DEUXIÈME REUNION DU GROUPE DE TRAVAIL DE GESTIONNAIRES DES PECHERIES ET D'HALIEUTES EN APPUI À L'EVALUATION DU STOCK DE THON ROUGE DE L'ATLANTIQUE OUEST

Île du Prince Édouard (Canada), 10-12 juillet 2014

1. Ouverture de la réunion

La Ministre canadienne des pêches et des océans, l'Honorable Gail Shea, a souhaité la bienvenue aux participants à l'Île-du-Prince-Édouard, et a souligné l'importance que revêt le thon rouge pour les communautés de pêcheurs et la nécessité de poursuivre les investissements aux fins de la collecte de données qui contribueront à dissiper les incertitudes actuelles planant sur la science. Elle a clôturé son allocution en notant la volonté commune d'assurer la durabilité de cette pêcherie et a souhaité aux délégués une réunion productive (**Appendice 3**).

2. Élection du Président

Mme Sylvie Lapointe (Canada) et le Dr Josu Santiago (Président du SCRS) ont été élus aux fonctions de co-présidents du Groupe de travail.

3. Adoption de l'ordre du jour et organisation des sessions

Les co-présidents ont souligné l'importance du dialogue actuel entre les scientifiques et les gestionnaires, car il aidera le SCRS à adapter ses travaux dans le but de soutenir plus efficacement les besoins de la Commission.

Après avoir apporté une légère modification à l'ordre du jour, celui-ci a été adopté (**Appendice 1**).

Le Secrétaire exécutif a présenté les CPC suivantes participant à la réunion : Canada, États-Unis, Japon, Mexique et Union européenne. En outre, les observateurs des organisations suivantes étaient présents : American Bluefin Tuna Association, Blue Water Fishermen's Association, Ecology Action Center, The Ocean Foundation, Pew Environment Group et the David Suzuki Foundation. La liste des participants est présentée à l'**Appendice 2**.

4. Désignation du rapporteur

Les États-Unis ont proposé que Mme Rachel O'Malley exerce les fonctions de rapporteur.

5. Examen des résultats de la première réunion du groupe de travail de gestionnaires des pêcheries et d'halieutes destiné à soutenir l'évaluation du stock de thon rouge de l'Atlantique Ouest et de la 23^{e} réunion ordinaire de la Commission

Le Dr Santiago a attiré l'attention sur certaines activités concernant les recommandations émanant de la première réunion des gestionnaires et des halieutes destiné à soutenir l'évaluation du stock de thon rouge de l'Atlantique Ouest, ainsi que sur le calendrier des plans de travail actuels du SCRS. Une mise à jour de l'évaluation des stocks de l'Est et de l'Ouest sera réalisée en septembre 2014 et une évaluation pilote du stock de l'Est sera également effectuée en utilisant de nouvelles informations incluant les données de prise par taille de la pêcherie à la senne de la Méditerranée. En ce moment, il est toujours prévu de réaliser une évaluation complète en utilisant de nouvelles méthodologies pour les deux stocks en 2015 et les travaux de développement d'une évaluation complète de la stratégie de gestion se poursuivront. Toutefois, les plans de travail seront examinés et pourraient être révisés lors de la réunion du SCRS de cet automne. Le Dr Santiago a fait part de son inquiétude quant au fait que les données essentielles de marquage électronique ne sont pas encore disponibles et a indiqué que celles-ci devraient être fournies dès que possible. Il a également indiqué que le financement complet du Programme de recherche sur le thon rouge englobant tout l'Atlantique (GBYP) est crucial.

Le Canada, le Japon, le Mexique et les États-Unis ont fourni des mises à jour sur les activités de recherche en cours de réalisation.

6. Examen des plans de recherche élaborés par les CPC

Le Dr Craig Brown a présenté les propositions des États-Unis visant à améliorer les informations scientifiques pour l'évaluation du stock de thon rouge (**Appendices 4 et 5**), qui comprenaient l'élaboration d'une étude pilote pour un indice d'abondance d'âge 0 s'appliquant au thon rouge et l'ampliation de la prospection larvaire actuelle, l'amélioration de la collecte actuelle de matériel biologique et l'élaboration d'une approche génomique (à savoir l'application d'une analyse de similitude (« close kin ») pour estimer l'abondance du stock reproducteur).

Le Dr Gary Melvin a présenté la proposition du Canada concernant le développement et la mise en œuvre d'un indice d'abondance indépendant des pêcheries concernant le thon rouge du golfe du Saint-Laurent au moyen d'une étude acoustique à la ligne trainante (**Appendice 6**).

Le Dr Michael Stokesbury a présenté la proposition du Canada concernant une étude de marquage-recapture du thon rouge dans le golfe du Saint-Laurent (**Appendice 7**).

Le Dr Tomoyuki Itoh a présenté la proposition du Japon concernant un plan de recherche pour identifier de nouvelles zones pour obtenir de nouveaux indices d'abondance, ou des indices améliorés, dans le centre de l'Atlantique Nord (**Appendice 8**).

Le Dr Alex Hanke (Canada) a donné une présentation sur l'application potentielle d'un modèle de production excédentaire en conditions de non-équilibre pour évaluer le stock de thon rouge de l'Atlantique Ouest (**Appendice 9**).

Le Dr Gary Melvin a donné une présentation sur des considérations visant à améliorer les indices utilisés par les gestionnaires (**Appendice 10**).

Le Dr Tomoyuki Itoh a présenté un document de travail sur la couverture des données halieutiques pour le stock de thon rouge de l'Atlantique Ouest (**Appendice 11**).

Certaines approches appliquées récemment pour étudier le thon rouge du Sud sont prometteuses aux fins de l'étude du stock de thon rouge de l'Atlantique Ouest. Il a été reconnu que différentes initiatives pourraient être conçues afin de se compléter mutuellement, par exemple en offrant la possibilité de recueillir du matériel biologique. Une approche coordonnée d'échantillonnage biologique pourrait être une façon efficace d'identifier et de compléter les lacunes en matière de données. Les indices actuels pourraient être améliorés en déployant davantage d'efforts dans le but de tenir compte des effets des changements des pratiques ou modes de pêche, des conditions environnementales et des réglementations de gestion susceptibles d'affecter la CPUE.

Il a été généralement convenu que les prospections et les programmes d'échantillonnage devraient couvrir la zone géographique la plus vaste possible, même si ces efforts peuvent être limités par des questions d'ordre logistique et par le budget disponible. Un échantillonnage dans des zones plus réduites ou pendant de courtes périodes refléterait davantage l'abondance locale plutôt que les tendances globales de l'abondance du stock. Les informations fournies par de nouveaux indices ne pourraient pas être utilisées dans l'évaluation avant de nombreuses années et ces indices devraient être considérés comme des investissements à long terme plutôt que des solutions à court terme. Des membres du Groupe de travail se sont déclarés intéressés par l'exploration de potentielles zones de frai en dehors du golfe du Mexique au moyen de nouveaux travaux de prospection.

Les CPC ont convenu que toute nouvelle initiative devrait être conçue dans le but de fournir des informations qui présenteront un avantage significatif pour les futures évaluations des stocks, notamment en documentant les travaux concernant la question du recrutement. Les engagements financiers pour de futurs projets devraient être envisagés en tenant compte de leurs avantages potentiels pour le processus d'évaluation du stock, ainsi que des questions d'ordre pratique et des coûts y afférents (par exemple en tirant profit du financement actuel et des plateformes de recherche). Quelques projets peuvent être explorés par le biais d'études pilotes et pourraient être étendus dès que les variables et les limitations auront été mieux comprises. La collaboration entre les pêcheurs de thon rouge de l'Ouest et les chercheurs d'autres régions a été encouragée.

En conclusion, les Parties ont convenu que :

1) Pendant la période intersession, les scientifiques nationaux des CPC pêchant le thon rouge de l'Ouest travailleront conjointement pour explorer des domaines de collaboration, identifier les coûts et établir un ordre de priorité des nouvelles propositions de recherche débattues lors de la présente réunion. Les

résultats de ces travaux et les nouvelles propositions seront présentés au SCRS en septembre 2014 à des fins d'examen et d'évaluation. Dans le même temps, il a été reconnu que les CPC poursuivront les travaux déjà en cours (à savoir l'ampliation des prospections actuelles) et les nouveaux projets pour lesquels des fonds ont été garantis.

2) Les CPC collaboreront dans l'analyse des données de prise et d'effort non agrégées dans le but d'améliorer les indices actuels d'abondance du stock et de développer un seul indice d'abondance intégrant les données de plusieurs CPC. L'accès aux données sera partagé de manière à ne pas enfreindre les normes de confidentialité des données.

3) Les CPC poursuivront leurs efforts visant à améliorer la quantité et la qualité des données recueillies et déclarées, conformément aux recommandations du SCRS. Plus particulièrement, les CPC sont encouragées à fournir des informations sur les changements des pratiques de pêche et d'autres variables susceptibles d'influencer le taux de capture de manière à ce que ces facteurs soient incorporés dans les modèles de standardisation.

7. Examen des possibilités d'amélioration de la gestion du stock

Le Japon a suggéré que le fait de maximiser la chance de survie des juvéniles de thon rouge de l'Atlantique Ouest devrait être considéré comme une stratégie de gestion alternative. Les États-Unis ont noté que le SCRS avait déjà formulé un avis en 2012 sur la question des mesures de gestion fondées sur la taille et que restreindre davantage la prise de certaines classes de tailles entrainerait la perte de données utiles employées dans l'évaluation.

Le Groupe de travail a atteint un accord sur les prochaines étapes relatives à ce point de l'ordre du jour (**Appendice 12**).

The Pew Charitable Trusts, Ecology Action Center, David Suzuki Foundation et The Ocean Foundation ont présenté une déclaration (**Appendice 13**).

8. Autres questions

Les participants étaient tous d'accord sur l'importance de poursuivre ce dialogue, dans le cadre d'une 3e réunion du groupe de travail de gestionnaires des pêcheries et d'halieutes destiné à soutenir l'évaluation du stock de thon rouge de l'Atlantique Ouest ou dans le cadre du Groupe de travail permanent dédié au dialogue entre halieutes et gestionnaires des pêcheries nouvellement constitué. Ce point sera débattu au sein de la Sous-commission 2 à la réunion de la Commission de 2014. Une discussion est nécessaire pour établir un mécanisme de renvoi au SCRS des recommandations formulées par ce groupe de travail et le Groupe de travail permanent dédié au dialogue entre halieutes et gestionnaires des pêcheries, en tenant compte de la lourde charge de travail du SCRS.

9. Adoption du rapport et clôture

Le rapport a été adopté et la réunion a été levée.

Appendice 1

ORDRE DU JOUR

1. Ouverture de la réunion

2. Élection du Président

3. Adoption de l’ordre du jour et organisation des sessions

4. Désignation du rapporteur

5. Examen des résultats de la première réunion du groupe de travail de gestionnaires des pêcheries et d’halieutes destiné à soutenir l’évaluation du stock de thon rouge de l’Atlantique Ouest et de la 23e réunion ordinaire de la Commission

6. Examen des plans de recherche soumis par les CPC en vue d'obtenir des indices fiables d'abondance du stock de thon rouge originaire de l’Ouest

7. Examen des possibilités d'amélioration de la gestion du stock

8. Autres questions

9. Adoption du rapport et clôture

Appendice 2

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Appendice 3

DISCOURS D'OUVERTURE DE MME GAIL SHEA, MINISTRE DES PECHES ET DES OCEANS DU CANADA

Merci d'être venus de différents pays afin de participer à cette importante réunion.

Je vous souhaite la bienvenue au Canada et dans ma province natale, l'Île-du-Prince-Édouard. Je suis très heureuse d'être ici à titre de ministre des Pêches et des Océans. Je suis revenue à ce portefeuille l'an dernier, et c'est avec beaucoup de plaisir que je travaille dur, de nouveau, au nom des pêcheurs canadiens.

Je suis très fière d'affirmer que le Canada dispose de l'une des pêches au thon les mieux gérées au monde — une pêche fondée sur des avis scientifiques, dont la gestion est efficace et l'application stricte.

La pêche du thon rouge de l'Atlantique Ouest pratiquée au Canada s'effectue de la même façon depuis des décennies, avec de petits bateaux de pêche côtière dans de nombreuses petites collectivités de pêcheurs. La municipalité de Tignish, où j'ai grandi, illustre bien cet état de choses. Bien que les pêcheurs de Tignish ne puissent pêcher qu'un thon rouge chaque année, c'est assurément un événement qu'ils attendent tous avec impatience. La pêche est également importante pour les pêcheurs de thon des autres provinces du Canada atlantique, soit Terre-Neuve-et-Labrador, le Nouveau-Brunswick, la Nouvelle-Écosse et le Québec.

La pêche de cette espèce emblématique est intense des deux côtés de l'océan Atlantique. Par ailleurs, la Commission internationale pour la conservation des thonidés de l'Atlantique, qui compte 49 membres, constitue une organisation importante. Pour que la Commission réussisse à gérer de façon durable les stocks de poissons grands migrateurs dont elle est responsable, des réunions comme celle-ci sont essentielles.

Manifestement, nous avons tous un intérêt dévolu dans l'avenir du stock de thon rouge de l'Atlantique Ouest et dans la santé du stock de thon rouge de l'Atlantique Est.

Comme plusieurs d'entre vous probablement, je sais que l'industrie canadienne a exprimé certaines préoccupations. Elle est déçue parce que les sacrifices qui ont été faits sous forme de réductions des quotas et les investissements majeurs dans la recherche scientifique n'ont pas été suffisants pour nous permettre d'aller de l'avant au cours des dernières années.

Je sais qu'une réunion très fructueuse a eu lieu l'année dernière à Montréal; les participants y ont souligné de nombreuses incertitudes liées à l'évaluation des stocks de thon rouge dans l'Ouest et ont insisté sur la nécessité d'obtenir des données nouvelles ou de meilleure qualité pour nous aider à faire passer le recrutement de faible à élevé.

Comme beaucoup d'entre vous, nous avons hâte de définir de nouvelles approches qui nous permettront de faire des progrès malgré les circonstances actuelles, car les preuves scientifiques dont nous disposons pour le moment ne sont pas concluantes et, pour parler concrètement, rendent très difficile pour les gestionnaires la prise de décisions relatives au stock.

Pour aller de l'avant, nous devrions axer nos efforts sur l'élaboration d'outils qui fournissent des avis scientifiques plus clairs et plus pratiques, et qui assurent la santé du stock afin qu'il puisse continuer à procurer des avantages économiques considérables aux communautés riveraines. Pour ce faire, des réunions comme celle d'aujourd'hui — qui regroupent des scientifiques et des gestionnaires — sont nécessaires et extrêmement utiles.

Pour faire confiance à la science, il faut avoir des données pertinentes, et je suis fière de mentionner que le Canada joue un rôle actif à cet égard. Nous continuons d'investir des ressources importantes en vue de lever les incertitudes dans l'évaluation du stock de thon rouge de l'Atlantique. En fait, le but de cette réunion est d'examiner les propositions qui visent soit à améliorer les indicateurs de l'état du stock existants soit à mettre en place des indicateurs complètement nouveaux. Il est encourageant de voir les propositions du Canada, des États-Unis et du Japon à ce sujet.

Il faudra attendre un certain temps pour que les résultats de tout nouvel indice soient fiables du point de vue statistique, mais j'espère que ces nouveaux indicateurs de l'état des stocks constitueront la base de judicieuses décisions de gestion axées sur les données scientifiques pour les années à venir. Cela assurera la durabilité à long terme de cette importante pêche pour les générations futures.

Évidemment, j'encourage aussi toutes les parties à explorer des façons de réduire les incertitudes à court terme, notamment à surveiller de près toutes les pêches pour garantir l'exactitude de la déclaration des prises. Je vous invite également à envisager d'autres approches pour l'évaluation des tendances des stocks.

J'ai bon espoir que cette réunion nous permettra de trouver une façon d'améliorer la collecte des données à l'avenir.

Au nom du gouvernement du Canada, je veux souligner le fait que nous avons à cœur d'assurer la durabilité de cette pêche lucrative en augmentant nos connaissances scientifiques et en collaborant avec nos partenaires.

Je vous souhaite beaucoup de succès cette semaine, et avec un peu de chance vous trouverez un moment pour profiter de cette île magnifique!

Appendice 4

DÉVELOPPEMENT DE NOUVAUX INDICES REPOSANT SUR LE DÉBUT DU CYCLE VITAL INDÉPENDANTS DES PÊCHERIES POUR LE THON ROUGE DE L'ATLANTIQUE OUEST

(Document présenté par les États-Unis[1])

RÉSUMÉ

Des indices indépendants des pêcheries reposant sur des prospections larvaires ont été utilisés pour estimer la biomasse du stock reproducteur du thon rouge dans l'ouest de l'Atlantique Nord depuis la fin des années 70. Sur la base des récents progrès accomplis en matière de modélisation de l'habitat et d'engins d'échantillonnage, nous proposons d'améliorer les indices actuels en :

1) modifiant la grille d'échantillonnage en y incorporant un système d'échantillonnage assisté par modèle reposant sur les modèles d'habitat ;
2) accroissant l'échantillonnage stratifié en profondeur pour définir la distribution verticale des larves de thon rouge. L'efficacité des engins d'échantillonnage actuels peut ensuite être évaluée ;
3) et en incorporant les estimations annuelles de l'âge et de la mortalité des larves recueillies dans différentes régions au sein du golfe du Mexique.

En outre, nous proposons de développer plusieurs nouveaux indices :

1) Un indice des proies des larves, de la capacité de se nourrir et de croissance à utiliser dans les évaluations de stocks de nouvelle génération en tant que facteur environnemental du recrutement.
2) Le développement d'un effort d'échantillonnage des œufs de thon rouge dans le cadre du relevé standard de plancton au printemps, ce qui donnera lieu à un indice plus direct de la biomasse du stock reproducteur (SSB).
3) Les efforts d'échantillonnage exploratoire dans les Caraïbes et l'ouest de l'Atlantique Nord dans le but de déterminer l'importance et l'étendue d'autres zones de frai. L'inclusion d'autres zones de frai dans le développement des indices pourrait mieux refléter les tendances de l'abondance.

MOTS CLES

Thon rouge, recrutement, évaluation de stock

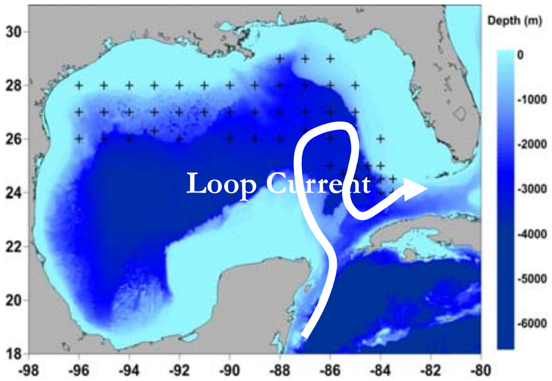
[1] John Lamkin, Barbara Muhling, Joanne Lyczkowski-Shultz, Walter Ingram, Estrella Malca, Glenn Zapfe, Trika Gerard, Andrew Millett, Sarah Privoznik

Introduction and research to date

Atlantic bluefin tuna are distributed throughout the north Atlantic and are exploited with a variety of fishing gears throughout their range. The western Atlantic bluefin stock is estimated to have declined precipitously during the 1970s and early 1980s, but has been relatively stable since the implementation of quotas in 1982. There are various uncertainties in the stock assessments; one avenue for reducing these uncertainties could be improvements in the various indices used in the models to reflect relative abundance trends. Most indices developed for stock assessment of bluefin tuna are fishery dependent, however, the NOAA Southeast Fisheries Science Center has developed a fishery independent index for the western bluefin stock using larval abundances from annual ichthyoplankton surveys. These surveys have been carried out since the late 1970s, and since 1982 have been completed as part of the Southeast Area Monitoring and Assessment (SEAMAP) program (Scott *et al*., 1993, Ingram *et al*. 2010). Larvae are collected from oblique bongo net tows to 200m depth, and surface neuston net tows across a 1 x 1° grid within the U.S. EEZ in the northern Gulf of Mexico. Sampling is conducted from late April to the end of May, with sampling continuing into June in some years. Larval abundances are converted to equivalent abundances of larvae with a first daily otolith increment per 100m^2, and standardized for spatiotemporal sampling variability. The resulting larval index, is used in stock assessment models to index the spawning stock biomass.

The index shows that larval bluefin were initially abundant from 1977-1983, but catches decreased substantially from 1984 – present (**Figure 1**). Because fish larvae are typically over-dispersed due to spawning behavior and transport of the eggs and larvae by ocean processes, the resultant catch data are zero-inflated, and not normally distributed. This typically results in a dataset with many zero values, and a very few large values, leading to a high coefficient of variation around the index (Ingram *et al*. 2010).

Gulf of Mexico plankton survey grid



Larval index, and coefficient of variation

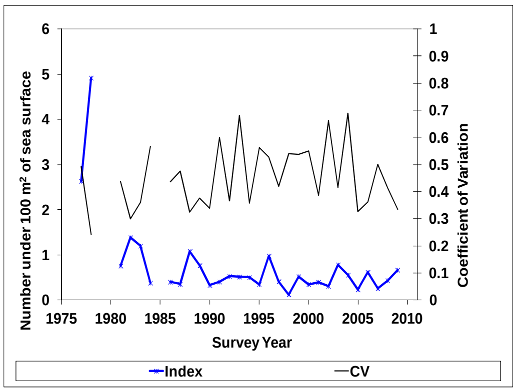


Figure 1. SEAMAP spring survey stations and the bluefin larval index and coefficient of variation.

To address this problem, work was begun in 2009 to develop a larval habitat model using historical catch data. The model used artificial neural networks to predict probabilities of larval abundance using *in-situ* environmental variables from CTD casts, and to therefore provide an additional means of standardizing the larval index. (Muhling *et al*. 2010). Results showed that bluefin tuna larvae were most likely to be collected in warm (24 – 28°C), low chlorophyll waters, outside of the Loop Current. To increase the predictive utility of the habitat model, it was then reconfigured to predict larval occurrences using only remotely sensed environmental data: sea surface temperature, surface chlorophyll, surface height, and surface current velocities. This updated model delivered similar results to the *in situ* model, and was applied to a study of the potential impacts of the 2010 Deepwater Horizon oil spill (**Figure. 2**: Muhling *et al*. 2012). Similar techniques have since been used to compare environmental constraints on bluefin tuna spawning habitat in the Gulf of Mexico vs. the western Mediterranean Sea (Muhling *et al*. 2013). Habitat models successfully predicted interannual variability in larval bluefin distributions, and highlighted the importance of water temperature to spawning activity in both regions.

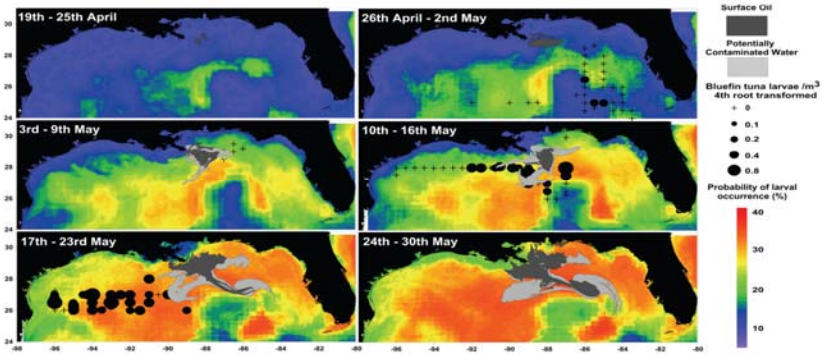


Figure 2: Predicted probabilities of occurrence for larval bluefin tuna in the northern Gulf of Mexico on a weekly basis during spring 2010. Probabilities were derived from a neural network model trained using archival larval collection data. Oil extents are derived from satellite products. Catches of larval bluefin tuna from spring 2010 (April 19th to May 23rd), are also shown.

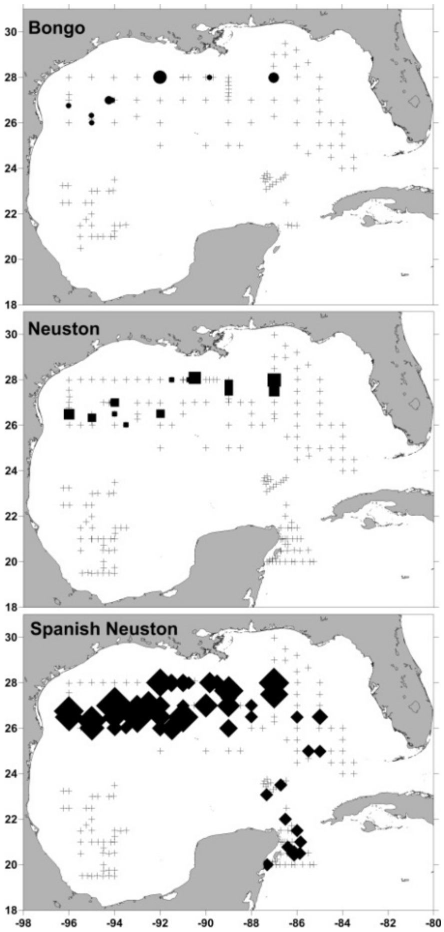


Figure 3. Bluefin tuna abundance using three gears, 0.333 mm bongo nets, 0.9 mm neuston, and 0.505 S-10 net.

One hurdle to developing the habitat model has been the low number of larvae collected each year, and the large number of zero catch stations. To address this, sampling protocols were changed to include a new plankton net (S-10) in 2010. This gear is a 1 x 2 m frame with a 0.505 mm mesh net towed in an undulating fashion from the surface to 10 meters depth for 10 minutes. This sampling method resulted in significantly higher catches of bluefin larvae, and a higher overall proportion of positive stations (**Figure 3**. Habtes *et al.* in press). In view of these results, it was decided to incorporate this sampling gear into the SEAMAP surveys, and to eventually develop a new larval index using the results from this gear.

In addition, depth-stratified sampling was initiated on the 2010 cruise, using a Multiple Opening and Closing Net Environmental Sensing System (MOCNESS). This gear samples in discrete 10 m depth increments from 50 meters to the surface, and has been deployed only sporadically to this point, due to time constraints. Initial results from this gear indicate that bluefin larvae are found primarily in the upper 20 meters of the water column.

While these efforts continue to improve the existing larval index, we propose additional efforts and the development of new indices:

Improvements to the current index

1. Expand existing sampling on annual surveys

Depth-stratified sampling has been limited to date, and as a result, the vertical distribution of bluefin tuna larvae is not well known. In order to better understand the effectiveness of our other depth-integrated sampling gears, depth-stratified sampling using the MOCNESS gear should be expanded in future years, and be made a standard component of annual surveys. Information from these samples will also be useful to ongoing studies of larval transport and dispersal potential, by providing depth distribution information for the construction of Individual-Based Models (IBMs).

