Northeast Regional Cod Tagging Program

Industry-Science Workshop 1

Gulf of Maine Research Institute, Portland, ME
1st March, 2007

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1. Overview

As part of its Year Four contract, the Gulf of Maine Research Institute (GMRI) is coordinating a two-part industry/science workshop for in depth presentation of contemporary cod tagging data from the Northeast Regional Cod Tagging Program (NRCTP). Individuals with a strong interest in both the fishery and the science addressing Atlantic cod in the Gulf of Maine have been invited to participate. The aims of the two-part workshop are as follows:

Workshop 1 – Initial presentation of data and findings to date (March 2007)

- Present in detail the data, analyses and findings to date from the NRCTP.

- Invite comment and suggestion from both industry and scientific stakeholders on what additional analyses would benefit our understanding and management of the cod fishery.

- Identify a short-list of key analyses which will be undertaken for presentation at the 2nd workshop.

Workshop 2 – Delivery of follow-up analyses (May 2007)

- Present back to the group the identified short-list of key analyses proposed at the 1st workshop.

- Develop a list of recommendations for future research and analyses for cod stocks in the Gulf of Maine and neighboring waters

- Identify which findings will be of most interest for inclusion in the final dissemination of results for distribution to stakeholders throughout the region (~5000 individuals).

Number of attendees: Twenty-three people attended this first workshop and while this was fewer than planned (~40 people) this number proved to be conducive to a productive meeting and a similar number will be sought for Workshop 2. The attendees of Workshop 1 are listed in Annex 1; the split between industry and science representatives was as planned, ~50:50.

The agenda is presented in Annex 2. The day essentially started with introductions and an overview of the Program with reminders of the NRCTP's objectives and the types of data we have collected to date. A warm-up exercise was also undertaken and the results of this are presented in this summary (p.3). Data analysis formed the focus of discussions with the first session being a presentation of descriptive movement analyses; the afternoon's focus was on how to quantify these movements through weighting models which incorporate biomass/abundance estimates, fishing effort and reporting rates. The final section addressed the time frame expected for when the data are likely to be used in stock assessments and management. Finally, a wrap-up period took place where major points made throughout the day were re-iterated and prioritized as key tasks for GMRI to undertake over the next two months.

These minutes serve to summarize just the key points/questions put forward by workshop participants. The actual results presented are too plentiful to be summarized in this document, and the reader will be referred to past reports (see Annex 3) for detail at times; however examples of analysis have been included when appropriate/necessary as a means of clarifying a comment/question.

Disclaimer: *When dialogue or comments are included, these convey the general gist of what the individual said and not necessarily the exact words they used.*

2. Warm-up exercise

At the start of the workshop, before any data had been presented, attendees were asked to complete a warm-up exercise which consisted of three tasks, the key one being: "Briefly describe your theory on how cod migrate in the Gulf of Maine". At the end of the day a summary of people's feedback (n=18) was presented (Figure 1).

Figure 1: Summary of attendees' theories on how cod migrate in the Gulf of Maine.
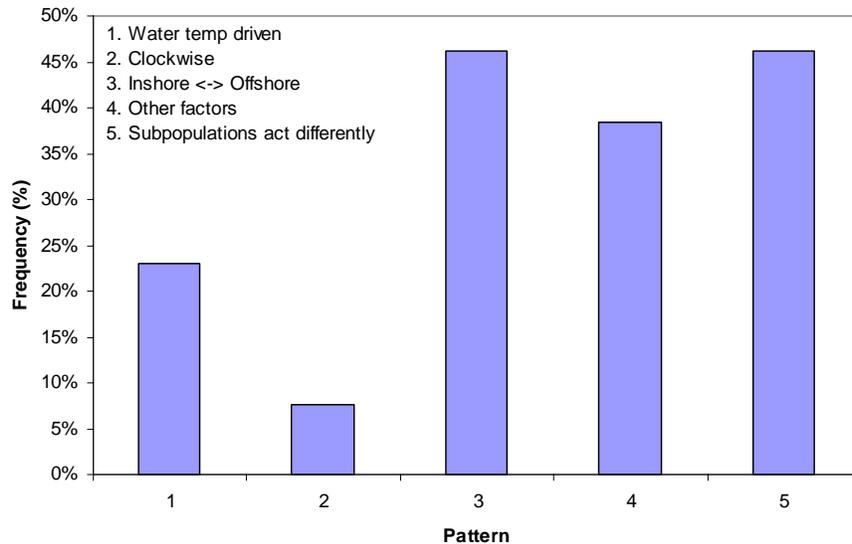
No single theory stood out as the most commonly considered, and it is evident that a variety of components were considered likely. The two most suggested theories were that 1) movements are of an inshore-offshore nature and that 2) sub-populations of cod move differently.

3. Review of Program history

A program-wide update was given starting with a review of the Program's goals to provide context for the data collected to date and the analysis being undertaken.

1) Identify the movement patterns of Atlantic cod throughout the Gulf of Maine and neighboring waters (Canadian Maritimes & southern New England)

- Growth information
- Spawning grounds

2) Develop a large-scale, collaborative cod tagging program;

- Fishermen and scientists to tag ~100,000 Atlantic cod throughout the study area.

