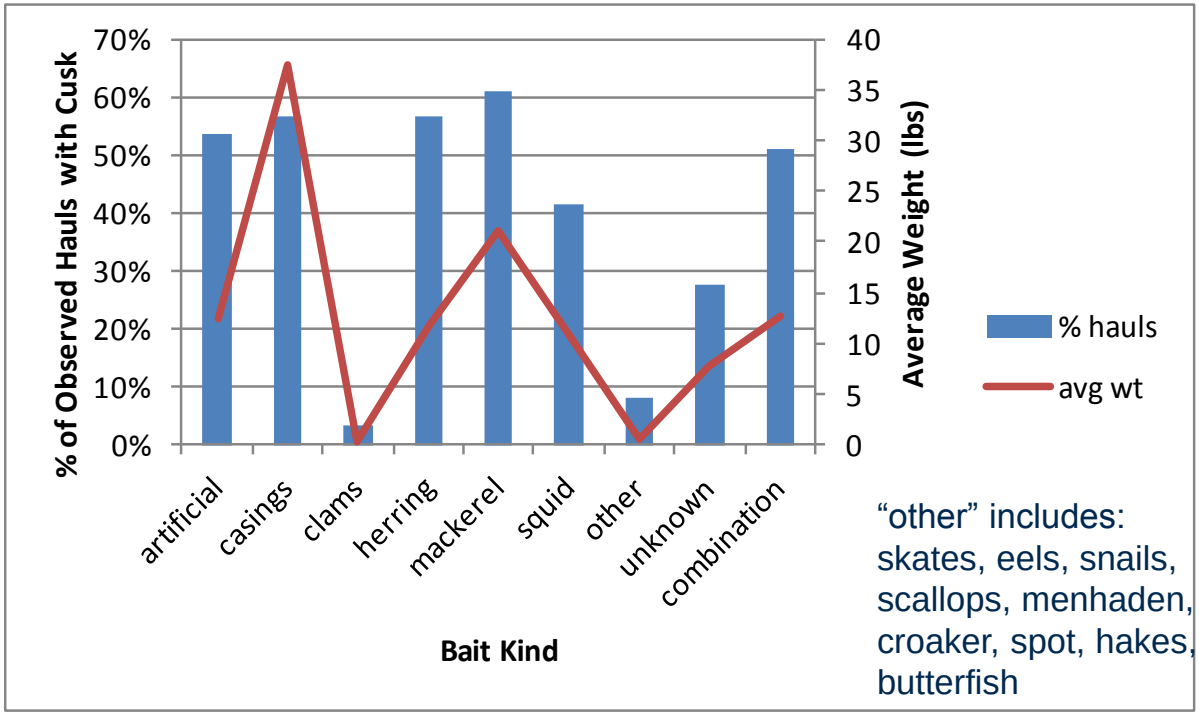
Longline Trends

No correlation with distance between hooks

No correlation with hook type (brand, pattern, size)