In addition, the current survey grid has a very coarse spatial resolution, which, when combined with the patchiness of larval distributions, can introduce high variability in the calculated larval indices. This grid may be partially modified to incorporate a model-assisted sampling scheme (Sarndal 1992), based on predictions from habitat models. Sufficient ship-time exists for the ~30 year time series of plankton sampling to be maintained, while allowing for some adaptive sampling in areas with high probability of larval occurrence.

2. Develop a dynamic age/growth mode and predictive recruitment model

Estimates of age at length are required for the standardization of raw larval abundances to an estimate of one day old larvae under 100m^2 of sea surface (Ingram *et al*., 2010). The current estimate of age at length matrix was developed by Brothers *et al*, (1983) from specimens collected off South Florida more than 30 years ago. This estimate was initially used because survey catches from 1984 onwards had become too small to support annual estimates of mortality, and as a result, it has been applied to all larval index mortality estimates ever since. The recent advances in sampling methods noted above have resulted in greatly increased larval catches, which could allow the development of annual growth and age estimates. Recent work in the western Mediterranean indicates that larval bluefin tuna growth may vary considerably on an interannual basis, which may have profound effects on recruitment variability (Garcia *et al*., 2013). We propose to address gaps in our understanding of larval bluefin tuna growth by investigating environmental drivers of growth and mortality in the Gulf of Mexico, and developing annual age/growth curves for the eastern and western Gulf. These will be incorporated into the larval index, and will improve the accuracy of the index by accounting for interannual effects of the pelagic environment on larval growth.

Growth rates will be examined using otoliths extracted from larvae collected across a wide variety of oceanographic features from both the eastern and western Gulf of Mexico, from multiple years. Understanding these drivers is essential for improving the larval index, and also for developing a predictive recruitment model. In addition, we will examine the relationship between growth and temperature throughout the larval stage by backtracking larvae using ocean models. This will reduce variation in growth estimates and inform models of daily growth rates driven by environmental parameters. Finally, results will inform and improve the larval index by adding regional and oceanographic feature-specific growth curves.

Development of new indices

1. Larval prey, feeding success and growth index

To understand the influence of larval survival on recruitment variability, the processes that are governing larval survival must first be understood. To survive, a larva has to eat and avoid being eaten. In addition, suboptimal feeding can influence a larva's susceptibility to be consumed by a predator, by both extending the larval period via slower growth, and by reducing a larva's ability to evade predation (Houde, 1987).

Recruitment processes for bluefin tuna are not well known, but appear to be episodic, and not always closely correlated to spawning stock biomass. Apparent peaks in recruitment, as determined by abundances of 1-year old fish, may be separated by decades. Given the large departure of these peaks from long term means, it appears likely that recruitment success is determined in very early life, when larvae are subject to high and variable mortality. An improved understanding of these processes should in turn lead to improved stock assessments and more effective management (e.g. this would enable better evaluations of the likely success of stock rebuilding plans). The proposed index of larval prey, feeding success and growth will fill a long-standing gap in knowledge of larval bluefin diets, feeding and survival, and potential effects on ultimate recruitment success.

This work will combine studies of larval growth (using otoliths), larval feeding success (using gut contents) and larval prey fields (using zooplankton samples). Conditions conducive to higher feeding success, faster growth and presumed enhanced survival will be defined, initially by using existing samples from recent years (2010-present). Once favorable conditions are defined, in terms of available prey and ambient environment, an index of these can be developed. This index can be extended back to 1982, using preserved samples and specimens from the SEAMAP collection, and archived plankton samples. Results will add to knowledge of how biophysical conditions may influence larval ecology and recruitment potential, and may help to explain recruitment peaks, such as that observed in 2003. In addition, if conditions favoring high recruitment can be elucidated, we may be able to search for historical supporting evidence of any past "regime shifts", an assumption implicit in the hypothesis that the western bluefin stock-recruitment relationship has changed from High to Low Recruitment Potential. (Rosenberg *et al*., 2013). The uncertainty regarding these two recruitment scenarios is a key issue in the stock assessment process.

2. Develop and index of daily egg production with continuous eggs sampling and genetic analysis of eggs

An alternative approach to assessing spawning stock biomass is through the use of a daily egg production model (DEPM). This technique provides a more direct estimate of spawning biomass than larval abundances, as it avoids the additional error associated with larval growth and mortality. The DEPM approach has been thoroughly developed on the U.S. West Coast for small pelagic fishes (Lasker, 1985). However, it has traditionally only been used on species whose eggs are easily identifiable visually, which limits its application. With current advances in genetic techniques, many previously indistinguishable fish species can now be identified from eggs. This includes species whose eggs are collected during the annual SEAMAP survey, such as bluefin tuna, yellowfin tuna, blackfin tuna, billfish, swordfish, snappers, and groupers.

To develop this index, we will use the DEPM described by Parker, (1985): $B = ((P \cdot A \cdot W)/(R \cdot F \cdot S))$, where B= biomass estimate, P = daily egg production (# of eggs produced per area per day), A = total survey area, W = average weight of mature females, R = fraction of mature female fish by weight, F = batch fecundity and S = fraction of mature females spawning per day. Eggs are collected in the same plankton sampling gears that are currently used to collect larvae, and will be identified genetically. We expect that mixtures of eggs collected could contain genomes from many species. However, it is now possible via massively parallel DNA sequencing to identify individual collections of eggs to species, and to simultaneously yield a reasonable estimate of relative abundance. We have already designed genetic assays for many species in the Gulf of Mexico, and these genetic assays can be used to identify most fish. Species not currently in our database can be identified via searches of the Fish Barcode of Life (FISBOL) or GenBank sequence repositories or the primary literature.

*3. **Extension of sampling efforts in the Caribbean and western North Atlantic***

Several exploratory cruises in the western Caribbean Sea and Bahamas regions have been completed during spring between 2009 and 2013. Scattered collections of bluefin tuna larvae have been found in the Yucatan Channel, east of the Yucatan Peninsula, and north of the Bahamas. However, the relative amount of spawning activity that takes place in these areas is currently unknown. Current assessment models assume that larvae collected in the Gulf of Mexico encompass all of the western spawning stock. The relative importance of alternate spawning grounds therefore needs to be determined, to better test this assumption. Genetic testing of bluefin larvae collected can be used to assess the closeness of the relationship between larvae collected inside and outside the Gulf of Mexico. In addition, hydrodynamic backtracking analyses will be used to estimate original spawning locations of larvae from the Caribbean and Atlantic. This information can be combined to focus sampling efforts on particular regions in space and time, and repeated sampling across several years should be completed to determine the importance of previously unknown spawning grounds.

Of the two alternative spawning grounds identified, the area north of the Bahamas is potentially the largest (**Figure 4**). Habitat models suggest that potential spawning grounds are extensive, though it is unknown how much of the area may be utilized. The cruise in 2013 sampled only a portion of the area (**Figure 5**) but results suggest some level of spawning activity, though the extent is unknown. We propose a series of cruises in May and June over two years in this area that would cover a larger geographical extent. Approximately 200 samples would be taken in each cruise concentrated in areas identified as high probability for larval bluefin habitat.

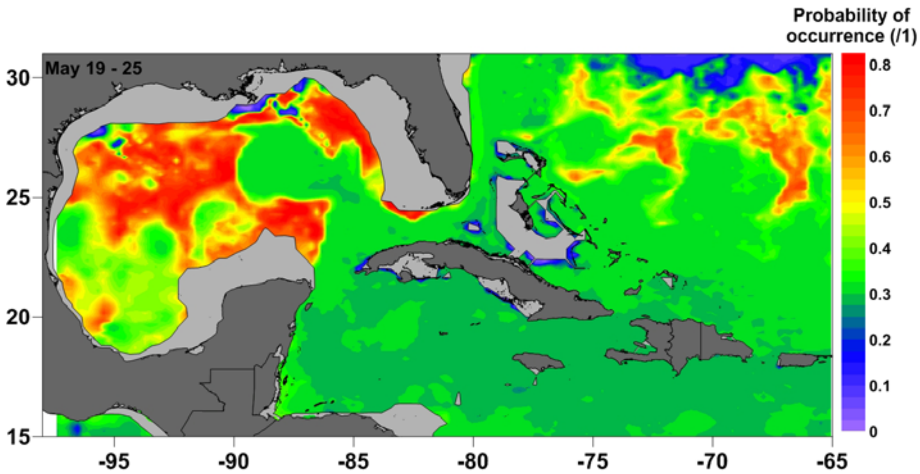


Figure 4. Probability of occurrence of bluefin tuna larvae.

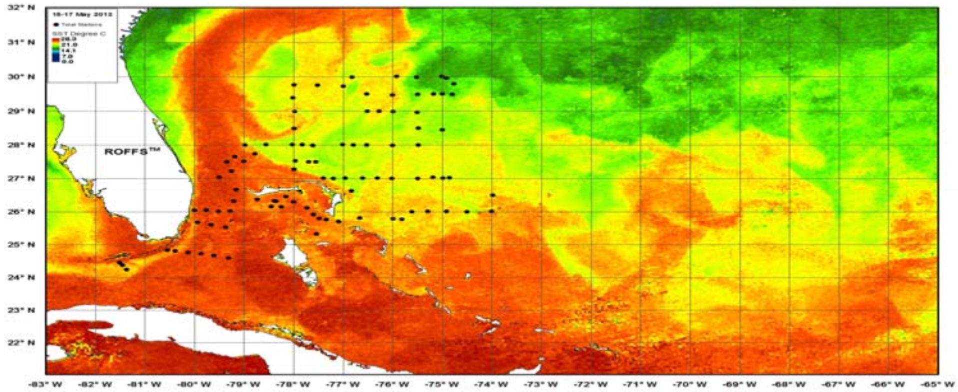


Figure 5. Stations sampled and possible extent of similar habitat.

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Appendice 5

PROPOSITIONS DES ÉTATS-UNIS CONCERNANT L'AMELIORATION DE L'INFORMATION SCIENTIFIQUE POUR L'EVALUATION DES STOCKS DE THON ROUGE DE L'ATLANTIQUE

(Délégation scientifique des États-Unis auprès du SCRS de l'ICCAT)

RÉSUMÉ

La délégation scientifique des États-Unis auprès du SCRS reconnaît la nécessité d'améliorer l'information scientifique pour évaluer le stock de thon rouge de l'Atlantique Ouest. À cette fin, la délégation propose une approche en trois parties : 1. Améliorer les indices actuels et/ou développer de nouveaux indices pour les évaluations des stocks, y compris améliorer la prospection larvaire existante et développer une prospection de l'âge 0. 2. Améliorer la collecte et le traitement du matériel biologique (otholithes, épines, échantillons de tissu) provenant de la pêcherie, à bord, dans les ports de débarquement ou sur les marchés. 3. Développer une approche fondée sur la génomique pour évaluer le thon rouge similaire aux estimations « close-kin » de la biomasse du stock reproducteur du thon rouge du Sud.

Les États-Unis reconnaissent la nécessité d'améliorer l'information scientifique pour évaluer les stocks de thon rouge de l'Atlantique. À cette fin, les États-Unis proposent une approche en trois parties:

1. Améliorer les indices actuels et/ou développer de nouveaux indices pour les évaluations des stocks. Les États-Unis appuient la création d'un indice pour les thons rouges d'âge 0 et accueillent favorablement la collaboration en matière de conception et de méthodologie. Les poissons de cette taille sont rarement observés dans les pêcheries américaines, cependant 41 thons rouges (267-413 mm de longueur à la fourche) ont été capturés à la ligne trainante dans les eaux au large de Miami, à la fin de l'été (Brothers et al. 1982). Cela donne à penser qu'il peut être possible de lancer une étude à la ligne trainante pour les thons rouges d'âge 0 (**Addendum 1 de l'Appendice 5**). Les États-Unis ont également proposé d'accroître la prospection larvaire actuelle (Lamkin et al. 2014**)** afin de couvrir une plus grande partie de la zone potentielle de frai du thon rouge de l'Atlantique Ouest et d'accroître l'efficacité de l'échantillonnage. Ces deux projets abordent des périodes temporelles clés (jeunes juvéniles et larves, respectivement) du cycle vital du thon rouge, et fournissent des échantillons dont l'origine est connue afin d'étayer les projets présentés au point 3 ci-dessous.

Les indices actuels peuvent également être améliorés en tenant mieux compte des effets des facteurs environnementaux et réglementaires qui altèrent l'interprétation de la CPUE (un processus que le SCRS est en train de réaliser et qui est recommandé par le groupe de travail sur les méthodes du SCRS). Nous signalons toutefois que les indices n'ajoutent de la valeur aux évaluations qu'après plusieurs années de collecte de données standardisées. De plus, les indices d'abondance relative ne sont qu'une information parmi d'autres qui sont utilisées dans les évaluations des stocks et le simple fait d'ajouter des indices supplémentaires ne dissipera pas la plupart des principales incertitudes entourant le thon rouge de l'Atlantique.

2. Améliorer la collecte et le traitement du matériel biologique (otholithes, épines, échantillons de tissu) provenant de la pêcherie, à bord, dans les ports de débarquement ou sur les marchés. Ce point est d'une importance critique pour améliorer les évaluations des stocks, la micro-chimie des otolithes et les analyses proposées au point 3 ci-dessous. Ces améliorations présentent une conception simple: commencer et soutenir la collecte exhaustive de tissus destinés à l'estimation de routine de l'âge et de la composition du stock, ce que la logistique d'échantillonnage complique souvent.

3. Développer une approche fondée sur la génomique pour l'évaluation du thon rouge (**Addendum 2 de l'Appendice 5**). Les résultats satisfaisant obtenus récemment en appliquant une analyse de similitude (« close-kin ») pour estimer l'abondance du stock reproducteur du thon rouge du Sud (Bravington et al 2013), conjugués à l'augmentation rapide de la résolution (et diminution des coûts) des techniques génétiques avancées découlant du projet de génome humain font en sorte que l'application d'approches génomiques soit particulièrement utile. Tout d'abord, l'amélioration de la résolution obtenue grâce au site de restriction de l'ADN fournit des milliers de loci aux fins de l'identification des différences au niveau de la population et au niveau individuel, augmentant ainsi considérablement la résolution par rapport au nombre beaucoup plus réduit de microsattelites disponibles actuellement. Ceci augmente la capacité de déterminer le stock d'origine et, au-delà de cet aspect, permet de réaliser des expériences de marquage-recapture génétiques telles que l'analyse de similitude (« close-kin ») pour estimer l'abondance absolue, les taux de mortalité ou de migration, en dissipant directement certaines des principales incertitudes entourant les évaluations de thon rouge. Plus particulièrement, l'analyse de similitude (« close-kin ») fournirait une estimation indépendante des pêcheries des nombres de stocks de reproducteurs de thon rouge de l'Ouest.

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Addendum 1 de l'Appendice 5

A FEASIBILITY STUDY ON THE DEVELOPMENT OF ANNUAL RELATIVE ABUNDANCE INDICES FOR YOUNG-OF-THE-YEAR BLUEFIN TUNA (*THUNNUS THYNNUS*) IN THE STRAITS OF FLORIDA

The SCRS recognized that "large uncertainty in stock status is exacerbated by the lack of appropriate information/data and scientific surveys" (ICCAT SCRS REPORT 2013). Current and future stock assessment models rely upon relative abundance indices. The youngest ages for which an index is available are ages 2 and 3. The availability of indices for the youngest age classes is particularly useful for improving the estimates of number of fish in these age classes in the most recent years of the data series, as there are fewer years of data available in the catch for these cohorts. Recruitment indices of Age 1 Southern bluefin tuna are developed for that species by a trolling survey off the coast of Western Australia, and considered for informing the management of fish when they enter the fishery two years later (Itoh *et al.* 2013).

Abundance indices for western Atlantic young-of-the-year (YOY/Age 0) will improve the assessment and management of the stock (albeit after the index has several some years of continuous information). However, such indices have not been developed, as bluefin of this young age are generally regarded as insufficiently available. Bluefin of this size are not targeted in the U.S. fisheries. Some Age 0 fish have been collected as part of targeted research projects, but even during such efforts, encounter rates are generally low. However, Brothers *et al*. (1983) collected a number of YOY during a study reporting on the growth of western Atlantic larval and juvenile BFT in 1982. Their approach to sampling juvenile BFT in the Straits of Florida was to request that local Miami charter boat operators retain YOY BFT. Forty-one (41) fish were caught on hook and line using techniques such as trolling small feather lures from mid-August through October of 1979-1980, ranging in size from 267 to 413 mm fork length. Although no similar effort has been made to acquire juvenile western Atlantic BFT of this size category in the years since, it is possible that such fish can still be found in the area and the season described by Brothers *et al*. (1983). Local fishermen may not identify these small tunas as BFT as at this small size they can be easily confused with blackfin tuna (*Thunnus atlanticus*). Hence, a primary step is determining the feasibility of developing a BFT YOY index is to ascertain the availability of these YOY fish.

It is reasonable to assume that a large fraction of the YOY of the Western Atlantic population spawned in the Gulf of Mexico pass through the Straits of Florida after leaving the Gulf of Mexico for Atlantic waters. Therefore, Phase One of the proposed feasibility study will be to characterize the availability (in time, location, vulnerability to various gears/techniques) of the Age 0 fish in the Florida Straits, to determine if YOY BFT can be collected in numbers sufficient to enable the development of indices of abundance for these young fish.

Phase One should be continued for 2 -3 years, to evaluate consistency of year-to-year availability. If warranted based on the data collected through Phase One, trials of standardized methods to collect data for ongoing abundance indices (Phase Two) can begin in parallel as early as year two of the study. Ideally, the availability and feasible logistics will permit the development of a scientific survey, perhaps employing methodologies similar to those of Itoh *et al.* (2013). Alternatively, some form of fishery dependent indices may be required.

Methods

We propose to make a comprehensive effort to access the availability of YOY BFT by liaising with the commercial and recreational (private and charter) fishing community fin the Florida straits (from West Palm Beach to Key West). From our initial query, we will identify fishers willing to participate but who are also conscientious in terms of communicating with the research team and procuring samples. To justify participants taking time to locate and catch small tuna during the presumed duration of presence in the Florida Straits (from mid-August through mid-October), monetary compensation may be necessary. Species identification information will be distributed to each participating boat captain. For YOY bluefin, the size and number of gill rakers on the first arch (34-43) is an easy distinguishing characteristic vs blackfin tuna (19-25), the most common similar scombrid in this area (Gibbs and Collette 1967). Communications to all participants when and where the schools of tuna are sighted will be essential. All cooperating participants would have to obtain an exempted fishing permit under NOAA's scientific permitting system, and an exemption under ICCAT regulations may be required. It is anticipated that the total catch from this feasibility study would still be quite minimal so as to not affect the stock or have any impact upon U.S. quotas of BFT.

Personal visits and regional face to face meetings will be an important aspect of program implementation. Brothers *et al*. (1983) made multiple in-person visits to talk to captains, most importantly at the beginning of the collections. As BFT enter the straights of FL at Key West, communications of first sighting in this location will raise awareness of the presence of YOY BFT. Some accommodation for freezer holding facilities may be required. One option may be to purchase small freezers for placement near cleaning stations at marinas or public ramps. This approach has been used successfully to obtain biological samples in some other surveys (e.g. Large Pelagic Biological Survey). As compensation, marina operators could be offered shared use of the freezers during survey operations, and exclusive use at other times. Participating fishers can leave whole or cleaned (head and attached skeleton only) specimens in the freezer, inside bags with id tags. Vessel interactions with YOY bluefin tuna will require log-book documentation so that time, date, location, fishing methods and catch rates are recorded and made available to the researchers.

Collection of additional information on catch rates and methodology will provide the necessary information for developing a full statistical design and power analysis for an operational survey. Information on timing, duration of passage and spatial distribution will be essential for designing a full survey. Data on capture and encounter rates, as well as successful fishing methods such as gear, lures, trolling speed, time of day and detection and identification of schools, will provide critical methodological details.

Phase Two of the project, if determined to be feasible based on the data collected in Phase One, would be the design and implementation of a pilot survey (fishery-independent designed survey or, if necessary, a fishery dependent survey). This could begin as early as Year Two of the project, while Phase One is continued in parallel, to confirm year-to-year consistency in availability.

The methodology employed in a scientific design may be similar to those used in by Itoh *et al.* (2013). Alternatively, other approaches may be considered. For example, YOY BFT have been caught in mid-water trawls in the Gulf of Mexico.

Budget

Costs for Phase One may include possible monetary compensation for participating fishery constituents, funds for travel to regularly meet with participants and recover specimens, securing freezer/ refrigerator facilities, and partial salary for a contracted scientist. Duration of the pilot is expected to be at least 2 or 3 years. The cost of design and implementation of a pilot scientific survey will depend upon the results of Phase One and the difficulty and complexities involved.

Anticipated results of feasibility study

1. Data on the availability, timing and duration of passage of YOY BFT through the Straits of Florida.
2. Data on the capture and encounter rates which will be critical for power and sample size analyses for an operational index.
3. Data on successful capture methodologies, such as gear, lures, trolling speed, time of day and detection and identification of schools to determine the most efficient sampling protocols.
4. Biological samples of known stock origin for genetics, age and growth analyses.
5. (Depending on results of Phase One) Survey design for the development of YOY BFT abundance indices. Pilot survey to test suitability.

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Addendum 2 de l'Appendice 5

DEVELOPMENT OF A GENOMIC-BASED APPROACH TO ASSESSMENT OF BFT

Introduction

The rapid development of high-throughput, high resolution genetic analytical methods coupled with the rapid decrease in the cost of these analyses has made quantitative genomics a powerful technology for population assessments. In contrast to previous methodologies (microsatellites, single nucleotide polymorphisms, etc.), that provided relatively few (10s) markers for resolution, restriction-site associated DNA sequencing (RAD) analysis produces thousands of genetic markers per individual (Baird *et al*. 2008, Davey and Blaxter 2011), vastly increasing the resolution of markers for population-level differences and allowing for the unique identification of individuals or their progeny. Improved population level resolution increases the potential for resolving one of the key uncertainties in ABFT- stock of origin in mixed fisheries. Unique identification of individuals provides the potential for mark-recapture analyses that eliminate several nuisance parameters, namely tag loss and reporting rates. Furthermore, the thousands of available loci from RAD analysis make it possible to conduct parentage analysis which provides the critical information for estimation of spawning abundance through close-kin analysis (CKA), an approach that allows for abundance estimation from sampling of spawners and juvenile.

In contrast to many other methods of assessing populations, genetic approaches offer some desirable properties. First is the potential to identify individuals and their progeny, a property that expands genetics as a tool for conducting mark-recapture type studies. Along these lines, genetic methods offer the potential for non-invasive tagging with a mark that cannot be shed, potentially augmenting any conventional tagging program. Lastly, the resolving power is increasing and the costs are decreasing quite rapidly due to the economy of the human genome project, making the genotyping of thousands of samples possible.

We propose a pilot project to evaluate the utility of using advanced RAD DNA methods to evaluate stock mixing, to identify individual BFT and their parents and to evaluate the existing sampling framework (larval surveys and biological sampling of the fishery) for conducting a full close-kin analysis to estimate spawning abundance, independently from and complimentary to traditional stock assessment approaches. The proposal objectives follow:

1. Estimate the feasibility of identifying stock origin using RADseq technology from previously collected samples of known stock origin (East and West).
2. Analyze existing western Atlantic bluefin tuna larval samples collected from the Gulf of Mexico to estimate diversity of parents to determine if the larval survey provides effective samples for close-kin analysis.
3. Initiate/evaluate sampling design to collect DNA samples from adult BFT.
4. Provided (1), (2) and (3) work, then initiate close-kin analysis to estimate the absolute abundance of spawning western Atlantic tuna.

Methods

RAD sequencing

Restriction-site associated DNA sequencing (RADseq) is a relatively new methodology for rapidly and cost-effectively obtaining 1000s of genetic markers per individual and analyzing a large number of samples concurrently (Baird *et al* 2007, Davey and Blaxter 2011). In conjunction with methodologies for parallel processing of samples, RADseq becomes a very efficient tool for genetic studies. In contrast to earlier means of identifying genetic diversity (microsatellites, single nucleotide polymorphisms, etc) which were costly to develop and limited usually to only a few markers in number, RADseq provides thousands of markers, of which some will indicate population-level differences, and others differences at the individual level. The output of the RADseq analysis is a table of presence/absence of a particular loci (of which there may be thousands) for each individual sequenced. Then a principal components analysis is performed to determined combinations of loci that distinguish individuals or groups.

Close-kin analysis (CKA)

Close-kin analysis was originally proposed for minke whales (Skaug, 2001) and has, most recently, been successfully applied to Southern Bluefin tuna (Bravington *et al* 2013) as a means to estimate spawning abundance in situations where conventional tagging, and standard surveys or indirect assessment methodology proves difficult or highly uncertain. This is certainly the case for ABFT. The method proceeds as follows: take a random sample of juvenile fish and random sample of spawners, compare the genetic composition of each juvenile and each spawner to determine if any of the spawners could be a parent and then count the number of matches - juveniles that had a parent in the spawners, or the Parent – Offspring Pairs (POPs). If the spawning population is high, there will only be a small proportion of the sampled juveniles will result in POPs. The estimate of absolute spawning stock numbers ($\hat{N}$) is then obtained from a mark-recapture model where the unique parental genetic contributions (one each from mother and father) present in juveniles serve as a tag that can be recaptured from adults in the fishery. The model follows below:

$$\hat{N} = 2 * J * A/POP$$

where *J* is the number of juveniles sampled and *A* is the number of adults sampled. Relatively independent of the population size, the target level for estimating the abundance of spawners is 50 POPs as the variance of the population size estimate stabilizes at that level. Secondarily, if the analysis is conducted over multiple years, observing the presence of the same adult (generally one spawning) in the juveniles over multiple years gives information on survival of adults.

Target levels of sampling for adults and juveniles to obtain 50 POPs is approximately 10*(*N*)^.5, so for a spawning population of 60,000 fish (current WBFT VPA estimates) one would need 2500 total fish (e.g. 1250 age-0 and 1250 adults).

Numerous other details will require further analysis for the full CKA, once the pilot project determines the feasibility of proceeding.

Sampling

One of the key requirements for a genomic approach to succeed will be obtaining adequate samples. To achieve the pilot part of this proposal all samples are currently archived and available. For the full CKA, the current larval survey averages between 1000 -1500 fish per sampling season, indicating that it may be sufficient for CKA, if the samples meet the genetic diversity requirement (i.e. larvae are sufficiently mixed such that individual larvae demonstrate high spawner diversity).

To obtain 1250 adult samples it may require some substantial sampling of the U.S., Canadian, Japanese or Mexican (the primary CPCs capturing Western origin BFT) fisheries, particularly as some of these fish could be of Eastern origin. Given that the total catch in any given year is ~7000 spawners (age 8+ fish) this would require obtaining a tiny tissue sample (~1 milligram, or a less than a pencil eraser size) from about 20% of the total catch.