3) Make data available to the public:

- Develop an online database with a GIS mapping interface for tracking tagged cod
- Feedback of tagging information, e.g. recaptures

4) Identify future research questions

3.1 Data collected and general analysis

The analytical focus to date has been: 1) reporting rates, 2) shedding rates (both of which are also necessary for weighting the releases and recaptures), 3) size relationships of tagged cod, 4) growth rates, 5) displacement (overall and seasonal), and 6) dispersal/exchange between areas. Since much detail on this analysis was presented in the NRCTP Final Report (http://www.codresearch.org/GMRI_Final_Report_2003-2006.htm), it will not be presented here. However, this section essentially covered:

Tag releases: How many tags were released (for each tag type, yellow (low-reward), orange (low-reward) and blue (high-reward)? Which gear types released tags (primarily hook and trawl gears)?

Outreach and visibility of data: An overview of the methods used by GMRI and partner organizations to achieve the goal of making sure the Program was well known and visible, from outreach materials, incentives and the program website (www.codresearch.org) to the online mapping database (www.gmamapping.org/codmapping.htm).

Recapture data: Who has been reporting tags? Which gear types have been reporting tags? How do return rates compare between regions/tagging organizations? How have tag return rates changed over time? How was the data quality?

Resolution of analysis: It was reiterated that depending on the question being asked, it will be necessary to undertake analysis at different resolutions (both temporal and spatial). For example, the spatial scales of key relevance to this dataset and anticipated analyses are: 1) stock management areas (MAs) (e.g. Gulf of Maine – 5Y, Georges Bank – 5Z and CA 4X); 2) general fishing areas (GAs) and 3) three-digit statistical squares. All analysis models and tools being applied are being designed with the capacity for application to data at each of these resolutions. Examples of these polygons are presented in Annex 4.

3.2 Discussion between participants

A number of questions were fielded in this first section, many of which were being addressed later in the day when more detailed analysis would be presented.

Reporting rates

- I'm interested in gillnet reporting rate by landing area (Ray Kane, FV Frenzy). It would also be interesting to see plotted the number of recaptures by gear by landing port, and the number of recaptures by fish size by landing port. **Response:** More detailed analysis on returns by gear type by statistical area will be covered later by Don Clark (DFO) during his presentation on reporting rates by region and by gear type (Shelly Tallack) (see p.10).

- RE decay in reporting rates (tag return rates are ~2% a year for two years, then drop considerably to <1%): Why have reporting rates decreased so sharply? (John Shusta, FV Special J). **Response:** The likely possibilities include: tag loss (tags drop out/wear off, etc.) and fish mortality (fish die) (Don Clark), and fishing mortality (Mark Terceiro, NMFS). It was noted that landings of cod have not decreased, just the number of tagged cod landed has decreased (Mike Russo, FV Susan Lee & John Shusta).

- What is the number of fish tagged that were of sublegal size (David Goethel)? **Response:** analysis by fish size is coming up, but a good proportion of the fish tagged in the Cape Cod area were of sub-legal size (Shelly Tallack, GMRI).

Analysis resolution / Polygons

- Could there be a Coxes Ledge general area (David Martins, SMAST)? **Response:** This can be added if we decide it is needed, as can other polygons (Shelly Tallack).

- Scotian shelf is important to the stock as a feeder (Bob Tetrault, FV Tara Lynn, Tara Lynn II, Robert Michael). **Response:** As will be seen later in the day, there is little evidence of interaction with the Scotian Shelf for this dataset (Shelly Tallack).

- How are the polygons defined? By depth? It would be interesting to expand the Cape Cod & Great South Channel general area out to 100 fm (Mike Russo). **Response:** These polygons can be tweaked if we decide it is needed; the polygons presented have been defined based on a combination of bathymetric factors, including depth (Shelly Tallack).

4. Movement and migrations – descriptive analysis

This section of the day gave a detailed overview of the types of tools being developed and used to assess movements of cod throughout the region. It was reiterated that this section only presents raw, un-weighted data and as such, attempts only to show the observations of actual movements indicated by the data. It was further noted that the seasonality of releases and recaptures can affect how this data is interpreted since if no fish are released in a given area at a given time of year, the movement of fish from that area at that time of year will not be evident. Figure 2 shows that the peak time of year for tag releases for the Program as a whole was the spring months, with fewer fish being tagged and released at other times of year. From this we can imply that if fish were released in smaller numbers at different times of year, their movements will appear less significant unless the data are weighted.

The scale of spatial analysis (see Annex 4) presented was mostly at the General Area resolution, with some analysis at the Management Area resolution. Analytical models have been written which enable fish movements to be analyzed for:

- Distance traveled as a function of fish size and time at large;

- Distance traveled relative to release location;

- Direction traveled (including circular statistics) as a function of release location;

- Evidence of seasonal homing trends (related to spawning?) through analysis on mean distance traveled for different release and recapture seasons and also fish size;

- Sequential seasonal movement trends observed by **release** polygon for each release season (presentation of animated movements);

- Sequential seasonal movement trends observed by **recapture** polygon for each release season (presentation of animated movements);

- Movements observed for individual tag release events (examples presented were from Cape Cod waters, presentation of animated movements);

- Generation of a preliminary "passages of travel" figure summarizing the primary migration paths for cod tagged and recaptured in the Gulf of Maine region.