Decreased cusk catch with clam bait

No evidence of change in overall kept weight when using clams



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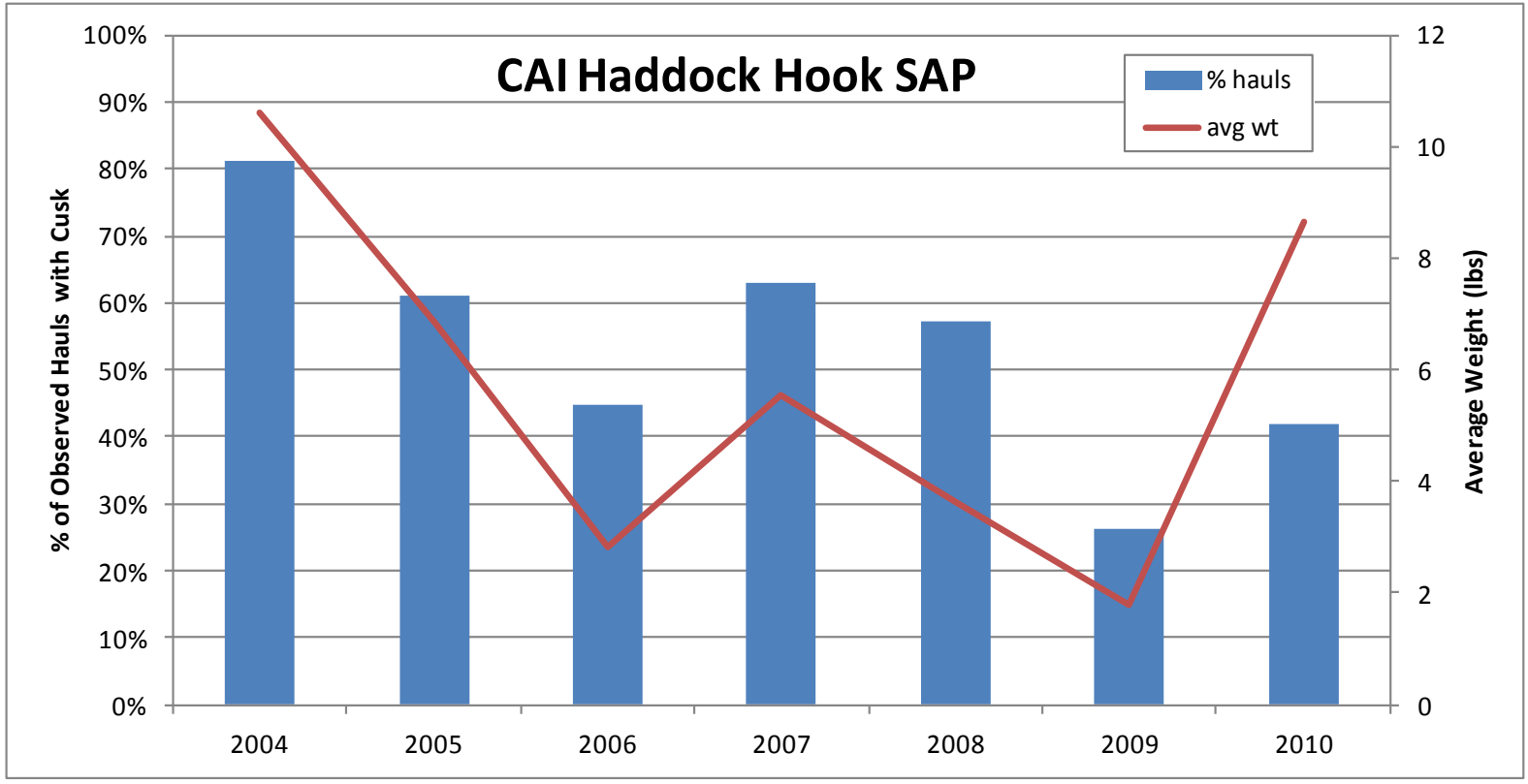
Closed Area 1 Haddock Hook SAP

Slight decrease in % occurrence over years

Increase in 2010?



Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

NOAA FISHERIES SERVICE

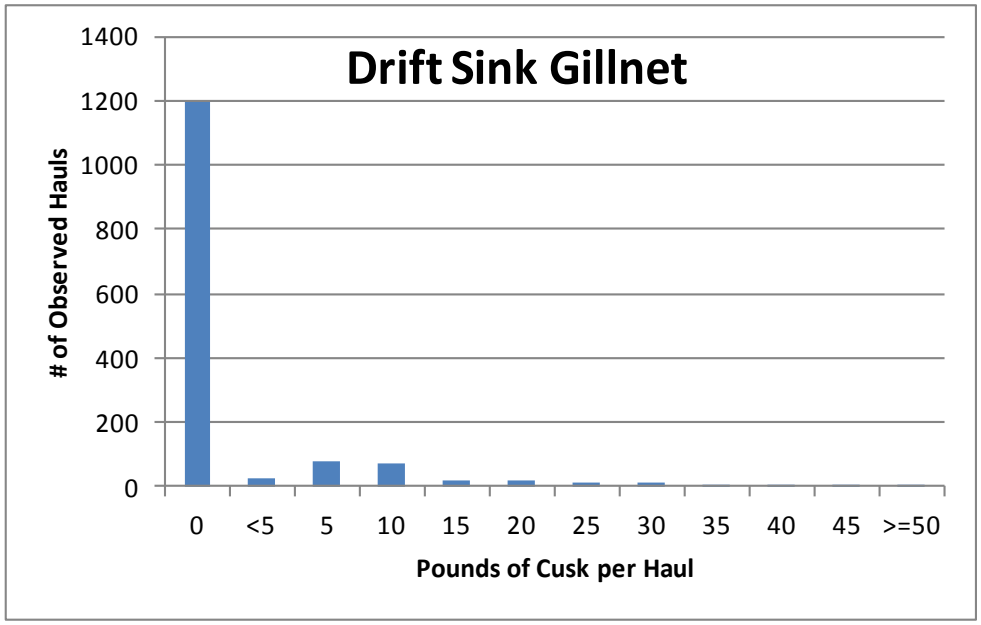
Gillnet Trends

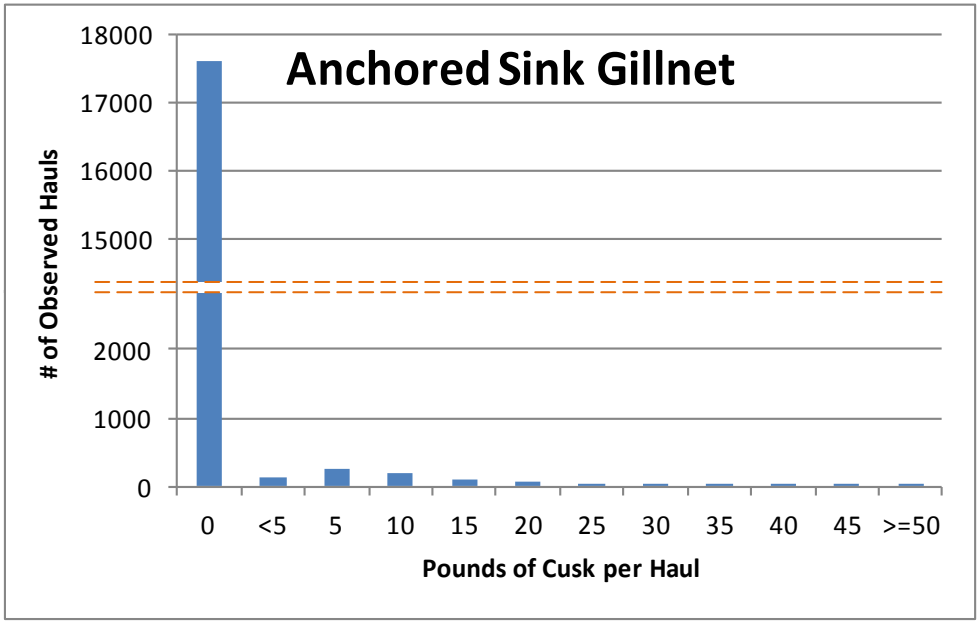
Drift Sink: 252 of 1446 hauls had cusk (17%)

Total 3754 lbs; average 2.6 lbs/haul

Anchored Sink: 782 of 18,393 hauls (4%)