Pilot project

The initial pilot project will be to determine the feasibility of determining stock origin with RAD analysis with existing samples of known origin collected from the spawning grounds in the Gulf of Mexico and Mediterranean Sea, and to evaluate genetic diversity in larvae. Collaborators on this pilot include Jan McDowell, John Graves (VIMS), Peter Grewe and Mark Bravington (CSIRO) and the large Pelagics Lab at University of New Hampshire (Lutcavage lab). Initial project costs are in **Table 2**.

Table 2. Initial costs for pilot project and close-kin genetic work (note that the initial cost of $50 per fish should decrease about $20 on an operational basis. Costs are in U.S. dollars and do not include labor, scientific support, travel or sample collection needed for part 3).

1. To screen known origin fish to determine whether stock origin can be determined			
	Target fish	Cost per sample	Total
Western origin	100	50	5000
Eastern origin	100	50	5000
2. Larval to determine number of parents and half-sibling within and between samples			
	Target fish	Cost/sample	Cost
Larval from 2009-2011	1000	50	50000
		Total	$60,000

3. Close kin analysis			
Larvae/juveniles	1250	50	62500
Adults	1250	50	62500
			$125,000

Expected results

a. Estimation of stock proportion

We expect that we will be able to evaluate the feasibility of stock identification through RAD analyses fairly soon. If this works, it will provide a relatively inexpensive and non-lethal means of determining stock origin.

b. Estimation of parentage diversity of larval samples

If unique parentage can be determined, this analysis will provide the necessary information to determine whether the larval survey provides samples with enough spawner diversity (number of parents) to be able to be considered a random sample of the juvenile. The analysis will evaluate, through rarefaction curves the number of unique parents as a function of number of larvae sampled, both within a larval tow and between larval tows. This will help determine whether it is better to sample more larvae in a location, if spawner diversity is high within a tow, whether it is necessary to sample more stations in time and space, or, if spawner diversity is low both within and between stations, whether the larval survey will not provide the necessary platform for randomly sampling juveniles.

c. Full close-kin analysis

Provided that parts (1) and (2) succeed and that an adequate number of spawners can be obtained from the fishery, then a full close-kin analysis can proceed which will provide an estimate of absolute abundance of the spawners that produced the juveniles in a given year. It is critical that adults that could have produced the juveniles in a given year be sampled, so the full CKA may need to be updated in future years as past spawners are encountered and included in the prior year's data.

Estimates of absolute spawning stock number will provide an independent check upon existing stock assessment estimates, increasing certainty in the abundance of the stock. Further, if ongoing, these estimates will greatly enhance the ability to estimate the stock-recruitment relationship as the spawning stock estimates will be independent of the recruitment estimated in the assessment model. These estimates can also be formally incorporated into the management procedure approach (MP) proposed for BFT (ICCAT 2013).

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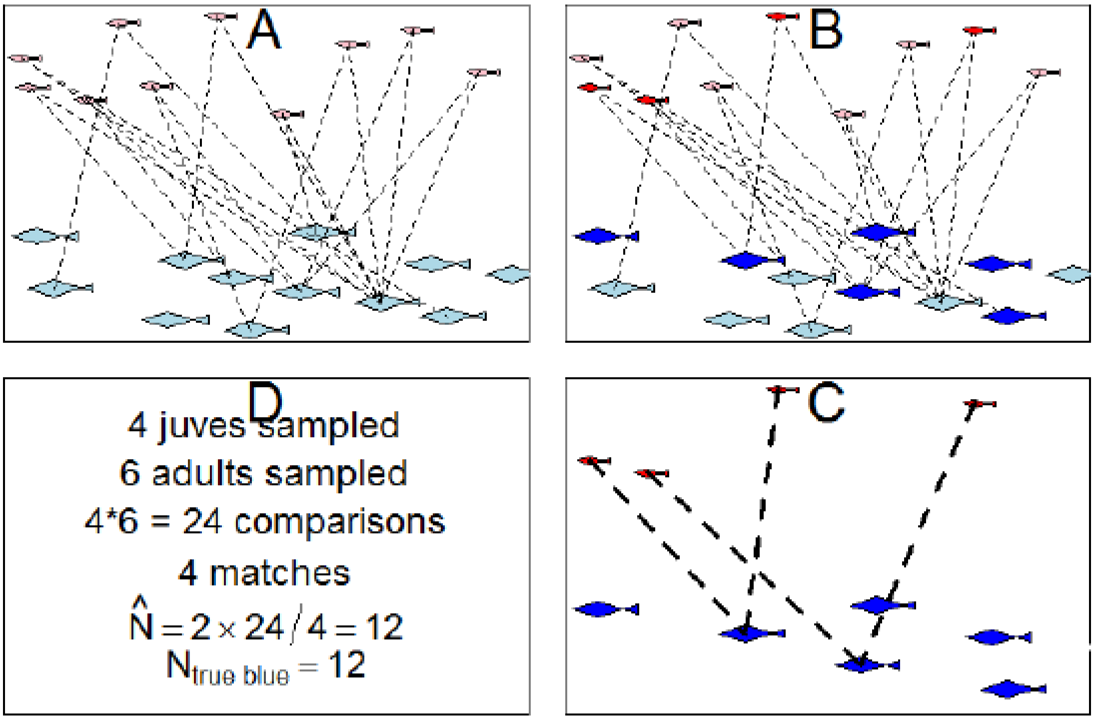

Figure 1 (reprinted with permission from Bravington *et al* 2014). Cartoon of close-kin: the DNA profile of the juvenile "tags" its two parents, and we check to see how many tags are recaptured. Clockwise from top left: A shows all the adults (blue), juveniles (pink), and parental relationships; B shows sampled juveniles (red) and sampled adults (deep blue); C shows only what we can actually observe, i.e. the samples and the identified POPs; D shows the calculation of the estimate, which in this slightly contrived example happens to be exactly equal to the true number. Note that two juveniles match to the same adult, but this still counts as two POPs.

Appendice 6

PROPOSITIONS DU CANADA DE DÉVELOPPEMENT ET DE MISE EN ŒUVRE D'INDICES D'ABONDANCE INDÉPENDANTS DES PÊCHERIES POUR LE THON ROUGE DU GOLFE DU SAINT-LAURENT

(Document présenté par le Canada[2])

1. Contexte

Les modèles d'évaluation analytique du thon rouge de l'Atlantique, *Thunnus thynnus*, sont calibrés principalement au moyen d'indices d'abondance reposant sur la prise par unité d'effort (CPUE) dépendants des pêcheries qui dépendent exclusivement des informations relatives aux pêcheries. Au cours de ces dernières années, le Comité permanent pour la recherche et les statistiques (SCRS) a exprimé son inquiétude quant à la représentativité de ces indices et leur capacité à suivre les tendances de l'abondance en raison de l'évolution des modes de pêche et de l'imposition de mesures de gestion en ce qui concerne les stocks de l'Est et de l'Ouest. Dans son dernier rapport, le SCRS a vivement recommandé de développer des indices d'abondance indépendants des pêcheries pour les deux stocks afin de venir compléter les indices actuels (ICCAT 2013, 2013a). À l'heure actuelle, le Canada fournit deux indices d'abondance, reposant sur la CPUE, pour calibrer l'évaluation du thon rouge de l'Ouest : l'indice de la canne et moulinet du golfe du St Laurent (1981-2013) et du Sud-Ouest de la Nouvelle-Écosse (1988-2013) (**Figure 1**). Les séries temporelles des deux indices ont été influencées par des facteurs externes qui pourraient refléter les fluctuations annuelles de l'indice qui ne sont pas directement associées aux changements de l'abondance. L'instauration de la soumission obligatoire des carnets de pêche en 1996, la mise en œuvre de quotas individuels transférables en 2004, modifiant ainsi les pratiques de pêche, et, dans certaines zones, les restrictions de la pêche imposées par les associations régionales ont eu des répercussions sur le calendrier de la pêche et contribuent tous aux tendances des indices. L'incertitude entourant l'augmentation importante de l'indice du golfe du Saint Laurent s'est traduite par l'exclusion des données de 2010 dans l'évaluation de 2012. L'indice du golfe du Saint Laurent est resté relativement élevé en 2011 et 2012 et les changements proposés concernant l'omission peuvent altérer davantage l'indice.

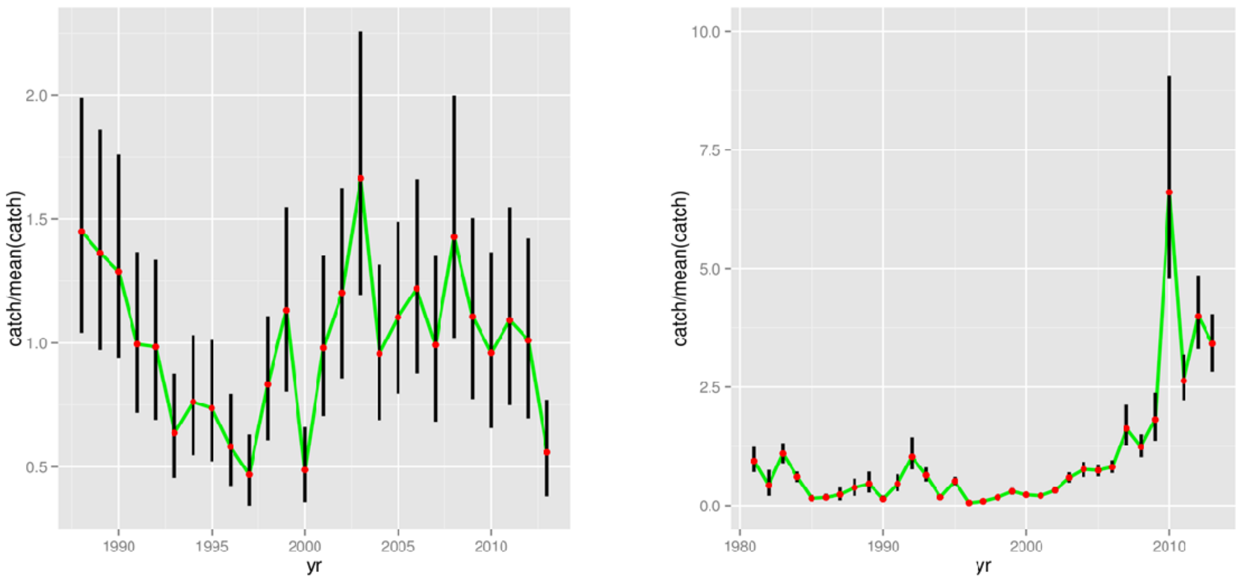

Figure 1. Indice d'abondance standardisé du thon rouge avec des intervalles de confiance de 95% pour le Sud-Ouest de la Nouvelle-Écosse (à gauche) et le golfe du Saint-Laurent (à droite).

L'incertitude principale entourant ces changements des tendances a trait à l'impact que ceux-ci ont sur le postulat de capturabilité constante des indices dépendants des pêcheries au cours du temps et à la question de savoir si les tendances de l'indice (à savoir les changements des indices) reflètent les changements réels de l'abondance et/ou les changements des initiatives de gestion ou de la pêcherie. Plusieurs exemples des deux côtés de l'Atlantique

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illustrent des cas où des modifications ou des adaptations de la gestion et de la pêcherie pourraient avoir affecté les indices d'abondance utilisés dans les évaluations du thon rouge de l'Est et de l'Ouest. En fait, une réelle préoccupation a été exprimée à la dernière réunion du SCRS concernant le fait que les indices du stock de l'Est peuvent être perdus à court terme en raison des modifications de la gestion. Cela a conduit le SCRS à recommander le développement d'indices d'abondance indépendants des pêcheries qui tendent à être relativement constants au cours du temps en termes d'engin, de couverture et de la conception de la prospection. Il est également important de relever que sept à dix ans devront s'écouler avant que le développement d'un nouvel indice d'abondance indépendant des pêcheries n'ait une influence sur les résultats des évaluations de stock.

2. Propositions

Nous présentons ci-dessous deux propositions indépendantes de développement et de mise en œuvre d'indices d'abondance indépendants des pêcheries pour le golfe du St Laurent : le premier est un indice reposant sur une étude acoustique à la ligne trainante et le second concerne une étude de marquage-recapture. Chaque proposition fournirait un nouvel indice d'abondance du thon rouge indépendant des pêcheries. De surcroît, alors que certains aspects de chaque démarche pourraient être intégrés dans d'autres conceptions de prospection, la simple combinaison des deux approches ne répondra pas aux exigences de l'un ou l'autre indice. En ce qui concerne l'étude acoustique à la ligne trainante, la couverture serait limitée par la proposition de marquage. Par contre, le nombre de thons rouges disponibles pour le marquage, et leur distribution, dans l'étude acoustique à la ligne trainante, serait considérablement réduit, même s'ils seront disponibles pour le marquage conventionnel. Les poissons capturés à la ligne traînante pourraient toutefois être utilisés pour l'apposition de marques pop-up reliées par satellite (PSAT) et/ou uniquement de marques acoustiques codées (V16 Vemco Inc., NS, Canada) tel que le propose l'étude de marquage-recapture. Les propositions n'ont pas été classées selon un ordre de priorité.

La combinaison de l'étude acoustique à la ligne trainante et de l'étude de marquage-recapture pourrait se traduire par un accès limité aux thons rouges destinés au marquage. Toutefois, les deux propositions ont différents postulats/exigences pour estimer l'abondance. L'étude acoustique à la ligne trainante est conçue en vue de couvrir une vaste zone à la recherche de signaux associés aux thons dans le but de recenser le nombre de poissons. La ligne traînante sera utilisée pour recueillir un sous-échantillon représentatif à des fins d'identification des espèces-cibles et d'estimation de la distribution des tailles. Des poissons supplémentaires pourraient être obtenus en collaborant avec la flottille de pêche commerciale dans chaque strate si la quantité provenant du navire utilisé pour l'étude n'est pas suffisante. Cela impliquerait bien entendu des coûts supplémentaires du navire dans la proposition. Le but de l'étude de marquage-recapture consiste à capturer et marquer le plus grand nombre de poissons possible pendant le temps disponible, en réduisant ainsi les intervalles de confiance de l'estimation de la biomasse. La proposition de l'étude de marquage-recapture recommande de pêcher des thonidés dans une vaste zone (4 régions) dans le golfe du St Laurent afin d'augmenter la couverture. Malheureusement, la pêche de thons destinés au marquage ne nécessite pas de mouvement du navire une fois que les poissons ont été localisés. Même si cette limitation de mouvement remplit toutes les exigences de l'étude de marquage-recapture, elle restreint considérablement la couverture acoustique qui requiert un mouvement quasi permanent. Par conséquent, bien qu'il existe certaines possibilités de combinaison de l'étude acoustique à la ligne trainante avec l'étude de marquage-recapture, cette combinaison compromettrait les deux approches. Il est donc recommandé que seule l'une des deux propositions fasse l'objet d'une demande de financement.

2.1 Proposal 1 – Acoustic-Trolling Survey

"Development and Implementation of a Fishery Independent Index of Abundance for the Gulf of St Lawrence Bluefin using Acoustic-Trolling survey."

2.1.1 Context

The first proposal to develop a fishery independent index of abundance for Gulf of St Lawrence (GSL) bluefin tuna combines a traditional approach (trolling) of capturing large pelagic species with state of the art acoustic technology (split-beam echo-sounder and multi-beam sonar). Currently the Gulf of St Lawrence rod and reel index of abundance is based on catch and effort from the logbooks of the commercial fishery which tends to be stationary during fishing. No acoustic information is available from the commercial bluefin tuna fleet, although fishers commonly use acoustics to observe tuna. The survey will employ acoustic to improve coverage within a predefined area or stratum and trolling to catch and sample fish. In essence, the acoustic technology will be used to quantify and count bluefin tuna like targets in the water column and the trolling to estimate catch rates and target identification/validation for backscatter estimation. The approach integrates the technology and capture gear such that two fishery independent indices of abundance will be available from a single survey. Data for both indices will be collected concurrently from the same vessel(s).

2.1.2 Objectives

The primary objectives of the proposed survey are to:

1) Develop one or more long term fishery independent indices of abundance for bluefin tuna in the Gulf of St Lawrence. This approach will involve the implementation of a combined trolling and acoustic survey that could result in two independent indices of abundance from the same survey design and vessel.
2) Enhance Biological sampling (size data and otoliths). In addition to standard measurements for all captured fish, a sub-sample of bluefin tuna caught during trolling could be retained for biological sampling (otoliths, sex/maturity, stomach content etc.) assuming scientific quota is available.
3) Collaborate with, and support, of other bluefin tuna research and researchers. Fish captured during trolling could be tagged (traditional or PSAT) or a tissue/genetic sample collected before the fish is released.

2.1.3 Equipment

Standard commercial baited trolling gear will be utilized to catch and to estimate the CPUE using standardized protocols during the survey. The specific configuration will be finalized after discussion the industry and international scientists. Options to strengthen the line will also be explored to decrease fish retrieval time and increase acoustic survey time. The size of bluefin tuna captured in the Gulf of St Lawrence has ranged from <10kg to >650kg between 1972 and 2013. Mean raw and flank sizes by year are described in **Table 1**.

The Department of Fisheries and Oceans own and operates several acoustic monitoring systems suitable for a bluefin tuna survey. It is proposed to utilize a calibrated 120kHz Simrad EK60 scientific echosounder (7 degree beam angle) combined with a 500kHz high resolution Mesotech M3 multi-beam sonar (range approximately 100m, swath 120 degrees and variable beam angles) to conduct the survey. The vessel mounted sounder would be orientated downward and the sonar forward. If more than one vessel is utilized an alternative configuration of a EK 60 echosounder (same beam angle) and a 200kHz MS2000 multi-beam sonar (180 degree swath) could be deployed. Both systems will be pole mounted to the side of the survey vessel, for easy deployment and retrieval, if possible. An example of bluefin tuna in an echogram is presented in **Figure 2.1.1**.

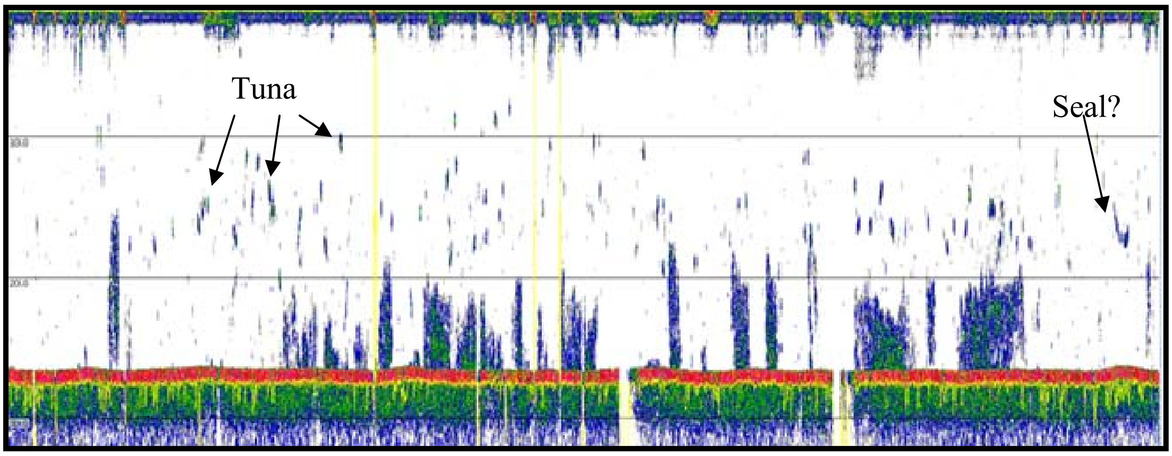

Figure 2.1.1. Echogram of herring schools and bluefin tuna observed on Fisherman's Bank September 28, 2013 recorded by a fishing vessel as it search for herring during a commercial fishing operation (below).

Several options are available for vessels to deploy the trolling and acoustic equipment. Given it compact size, the equipment can be deployed from almost any commercial, recreational or scientific vessel, however because of the shallow water around PEI it is recommended that only smaller vessels be consider for the survey (<85', preferably 45' or less).

2.1.4 Survey design

The actual survey design is not finalized, but will incorporate historical data on bluefin tuna catches and up to date information from the fishing/recreational industry. **Figure 2.1.2** illustrates the location of bluefin tuna catches from 1997 to 2013 and **Figure 2.1.3** the same information annually. Based on this information it is evident that bluefin tuna tend to be concentrated in a few locations and within a 15-20 km distance along the northern shore of PEI, as well as in a 10-20km band that extends from Fisherman's Bank to coast of Cape Breton from Port Hood to Inverness, broadening slightly near Cape Breton. The areas of concentrations include 1) North Cape eastward to Malpeque Bay, 2) Crowbush to East Point, 3) Fisherman's Bank eastward to about half way between PEI and Cape Breton, and 4) the southwestern coast of Cape Breton.

The Gulf will be divided into 5 or 6 stratum (**Figure 2.1.4**) and effort focused in those strata where bluefin tuna are known to concentrate, however, the coordinates of the strata may change slightly after discussions with the tuna industry. The amount of time spent in each stratum will depend upon the amount of vessel time available. A series of transects (either systematic parallel or zig-zag) will be established in each stratum based on historical catches and recent effort. It is anticipated that 2 surveys of 10-12 day duration will be conducted each year, one in August and one in late September. Acoustic data will be collected continuously throughout the survey.

Acoustic data will be analyzed using Echoview and in-house software and the results presented as acoustic backscatter, observed biomass, and the number of observed tuna per stratum. Trolling data will be expressed in terms of CPUE where effort will be per hour or multiple hours fished.

Biological measurements will be undertaken when the bluefin tuna are alongside the survey vessel. It is the intent of this survey to release all captured bluefin tuna alive, unless they are required for specific studies and a quota source has been identified. Incidental mortalities (expected to be few) will use the ICCAT research mortality allowance (Total 20t annually) to accommodate any unforeseen mortality.

2.1.5 Reporting

An annual report on the project's progress and results will be provided/presented to the industry, DFO and the SCRS.

Table 1. Summary of Gulf of St Lawrence bluefin tuna mean lengths and weights from 1997 to 2013.

		Raw Weight (kg)			Flank length (cm)			
Year	**Number**	**Average**	**Min**	**Max**	**Number**	**Average**	**Min**	**Max**
1997	226	426.8	19.5	595.1	226	288.3	104.9	321.3
1998	227	421.1	281.2	600.6	227	288.2	251.3	326.6
1999	385	371.7	23.1	586.9	385	275.7	110.9	319.8
2000	573	354.9	38.6	658.2	573	272.2	131.9	332.1
2001	376	305.6	151.5	505.8	376	260.6	208.4	309.0
2002	597	272.7	24.0	493.5	597	250.6	112.3	303.9
2003	590	257.3	95.3	460.8	590	247.6	178.8	295.6
2004	736	252.2	70.8	437.3	736	246.1	160.0	298.7
2005	792	251.0	100.2	421.8	792	245.1	181.9	295.1
2006	962	257.0	72.1	466.3	962	246.7	162.8	296.6
2007	586	281.4	4.5	505.3	586	251.2	65.0	304.5
2008	736	279.3	117.9	478.1	736	251.7	193.2	299.1
2009	802	317.7	68.5	585.6	802	260.4	158.3	319.6
2010	585	335.6	86.2	537.1	585	263.7	170.6	310.7
2011	637	300.4	59.0	504.4	637	255.2	152.2	304.3
2012	817	276.3	90.7	527.5	817	247.6	175.9	308.9
2013	734	297.7	133.8	489.9	734	254.3	197.1	301.5
Total	10361	295.0	4.5	658.2	10361	255.4	65.0	332.1

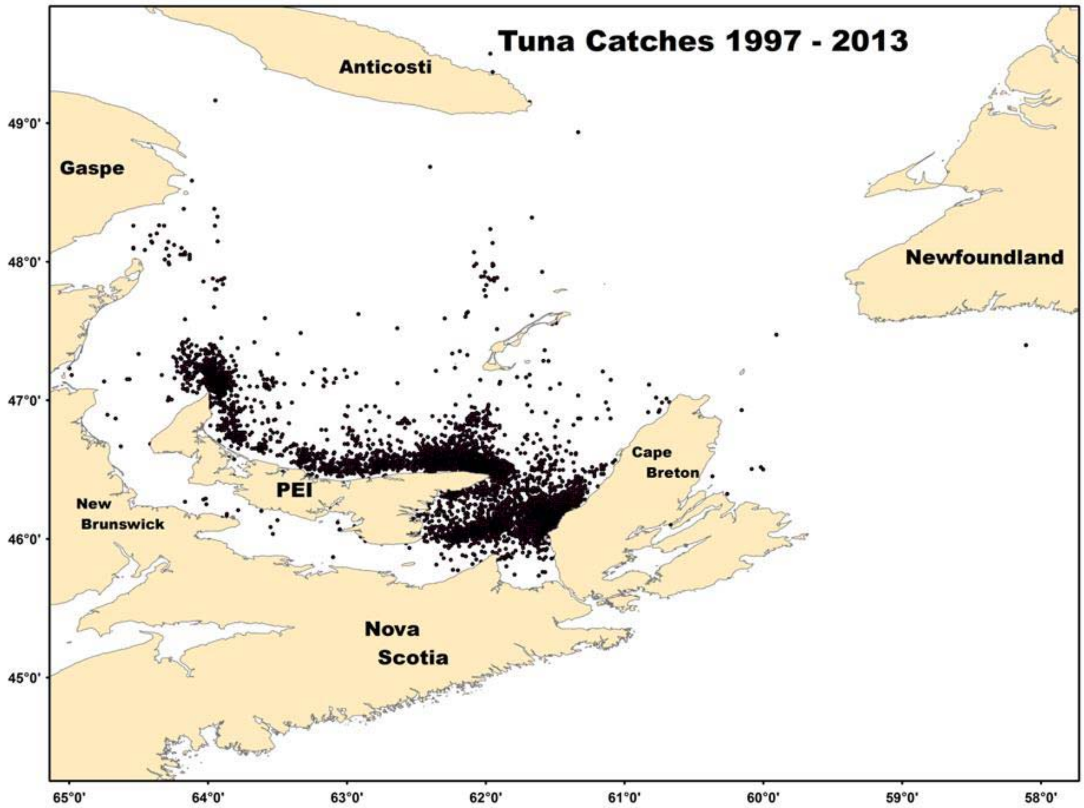

Figure 2.1.2. Location of bluefin tuna catches in the Gulf of St Lawrence from 1997 to 2013. Each point represents a single fish.