Figure 2: The seasonality of releases and recaptures for the NRCTP to date: fluctuations in releases periods were dictated by when different tagging organizations planned to tag cod (primarily spring and fall) and when cod were available to tag, while fluctuations in recapture rates likely follow fluctuations in fishing effort.
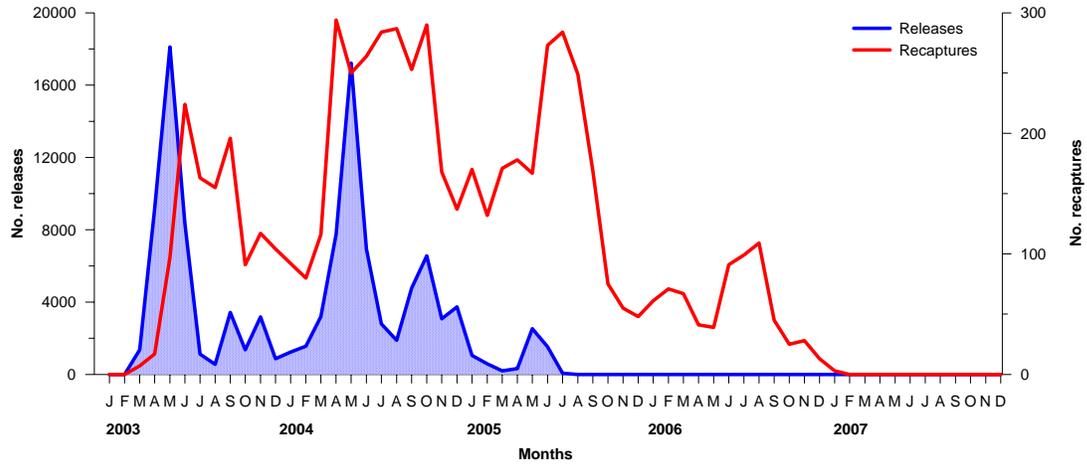
Figure 3: A preliminary depiction of "passages of travel" which summarizes the primary migration paths for cod tagged and recaptured in the Gulf of Maine region. NOTE: this is based on raw, un-weighted data and serves to indicate only the major paths of migration, not necessarily the magnitude of these migrations.
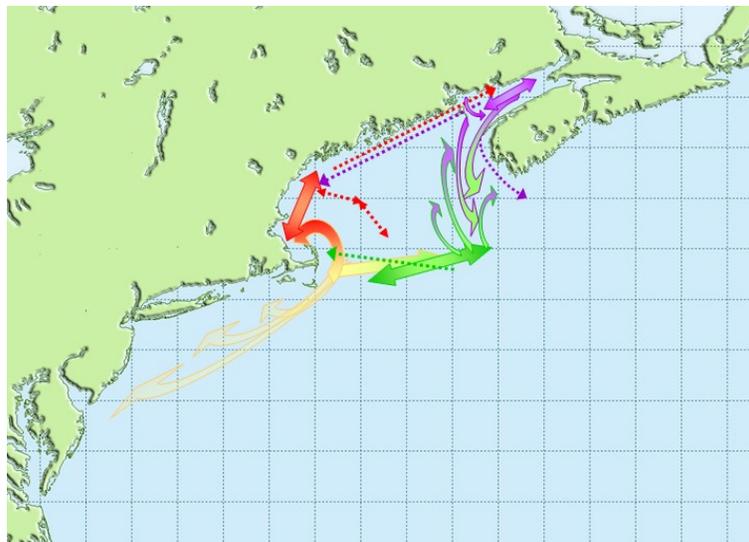
4.1   Discussion points from participants

Seasonality of tagging & fishing

- For future studies we should find spots where we can consistently tag and then tag there at specific times of year (David Martins). **Response 1:** Pulse tagging has been recommended before [by Mark Terceiro], but still the reality of definitely finding the required number of fish each target month or season at the same location may still not be feasible and we're still likely to fall short sometimes (Shelly Tallack). **Response 2:** To some extent, when fish are around they have been tagged and when they're not around, they aren't tagged, this may be as good as we can hope for (Don Clark).

- Tagging during the day vs. tagging at night will produce different results (Tony Pereira, FV Blue Seas II). **Response:** Yes, this was a point made during one annual meeting and certainly there were no restrictions on whether the Program tagged by day or night, this was more what was decided by the tagging organization or vessel captain (Shelly Tallack).

Fish movements and factors involved

- How do you take account for the regulatory impact since there aren't any recaptures in the closed areas except for by recreational fisherman or at certain times of year (Bob Tetrault). **Response:** this is difficult to account for, it's easier for permanent closures but tricky for rolling closures (Shelly Tallack). There is some effort in closed areas, including recreational fishing and surveys, just not commercial effort (Bill Hoffman, MADF).

- Larger fish move furthest (David Martins, as noted by Bob MacKinnon). **Response:** This is not what is seen in this NRCTP dataset; medium sized fish moved the furthest, but the largest fish (>93cm at release) move shorter distances, though this may in part be due to where these larger fish were located in this study (i.e. inshore GOM) and the fact that most fish from this area do not seem to move far (Shelly Tallack).

- Movement effects seen are likely associated with foraging and spawning (Bob Tetrault, Shelly Tallack). If you want spawning fish, you need to tag at night (Curt Rice, FV Robert Michael) and depth will also affect where spawning cod are (Mark Terceiro); the spawning time of year will also vary by area (Tony Pereira, Fred Marques, FV Voyager); to get spawning fish, you need to fish inland and in closed areas (Bob Tetrault). If you look at the Georges Bank trip in April/May 2004 you will see many spawning fish (David Martins). This study did not target the real spawning grounds, e.g. in Saco River (Bob Tetrault).