Total 9788 lbs; average 0.5 lbs/haul





Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

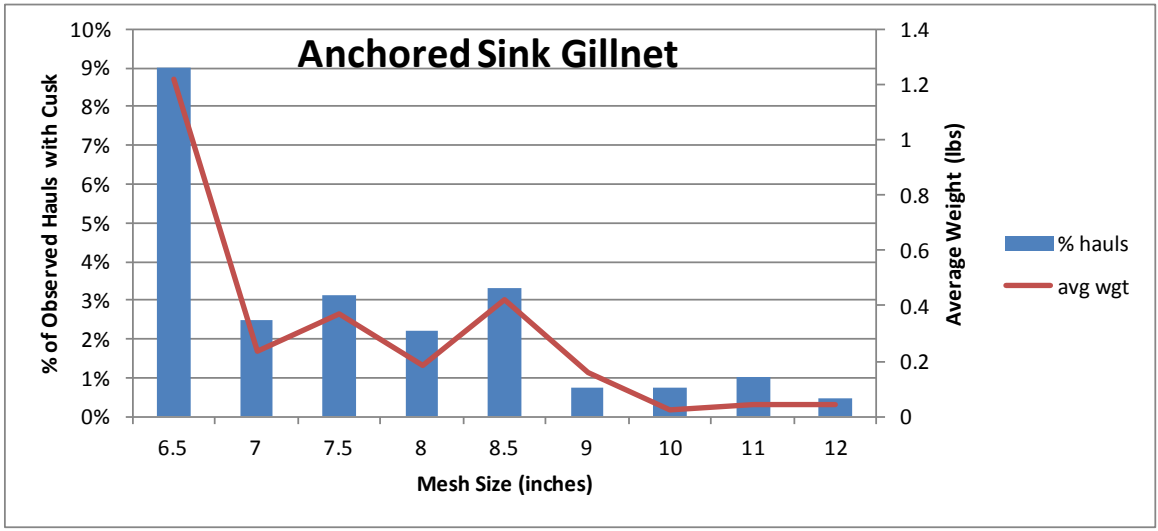
NOAA FISHERIES SERVICE

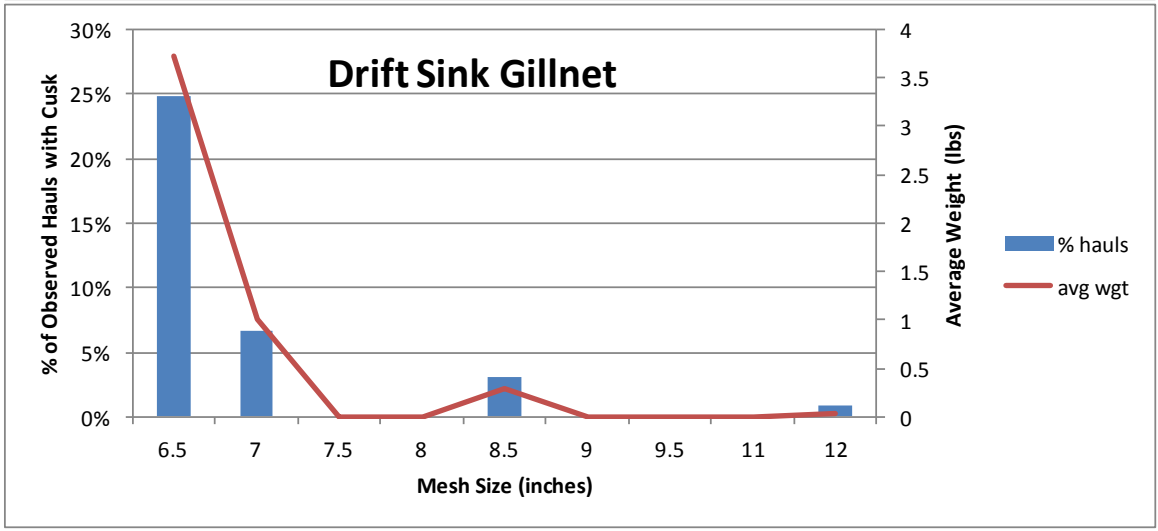
Gillnet Trends

6.5” mesh has highest rate of interaction, but also most commonly used

Some correlations with net height, but probably confounded by target species – needs further analysis

Rarely found in nets w/ tie downs (~1%)





Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)

NOAA FISHERIES SERVICE

Trawl Trends

Trawl Type	Hauls w/ Cusk	Total Hauls	% Hauls w/ Cusk	Average lbs per haul
Shrimp	40	429	9%	0.07
Bottom (<5.5”)	166	3,731	4%	0.68
Bottom (>=5.5”)	3,142	61,002	5%	0.76
Had. Sep.	37	1,141	3%	0.39
Rhule	1	135	1%	0.06

No difference between large & small mesh

Liner does not have noticeable effect

Diamond mesh more likely to catch cusk than square (7% vs 2%); average weight the same

Related to time/area fished?

Average weight per haul includes hauls with no cusk catch, not standardized for effort (e.g., soak duration)