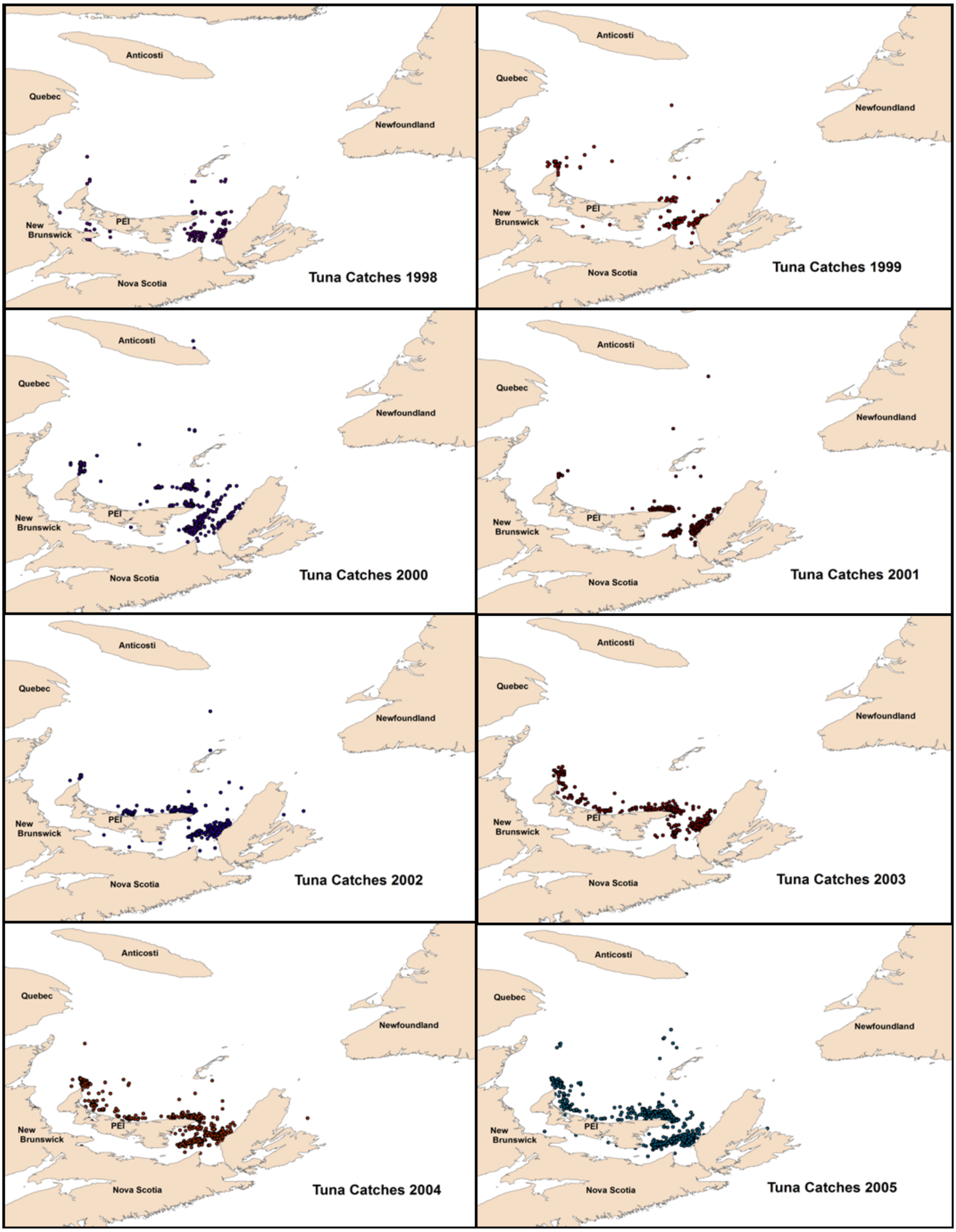

Figure 2.1.3a. Location of bluefin tuna catches in the Gulf of St Lawrence by year from 1998 to 2005. Each point represents a single fish.

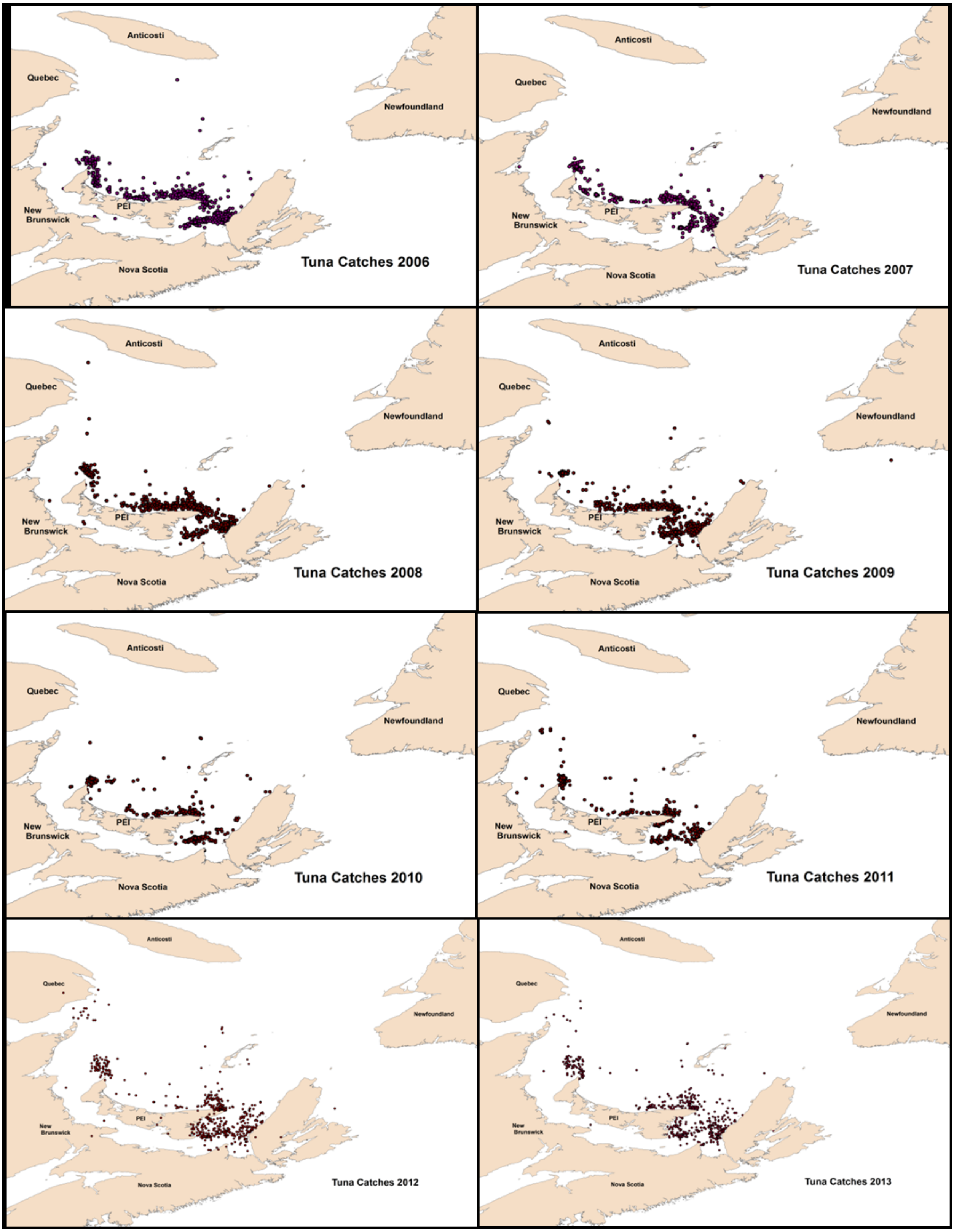

Figure 2.1.3b. Location of bluefin tuna catches in the Gulf of St Lawrence by year from 2006 to 2013. Each point represents a single fish.

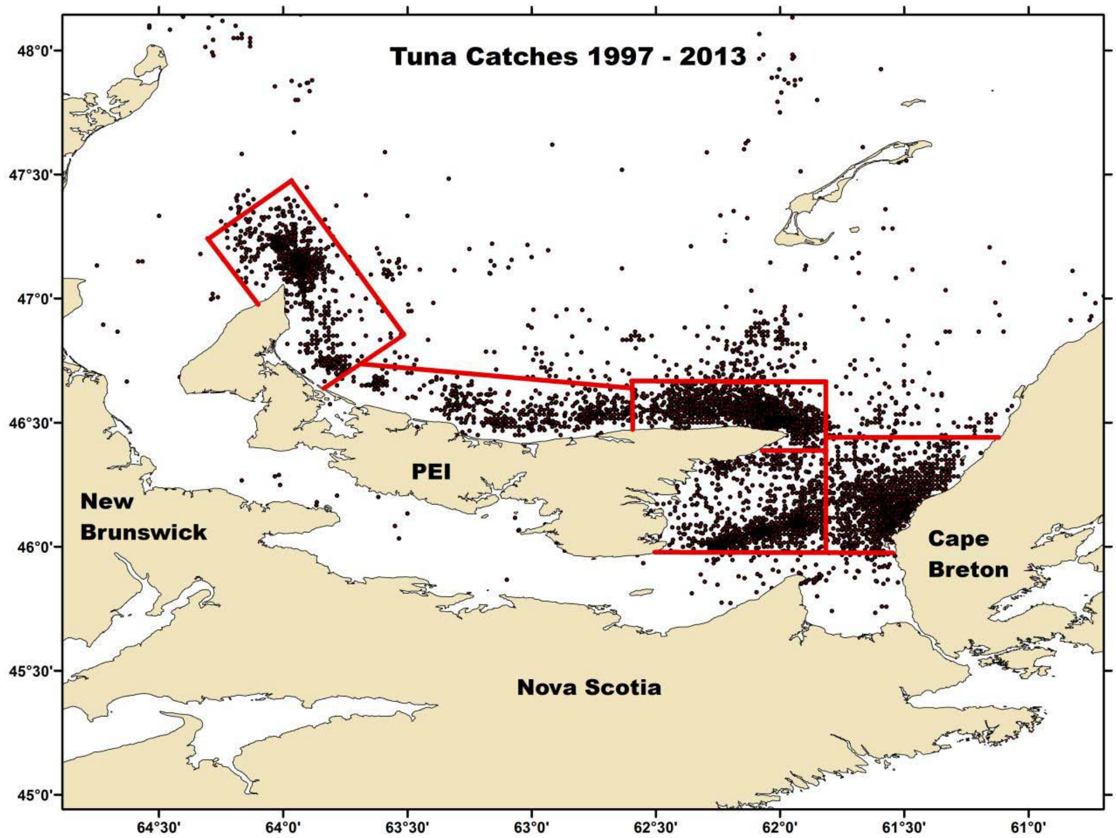

Figure 2.1.4. Approximate location of the Gulf of St Lawrence trolling-acoustic survey strata with the catches from 1997 to 2013. Transects will defined for the stratum one the amount of vessel time is determined.

2.2 Proposal 2 – Mark-Recapture Study

"A Mark and Recapture Experiment to Determine the Abundance of Atlantic Bluefin Tuna Present on a Seasonal Basis each Year in the Gulf of St. Lawrence, Canada".

2.2.1 Overview

Accurate estimates of bluefin tuna abundance are vital for both sustainable commercial and recreational exploitation and conservation, but are difficult to achieve due to their highly migratory behaviour. In this multi-year project, in collaboration with both commercial and recreational fishers from the Gulf of St. Lawrence, we will deploy both conventional and electronic tagging technology inside a Jolly-Seber open population mark and recapture experimental framework to obtain an abundance estimate for bluefin Tuna in the Gulf of St. Lawrence. The critical assumptions of a Jolly-Seber mark and recapture abundance models for open populations are: 1) Every animal has the same probability of capture; 2) marked animals have the same probability of survival; and 3) marks are not lost or overlooked. Based on our past tuna tagging work in the Gulf, we are certain there will be no or extremely limited tagging mortality, so the stock will be unaffected. All fishers in the Gulf of St. Lawrence will be encouraged to participate (see attached letters of support). Also, this proposal can benefit from, and add value to proposed broad band acoustic surveys and otolith collection by DFO by leveraging human resources, ship time and increased tagging opportunities. Critical infrastructure is already in place including lines of acoustic telemetry receivers at the entrances to the Gulf of St. Lawrence operated by Dalhousie University's Ocean Tracking Network (OTN). A portion of project support has been secured from the National Research and Engineering Council of Canada through the Discovery Grant Program to MJWS.

2.2.2 Context

Studying large-pelagic, highly migratory marine fishes is difficult due to the expense of access and monitoring of movement (Donaldson *et al*. 2008). Fisheries dependent methods (i.e., Catch Per Unit Effort (CPUE)) have been used to estimate abundance for large pelagic fishes though the shortcomings of these methods have been well documented (Hilborn and Walters 1992). Large pelagic fishes are difficult to census by traditional population assessment methods, such as mark and recapture, as access to fish for release is often minimal. Regardless, interest in fish tagging data for stock assessment has increased (Anon. 2007) and tagging data may provide the only viable alternative to traditional fisheries dependent methods for the measurement of population abundance (Polacheck *et al*. 2006).

Atlantic bluefin tuna (*Thunnus thynnus*) are a large marine, highly migratory, pelagic fish that breed in tropical waters but feed throughout tropical and temperate areas. Bluefin tuna have the ability to retain heat through counter current heat exchangers (Carey and Teal 1966) and can have internal temperatures that are 5^{o}C to 13^{o}C above the ambient water temperature (Graham and Dickson 2001), which allows them to range widely into cool productive oceanic waters in the western and eastern Atlantic Ocean, including the southern Gulf of St. Lawrence.

In the North Atlantic Ocean, Atlantic bluefin tuna are fished commercially by fishers from more than 40 countries (National Research Council 1994). Atlantic bluefin tuna are managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) as two separate stocks; a western stock that breeds in the Gulf of Mexico and an eastern stock that breeds in the Mediterranean Sea (National Research Council 1994). The abundance of western Atlantic bluefin tuna has been severely reduced with a currently estimated population of approximately 98,000 individuals (age 8 and older; Anon 2012) that is considered to be approximately 25 to 36 % of the 1970 level (Anon 2012). Because of low abundance, in 2010 Atlantic bluefin tuna were proposed for listing and protection under the Convention on International Trade in Endangered Species (CITES), although the proposal was not accepted by CITES member nations. Recently (2011) bluefin have been recommended for listing as Endangered under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; http://www.cosewic.gc.ca) and assessment for a listing by the Species At Risk Act (SARA) is underway. Because of conservation concerns commercial quotas for Atlantic bluefin tuna in Canadian waters have been reduced in recent years as managers attempt to rebuild the western stock (**Figure 1**).

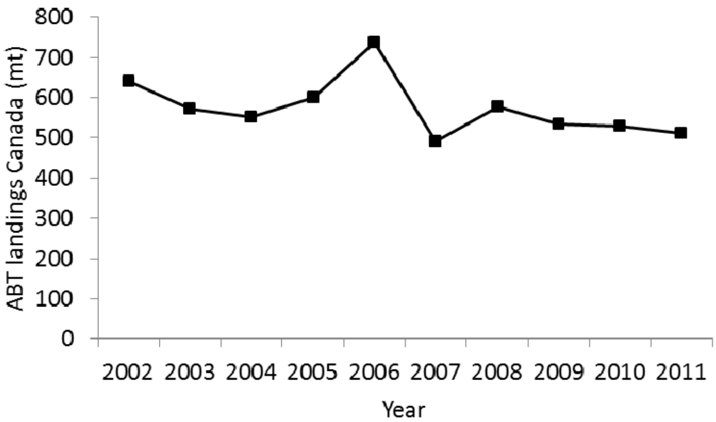

Figure 2.2.1 Atlantic bluefin tuna landings and discards in metric tonnes by year 2002-2011 (from DFO 2011, and Hanke *et al*. 2013).

Atlantic bluefin tuna migrate seasonally into Canadian waters to feed on abundant prey including Atlantic Mackerel (*Scomber scombrus*), Atlantic Herring (*Clupea harengus*) and Atlantic Saury (*Scomberesox saurus*). They are accessed in two main regions in the Maritime Provinces of Canada, in southwest Nova Scotia and in the Gulf of St. Lawrence. In the southern Gulf of St. Lawrence they are fished by fleets from Quebec, New Brunswick, Prince Edward Island, and Nova Scotia. Bluefin tuna are generally present in Canadian waters from June to December and are fished by Canadian fleets in the Bay of Fundy, on the Scotian Shelf, in the Gulf of St. Lawrence and off Newfoundland (**Figure 2**). Atlantic bluefin tuna fished in the southern Gulf of St. Lawrence are part of the western Atlantic Ocean stock (Rooker *et al*. 2008).

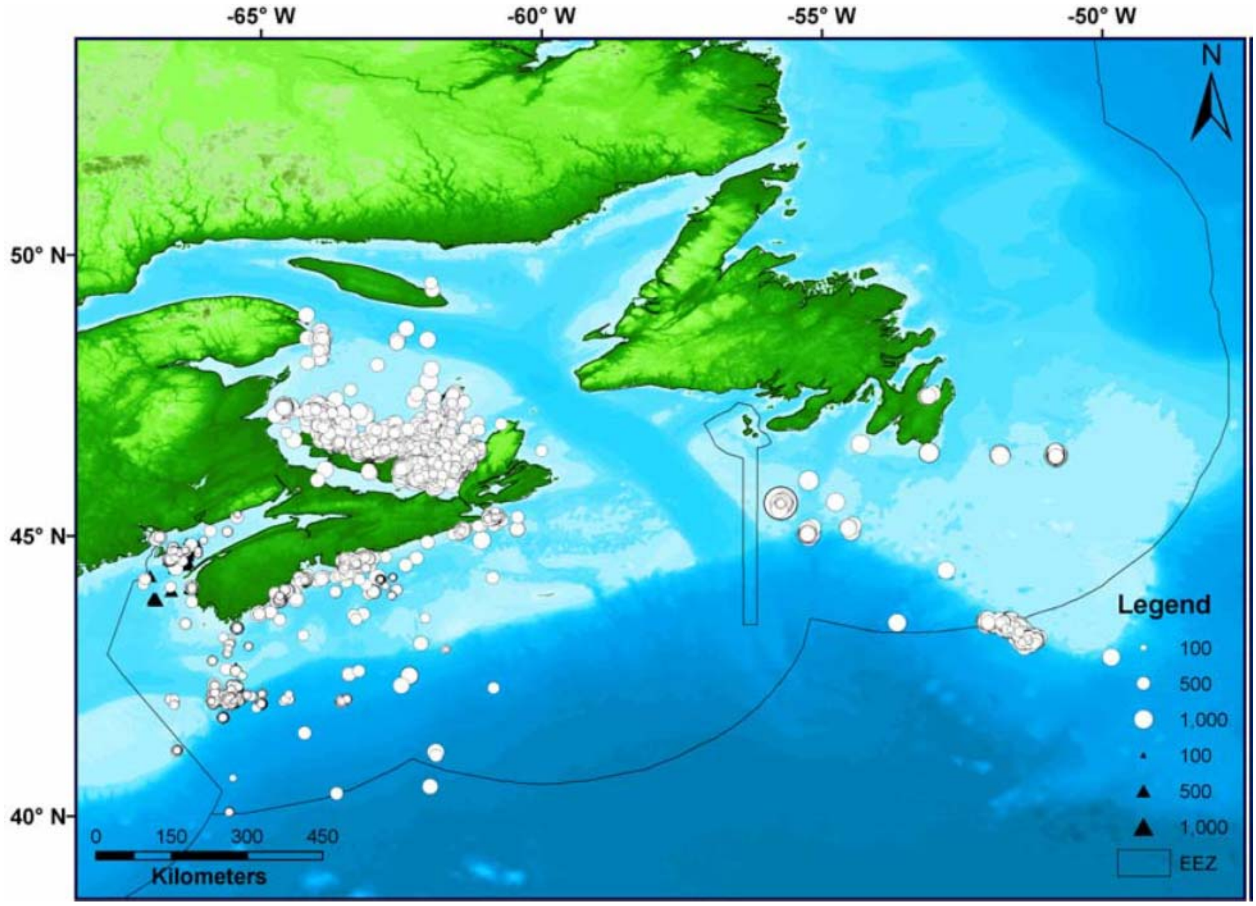

Figure 2.2.2 Location and landed weight in lbs from logbooks of Atlantic bluefin tuna caught by Canadian fishers from 2000-2009. Symbols represent landed weight by gear (white circles = hook and line; black triangles = electric harpoon). Black line is the boundary of the Canadian Exclusive Economic Zone (Figure from DFO 2011).

The CPUE for Atlantic bluefin tuna has risen dramatically in the last few years in the southern Gulf of St. Lawrence (**Figure 1**) to the point where in 2010 the Prince Edward Island fleet (310 licenses) caught their entire quota in 3 days (Hanke *et al*. 2013). Historically this took months to achieve. These data and similar observations have caused both fishers and scientists to question the accuracy of the current western Atlantic tuna abundance estimates (Bluefin RPA meeting, St. Andrews, New Brunswick, 2011).

There are other indications of stock resurgence of bluefin tuna including the data from 59 pop-up archival satellite tags that we deployed on Atlantic bluefin tuna in the southern Gulf of St. Lawrence two weeks prior to the opening of the Prince Edward Island, Gulf Nova Scotia and Gulf New Brunswick commercial fisheries in 2010 (Stokesbury *et al*. 2011). After approximately 533 Atlantic bluefin tuna were harvested from the southern Gulf of St. Lawrence (Hanke *et al*. 2013) only 2 fish with satellite tags were re-captured. However 53 of 59 tags (4 failed to report) reported from live fish after the close of the commercial season (Stokesbury *et al*. 2011). Though not rigorous, this indicates that there may be more Atlantic bluefin tuna present in the southern Gulf of St. Lawrence than have been previously estimated.

In summary, for proper management and conservation, there is a significant and timely need to development accurate indices of abundance Atlantic bluefin tuna in the southern Gulf of St. Lawrence. The goal of this project is to obtain this information through a multi-year mark and recapture experiment using a Jolly-Seber open population model (Jolly 1965, Seber 1965, Ricker 1975, Amstrup 2005).

2.2.3 Experimental design

Study site - The Gulf of St. Lawrence is bounded by Nova Scotia, New Brunswick, Quebec and Newfoundland and Labrador. It is similar to an inland sea as it has distinct physical characteristics and is partially isolated from the North Atlantic Ocean (**Figure 2**). Historical micro constituent analysis (Rooker *et al*. 2008) and archival tagging (Wilson *et al*. 2010) have established that Atlantic bluefin tuna in the Gulf of St. Lawrence belong almost exclusively to the western stock.

Approach - We will design and test a procedure that utilizes both mark and recapture using conventional dart tags (Ricker 1975, Amstrup 2005, Stokesbury *et al*. in press), and spatial and temporal animal movement data derived from acoustic (Stokesbury *et al*. 2005) and archival satellite tags (Stokesbury *et al*. 2004, Block *et al* 2005, Stokesbury *et al*. 2007, Stokesbury *et al*. 2011). Historical data from archival satellite tagging and new data from acoustic and conventional tagging will be used to address the assumptions that are required for estimating abundance through mark and recapture for an open population.

An "open" population changes in abundance during the study due to births, deaths, immigration and emigration (Krebs 1989). For a Jolly-Seber estimate (Jolly 1965, Seber 1965, Ricker 1975, Pollack *et al*. 1990) mark-recapture samples are taken on three or more occupations. The key point is that you must determine, "When was the individual last captured?" The time interval can vary between captures but fish must be individually marked. The population size is calculated from dividing the size of the marked population by the proportion of animals marked (number of animals caught in a sample compared to how many of those animals were marked; Krebs 1989). The increase in the numbers of bluefin tuna that will be examined for marks in the Gulf of St. Lawrence due to the growing catch-and-release charter fishery (catch and release 600 to 800 fish per year) and therefore the increase in tags that will be recaptured, will allow this experiment to be conducted at a higher level of precision than has been possible previously.

A Jolly-Seber mark and recapture experiment will be performed in collaboration with Fisheries and Oceans Canada, the Prince Edward Island Fishermen's Association, the Gulf Nova Scotia Fishermen's Association (see included letters of support) and other bluefin tuna fishers from the region. There is now a recreational charter fishery for Atlantic bluefin tuna in the southern Gulf of Saint Lawrence. Many tuna are now captured in this recreational fishery, and released back into the population. By tagging bluefin tuna captured in this fishery, as well as the wide spatial distribution provided by tagging with commercial fishers, there is an opportunity to apply conventional tags (Floy spaghetti streamers) to large numbers of tuna during the summer and early autumn. Researchers will be deployed on fishing boats in four locations during the months of August to November (North Lake and Tignish PEI, Port Hood and Arasaig NS; **Figure 4**) and two locations where opportunistic tagging can occur (Richibucto, NB, Magdalen Islands PQ; **Figure 4**) to attach conventional tags to bluefin tuna captured and released by fishers. Returns of marked animals will occur, both through recapture in the charter fishery and through the commercial fisheries that open in the autumn.

2.2.4 Implementation and staff

2014 – Preparation for execution of the project will start during the summer of 2014. Multiple years of tagging and tag recapture will be required to provide the first valid estimate of abundance. This procedure is necessary as the number of tagged fish must build up over at least two seasons to provide enough tagged fish and tag returns to create a valid estimate of abundance. Based on the recapture of our archival tags in 2010 in relation to the total estimated catch (2/55 = u = 0.036) we suggest a provisional population of ~ 14,000 tuna are now in the Gulf each year, keeping in mind that this is only a portion of the total stock abundance as not all bluefin tuna enter the Gulf of St. Lawrence each year. Based on the estimated provisional population we will be required to tag between 200 to 250 tuna a year to obtain a valid estimate that will have either the 25 or 10 % probability of accuracy that is required for management and scientific study, respectively (Krebs 1989).

One Post-Doctoral Fellow (Post-Doc) will be hired to work on the project year round. This responsible scientist will assist in experimental design, lead the field crews and assist in data analysis, report preparation and information dissemination to fishers and managers. The field research team will consist of the responsible scientist and three technicians who will be hired for 3-4 months a year augmented with field assistance from the study P-I's and fishers. Post-Doc and technicians will undergo training including safety training (MEDS A-3 Dartmouth Survival Systems Inc.), training in conventional and acoustic tagging techniques, otolith and tissue removal and sample preparation, metadata recording and data analysis.

To perform the experiment we will be required to tag approximately 200-250 bluefin tuna/yr in regions of the Gulf where we anticipate, from past years knowledge, that they will randomly mix with the population. The study design will consist of either the Post-Doc or technicians being stationed in all four locations (**Figure 4**; North Lake and Tignish, PEI and Port Hood and Arasiag NS) that geographically coincide with past areas of high catch rates (**Figure 1**). Also, tagging will be performed from ports in New Brunswick and the Magdalen Islands when possible. Opportunistic tagging opportunities are also expected (tagging that is not directly chartered for). Each researcher in each region will be responsible for: 1) Deploying conventional and acoustic tags; 2) gathering recaptured tags from fishers; 3) providing information to fishers regarding the projects objectives and experimental design and 4) dockside sampling of otoliths and tissue for the DFO monitoring program examining mixing rates of eastern and western bluefin tuna through otolith structure.