- Fish in one school will stay together (Tim Tower, FV Bunny Clark); Tim tracked them and found, they were still together after a long period of time. **Response 1:** It will be interesting to look at batch releases (e.g. large tagging events like that on Georges Bank in Spring 04) (David Martins). **Response 2:** Some of the Cape Cod trips have already been analyzed for this type of group fidelity and are presented later today, we also see this when we look at some of the DE releases for large trips in e.g. Jordan Basin or fish released in Passamaquoddy Bay, these fish all move together either into the Bay of Fundy, or southwards into deeper Canadian waters (Shelly Tallack).

- We should look at how herring migration studies relate to cod movement, especially downeast ME (Ted Ames). **Response 1:** Herring move further than cod so cod you might catch herring as they go by and follow the herring for a while (Don Clark). **Response 2:** We should look at how cod migrations follow other species on Georges Bank, like sand eels, herring and moon snails (Tony Pereira). Spawning cod in inshore Gulf of Maine disappeared when alewives disappeared, how do we tie forage stocks to cod stocks? (Ted Ames).

5. Quantification of mixing

5.1 Weighting of releases and recaptures

Appropriate weighting of data is crucial for providing accurate estimates of movement and mixing between areas (weighting may not be necessary when doing within-area analyses, Don Clark); this is particularly true for the NRCTP data since the experimental design did not plan for releasing tagged cod in numbers relative to biomass present. It had been decided previously, through a combination of meetings with NMFS and DFO that the weighting approach taken by Hunt *et al.* (1999) should be used as a starting point. The weighting needed is summarized in Figure 4.

Figure 4: The components involved in weighting tag releases and tag recaptures, after Hunt *et al.* (1999), with modifications.
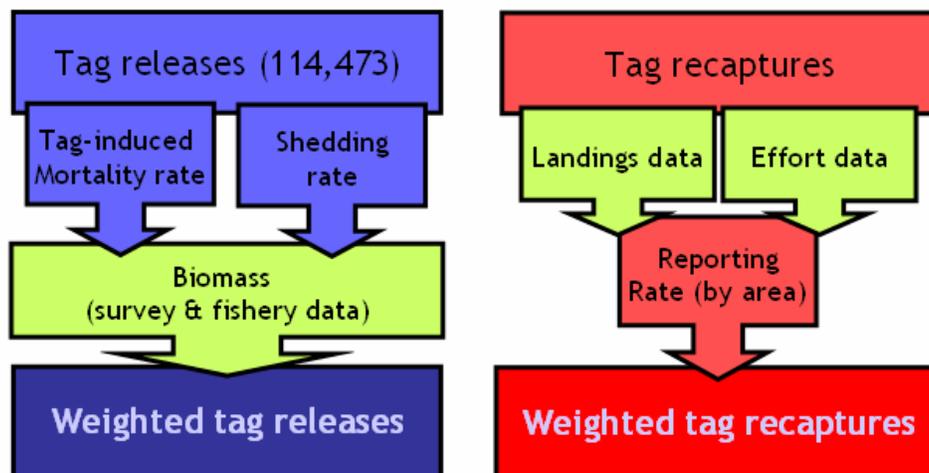
Weighting of tag releases

Tag shedding: The tag shedding rate for this Program's dataset is estimated at 15.6% (i.e. 15,137 single-tagged cod). This estimate has been obtained by determining the proportion of double-tagged cod which have been recaptured and only one tag has been reported. Further detail on shedding analysis has been presented in previous meetings and reports (e.g. End of Year 3 Meeting, Final Report June 2006) and in this workshop was limited to showing that it was not significantly affected by tag color (e.g. yellow vs. orange) or by tagger type (e.g. fishermen vs. scientist taggers).

Tag-induced mortality: This Program did not have funding to undertake specific tagging mortality work. Thus an estimate of tag-induced mortality has been taken from literature on cod tagging elsewhere. Tagging mortality observations by CCCHFA were also considered, though sample numbers were very low and all fish used were small fish. The tag-induced mortality estimate used in all models run to date is 9% (i.e. 10,325 tagged cod).

Biomass weighting: A total of four different tag release weighting scenarios are currently being run: 1) raw, un-weighted data, 2) weighted by biomass (NMFS/DFO survey data) (i.e.

fishery independent index), 3) weighted by catch per unit of effort (CPUE) data (i.e. fishery-dependent index), and 4) weighted by Virtual Population Analysis (VPA) data. It was shown that each method 'distributes' the number of tag releases (after accounting for tag shedding and tag-induced mortality) slightly differently between tagging areas while keeping the overall number of tagged cod released constant (Table 1). Future analysis (post-weighting) will include stepwise multivariate GLM (General Linear Model) analysis to determine the relative sensitivity of reporting rates to fish size at initial release.

Table 1: The relative 'distribution' of tagged cod releases, after removal of tag-induced mortality and tag-shedding, and after weighting by biomass, CPUE and VPA data.

Management area	RAW tag releases			Relative Distribution (%)			
	Total	Low-reward tags	Less tag losses (shedding & tag-induced mortality)	Raw	Biomass	CPUE	VPA
GOM-5Y	25,515	24,324	19,604	22%	32%	8%	11%
GB-5Z	80,230	79,386	63,004	71%	54%	79%	70%
CA-4X	8,467	8,267	6,502	7%	14%	13%	19%
Total	114,212	111,977	89,110	100	100	100	100

Weighting of recaptures

Landings and effort data: Recaptures are weighted in part relative to the amount of fishing activity per polygon, as determined by both landings data and effort data (i.e. exploitation rate).

Reporting rates: Recaptures are then further corrected by estimating a reporting rate, which is determined for a given polygon by the difference in return rates of regular vs. high-reward tags. Considerable attention was paid to factors affecting reporting rates but detail on analyses is not presented here since it is already documented in the June 2006 NRCTP Final Report (http://www.codresearch.org/GMRI_Final_Report_2003-2006.htm. The reader is referred to this report for more detail. The key factors may be summarized as follows:

- Tag shedding rates (~15%) (see p.8);
- Tag-induced mortality rates (~9%) (see p.8);
- No. of tags released relative to fishing effort (Figure 5);
- Seasonality of tag releases & recaptures (also linked to fish availability and fishing effort) (Figure 2);
- Catchability (e.g. fish size & gear);
- Effectiveness of outreach;
- Ease of reporting procedure & responsiveness of program;
- Willingness of tag reporters to report tags;
- Tag type/color – visibility & bias.

Reporting rates by gear type: Don Clark (DFO) then presented more detailed analysis on reporting rates by gear type by statistical square. In summary:

- **Hook caught-tags:** Most tags were returned in area 521, but a lower percentage were in other regions.
- **Otter trawl-caught tags:** Most regular tags caught by otter trawl were returned, except in 5Y (Gulf of Maine) and Western Bay of Fundy (4Xs)
- **Gillnet-caught tags:** A high proportion of tags caught by gillnet were not returned, the proportion returned was particularly low in 5Y (Gulf of Maine).

Figure 5: The number of tags released and recaptured, relative to total catch (a proxy for fishing effort) at GA resolution. It is evident that in some areas no tagged cod were released so any recaptures are fishing moving into that area; in other areas the number of tagged cod releases are very high relative to landings (e.g. Cape Cod area). This figure shows why it is important to weight the tag releases by some measure of biomass/fishing effort before attempting to interpret movements.
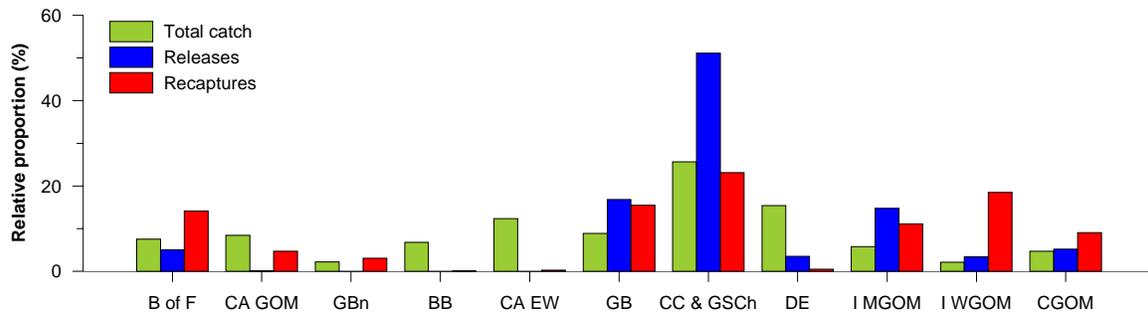

5.2   Mixing rates

Models to quantify relative residency of cod in a given polygon and mixing rates between polygons have been developed. These run on release and recapture data in both the raw and weighted state. During the workshop, examples of how these models work were presented at the resolution of Management Areas. However, these models can be applied to any of the polygon areas defined earlier (p.4) and they allow us to determine the level of residency within an area (Figure 6) the proportion of immigration and emigration between areas (Figure 7). These data can then be displayed in a manner which shows the relative residency/exchange between areas; the example included here is for release/recapture data weighted by the biomass method (Figure 8).

Note: This is the first time these models have been presented to the group and for the sake of simplicity and time efficiency, the chosen resolution of analysis was Management Areas; furthermore, the data were pooled (2003-2005) to just show the workings of the model. Future analysis will be more refined, addressing finer spatial resolution (e.g. statistical squares and General Areas) and temporal resolution (e.g. analysis by year, or by quarter if possible).