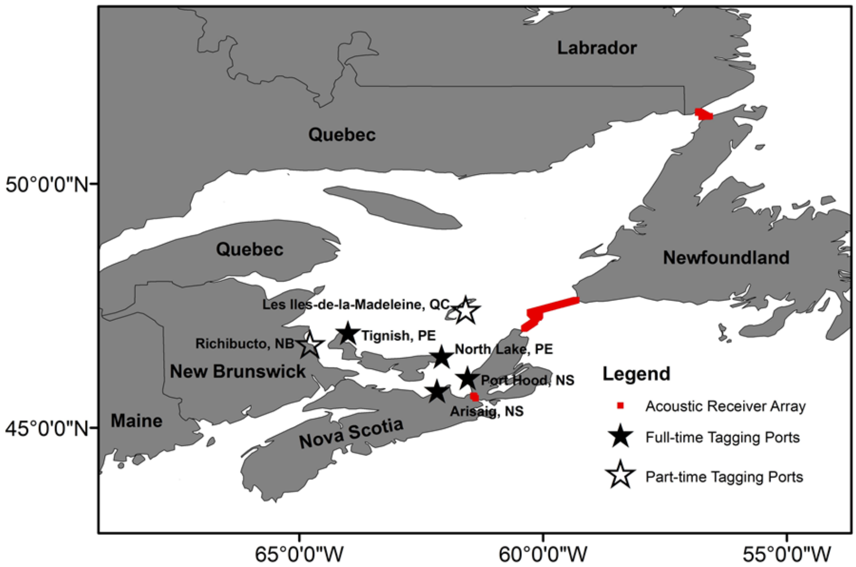

Figure 4. Map of the Gulf of St. Lawrence with positions of hydroacoustic receiver lines operated by the Ocean Tracking Network, Dalhousie University, and positions of proposed placement of our Atlantic bluefin tuna team for tagging operations in 2014.

In each of these regions we will have a local draw where each fisher from PEI (in the two PEI locations) or Nova Scotia (in the two Nova Scotia locations) regardless of whether they fish commercially or in the charter fishery, will have an equal chance to take a researcher on their boat to tag tuna. No commercial capture will be allowed during this process, so there is no possibility of high-grading. The fisher will be paid $700 per day and will be responsible for all costs (including fuel, tackle, bait, and wages for crew). This amount of money is meant only to offset costs and money made by fishers will be negligible. We have budgeted for 80 tagging day trips (20 per location). We also anticipate opportunistic tagging opportunities that may present themselves such as collaboration with other projects answering this call for proposals, or when fishers with the blessing of their associations provide tagging opportunities.

During tagging, tuna will be captured using rod and reel, and fishers will only use barbless circle hooks to reduce impact on fish. Hooked tuna will be fought and brought to the side of the boat where they will be tagged with either 1 or 2 Floy conventional tags, sampled for a DNA plug, weight estimated and the fish will then be released. While tagging takes place the tuna will be held at side of a boat while the boat slowly moves forward allowing the fish to ram ventilate as described in Stokesbury *et al*. (2011).

Our tagged tuna will be recaptured during tagging operations and during regular charter and commercial fishing activities. Tags must be returned to researchers. To ensure this, we will work diligently to introduce all fishers to the project, objectives and experimental design. Also, to provide added incentive for tag return a yearly lottery will be held with a single $5k prize. Each conventional tag returned by a fisher will provide one opportunity to win the prize. Our project will provide yearly estimates of relative abundance based on exploitation rate as well as a final, valid population estimate. Activities for the first 3 years (2014-2016) are shown in the Grant chart (**Figure 5**).

2.2.5 Chronology

	2014		**2015**				**2016**			
Task	**July-Sept**	**Oct-Dec**	**Jan-Mar**	**Apr-June**	**July-Sept**	**Oct-Dec**	**Jan-Mar**	**Apr-June**	**July-Sept**	**Oct-Dec**
Experimental Design Refinement	XXX	XXX	XXX				XXX			
Hiring of Post-Doc & Techs	XXX	XXX		XXX				XXX		
Training of Post-Doc & Techs (sampling)	XXX			XXX				XXX		
Survival Systems Inc. training	XXX			XXX				XXX		
Field training Post-Doc and Techs (tagging)	XXX				XXX				XXX	
Field logistics (accommodation etc.)	XXX		XXX				XXX			
Ordering tagging supplies	XXX		XXX				XXX			
Meetings with fishers & associations	XXX	XXX		XXX	XXX			XXX	XXX	
Conventional tagging	XXX	XXX			XXX	XXX			XXX	XXX
Acoustic tagging	XXX	XXX			XXX	XXX			XXX	XXX
Tag recapture	XXX	XXX			XXX	XXX			XXX	XXX
Otolith & Tissue sampling	XXX				XXX	XXX			XXX	XXX
Data Analysis			XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
OTN line download (OTN Dalhousie)		XXX				XXX				XXX
Lottery for tagging trips	XXX			XXX				XXX		
Tag prize lottery ($5k)		XXX				XXX				XXX
Lottery for tagging trips	XXX			XXX				XXX		
First relative abundance estimate						XXX				
Annual Relative abundance estimate						XXX				XXX

Figure 5. Grant chart of activities (2014-2016) for a mark and recapture experiment to estimate relative abundance of Atlantic bluefin tuna annually present in the Gulf of St. Lawrence, Canada.

2.2.6 Tagging

Each year 30 Atlantic bluefin tuna will be tagged with uniquely coded acoustic tags (V16 Vemco Inc., NS, Canada). Bluefin tuna enter and exit the Gulf of St. Lawrence through the Cabot Strait in the south or the Strait of Belle Isle in the north. The Ocean Tracking Network at Dalhousie University (www.OceanTrackingNetowrk.org) has both of these passages completely covered with a continuous line of hydroacoustic receivers that will log on data from acoustic tags that allow individual identification of fish and provide a time and location stamp when the fish enters or leaves the Gulf. Report authors (MJWS, SJC and MJD) are primary investigators in the Ocean Tracking Network and have many years of experience with electronic and conventional tag data capture, storage, access and analysis.

Acoustic tags with a 10 year life span will be utilized in this study. Therefore we will have a record each time an individual acoustic tagged tuna enters or exits the Gulf of St. Lawrence. These data will allow us to gain critical information on immigration and emigration for the Jolly-Seber population estimate that we can use to validate the model and allows a measure of what portion of the tuna return to the Gulf of St. Lawrence on an annual basis. These data, when applied to the numbers of tagged tuna in the Gulf of St. Lawrence, will give us an accurate estimate of the number of tuna that are present in the Gulf of St. Lawrence from each year of tagging and provide an accurate estimate of M_i (The number of marked animals in the population at the time of the *i*th sample; Table 1). The project will take place over several years so that the marked population will gradually build up, and the recaptures over years will provide accurate and robust estimates of abundance over time.

Table 1. Key Parameters and Statistics necessary for the execution of a Jolly-Seber mark-recapture experiment (Information from Pollack *et al.* 1994; Table 4.1).

Parameters	**Definition**
M_i	The number of marked animals in the population at the time the *i*th sample is taken ($i = 1,\dots, k$; $M_1 = 0$).*
N_i	The total number of animals in the population at the time the *i*th sample is takes ($i = 1,\dots, k$).
B_i	The total number of new animals entering the population between the *i*th and the (i + 1)th sample and still in the population at the time of the (i+1)th sample is taken ($i = 1,\dots, k - 1$).**
Θ	The survival probability for all animals between the *i*th and (i + 1)th sample ($i = 1,\dots, k - 1$).
p_i	The capture probability for all animals in the *i*th sample ($i = 1,\dots, k$).
Statistics	
m_i	The number of marked animals captured in the *i*th sample ($i = 1,\dots, k$).
u_i	The number of unmarked animals captured in the *i*th sample ($i = 1,\dots k$).
n_i	$m_i + u_i$, the total number of animals captured in the *i*th sample ($i = 1,\dots, k$).
R_i	The number of the n_i that are released after the *i*th sample ($i = 1,\dots, k - 1$). This may not be all of the n_i due to losses on capture.
r_i	The number of the R_i animals released at I that are captured again ($i = 1,\dots, k - 1$).
z_i	The number of animals captured before I, not captured at I, and captured again later ($i = 2,\dots, k - 1$).

*Each year 40 Atlantic bluefin tuna will be tagged with uniquely coded acoustic tags (V16 Vemco Inc., NS, Canada). Bluefin enter and exit the Gulf of St. Lawrence through the Cabot Strait in the south or the Strait of Belle Isle in the North. The Ocean Tracking Network at Dalhousie University has both of these passages completely covered with a continuous line of hydroacoustic receivers that will log on data from acoustic tags that allow individual identification of fish and provide a time and location stamp, when the fish enters or leaves the Gulf. This will determine the ratio of tagged fish returning to the Gulf on a yearly basis.

**Estimates of immigration will be obtained from an examination of historical monthly trends in CPUE through the year. These data when compared with estimates of rate of emigration from acoustically tagged fish will give an estimate of immigration to the aggregation.

Assumptions: A Jolly-Seber (Ricker et al. 1975, Pollock *et al.* 1990, Amstrup 2005) mark- recapture model for an open population has three critical assumptions that must be fulfilled for the accurate and unbiased assessment of abundance. They are: 1) Every animal has the same probability of capture; 2) marked animals have the same probability of survival; 3) marks are not lost or overlooked. Assumptions will be fulfilled as: 1) Bluefin tuna will be fished with non-selective gear, on a broad geographical scale (tagging locations very similar to areas of high commercial catch). 2) All marked animals will have the same probability of survival as tags will not affect catchability after the 14 day period used to provide random mixing of tagged fish back into the population. 3) We will double tag a portion of the tuna (20%) to obtain an estimate of tag shedding (tag loss).

Additionally, we will invest a large amount of effort to include fishers in the project as well as provide project information to the public through outreach programs in order to increase the accuracy of the tag return data. It is well known that regulation of fisheries can cause problems and a decline in tag return accuracy (Stokesbury *et al.* 2009). Our research team will attempt to talk to every captain fishing in the area, singly or in groups, to impress upon them the importance of tag return data to the overall project and how the information will help them and DFO manage the resource. Also, as mentioned above, there will be lottery ($5,000 prize) held each year with one chance to win for each tag that you have returned, to add extra incentive for tag return.

2.2.7 Significance of work

By improving estimates of abundance we will make possible the development of sustainable management targets for commercial harvest and for setting conservation targets.

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Annex 1. Proposed budgets

1.1 Trolling-Acoustic Proposal Budget

A major source of uncertainty associated with this project is that no funding source has been identified and no funds have been allocated to conduct this, or any other, survey to develop a fishery independent index of abundance for bluefin tuna. The following budget is based on the estimated cost to undertake the survey for both the start-up and subsequent year's. The largest portion of the budget is attributed to vessel costs to conduct the survey. Major cost saving could be achieved through vessel contributions from industry and/or DFO. The proposed survey is budgeted with and without the vessel costs.

Year 1:

Technical support:	
1 field technician (EG 4/5 $80K/year)	$20,000
1 full time technician (EG 4/5 $80K/year)	$80,000
Travel:	
Field Costs	$9,000
Consultations (Industry/Scientific)	$7,000
O&M:	
O&M (equipment, maintenance, material, supplies)	$60,000
Software upgrades	$10,000
Over-time in field	$5,000
Sub-Total Start-up year	$191,000
Vessel Charter	
28 days at 8k/day	$224,000
Total Start-up year	**$415,000**

Year 2 (and after without inflation):

Technical support:
1 field technician (EG 4/5 $80K/year) $20,000
1 full time technician (EG 4/5 $80K/year) $80,000
Travel:
Field Costs $9,000
Consultations (Industry/Scientific) 2,000
O&M:
O&M (equipment, maintenance, material, supplies) $10,000
Software upgrades $10,000
Over-time in field $5,000
Vessel Charter
Sub-Total Start-up year $136,000
Vessel Charter
28 days at 8k/day $224,000
Total Start-up year **$360,000**

1.2 Mark-Recapture Proposal Budget

Budget

Category	Number	Cost	Total	Sub Totals
Salaries				
Post-Doc	1	50,400	50,400	
Technician (3 months)	3	7,560	22,680	73,080
Equipment				
Floy Tags	400	4	1,600	
Floy Tag Return Lottery	1	5,000	5,000	
Coded Acoustic Tags (V16)	40	462	18,480	
Vessel Charter	80	700	56,000	81,080
Office Supplies	1	1,000	1,000	1,000
Travel & Accommodations (Field work)				
Mileage	4	2,500	10,000	
Accommodations	4	2,500	10,000	
Food	4	2,500	10,000	
Supervisor (Mileage and accommodation)	1	3,000	3,000	33,000
Consultants				
Program management consulting	15	600	9,000	
Scientific consulting	10	600	6,000	15,000
			Subtotal	203,160
Acadia university Overhead (20%)				40,632
			Grand Total	**$243,792 per year**

Budget justification

1. Salaries and benefits (Total = $73,080/year)

A. Post doctoral fellow and technicians – Total Amount: $73,080/year
Context: Funds are requested to support one Post-Doc (Mr. Aaron Spares) during each year of the program. The NSERC approved annual salary for a Post-Doc is $45,000 (plus 0.12 benefits) for a total cost of $50,400/year. Also, we will need three technicians for 3 months each ($15/hour, 37.5 hours/week, plus 0.12benefits = $7,560/tech/year; Tech total = $22,680).

Post-Doc and technicians will be responsible for specific focused tasks. They will receive training (some already have) in conventional (Floy) tag deployment on bluefin tuna. They will also receive training in metadata recording, structure and quality. Our researchers will be placed in major tuna landing or access centres in the southern Gulf of St. Lawrence. They will be responsible for deploying conventional tags on tuna. They will also gather recaptured tags from fishers in their area. Generally researchers develop a good relationship with local fishers because they have a project presence in each region to answer questions and provide a point of contact. Their presence will have a very positive impact on the quality of the data acquired. This factor will also greatly increase the rate of tag return. As a side benefit to bluefin tuna research, researchers will be trained in otolith removal, care and storage, as well as tissue removal, storage and data capture. Our researchers placed in the major landing centers will be able to sample bluefin tuna heads and tissue for the Department of Fisheries and Oceans, to assist the otolith analysis now underway (contact: Dr. Alex Hanke, DFO, St. Andrews, NB).

2. Equipment or facility (Total = $81,080/year)

A. Purchase – Total Amount: $20,080 /year

Funds are requested to purchase 400 Floy ™ conventional tags with applicators ($4k). These tags will be deployed on bluefin tuna throughout the study (Total = $1,600).

Funds are requested to purchase 40 V16 coded acoustic tags. (Total cost $18,480). These tags, in conjunction with Ocean Tracking Network receiver lines in place across all opening of the Gulf of St. Lawrence, will provide information on seasonality, emigration and immigration into the Gulf of St. Lawrence. Tags will be programed for 10 years, which will provide a long data set of Atlantic bluefin tuna activity.

B. Charter – Total Amount: $56,000/year

Fishing boat charter will be used to deploy tags. The estimated cost will be $700 per day. We have budgeted for 80 days per year (20 days per major tuna port total = $56,000/year). This will provide coverage of the major areas of tuna distribution and having 4 tag deployment centres over time will address the assumption of the tags being randomly mixed with the population.

C. Tag Return Lottery: $5,000

Conventional tags that are recaptured must be returned in order for the population assessment model to be accurate. The best way to ensure compliance is to have good communication between the science team and fishers. Also, instead of a small reward ($10 or hat per tag return) we will conduct a lottery. For each tag returned that fishing captain gains one chance to win an end of the year lottery for $5,000.

***3. Materials and supplies* (Total = $1,000/year)**

Yearly user fee for operation of ESRI products (ArcGIS Geostatistical Analyst ($45), ArcGIS Tracking Analyst ($45), ArcGIS Spatial Analyst ($45), ArcINFO ($450), and ArcGIS 3D Analyst ($41) = $720/year (HST included). Also, support is required for materials and supplies for students in the program such as printer paper and ink, production of posters for poster presentations, office supplies (Total = $1,000/year)

4. Field work travel – Total = $33,000/year

A. Field work

Tagging of large pelagics will be performed in the southern Gulf of St. Lawrence from 4 locations, Tignish PEI, North Lake PEI, Port Hood, NS, and Ballentyn's Cove / Arasaig NS. Tagging and tag recapture will take place July-September. We estimate mileage costs of $2500/ year per location, accommodation costs of $2500/year per location (for house rental or motel, whichever is the least expensive) and per diem costs of $2500/year per location (Total = $30,000/year). As the project supervisors the total for PI's will travel costs will be similar to each field operation since they must visit the four locations regularly and also make trips to New Brunswick and Quebec (Magdalen Islands) for information dissemination, and tag retrieval ($3,000). Total travel field costs for PI's are $30,000 + $3,000 = $33,000).

5. Consultants

The hiring of a consultant for program management includes interacting with funding partners, and dissemination of information to industry and government groups.
Scientific consultant includes experimental design and statistical assistance to ensure maximum benefit is derived from data on mark and recapture abundance (Total = $16,000/year)

Cash and In- Kind contributions from other sources

In Kind contributions include salaries for scientific team, and some administrative support from the Prince Edward Island Tuna Fishermen's association. Also, the Ocean Tracking Network has invested over $1,000,000 in this region to provide coverage to detect animals carrying acoustic tags that cross the Cabot Strait and Strait of Belle Isle receiver lines.

Cash contributions to the proposed research program are detailed in the table below.

Source	**Status**	**Year 1**	**Year 2**	**Year 3**
		2014	**2015**	**2016**
NSERC DG to MJWS	Secured for year 1-3	20, 000	20,000	20,000
NSERC IRDF	Unsecured	30,000	30,000	30,000
NSERC IUSRA (3)	Unsecured	13,500	13,500	13,500
Total Cash Contribution		**63,500**	**63,500**	**63,500**

Annex II: Research Team

II 1.0 Acoustic Trolling Survey

Dr. Gary D. Melvin is Head of the Pelagic (large and small) unit at the DFO St Andrews Biological Station responsible for research and assessment of Atlantic bluefin tuna. Nationally and internationally he is a recognized expert in fish stock assessment and hydroacoustics. His experience covers many aspects of fisheries, aquaculture, and environmental science as a researcher, scientific advisor, and manager. His current research involves adapting acoustic technology (single, split, and multi-beam) to addressing fisheries issues, monitoring behaviour, evaluating the potential impact of tidal power development and developing collaborative projects with the fishing industry and universities.

Dr. Alex Hanke is a Research Scientist in the Population Ecology Section at the St. Andrews Biological Station. He has broad experience as an oceanographer, a fish geneticist and quantitative fisheries ecologist. As part of the Large Pelagics Group, he is concerned with International Governance Strategy issues related to Atlantic bluefin tuna, swordfish and marine turtles. His current research interests include understanding the life cycle and behaviour of the western Atlantic bluefin tuna population, improving the western Atlantic bluefin tuna stock assessment through improved indices of abundance, and examining ocean climate influences on the distribution and abundance of western Atlantic bluefin tuna.

Technical support: Technical support for the acoustic analysis and field operations will be recruited from a pool of qualified technicians/biologists.

II 2.0 Mark-Recapture Study

Dr. Michael Stokesbury is a Canada Research Chair in Ecology of Coastal Environments at Acadia University. He has published many tagging and tracking studies, including migration and behavior research on Atlantic bluefin tuna, Atlantic salmon, Greenland sharks, Atlantic sturgeon. He has also co-authored a paper in *Nature* on Atlantic bluefin Tuna population structure and authored a paper detailing the post-release survival rate for Atlantic bluefin tuna in the Gulf of St. Lawrence.

Mr. Aaron Spares is a doctoral candidate at Dalhousie University and is nearing completion of his thesis. He has authored and co-authored several publications on the open ocean marine migration of Atlantic salmon and Arctic char. Aaron has also worked tagging Atlantic bluefin tuna off North Carolina and Nova Scotia with the Tag-A-Giant Foundation and, most recently, with the PEI Fishermen's Association off Prince Edward Island.

Dr. Steve Cooke is a Canada research Chair in fish ecology and conservation physiology at Carleton University in Ottawa. He has published over 330 articles that focus on understanding the interface between behaviour, physiology, and fitness in wild fish. He is a globally recognized expert in conducting fish tagging experiments and worked with M. Stokesbury to determine the post release mortality for Atlantic bluefin tuna, captured and released in the Gulf of St. Lawrence.

Dr. Kevin Stokesbury is Chair of the Department of Fisheries Oceanography at the University of Massachusetts, Dartmouth, MA, USA. He is responsible for the Fisheries program conducted at SMAST which includes sea scallops, lobsters and groundfish research. His is laboratory and members of the commercial sea scallop industry and the Massachusetts Department of Marine Fisheries have provided critical data that has been used in sea scallop fisheries management plans and the Habitat omnibus.

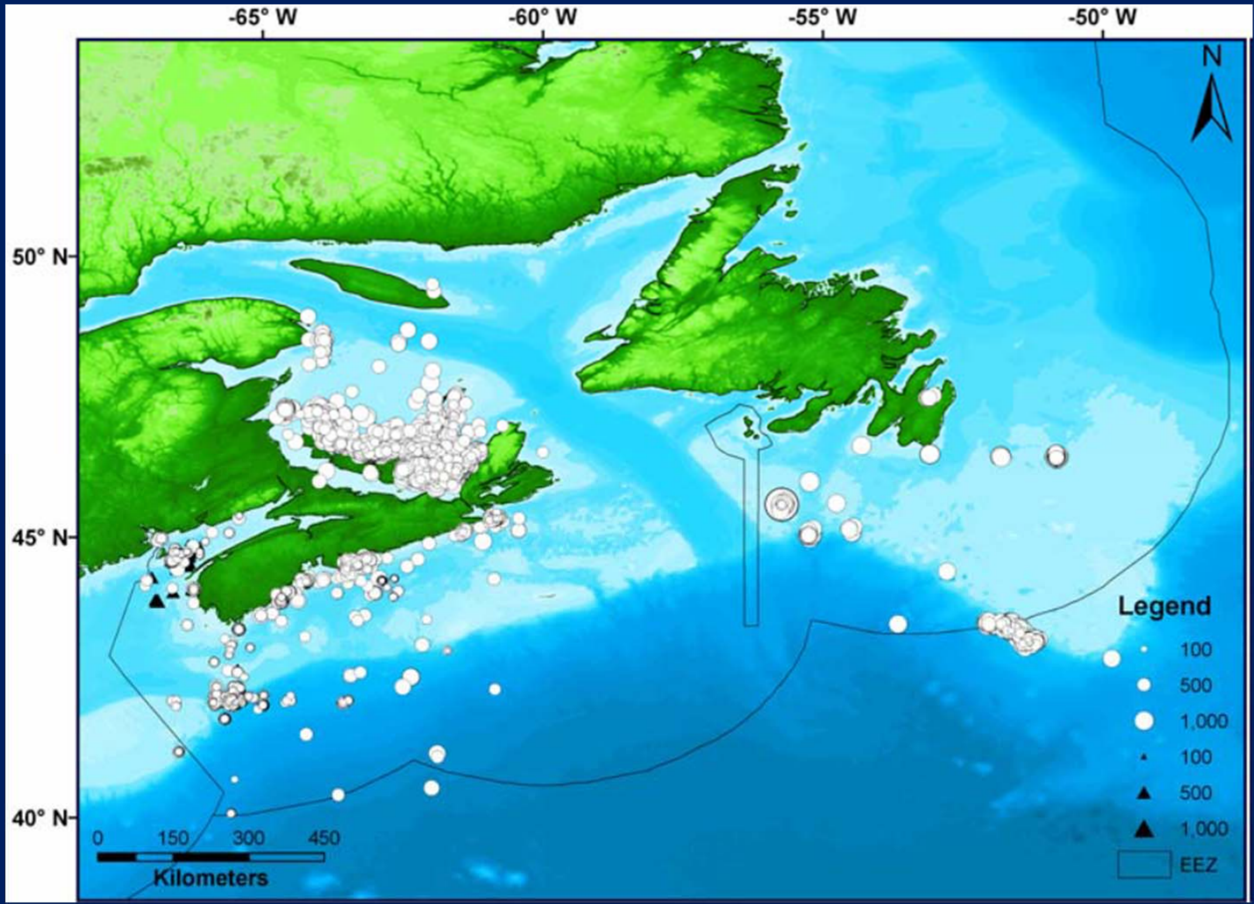
Dr. Michael Dadswell is a Professor of Biology at Acadia University, Wolfville, Nova Scotia. His research focuses on the life history and migratory behavior of fishes. He has published numerous papers and articles on marine migration and population estimates of marine fishes using mark-recapture methods including shortnose sturgeon, Atlantic sturgeon, alewife, American shad, Atlantic salmon and striped bass.