Figure 6: Preliminary estimates of residency within stock Management Areas; applied to raw data and data weighted by biomass, CPUE and VPA.
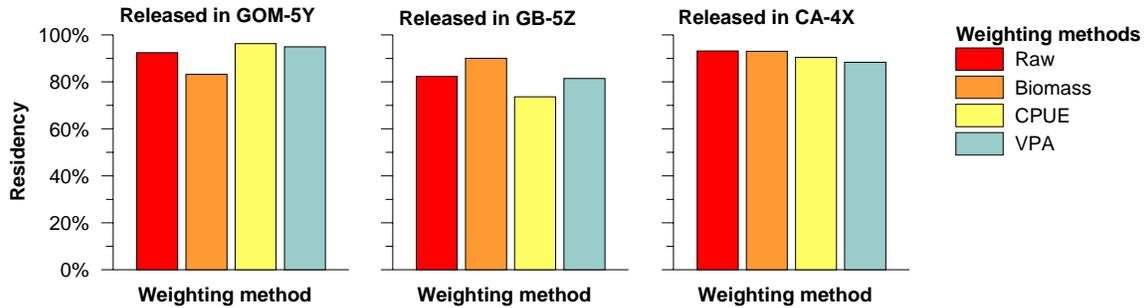
Figure 7: Preliminary estimates of emigration/immigration between stock Management Areas; applied to raw data and data weighted by biomass, CPUE and VPA.
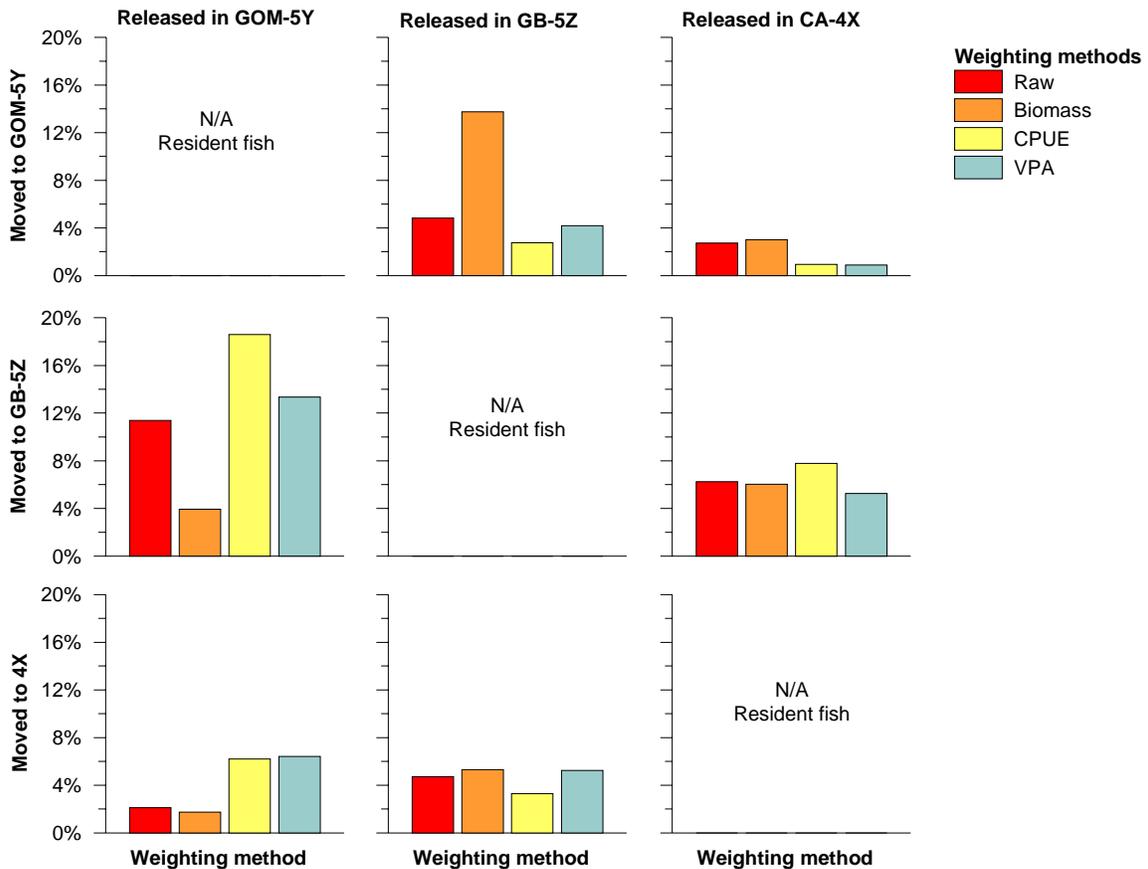
Figure 8: An example of depicting mixing between stock Management Areas; this example is on data weighted by biomass (survey data). Arrows indicate emigration/immigration while the boxes indicate the proportion of recaptures caught with the same polygon they were released in.
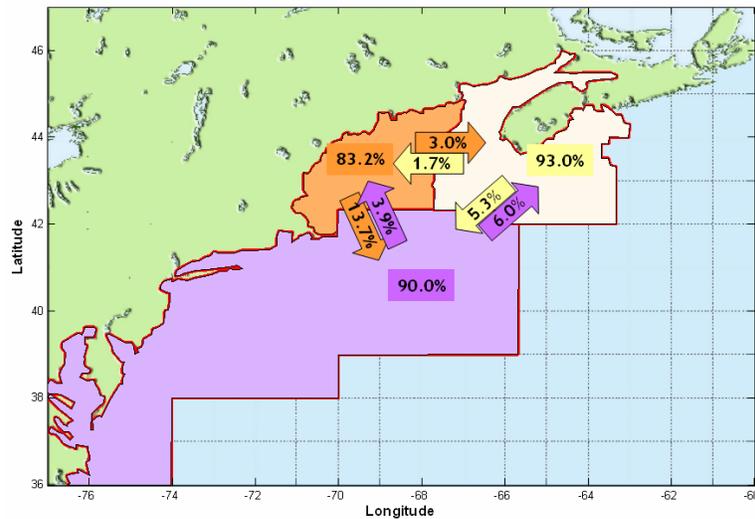
5.3   Discussion between participants

RE Catchability by fish size

- You only find big fish inshore (David Goethel and Bob Tetrault).