Appendice 7

A Mark and Recapture Experiment to Determine the Abundance of Atlantic Bluefin Tuna Present on a Seasonal Basis each Year in the Gulf of St. Lawrence, Canada

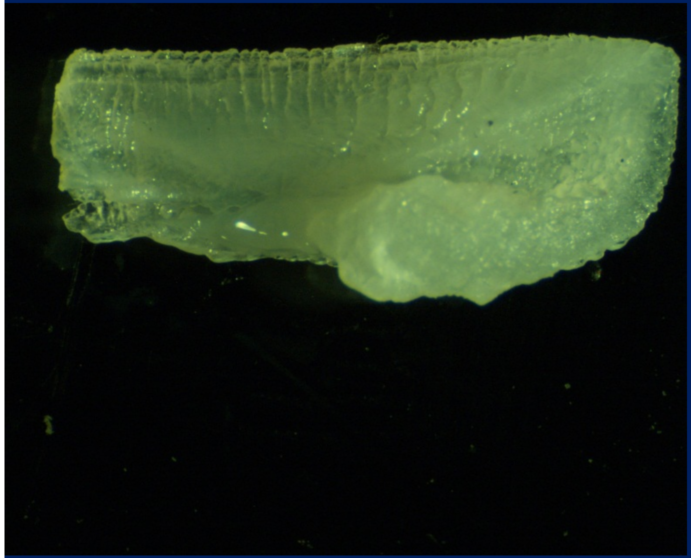
Dr. Michael Stokesbury
Canada Research Chair in the
Ecology of Coastal Environments
Acadia University

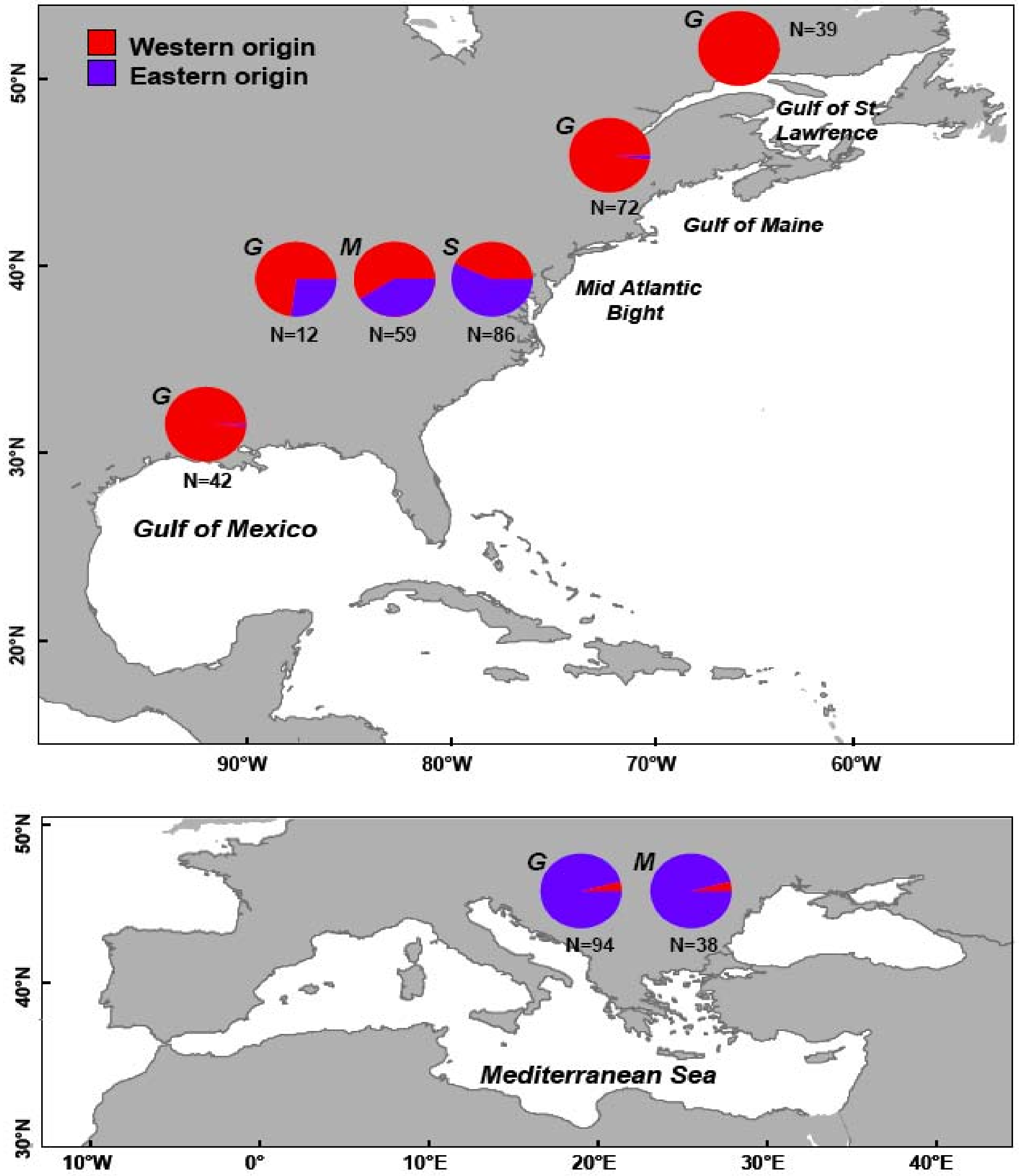
GSL Study Site



Location and landed weight in lbs from logbooks of Atlantic Bluefin Tuna caught by Canadian fishers from 2000-2009. Symbols represent landed weight by gear (white circles = hook and line; black triangles = electric harpoon). Black line is the boundary of the Canadian Exclusive Economic Zone (Figure from DFO 2011).

Microconstituent Analyses Indicate Origin

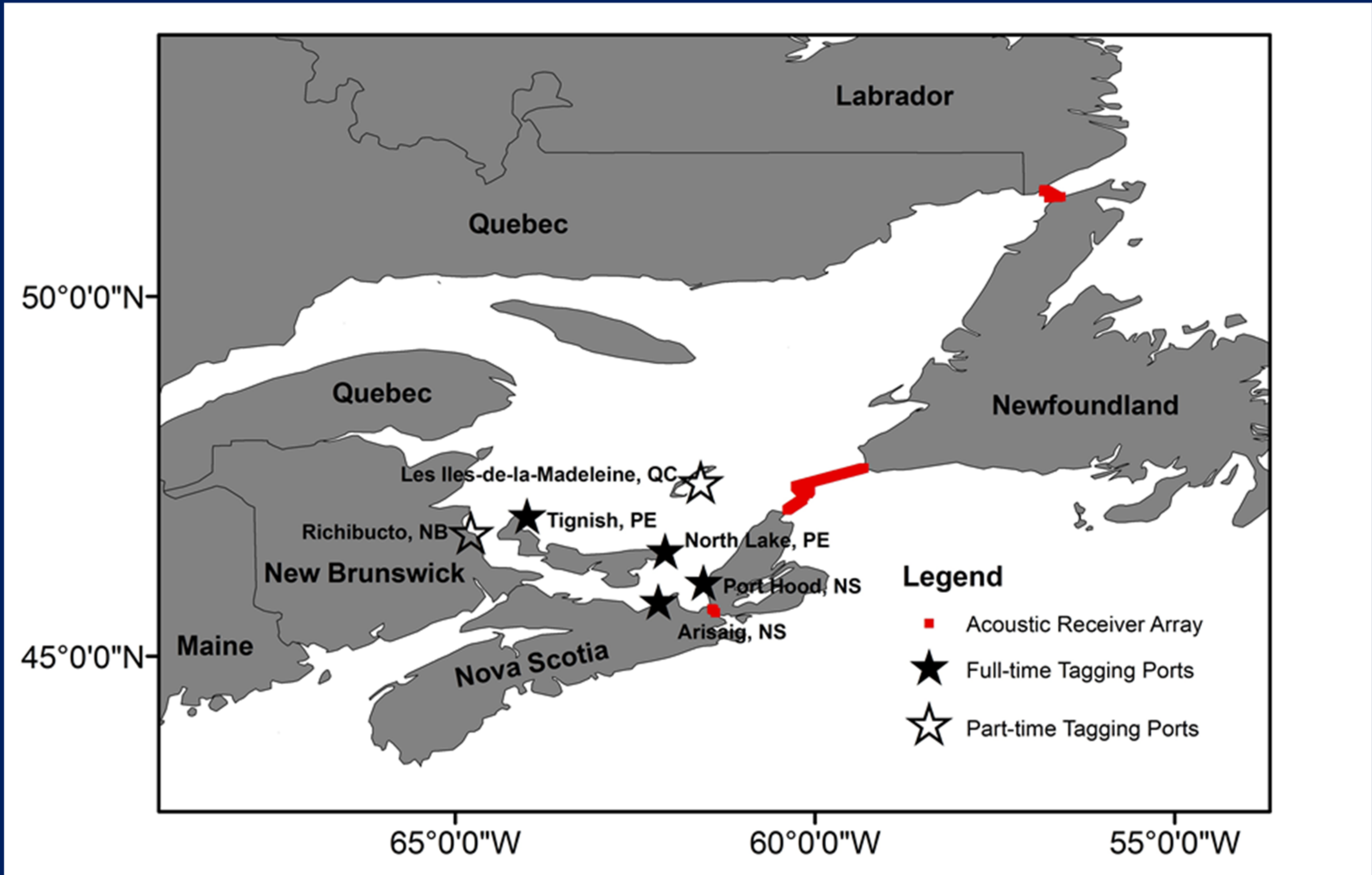




Science

Rooker, Secor, DeMetrio, Schlosser, Neilson & Block, 2008 322:742-744.

Historical archival, acoustic and conventional tagging



Map of the Gulf of St. Lawrence with positions of hydroacoustic receiver lines operated by the Ocean Tracking Network, Dalhousie University, and positions of proposed placement of our Atlantic Bluefin Tuna team for tagging operations in 2014.

Jolly-Seber Mark and Recapture Experimental Design for an open population

Key Assumptions for the accurate and unbiased assessment of abundance.

- 1) every animal has the same probability of capture
- 2) marked animals have the same probability of survival
- 3) marks are not lost or overlooked

Assumptions will be fulfilled as:

- 1) Bluefin Tuna will be fished with non-selective gear, on a broad geographical scale (tagging locations very similar to areas of high commercial catch).
- 2) All marked animals will have the same probability of survival as tags will not affect catchability after the 14 day period used to provide random mixing of tagged fish back into the population.
- 3) We will double tag a portion of the tuna (20%) to obtain an estimate of tag shedding (tag loss) and engage fishers thoroughout the fishery to ensure high rates of return of tags that have been captured.

Valid Estimate (archival)

- Multiple years of tagging and tag recapture will be required. The number of tagged fish must build up over at least two seasons to provide enough tagged fish and tag returns to create a valid estimate of abundance.

- Based on the recapture of our archival tags in 2010 in relation to the total estimated catch (2/55 = u = 0.036) we suggest a provisional population of ~ 14,000 tuna are now in the Gulf each year, keeping in mind that this is only a portion of the total stock.

- Based on the estimated provisional population we will be required to tag between 200 to 250 tuna a year to obtain a valid estimate that will have either the 25 or 10 % probability of accuracy that is required for management and scientific study, respectively.

Tag and Release

- Commercial and Charter boats involved
- Barbless circle hooks
- Heavy leaders
- Fish brought to surface and tagged over the side while moving forward
- Fish released

Experimental Design (Conventional tags)

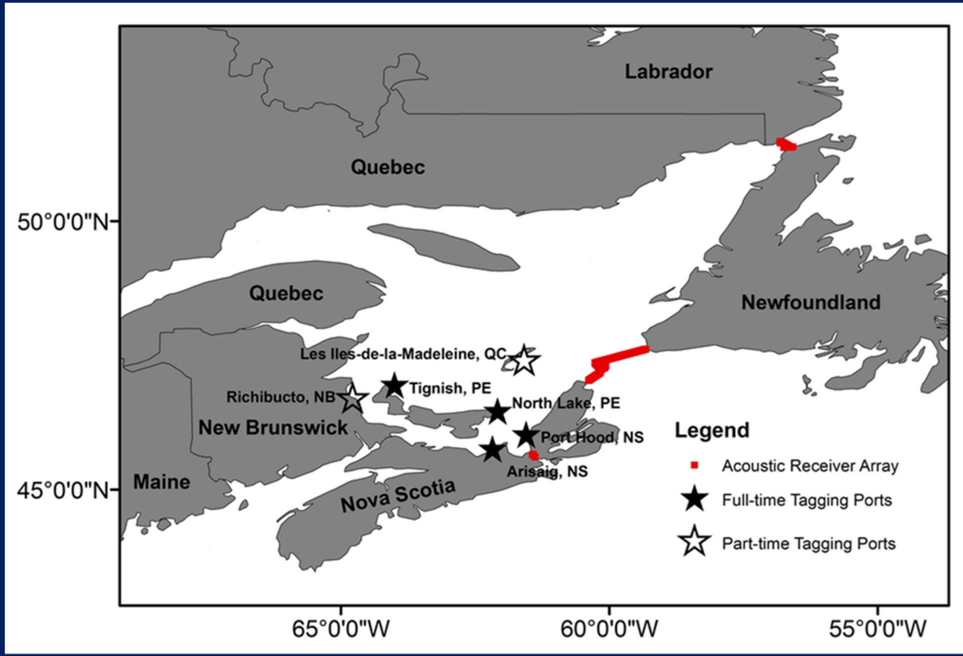
- By tagging Bluefin Tuna captured recreational fishery, as well as the wide spatial distribution provided by tagging with commercial fishers, there is an opportunity to apply conventional tags to large numbers of tuna during the summer and early autumn.

- Researchers will be deployed in four locations during August to November (North Lake and Tignish PEI, Port Hood and Arasaig NS). Opportunistic tagging can occur in other locations i.e., Richibucto, NB, Magdalen Islands PQ.

- Returns of marked animals will occur both through recapture in the charter fishery and through the commercial fisheries that open in the autumn.

Immigration and Emigration (Acoustic Tags)

- 40 bluefin/ year will be tagged with uniquely coded acoustic tags
- OTN has both passages to the GSL gated with hydroacoustic receivers.
- This will determine the ratio of tagged fish returning to the Gulf on a yearly basis
- Immigration rate from historical monthly trends in CPUE through the year compared with estimates of emigration from acoustically tagged fish



Timeline

	2014	2015				2016			
Task	**Oct-Dec**	**Jan-Mar**	**Apr-June**	**July-Sept**	**Oct-Dec**	**Jan-Mar**	**Apr-June**	**July-Sept**	**Oct-Dec**
Experimental Design Refinement	XXX	XXX				XXX			
Hiring of Post-Doc & Techs	XXX		XXX				XXX		
Training of Post-Doc & Techs (sampling)	XXX		XXX				XXX		
Survival Systems Inc. training	XXX		XXX				XXX		
Field training Post-Doc and Techs (tagging)	XXX			XXX				XXX	
Field logistics (accommodation etc.)	XXX	XXX				XXX			
Ordering tagging supplies	XXX	XXX				XXX			
Meetings with fishers & associations	XXX		XXX	XXX			XXX	XXX	
Conventional tagging				XXX	XXX			XXX	XXX
Acoustic tagging				XXX	XXX			XXX	XXX
Tag recapture				XXX	XXX			XXX	XXX
Otolith & Tissue sampling				XXX	XXX			XXX	XXX
Data Analysis		XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
OTN line download (OTN Dalhousie)					XXX				XXX
Lottery for tagging trips			XXX				XXX		
Tag prize lottery ($5k)					XXX				XXX
Lottery for tagging trips			XXX				XXX		
First relative abundance estimate					XXX				
Annual Relative abundance estimate					XXX				XXX

Grant chart of activities (2014-2016) for a mark and recapture experiment to estimate relative abundance of Atlantic Bluefin Tuna annually present in the Gulf of St. Lawrence, Canada.

Budget

Category	Cost
Salaries	73,000
Equipment	82,000
Field work travel	33,000
Consultants	15,000
Overhead	41,000
Grand Total	**244,000/year**

Key Collaborators

- PEIFA
- GNSTFA
- DFO
- OTN
- Aaron Spares, Dalhousie U., Canada
- Dr. Steve Cooke, Carleton U., Canada
- Dr. Kevin Stokesbury, U. Mass., USA
- Dr. Mike Dadswell, Acadia U., Canada

NSERC CRSNG

OCEAN TRACKING NETWORK

ACADIA UNIVERSITY

Appendice 8

PLAN DE RECHERCHE ADDITIONNEL DU JAPON POUR LE THON ROUGE DE L'ATLANTIQUE OUEST À DES FINS DE DISCUSSION EN 2014

(Document présenté par le Japon) [3]

Lors de la première réunion du Groupe de travail de gestionnaires des pêcheries et d'halieutes en appui à l'évaluation du stock de thon rouge de l'Atlantique Ouest, tenue en 2013, le Japon a proposé un plan de recherche (Itoh 2013). Compte tenu des discussions qui ont eu lieu à la réunion ainsi que des articles récemment publiés dans des revues et des informations pertinentes, nous proposons que soit envisagé un plan de recherche alternatif pour le thon rouge de l'Atlantique.

Golet et al. (2013) a signalé qu'au cours de ces dernières années, la répartition des thons rouges de l'Atlantique de grande taille dans le golfe du Maine s'est déplacée vers l'Est (en haute mer) et que les prises de thon rouge de l'Atlantique des États-Unis s'étaient par conséquent réduites (**Figure 1**). Vanderlaan et al. (2014) a souligné que l'une des raisons éventuelles de l'augmentation de la CPUE des grands thons rouges de l'Atlantique dans le golfe du St Laurent provenait du déplacement de leur répartition du golfe du Maine vers le golfe du St Laurent. Ces faits suggèrent qu'il est dangereux de se baser sur des indices d'abondance du stock provenant d'une époque, d'une zone ou d'un engin de pêche limité(e), notamment dans le cas du thon rouge de l'Atlantique, espèce hautement migratoire dont la répartition et la migration semblent varier considérablement à long terme.

Afin de dissiper ces incertitudes, nous proposons de réaliser des programmes de recherche qui obtiendront cinq indices des pêcheries pour le thon rouge de l'Atlantique de grande taille (185 cm de longueur courbée à la fourche, 177 cm de longueur fourche en projection horizontale) dans la zone trophique de l'Atlantique Nord-Ouest. Ces cinq indices devraient être obtenus tous les ans de manière sûre.

- Indices des pêcheries opérant dans le golfe du St Laurent au Canada.
- CPUE palangrière au Sud-Ouest de la Nouvelle-Écosse au Canada.
- CPUE à la canne et moulinet dans la zone du golfe du Maine et du banc Georges aux États-Unis.
- CPUE palangrière japonaise dans la zone 40º-50ºN, 45ºW-55ºW.
- CPUE palangrière japonaise dans la zone 40º-50ºN, 55ºW-70ºW.

En ce qui concerne les indices des pêcheries et les programmes de recherche pertinents menés au Canada et aux États-Unis, nous espérons recevoir des propositions de ces pays. De nombreuses opérations palangrières ont été réalisées par le Japon tous les ans dans la zone 45ºW-55ºW, autour de 40ºN ; toutefois, il s'agissait d'un nombre réduit d'opérations dont le chiffre fluctuait dans la zone occidentale (Kimoto et al. 2013) (**Figure 2**). Nous avons analysé les données des livres de bord de la pêche palangrière japonaise couvrant 21 années (1993-2013) depuis l'établissement du formulaire de déclaration actuel. La **Figure 3** illustre la proportion du nombre d'années au cours desquelles les palangriers japonais ont capturé le thon rouge de l'Atlantique dans le cadre de plus de 10 opérations, par carré de 5ºx5º. Dans la zone à l'Ouest de 55ºW, les proportions étaient faibles (moins de 43%). Cette zone se situe au centre des quatre zones : la principale zone de pêche pour les navires japonais (autour de 45ºW), le golfe du St Laurent, la Nouvelle-Écosse et le golfe du Maine. Il est intéressant d'obtenir les données de cette zone afin de connaître la continuité de la distribution du thon rouge de l'Atlantique entre les quatre zones, ainsi que la proportion relative de l'abondance dans chaque zone. L'obtention des données de distribution dans cette zone centrale permettra d'avoir une image complète de la situation.

Les palangriers japonais sont les meilleurs candidats pour la recherche scientifique. L'utilisation de navires commerciaux revêt des avantages pour garantir la cohérence de la capturabilité pour comparer l'indice à l'intérieur de la zone pour les années antérieures et les zones voisines.

Pour les besoins de la recherche, afin d'obtenir des indices d'abondance fiables et, dans le même temps, dans un souci pratique, il serait approprié que trois navires réalisent 20 opérations par mois, en novembre et décembre. La zone de recherche s'étendra entre 40ºN et 43ºN et entre 55ºW et 66ºW, la ZEE étant exclue. La zone pourrait être divisée entre quatre sous-zones afin de garantir un certain nombre d'opérations dans chaque sous-zone.

[3] Tomoyuki Itoh. National Research Institute of Far Seas Fisheries, Fisheries Research Agency. 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, JAPON. itou@fra.affrc.go.jp

Dans le jeu de données émanant des carnets de pêche, la CPUE annuelle (nº thons rouges/1.000 hameçons) fluctuait entre 0,59 et 9,71 avec une moyenne de 3,25 dans la zone. Le poids vif total du thon rouge de l'Atlantique par opération s'élevait à 751 kg en moyenne. La prise escomptée en poids vif, si aucun poisson n'a été remis à l'eau, s'établit à 3 navires x 2 mois x 20 opérations x 0,751 t = 90,1 t.

Il convient de noter que les thons rouges de l'Atlantique capturés n'étaient pas tous de gros poissons dans la zone. Certaines années ou dans des zones spécifiques, une grande partie de la capture comprenait des poissons de plus petite taille. Aucune information détaillée sur les tailles n'était disponible pour les années antérieures à 2008.

Étant donné que le volume et la taille de la capture fluctuent considérablement d'année en année, il est assez difficile de prédire avec précision le volume de la capture et sa composition par tailles. Si les prises réelles sont bien plus importantes que prévu, il convient d'arrêter plus tôt la recherche ou bien de remettre à l'eau le poisson hameçonné afin de maintenir la mortalité à un niveau inférieur au niveau autorisé. L'observateur scientifique devrait observer à bord de l'embarcation les opérations et les poissons capturés et ses activités devraient faire l'objet d'un suivi par le biais de la déclaration journalière.

Comme les CPUE dans la zone sont bien inférieures à celles de la zone de pêche principale, les palangriers commerciaux ne vont vraisemblablement pas opérer dans cette zone dans le cadre de leurs activités commerciales. S'ils sont utilisés, il conviendra d'envisager une certaine forme d'encouragement ou un cadre alternatif, tel que le recours à un navire de recherche.

Parmi les cinq éléments décrits ci-dessus, une autre question fondamentale qu'il convient de nous poser est de savoir si les poissons que nous ciblons sont indépendants (ils ne demeurent que dans une zone) ou sont liés à une autre zone (ils se déplacent entre les zones) dans une période de deux mois. Cette dynamique de distribution devrait être étudiée au moyen de marques électroniques, y compris les marques-archives et les marques pop-up reliées à des satellites.

Une autre question à se poser porte sur l'origine des poissons. Alors que les poissons de grande taille qui se trouvent dans le golfe du Maine et le golfe du St Laurent s'avèrent être originaires de l'Ouest, les conclusions provisoires auxquelles est parvenu le GBYP suggèrent que les poissons capturés dans la zone de pêche des palangriers japonais sont un mélange de spécimens originaires de l'Est et de l'Ouest. Dans le programme de recherche, un nombre suffisant d'otholites devraient être prélevé afin de pouvoir répondre à cette question.

Références

Golet, W. J., B. Galuardi, A. B. Cooper and M. E. Lutcavage (2013) Changes in the distribution of Atlantic bluefin tuna (*Thunnus thynnus*) in the Gulf of Maine 1979-2005. PLoS ONE 8(9) e75480

Itoh, T. (2013) Research proposal to improve stock abundance indices for western stock of Atlantic bluefin tuna. SCRS-13-200.

Kimoto, A., Y. Takeuchi and T. Itoh (2013) Updated standardized bluefin tuna CPUE from the Japanese longline fishery in the Atlantic to 2012 fishing year. SCRS/2013/185.

Vanderlaan, A. S. M., A. R. Hanke, J. Chasse and J. D. Neilson (2014) Environmental influences of Atlantic bluefin tuna (*Thunnus thynnus*) catch per unit effort in the southern Gulf of St. Lawrence. Fisheries Oceanography 23: 83-100

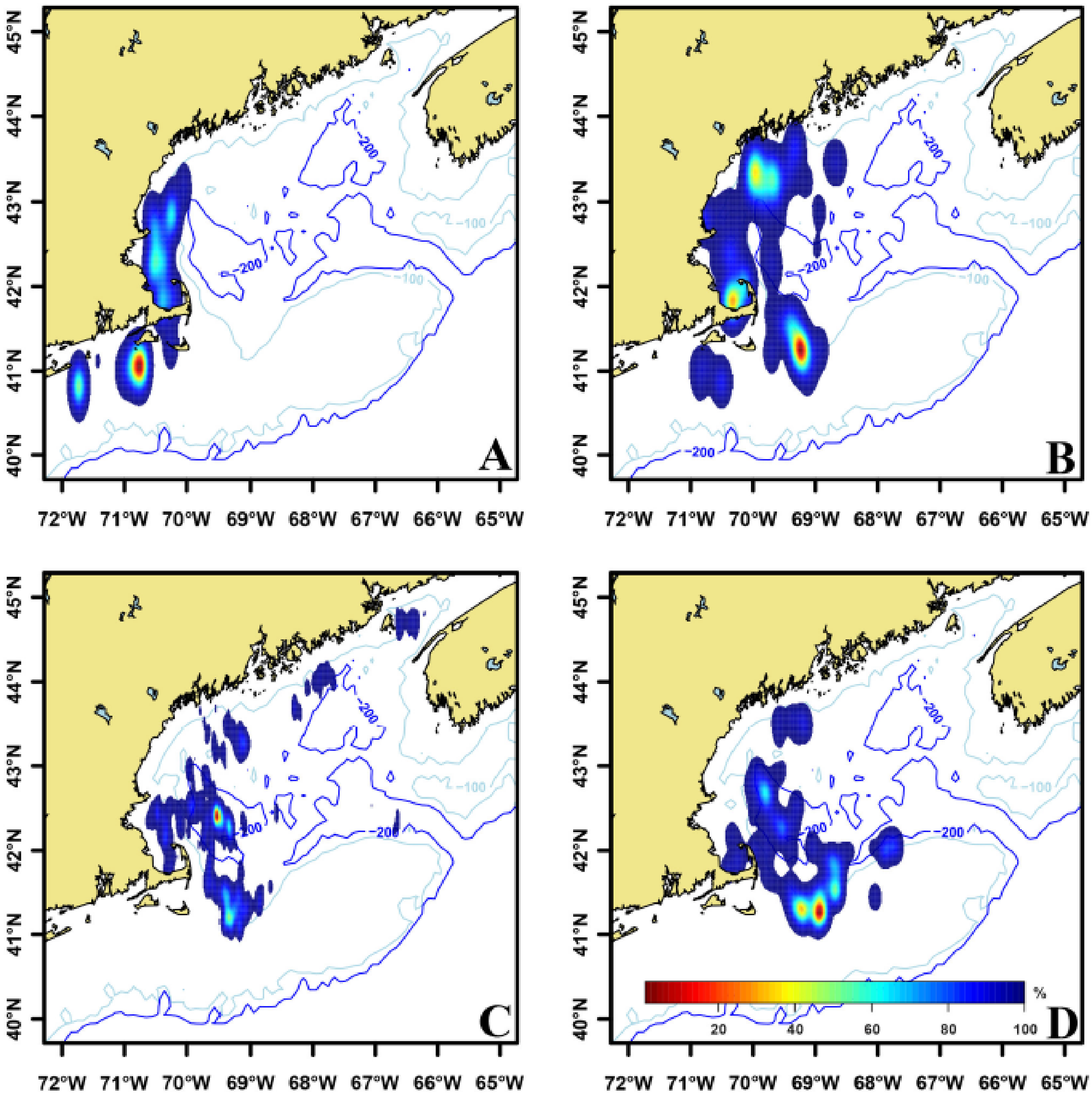


Figure 1. Répartition du thon rouge de l'Atlantique dans le golfe du Maine. Les estimations de la densité Kernel ont été réalisées sur la base du nombre de poissons observés dans chaque banc sur quatre périodes temporelles sélectionnées. Les estimations de la densité ont été normalisées en produisant des distributions d'utilisation qui affichaient une probabilité de présence pendant quatre périodes temporelles, A) 1979-1985, B) 1986-1992, C) 1993-1999 et D) 2000-2005. (Figure 2 de Golet et al. 2013)

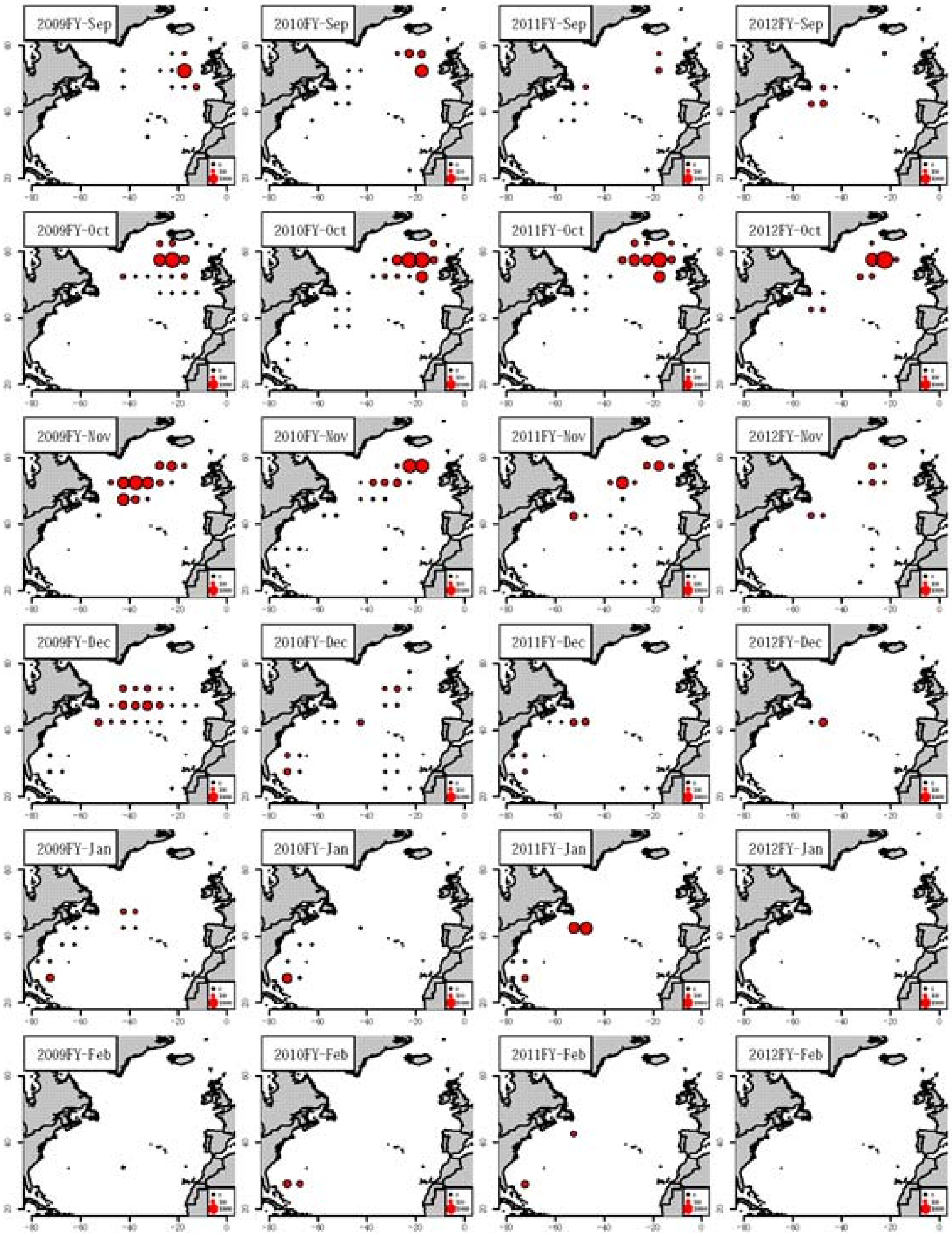


Figure 2. Distributions mensuelles de la prise numérique cumulée de thon rouge réalisée par les palangriers japonais, par carrés de 5ºx5º au cours de la saison principale (septembre-février : panneau supérieur à panneau inférieur) entre les années de pêche 2009 et 2012 (de gauche à droite). (de Kimoto et al (2013)).

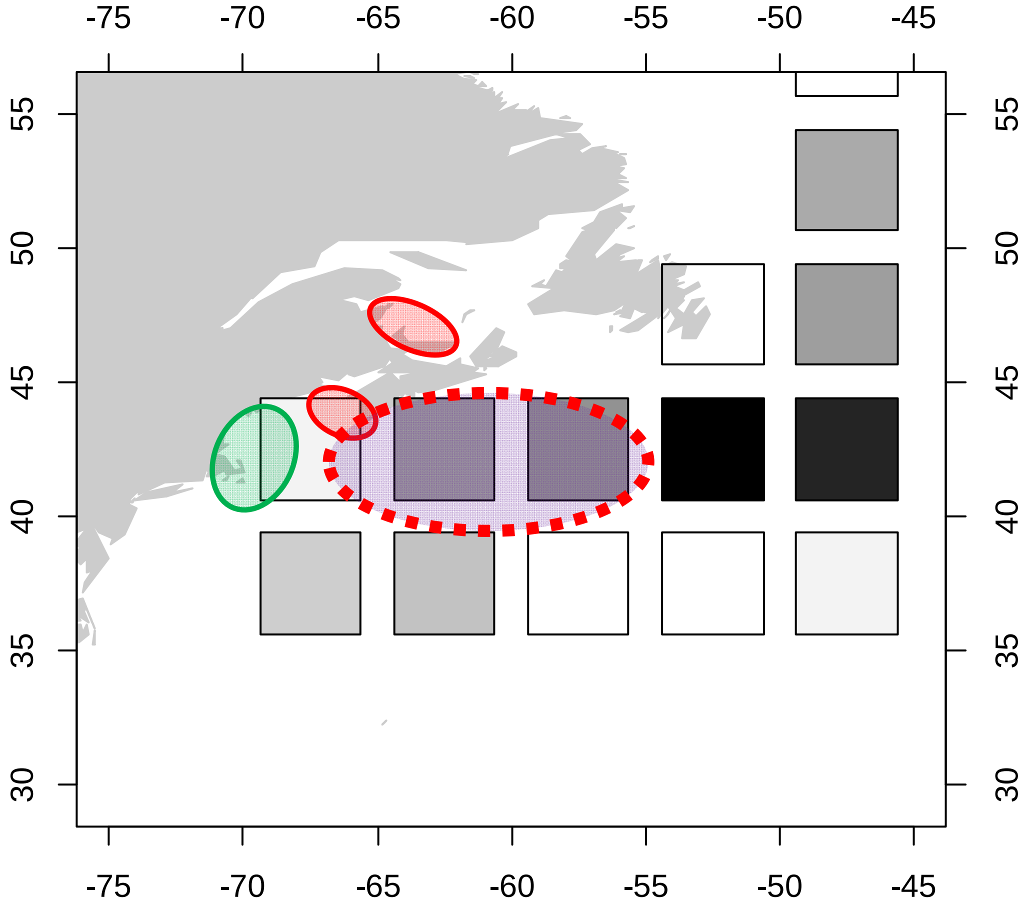


Figure 3. Proportion des années pendant lesquelles les palangriers japonais ont capturé du thon rouge dans plus de 10 opérations, dans un carré de 5ºx5º, pendant 21 années (1993-2013) dans l'océan Atlantique Nord-Est, d'après les données des carnets de pêche palangriers japonais. Les carrés foncés représentent la proportion plus élevée. L'ovale entouré de pointillés rouges représente la zone proposée pour la recherche palangrière japonaise. Les ovales dans la zone rouge sont les zones de recherche de la pêcherie canadienne dans le golfe du St Laurent et le Sud-Ouest de la Nouvelle-Écosse. L'ovale vert représente la zone de recherche de la pêcherie de canne et moulinet des États-Unis dans le Sud du golfe de Maine.

July 12, 2014

A Perspective on Bluefin Tuna Stock Status:

A case for the *lowly* Surplus Production Model

1

By AR Hanke

Concept:

"wherever possible, multiple options should be used"

On the plus side

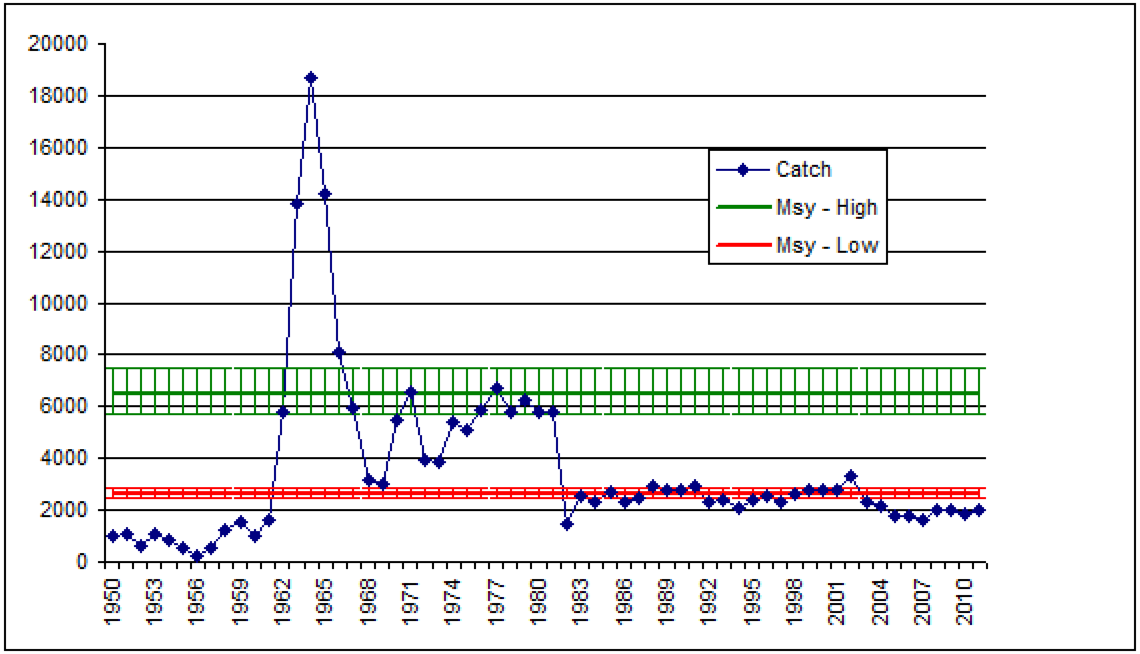
- Minimal data requirements
- Stock and dynamics can be described in terms of biomass
- Can lead to the conclusion that the data provide no information

Caution

- Biomass can be either recruitment or growth
- If no contrast in effort over biomass levels, model confuses high growth and low biomass with low growth and high biomass
- Catch rate not sensitive to changes in biomass

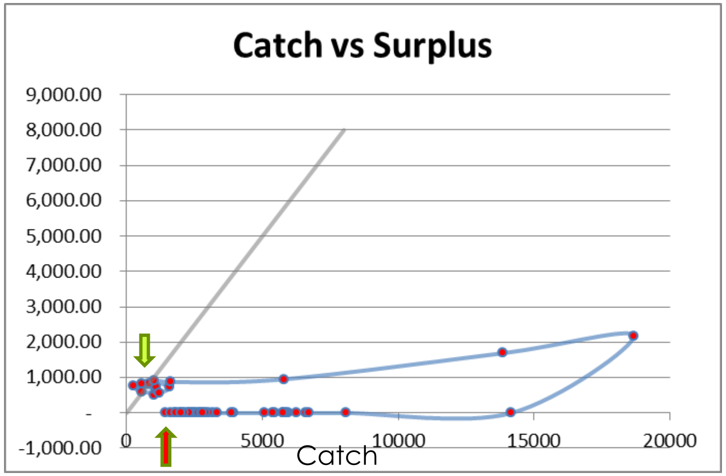
BFT Catch Relative to MSY

"I wouldn't walk over a bridge if it was called VPA!"

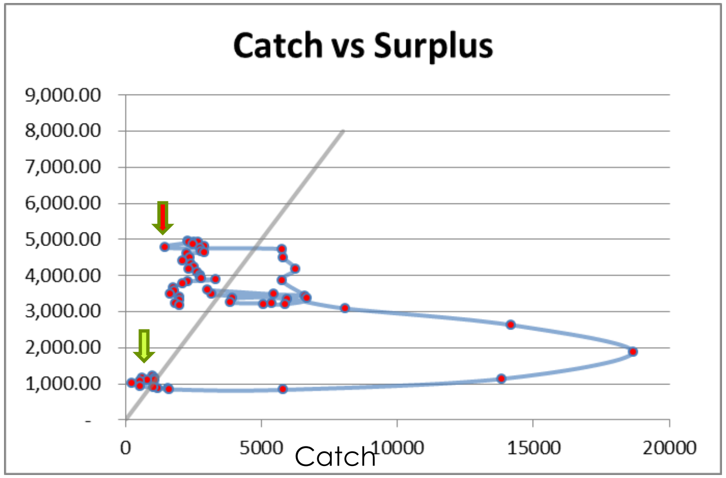


Sustainable Removals:

Low Recruitment

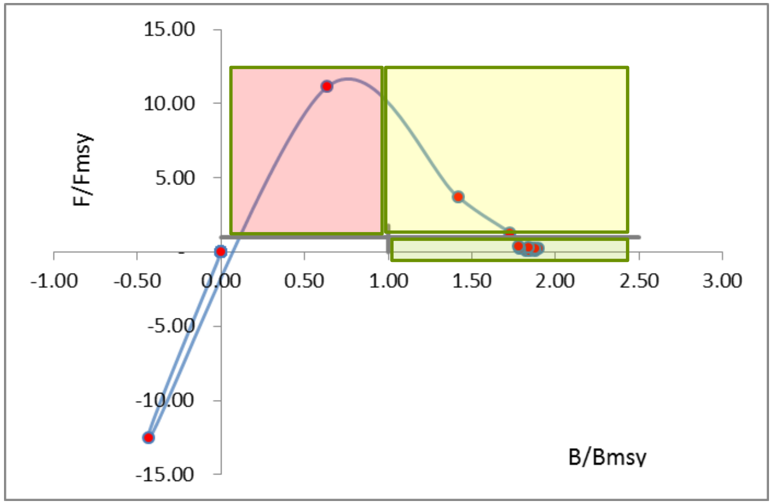


High Recruitment

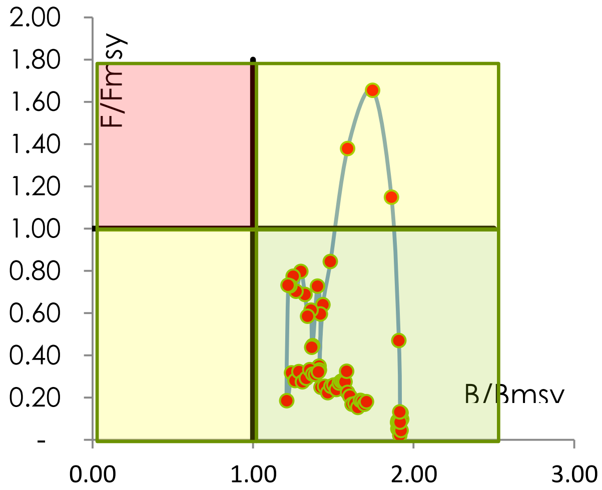


Phase Plots:
Relative Biomass vs Relative F

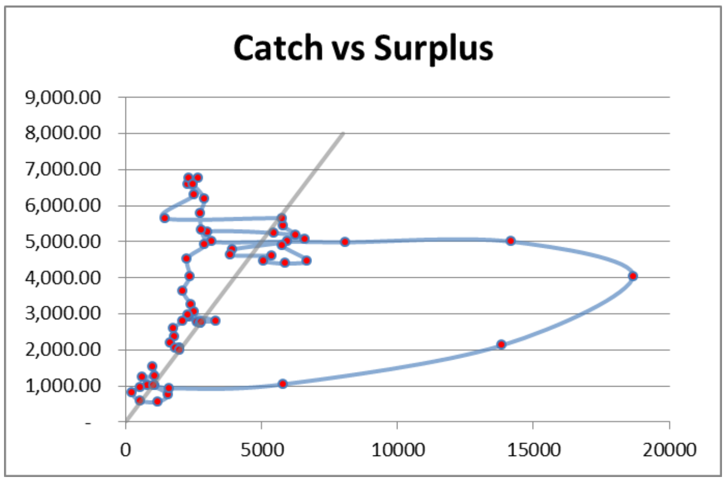
Low Recruitment

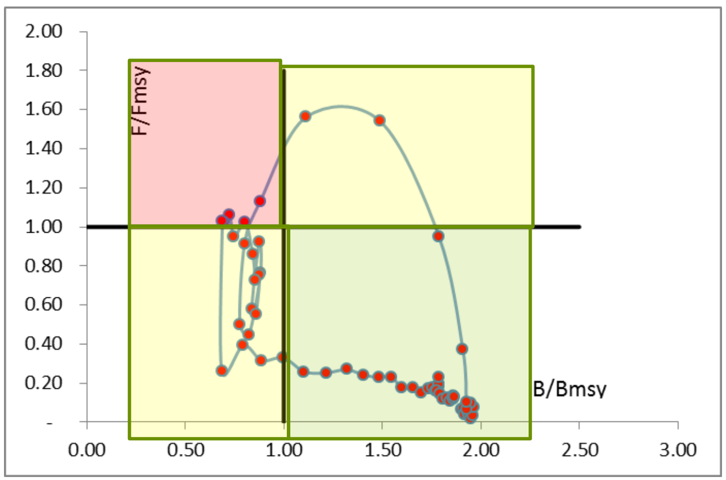


High Recruitment



An Alternative Reality:





Potential Areas of Study

"it is far better to know that the information one has is not informative than to follow model results blindly"

- Stock status: VPA vs SPM
- What is reasonable:
  - Conditions for equivalence
- Stability of model and outputs (hindcasting)

Conclusion:

"simple production models should often be used in stock assessments based on catch/effort data, even when more realistic and structurally correct models are available to the analyst"

- Useful tool when limited information is available or extra information is of dubious quality
- Simple model, more cautious interpretations
- Provide insights into relative performance of the stock through time

Conclusion (cont'd)

- Useful in risk assessments
- Have developed to a point where "*even if more information is available and more complex and realistic models can be implemented, it would be sensible to implement a simpler model if only to act as a contrast*".

The End

Hind Casting:

"wherever possible, multiple options should be used"

- Hind casting trials that compare assessment results for different series of years speak to the stability of the model and outputs.

1970 to 2013 vs 1970 to 2012

or

1970 to 2010 vs 1971 to 2013

Data problems:

Lack of contrast

- Need high F's to observe r at low biomass
- Need low F's to detect K and any density-
- dependent changes in recruitment, growth,
- or mortality at high biomass

Changes in catchability

- Variation in gear, electronics, knowledge, fish distributions
- Violates CPUE = qB

Assumptions

- abundance index (CPUE) is proportional to true abundance (Biomass)
- instantaneous reaction of stock
- symmetric parabola
- need large range of efforts (high and low)
- stock is self-contained
- any loss is mortality
- no interspecific interactions
- the environment is constant
- fishing is density-independent

Advantages (check)

- calculate MSY and Fopt without catchability
- requires only catch and effort data
- don't need to know size or age structure
- inexpensive

Disadvantages

- does not incorporate environmental factors
- excludes trophic linkages
- assumes stock has stabilized at current rate of fishing
- doesn't tell us much about the mechanisms affecting the population dynamics

http://people.uncw.edu/scharff/courses/458/Lecture%2011%20-%20surplus%20production%20models.pdf

- VPA and surplus production models are based on a fairly simplistic view of fish population dynamics. In reality the processes governing fish population size are much more complex. Furthermore, these two methods suffer from specific peculiarities and limitations. VPA models assume that fish cohorts are well defined whereas in reality cohorts are mixed and difficult to distinguish. Closely related to this problem, VPA's are heavily dependent on the ability to age fish, which is problematic.
- VPAs also work best for long-lived species, and tend to be more reliable for estimating historic rather than recent population sizes. Surplus production models, on the other hand, are heavily dependent on the assumption of proportionality between CPUE and resource biomass. Although this assumption may be reasonable for non-shoaling species such as hake or cod, it is clearly invalid for small shoaling species like anchovy and pilchard caught by purse-seine gear. As a result both VPAs and surplus production models are unsuited to the management of small shoaling species.

http://www.olrac.com/index.php?option=com_content&view=article&id=133:surplus-production-models-the-black-box-approach-to-the-estimation-of-fish-stock-size-and-productivity&catid=58:knowledge-base&Itemid=161

Are Age-Structured Models Appropriate for Catch-Effort Data?

- The implication of these findings is that simple production models should often be used in stock assessments based on catch/effort data, even when more realistic and structurally correct models are available to the analyst; the best choice depends on how much contrast has occurred in the historical effort and catch per unit effort data, rather than on prior knowledge about which model structure is biologically more realistic.

Canadian Journal of Fisheries and Aquatic Sciences, 1985, 42(6): 1066-1072, 10.1139/f85-132

Performance of production models on simulated data

Comparing the two models side by side, a general result was that the simple surplus production model did as well as, if not better than, the age structured production model in estimating B/Bmsy, F/Fmsy, and typically outperformed the age structured model in estimating MSY.

http://www.sefsc.noaa.gov/sedar/download/S9RW01%20Productionmodelsimulation.pdf?id=DOCUMENT

Improvement of Management Indices

Gary Melvin

Department of Fisheries and Oceans

Canada

Introduction

- The Main purpose of this presentation is:
  - to promote a better understanding between Science and Managers, and
  - to stimulate discussion and debate on the management/science interactions
- Each field of expertize has its own language and understanding of what is being stated.
- Would like to provide 3 examples of what might be considered misconceptions or uncertainty
  - Subtle indication for manager consideration
  - Real uncertainty – high/low recruitment scenarios
  - Inaccurate assumptions - Potential improvement

Subtle indicator or Indications

- Within the stock assessment world there is an obligation to report specific values following a standardized protocols (e.g., biomass estimate and probabilities).
- Most cases Management will take these outputs and use them in a typical manner to provide their recommendations on catch levels and other aspects
- There are cases where Science has concerns or uncertainties as to whether or not these outputs (theoretically valid) are reflective of the stock status (garbage in, garbage out).

Subtle Indicators (Cont)

- Where this concern or uncertainty occurs Science will usually put caveats or qualifiers on their advise to Management.
- It is here that Management must take heed in this subtle indicator of uncertainty, and incorporate it into their advice.
- Recent Case in point is the last eastern BFT assessment.

Eastern BFT Assessment

- Unquantified uncertainties are coming from various sources
- Poor quality of fisheries information. SCRS acknowledges there are considerable data (Catch/effort) limitations for the eastern stock up to 2007. (insufficient before 1990's and even worse up to early 2000's).
- All CPUE indices have been strongly affected by recent management measures making it difficult to track changes in abundance.

Eastern BFT (Cont)

- Lack of knowledge on key biological/ecological process (natural mortality, population structure, productivity, recruitment dynamics, impact of environmental changes, selectivity patterns, etc).
- The Kobe Matrices provides a mechanism to account for uncertainty in the estimates for the information as provided, however, it cannot integrate many important sources of uncertainty.

Eastern BFT cont

- Result: Even though all CPUE indices are showing an increasing trend, given the multitude and magnitude of the unquantified uncertainties the SCRS cannot provide robust advice to support a substantial change in TAC.
- Important that Management take these subtle indicators from Science that all is not well into their recommendations.
- In other words Management should not take all numbers literally when multiple serious qualifiers are provided by Science.

Real Uncertainty – High/Low Recruitment

- Important to separate stock assessment/ biomass estimates from projections.
- Last Stock assessment (2012) for wBFT shows a gradual increase in SSB since about 2008
- Current Projections based on Beverton Holt (high) and two-line (low) recruitment scenarios for western BFT essentially provide no advice to Management.
- The dilemma dates back to 1982 with the introduction of VPA with 2 options:
    - Constant recruitment – allowed fishing to continue
    - SSB/R relationships – suggested no fishing

Real Uncertainty cont

- In 1993 as part of a separate recovery plans for East and west BFT, two recruitment options proposed SSB/R relationship or geometric mean 1983-1992.
- 1996 Methods working group explored Beverton-Holt and “two line” models, however projections based only on the latter.
- Beyond 1996 both recruitment scenarios were used for projections.

Real Uncertainty cont

- Report of 2000 assessment describes the alternative SSB/R relationships and their relationship to established rebuilding targets.
- First time relationships referred to as the high and low recruitment scenarios.
- Interestingly, both recruitment scenarios give at least a 50% probability of rebuilding to the 1975 biomass by 2018.

Divergent advice:

- Unfortunately, over time there has been a divergence in the projections from each model such that
  - the Beverton-Holt relationship no longer permits fishing nor a recovery by 2018, whereas
  - the “two line” relationship fishing can occur and a recovery by 2018
- Workshop in Washington DC (2012) to review the available data and relationship between SSB/R and to come to a consensus.

Workshop Summary

- Workshop made “No” recommendation for one model over the other, although little support for the two-line model.
- Advice was to keep fishing mortality low and rebuild SSB to 30,000mt (possibly a decade).
- No consideration was given to errors in estimating SSB and R in the VPA
- Bottomline Science/management still stuck with two equally plausible scenarios.

Overview High Low Recruitment

- From a Science perspective this has been ongoing for a couple decades and is a bit embarrassing that it hasn’t been resolved.
- From a management perspective Science is not providing any advice on future stock status or targets based on projections.
- On the one hand (low) every thing is well and the fishery is operating at about BMSY, while on the other (high) targets can not be reached even by closing the fishery.

Overview High Low Recruitment

- Overall the two extremes essentially tell managers nothing on how to reach their targets.
- Alternatives approaches to estimate recruitment used in other fisheries must be explored (e.g., geometric mean of time period or fixed recruitment).
- Important to acknowledge that the wBFT stock is low relative to the 1970's, but slowly rebuilding since about 2008.

Inaccurate assumptions – Potential for improvement

- The SCRS has been expressing concern regarding fishery dependent indices of abundance (CPUE) used in BFT stock assessment due to changing fishing patterns and management initiatives.
- Basic assumption of any index of abundance is that factors affecting the index remain relatively constant over time, thus observed changes in the index are reflective of changes in abundance.
- The impact of deviations from this assumption can range no significant effect to inaccurate representation of trends in biomass (random noise) .