- Are there mortality differences in gear or size? Look closer at >60 cm fish since they are usually close to 100% landed (David Goethel). [Analysis to this effect was shown: When looking at gear effects and size effects, analysis has been also run on legal sized fish only and differences between return rates by fish size and gear type were still found; catchability increases with increasing fish size, and trawl-released fish (which tend to be larger) are caught reported more frequently than hook-caught fish (which were smaller in this study)]. **Response:** It is easy to further filter the dataset and in future, we could also run the weighting and mixing analysis on just legal fish (e.g. >63 cm), and maybe also on sublegal fish as a separate analysis (Shelly Tallack).

RE Reporting rates

- Would it not have been better to keep the lottery, rather than the HR tags (John Shusta)? **Response:** The high-reward tags had a different purpose, to calibrate reporting rates, and we only had a budget for two years of a lottery (Shelly Tallack).

- Closed areas have an effect on reporting rates. How do we take this into account within the polygons we are addressing?

- How do we reach the parties who aren't reporting tags? How do we deal with people who catch a cod as bycatch that they're not supposed to land? (David Goethel). **Response:** We only need the tag, not the fish so this should still be possible, but people don't necessarily want to show that they even catch cod. How we overcome this I don't know (Shelly Tallack).

- The IBS (Industry Based Survey) has 100% reporting rate on tagged fish, you could use this to look at reporting rates (Bill Hoffman). **Response:** Yes, we have discussed this before, and we can certainly try to incorporate this calibration. We have also talked about looking at reporting rates by observers, and reporting rates by tagging vessels during tagging trips (Shelly Tallack).

RE Weighting & mixing rates

- RE tag-induced mortality, since you don't have hard information available on tag-induced mortality rates, can you try to incorporate estimates of regular discard mortality from different gear types (apportioned to cod tagged and released by different gear types)? (Kohl Kanwit, DMR). **Response 1:** We can look into this, providing that there are good estimates of discard mortality estimates by gear types (Shelly Tallack). Repsonse 2: I don't think there is enough information on discard mortality rates by gear type for cod (Don Clark).

- Why was it not decided before the Program started to release tags in relation to biomass so we didn't need to worry about weighting (John Shusta). **Response 1:** We need to keep improving protocols of tagging programs and this is a good example of a program that has done that (i.e. no other tagging programs have the protocol on waterproof paper), there is lots of tagging occurring, there is lots of unused data (i.e. shark), how do you get the biggest bang for your buck (John Hoey, NMFS). **Response 2:** Mixing rates were not original goals of the Program, as such weighting was not as important, but as people have seen the quality of data this Program has obtained we are trying to get more out of it, so now weighting is needed (Don Clark). **Response 3:** Also, different tagging organizations had different goals in terms of numbers of tags they planned to release. Overall, there is a learning curve associated with tagging programs and this program has not only evolved as a result, but events like the October 2004 Mark-Recapture Workshop (http://www.codresearch.org/WS/PROCEEDINGS_Fish_M-R_Workshop_Oct_2004.pdf) provided a great way for multiple regional tagging projects to come together and learn from each other; weighting was just not identified at the outset so we're taking care of it now. It's not the end of the world, it's just a step that we have to now include.

- The next step in the analysis of mixing rates is to undertake the analysis on 'hot-spot' areas, at the statistical square resolution. It will be important to do this year by year, and also to provide a net rate of exchange between areas. This is the level of detail which will be necessary for presentation to the cod stock assessment group (Mark Terceiro).

6. Delivery of data to NEFSC & use in management

The value of tagging data was discussed in relation to stock assessments. It was highlighted that the key deliverables from this Program's data should be to provide stock assessment scientists at the Northeast Fisheries Science Center (NEFSC) and Canada DFO with: 1) an estimate of immigration, emigration for the management areas (i.e. mixing rates), and 2) and an estimate of growth.

John Hoey is responsible for ensuring that the stock assessment teams have access to additional historical tagging datasets. GMRI will have completed the required analysis in the next six months for presentation at an upcoming workshop (planned for August/September 2007), which will focus on the application of tagging data in stock assessments. This workshop will investigate data issues and modeling approaches (Mark Terceiro).

After presentation to the cod stock assessment team, if it is decided that migration evidence suggests that a change in stock assessment methodologies is required, this will have to take place in time for the 2008 Benchmark stock assessments, when all major groundfish will be re-assessed (John Hoey).

Making sure that fishery managers also see these results will be key to ensuring that the tagging data is considered in future management efforts.

6.1 Discussion between participants

- How do we get this data out to people? Aside from Fishermen's Forum, scientific meetings, fishing association meetings etc (Shelly Tallack). **Response 1:** Only a small percentage of people are really interested unfortunately. You can't go all over talking to small groups of people, we need to produce a video or an online presentation or DVD to distribute around, have an interactive Q&A session online, or have a symposium on tagging programs at the NEFSC. Show the time-series data like you showed today (David Goethel). **Response 2:** Maybe we could try to broadcast something like this on local TV networks, public access channels or something like that (Earl Meredith, NOAA Fisheries). **Response 3:** Have a link on the Census of Marine Life web page (Ted Ames).

- Fine-scale analysis would be most interesting and from what I've seen today, this could be used as a tool to better manage and protect a stock; if you see the extent of movement, you can practice sustainable fishing accordingly. Include this in future presentations (Ted Ames).

- Fishermen need a success story to get behind collaborative research, so far there have been few examples of when fisheries research has led to an improvement in the regulations on fishing (Curt Rice).

- Show the ebb and flow of the fish movements, e.g. those shown for inshore GOM waters; this will encourage better stewardship within fishing groups (Curt Rice).

- Carolyn Woodhead – have a collaborative research meeting. **Response 1:** Make sure people from the council are at the meetings (Ray Kane). **Response 2:** We need to get this Program put on the Agenda to present to the Council (David Goethel).

- Someone at the NEFSC recently showed water temperature analysis; is there a way to look at the cod data in relation to this? (Phil Rule). **Response 1:** This is something I've been wanting to get to, but it's not realistic within the current contract's time frame (Shelly Tallack). **Response 2:** This would be a big task and is better left as a suggestion for future analysis ideas rather than trying to do this by the next workshop (Don Clark).

7. Wrap-up & review of analysis requests

The findings of the warm-up exercise (Figure 1) were presented back to workshop participants. On the whole it appeared that most people were enthused by what had been presented and the fish movements shown were generally in line with findings from past, more localized studies but by seeing releases throughout the region all at once, it was possible to show the overall movements in the same time frame (i.e. March 2003 – March 2007). Possibly the biggest surprises were the links between Cape Cod and the nearshore Gulf of Maine waters, and the strong links between Downeast ME / Bay of Fundy with Georges Bank.

A summary of the key recommendations made during the course of the day is presented in Table 2 with level of priority / realistic achievability indicated.

Table 2: Suggested priority actions to focus on before the second workshop; 'other' tasks were considered too large to attempt in the two-month time frame available.

Priority	Description
1	Refine estimates of reporting rate by gear type by region, work this into the current weighting models. (If possible, look at incorporating IBS/observer reporting rates into this).
2a	Look at 'hot spots' where high interaction appears likely. Re-analyze on the resolution of statistical squares; this will avoid masking movements because the scale of analysis is too large.
2b	Repeat analysis for each year. Are there inter-annual consistencies? Maybe even look quarter by quarter if data allows?
2c	Provide a net movement; i.e. if X% move from A to B and Y% move from B to A, what is the overall net exchange between A and B?
3	High-reward tag reporting rates, refine this calculation further by just looking at reporting rates from May 2004 onwards (when high-reward tagging started) and then extrapolate this backwards.
4	Filter the dataset by fish size and re-run the weighting and mixing analysis on just legal fish (e.g. >63 cm), and maybe also separately on sub-legal fish.
5	It was suggested that the polygons used (particularly those at the General Fishing Areas resolution) may need some tweaking of boundaries. As such, attendees will be provided with a map on which to draw suggested polygons and where there appears to be consensus, modifications to the polygon areas will be made.
Other	
1	Involve water temperature analysis within movement/mixing analysis. Use NEFSC temperature survey data. Contact Dave Mountain (NMFS)?

8. References

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9. Acknowledgements

Annex 1: Attendees of the NRCTP Industry-Science Workshop 1.

Industry/Science	First	Last	Affiliation	Phone	Email
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Annex 2: Agenda for the Northeast Regional Cod Tagging Program, Industry-Science Two-part Workshop – Workshop 1.

Thursday, March 1st 2007
Joe's Dockhouse, South Portland, ME 04106

8.30	**Breakfast** (coffee & pastries)
9.00	**Introductions**
9.05	**Warm up exercise**
9.15	**Review of Program history**: - Background & aims - Review of and familiarization with data collected - Review of data and general analyses
10.15	**Break** - refreshments
10.30	**Movement & migration** - Descriptive analysis of movement patterns - Impacts of season, region, fish size, etc. - Suggestions from participants
11.30	**Quantification of mixing: Part 1** - Data requirements – weighting releases & recaptures - Reporting rates
12.30	**Lunch** – Buffet lunch provided, walk to Spring Point Lighthouse if you feel like it! (http://lighthouse.cc/springpoint/)
1.30	**Quantification of mixing: Part 2** - Movement and migration after weighting analysis - Suggestions from participants
2.30	**Delivery of data to NEFSC & use in management** - Plans for this information - Future presentation/audiences - When will the data be considered in management? - Suggestions from participants
3.00	**Break** - refreshments
3.15	**Wrap-up & review of analysis requests** - Prioritization of key future analysis - Review of warm-up exercise
4.00	**End**

Annex 3: A list of relevant web pages associated with key documents or components of the Northeast Regional Cod Tagging Program.

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Program website - http://www.codresearch.org

Database mapping website - http://www.gmamapping/codmapping.htm

Industry-Science workshops: Information about the two industry-science workshops (i.e. today's and the next one), in addition to summary materials produced from this workshop, will be downloadable from:

http://www.codresearch.org/IndustryScienceWorkshop.htm

Final Report from this Program's first 3.5 years is available at:

http://www.codresearch.org/GMRI_Final_Report_2003-2006.htm

Proceedings from the Mark-Recapture workshop (October 2004):

http://www.codresearch.org/WS/PROCEEDINGS_Fish_M-R_Workshop_Oct_2004.pdf

All past and current Program posters are viewable at:

http://www.codresearch.org/Program_posters.htm

Analysis to date – this page is likely to be the page receiving most updates in future months as we begin posting more of our findings online.

http://www.codresearch.org/Analysis_to_date.htm

Annex 4: The spatial polygons created for analysis at different resolutions; most analytical programs being developed will have the capacity for application at each resolution.