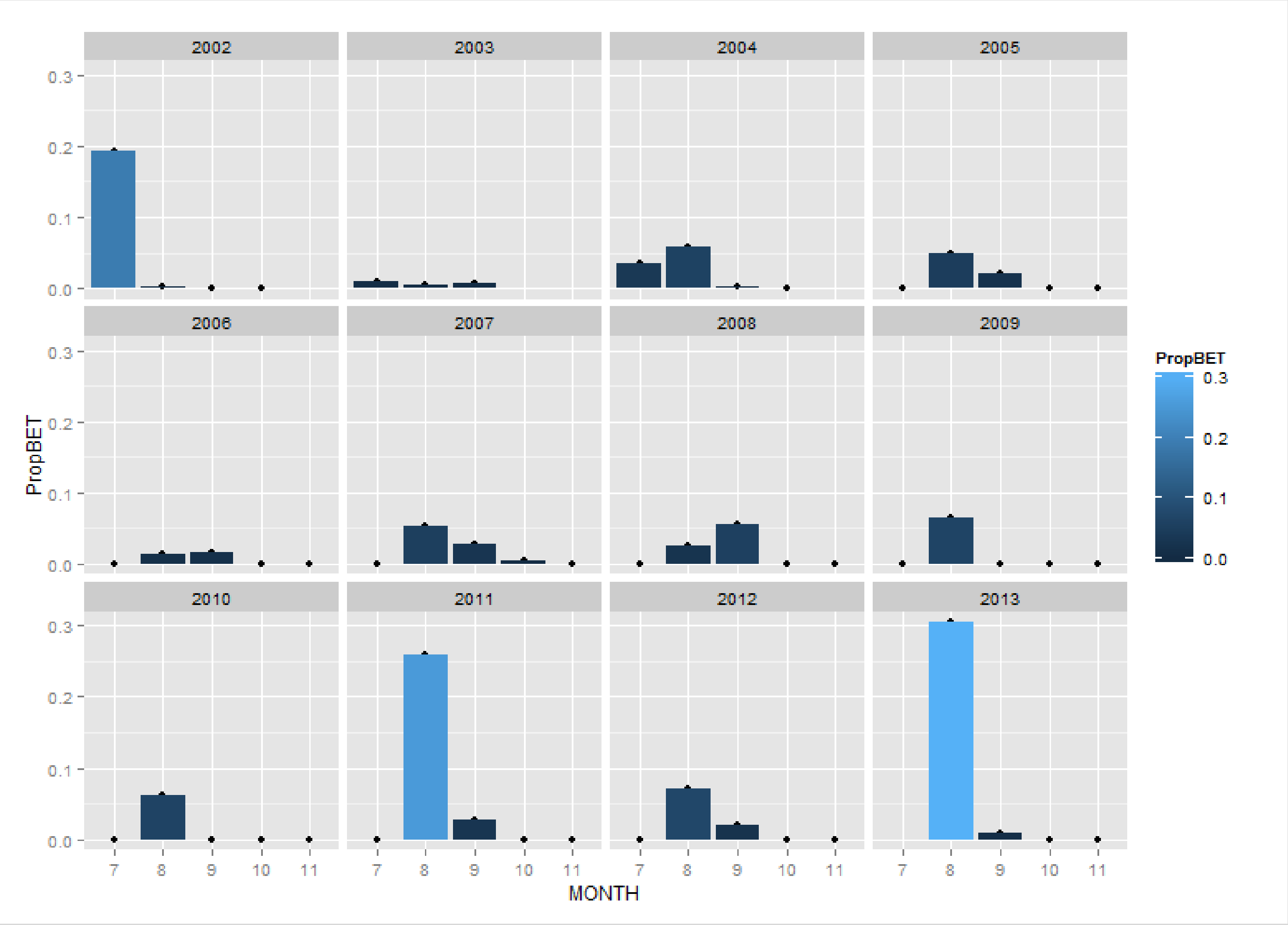
Canadian Example

- The TL/HL CPUE index of abundance for BFT from SWNS is based on the number tuna caught per 100 hours of fishing standardized for several factors (month, gear, year, etc).
- Effort (hours fishing) is determined from the log books identified as targeting BFT under the general assumption the all effort for the trip has been directed at fishing for bluefin tuna.
- While in the past this may have been true, in the last 10 years or more the fishery has been targeting other tuna species such as big eye for part of the fishing trip.
- This change in fishing practice is variable from year to year and the reduction in effort directed for BFT is not accounted for in the SWNS BFT index of abundance.

Big Eye Tuna

- The practice is to hail out as BFT then to spend some unknown portion of time directing for Big Eye before targeting BFT.
- Anecdotal information suggests that for a 5 day trip up to 4 days may be directed at species other that BFT due to the low quota and or market.
- The result is that effort may be over estimated substantially, thereby reducing the index of abundance. (in above 80%).
- The amount of targeting for other species also varies by month and year.

Proportion of BFT trips where the catch of BET exceed BFT by month and year. Effort directed at BET should not be attributed to BFT.



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Multi-Species Fishing trips:

- Multi-species fishing trips can introduce a bias depending upon the effort directed at the species.
- Total trip effort will result is an over-estimate of effort and an underestimate of CPUE.
- As with the Big Eye example, the amount of time will and has varied by month and year.
- Logbooks need to be sufficiently detailed so that effort can be apportioned into it species components.
- For some fisheries sufficient detail may already exist in the original logbooks to address this issue.

Summary

- Management needs to take into the consideration the subtle indicators associated with advice from Science.
- Outstanding long term issues such as the high/low recruitment scenario projections must be resolved or overcome (alternative approaches)as they provide no advice to management and generally enhance confusion and uncertainty around the advice.
- Indices of abundance should be examined to determine if fishing patterns have changed or management initiatives have impacted the index and corrected where possible.

Appendice 11

COUVERTURE DES DONNEES DES PECHERIES POUR LE STOCK DE THON ROUGE DE L'ATLANTIQUE OUEST A L'ICCAT

(Document présenté par le Japon[4])

La couverture des données de prise et d'effort et des données de tailles par rapport à la prise totale du stock de thon rouge de l'Atlantique Ouest a été calculée en utilisant la base de données de l'ICCAT concernant les principales pêcheries. Cette couverture englobe les États-Unis (palangriers opérant dans le golfe du Mexique (GOM), palangriers opérant ailleurs que dans le golfe du Mexique et pêcherie à la canne et au moulinet), le Japon (palangriers uniquement), le Canada (combinaison de plusieurs pêcheries) et le Mexique (palangriers opérant dans le golfe du Mexique).

Bien que la base de données de l'ICCAT soit systématique, ses différents types de codes et d'éléments sont difficiles à comprendre complètement. Il est souhaitable de vérifier à deux reprises les résultats de ce document de travail.

Matériels et méthodes

Les fichiers de données utilisés sont les suivants :

- Prise totale en poids: Tâche 1. Le fichier t1nc_20131210.xlsx a été utilisé.
- Prise et effort: Task2_ce. Le fichier t2ce_20131210.mdb. a été utilisé.
- Taille: Task2_sze. Le fichier t2sz_20131210.mdb. a été utilisé.

Les données ont été obtenues comme suit :

Palangriers (LL) arborant le pavillon des États-Unis opérant dans le GOM

- Prise totale en poids: Species="BFT" & Stock="ATW" & Flag="U.S.A." & Area="GOFM" & GearGrp="LL". Rejets de poissons morts compris.
- Prise et effort : QuadID=4 & Lon>=45 & FlagCode="USA & GearGrpCode="LL" & Lat >= 15 & Lat <= 35 & Lon >= 81 & Lon <= 100
- Taille: Flag="U.S.A." & GearGrpCod="LL" & SampAreaCod="BF60"

Palangriers (LL) arborant le pavillon des États-Unis opérant ailleurs que dans le GOM

- Prise totale en poids: Species="BFT" & Stock="ATW" & Flag="U.S.A." & Area≠"GOFM" & GearGrp="LL". Rejets de poissons morts compris.
- Prise et effort : QuadID=4 & Lon>=45 & FlagCode="USA & GearGrpCode="LL" & Lat > 30 & Lon <= 80
- Taille : Flag="U.S.A." & GearGrpCod="LL" & SampAreaCod=(BF51, BF52W, BF55, BF56W, BF61, BF67W, BF63, BF64W, BF66W)

Canne et moulinet (RR) des États-Unis

- Prise totale en poids: Species="BFT" & Stock="ATW" & Flag="U.S.A." & GearGrp="RR". Rejets de poissons morts compris.
- Prise et effort : QuadID=4 & Lon>=45 & FlagCode="USA & GearGrpCode="RR"
- Taille : Flag="U.S.A." & GearGrpCod="RR" & SampAreaCod=(BF51, BF52W, BF55, BF56W, BF60, BF61, BF67W, BF63, BF64W, BF66W)

[4] Tomoyuki Itoh, Institut japonais de recherche sur les pêcheries hauturières, Agence de recherche halieutique, Japon

Palangriers arborant le pavillon du Japon

- Prise totale en poids: Species="BFT" & Stock="ATW" & Flag="Japan" & GearGrp="LL".
- Prise et effort: QuadID=4 & Lon>=45 & FlagCode="JPN & GearGrpCode="LL"
- Taille: Flag="Japan" & GearGrpCod="LL" & SampAreaCod=(BF51, BF52W, BF55, BF56W, BF60, BF61, BF67W, BF63, BF64W, BF66W)

Canada

- Prise totale en poids: Species="BFT" & Stock="ATW" & Flag="Canada".
- Prise et effort : QuadID=4 & Lon>=45 & FlagCode="CAN
- Taille: Flag="Canada" & SampAreaCod=(BF51, BF52W, BF55, BF56W, BF60, BF61, BF67W, BF63, BF64W, BF66W)

Palangriers (LL) arborant le pavillon du Mexique opérant dans le GOM

- Prise totale en poids: Species="BFT" & Stock="ATW" & Flag="Mexico" & GearGrp="LL" & Area=="GOFM".
- Prise et effort : QuadID=4 & Lon>=45 & FlagCode="MEX" & GearGrpCode="LL" & Lat >= 15 & Lat <= 35 & Lon >= 81 & Lon <= 100
- Taille: Flag="Mexico" & GearGrpCod="LL" & SampAreaCod=BF60

La couverture de la prise et de l'effort a été dérivée de N_BFT au sein de Task2_ce / prise totale en nombre.

La couverture de la taille a été obtenue en additionnant les nombres Task2_sz pour "siz" (registres de données incluant les poissons ayant été réellement mesurés) / prise totale en nombre.

Étant donné que les données de Tâche I n'incluent pas la prise totale en nombre, la prise totale en nombre n'était pas claire dans certains cas. La prise totale en nombre utilisée dans le cas présent correspondait à la somme de la prise par taille pour les pêcheries des États-Unis reposant sur une suggestion formulée par le Dr Craig Brown. Dans le cas de la palangre japonaise, le nombre de la prise et de l'effort a été additionné. En ce qui concerne le Canada, la prise en poids a été utilisée pour la couverture de la prise et de l'effort et la prise par taille pour le total de la couverture des tailles. Quant au Mexique, la prise en poids a été utilisée pour la couverture de la prise et de l'effort.

Résultats

Les données de la période s'inscrivant entre 1990 et 2012 ont été utilisées. Les détails de chacune des six pêcheries sont présentés dans le **Tableau 1**.

Le **Tableau 2** résume la couverture de la prise et de l'effort. Les données de la canne et moulinet des États-Unis de 2011 et 2012 n'ont pas été incluses dans le jeu de données utilisé. La couverture était élevée pour les palangriers japonais, la pêcherie canadienne et les palangriers mexicains opérant dans le golfe du Mexique. La couverture de la canne et moulinet des États-Unis était faible de 2007 à 2010, s'inscrivant entre 5,8 et 11,0 %. Celle des palangriers des États-Unis du golfe du Mexique se chiffre à environ 80% depuis 2006.

La couverture des mesures de tailles a été résumée dans le **Tableau 3**. En ce qui concerne la base de données de l'ICCAT, tant le nombre de poissons dont la taille a été mesurée que la prise par taille estimée qui a été extrapolée de la prise totale devraient être déclarés. Ces déclarations étaient incomplètes tant pour le nombre de poissons dont la taille a été mesurée pour les États-Unis en 2011 et 2012 que pour le Japon en 2012.

La couverture par taille était élevée pour la pêcherie canadienne. Celle des États-Unis était faible, s'inscrivant entre 5 et 32% de 2008 à 2010.

La couverture par taille des dernières années des palangriers japonais était relativement faible jusqu'en 2007, à savoir 0-7%. Elle a ensuite augmenté, passant à 16% en 2008 et à 51% en 2010. Cette augmentation a été le fait de l'inclusion des données des observateurs scientifiques. De surcroît, il a été décidé de déclarer les poids des corps de tous les spécimens individuels de thon rouge de l'Atlantique capturés par les navires japonais en 2008. Une couverture presque intégrale des données de tailles est atteinte depuis 2008. Même si le Japon n'a pas encore soumis les données des poids individuels à l'ICCAT en tant que registres "siz" dans le Task2_sz, les données de prise par taille soumises (registres "cas" dans le Task2_sz) ont été obtenues à partir de ces données.

Tableau 1. Couverture des données de la prise de thon rouge

Tableau 1.1. Palangriers arborant le pavillon des États-Unis opérant dans le GOM

Source YearC unit	Task_1 Total catch Ton	Task2_CE N_BFT Number	Task2_CE W_BFT kg	Task2_Size Num (size measured) Number	Task2_Size Num (catch-at-size) Number	Percent CE %	Percent size %
1990	153	207	0	71	0		
1991	184	360	0	111	0		
1992	112	161	0	73	0		
1993	54	88	0	0	0		
1994	52	63	0	0	0		
1995	35	63	0	0	0		
1996	36	71	0	79	0		
1997	24	55	0	0	0		
1998	18	35	0	0	0		
1999	48	119	0	0	0		
2000	43	472	0	85	0		
2001	20	205	0	36	0		
2002	33	0	0	102	0		
2003	54	361	0	186	0		
2004	151	516	0	93	232	222%	40%
2005	118	314	0	78	0		
2006	88	148	0	0	367	40%	0%
2007	81	302	0	23	344	88%	7%
2008	112	354	0	22	469	76%	5%
2009	112	345	0	69	454	76%	15%
2010	56	201	0	37	219	92%	17%
2011	13	33	0	0	51	65%	
2012	105	345	0	0	422	82%	

Tableau 1.2. Palangriers arborant le pavillon des États-Unis opérant ailleurs que dans le GOM.

Source YearC unit	Task_1 Total catch Ton	Task2_CE N_BFT Number	Task2_CE W_BFT kg	Task2_Size Num (size measured) Number	Task2_Size Num (catch-at-size) Number	Percent CE %	Percent size %
1990	122	57	0	48	0		
1991	121	83	0	20	0		
1992	235	127	0	59	0		
1993	123	176	0	151	0		
1994	133	128	0	176	0		
1995	176	87	0	204	0		
1996	199	61	0	101	0		
1997	167	80	0	148	0		
1998	138	117	0	163	0		
1999	174	86	0	171	0		
2000	199	428	0	79	0		
2001	110	278	0	58	0		
2002	191	0	0	167	0		
2003	246	649	0	224	0		
2004	124	928	0	163	232	400%	70%
2005	93	785	0	103	0		
2006	116	901	0	0	906	100%	0%
2007	92	1,336	0	100	928	144%	11%
2008	121	1,349	0	149	841	160%	18%
2009	223	1,393	0	340	1,431	97%	24%
2010	183	1,471	0	228	1,518	97%	15%
2011	228	878	0	0	1,184	74%	
2012	187	416	0	0	1,124	37%	

Tableau 1.3. Canne et moulinet (RR) des États-Unis

Source YearC	Task_1 Total catch	Task2_CE N_BFT	Task2_CE W_BFT	Task2_Size Num (size measured)	Task2_Size Num (catch-at-size)	Percent CE	Percent size
unit	Ton	Number	kg	Number	Number	%	%
1990	752	4,057	0	1,781	0		
1991	696	6,374	0	1,126	0		
1992	324	812	0	1,181	1,455	55.8%	81%
1993	540	703	0	1,712	0		
1994	462	360	0	1,716	0		
1995	844	479	0	1,760	0		
1996	840	0	0	3,094	0		
1997	931	1,976	0	3,787	0		
1998	777	1,395	0	2,466	0		
1999	760	656	0	2,898	0		
2000	683	413	0	2,424	0		
2001	1,244	1,038	0	7,464	1,363	76.2%	548%
2002	1,523	2,163	0	5,639	0		
2003	991	2,929	0	3,480	0		
2004	716	6,596	0	4,853	0		
2005	425	9,123	0	1,218	0		
2006	376	7,029	0	129	6,146	114.4%	2%
2007	634	1,022	0	817	15,069	6.8%	5%
2008	658	655	0	1,757	11,302	5.8%	16%
2009	860	1,239	0	2,760	11,561	10.7%	24%
2010	682	829	0	2,398	7,569	11.0%	32%
2011							
2012							

Tableau 1.4. Palangriers arborant le pavillon du Japon

Source YearC	Task_1 Total catch	Task2_CE N_BFT	Task2_CE W_BFT	Task2_Size Num (size measured)	Task2_Size Num (catch-at-size)	Percent CE (N_CE)	Percent size (N_CE)
unit	Ton	Number	kg	Number	Number	%	%
1990	550	6,760	0	684	0	*100%*	10.1%
1991	688	7,238	0	783	0	*100%*	10.8%
1992	512	4,470	0	1,180	0	*100%*	26.4%
1993	581	6,059	0	1,357	0	*100%*	22.4%
1994	427	6,329	0	1,352	0	*100%*	21.4%
1995	387	5,181	0	25	0	*100%*	0.5%
1996	436	4,277	0	954	0	*100%*	22.3%
1997	330	3,232	0	86	0	*100%*	2.7%
1998	691	6,690	0	93	0	*100%*	1.4%
1999	365	4,258	0	154	0	*100%*	3.6%
2000	492	5,195	0	8	0	*100%*	0.2%
2001	506	3,282	0	0	0	*100%*	0.0%
2002	575	5,163	0	11	4,054	*100%*	0.2%
2003	57	759	0	14	744	*100%*	1.8%
2004	470	4,072	0	84	6,023	*100%*	2.1%
2005	265	8,415	0	498	4,160	*100%*	5.9%
2006	376	9,289	0	365	6,113	*100%*	3.9%
2007	277	7,757	0	548	6,679	*100%*	7.1%
2008	492	5,312	0	847	3,196	*100%*	15.9%
2009	162	1,080	0	406	1,079	*100%*	37.6%
2010	353	2,091	0	644	2,088	*100%*	30.8%
2011	578	4,890	0	2,513	4,886	*100%*	51.4%
2012	289	4,099	0	0	1,803	*100%*	0.0%

Tableau 1.5. Canada

Source YearC	Task_1 Total catch	Task2_CE N_BFT	Task2_CE W_BFT	Task2_Size Num (size measured)	Task2_Size Num (catch-at-size)	Percent CE (weight)	Percent size
unit	Ton	Number	kg	Number	Number	%	%
1990	438	0	437,400	2,169	2,169	100%	100%
1991	485	0	484,600	2,129	2,129	100%	100%
1992	443	0	413,500	1,782	1,782	93%	100%
1993	459	0	458,700	0	0	100%	
1994	392	0	391,800	1,514	1,514	100%	100%
1995	576	0	576,000	0	0	100%	
1996	597	0	598,100	0	0	100%	
1997	509	0	504,400	1,899	1,899	99%	100%
1998	611	0	596,300	2,345	2,345	98%	100%
1999	587	0	227,800	7	7	39%	
2000	595	0	548,188	47	47	92%	
2001	537	0	523,683	2,168	2,168	98%	100%
2002	641	0	608,683	2,473	2,473	95%	100%
2003	571	0	556,614	5,201	5,201	98%	100%
2004	552	0	536,925	5,115	5,115	97%	100%
2005	600	0	599,526	6,456	6,456	100%	100%
2006	735	0	732,871	8,616	8,616	100%	100%
2007	491	0	490,918	4,808	4,808	100%	100%
2008	576	0	570,769	7,125	7,125	99%	100%
2009	533	0	530,187	6,231	6,231	99%	100%
2010	530	0	504,397	4,134	4,134	95%	100%
2011	510	0	474,082	4,260	4,260	93%	100%
2012	493	0	472,925	4,016	4,016	96%	100%

Tableau 1.6. Palangriers arborant le pavillon du Mexique opérant dans le GOM.

Source YearC	Task_1 Total catch	Task2_CE N_BFT	Task2_CE W_BFT	Task2_Size Num (size measured)	Task2_Size Num (catch-at-size)	Percent CE (weight)	Percent size
unit	Ton	Number	kg	Number	Number	%	%
1994	4	15	9,700	14	0	243%	
1995	0	0	0	16	0		
1996	19	59	18,600	57	0	100%	
1997	2	0	2,300	3	0	115%	
1998	8	0	7,800	14	0	98%	
1999	14	0	14,800	16	0	106%	
2000	29	0	35,900	120	0	125%	
2001	10	46	0	41	4		
2002	12	50	0	47	0		
2003	22	0	22,153	71	0	100%	
2004	9	0	9,028	40	0	100%	
2005	10	0	10,137	46	0	100%	
2006	14	0	14,115	60	0	100%	
2007	7	0	7,100	27	26	100%	
2008	7	0	7,167	30	0	100%	
2009	10	0	9,904	35	0	100%	
2010	14	0	14,058	58	0	100%	
2011	14	0	13,501	55	0	99%	
2012	52	0	50,617	200	0	98%	

Tableau 2. Tableau récapitulatif de la couverture du nombre de thons rouges capturés pour les données de prise et d'effort.

	US.GOM	US.LL	US.RR	Jpn.LL	Canada	MEX.GOM
1990				*100%*	100%	
1991				*100%*	100%	
1992			55.8%	*100%*	93%	
1993				*100%*	100%	
1994				*100%*	100%	243%
1995				*100%*	100%	0%
1996				*100%*	100%	100%
1997				*100%*	99%	115%
1998				*100%*	98%	98%
1999				*100%*	39%	106%
2000				*100%*	92%	125%
2001			76.2%	*100%*	98%	0%
2002				*100%*	95%	0%
2003				*100%*	98%	100%
2004	222%	400%		*100%*	97%	100%
2005	0%	0%		*100%*	100%	100%
2006	40%	100%	114.4%	*100%*	100%	100%
2007	88%	144%	6.8%	*100%*	100%	100%
2008	76%	160%	5.8%	*100%*	99%	100%
2009	76%	97%	10.7%	*100%*	99%	100%
2010	92%	97%	11.0%	*100%*	95%	100%
2011	65%	74%		*100%*	93%	99%
2012	82%	37%		*100%*	96%	98%

Il convient de noter que la couverture de Jpn_LL a été définie comme la prise totale dans la prise et effort de manière à ce qu'elle s'élève à 100%.

Tableau 3. Tableau récapitulatif de la couverture du nombre de thons rouges capturés pour les données de taille.

	US.GOM	US.LL	US.RR	Jpn.LL	Canada	MEX.GOM
1990				10%	100%	
1991				11%	100%	
1992			81%	26%	100%	
1993				22%		
1994				21%	100%	
1995				0%		
1996				22%		
1997				3%	100%	
1998				1%	100%	
1999				4%		
2000				0%		
2001			548%	0%	100%	
2002				0%	100%	
2003				2%	100%	
2004	40%	70%		2%	100%	
2005				6%	100%	
2006	0%	0%	2%	4%	100%	
2007	7%	11%	5%	7%	100%	
2008	5%	18%	16%	16%	100%	
2009	15%	24%	24%	38%	100%	
2010	17%	15%	32%	31%	100%	
2011				51%	100%	
2012					100%	

Appendice 12

PROPOSITION DE CONCLUSIONS DU POINT 7 DE L'ORDRE DU JOUR DE LA DEUXIÈME RÉUNION DU GROUPE DE TRAVAIL DE GESTIONNAIRES DES PÊCHERIES ET D'HALIEUTES EN APPUI À L'ÉVALUATION DU STOCK DE THON ROUGE DE L'ATLANTIQUE OUEST

À condition de ne pas porter atteinte au plan de travail actuel du SCRS reposant sur des décisions prises préalablement par le SCRS et la Commission, le Groupe de travail demande au SCRS de :

1) Examiner la proposition du Canada visant à utiliser le modèle de production excédentaire tout en actualisant l'évaluation de stocks en 2014.

2) Dans le cadre de la mise à jour de l'évaluation du thon rouge de l'Atlantique Ouest de 2014, fournir une orientation sur une gamme de mesures de gestion sur la taille des poissons en ce qui concerne le thon rouge de l'Atlantique Ouest, et leur impact sur des considérations relatives à la production par recrue et la reproduction par recrue. Le SCRS devrait également commenter l'effet des mesures de gestion concernant la taille des poissons sur leur capacité à contrôler l'état des stocks.

3) Fournir les éléments suivants à la réunion de la Commission de 2014 aux fins de leur examen :

   - Une gamme de points de référence cible potentiels, provisoires et reposant sur des niveaux exprimés dans le pourcentage de la biomasse du stock reproducteur estimée en tenant compte des facteurs pertinents, y compris, mais sans s'y limiter, la vitesse estimée d'accroissement de la biomasse du stock reproducteur, les niveaux du recrutement récent et le niveau correspondant à une biomasse qui permettra au SCRS de déterminer s'il existe un scénario de recrutement applicable au stock de thon rouge de l'Atlantique Ouest.
   - Une matrice de stratégie permettant d'atteindre ces points de référence cible provisoires.
   - Un point de référence limite, en tenant compte du niveau historique le plus faible de la biomasse du stock reproducteur.
   - Une matrice de stratégie visant à éviter de chuter en deçà du point de référence limite provisoire.

4) Examiner les indices d'abondance actuels du stock de thon rouge de l'Ouest lors de la réunion de préparation des données dont la tenue est prévue au début de l'année 2015 dans le cadre de laquelle l'accès aux données originales de prise et d'effort avant leur agrégation devrait être autorisé à tous les scientifiques des CPC participantes dans le respect des normes de confidentialité

Appendice 13

DÉCLARATION CONJOINTE DES OBSERVATEURS DE THE PEW CHARITABLE TRUSTS, ECOLOGY ACTION CENTER, DAVID SUZUKI FOUNDATION ET THE OCEAN FOUNDATION

Merci madame et monsieur les co-présidents. The Pew Charitable Trusts, Ecology Action Centre, David Suzuki Foundation et The Ocean Foundation saluent les efforts déployés par ce groupe de travail en vue d'améliorer l'évaluation du stock de thon rouge de l'Ouest. Nous soutenons l'élaboration de nouveaux indices indépendants des pêcheries ainsi que la collaboration visant à améliorer les indices actuels. Nous appuyons également vivement l'évolution dans le sens d'une gestion reposant sur des points de référence au moyen de normes de contrôle de la ponction. Nous constatons que le SCRS a déjà dressé un plan de travail en vue d'élaborer des options de normes de contrôle de la ponction (HCR) étayées par une évaluation de la stratégie de gestion (MSE).

Quinze des vingts années du programme de rétablissement de l'ICCAT se sont écoulées et la dernière évaluation de stocks indiquait que le stock ne se situe qu'à 36% du niveau du stock déjà décimé de 1970. Le programme de rétablissement arrivant à terme dans cinq ans, nous applaudissons la volonté de mettre au point rapidement un modèle amélioré et une meilleure approche de gestion. Toutefois, prendre des décisions hâtives au sujet des modèles à utiliser ou freiner le SCRS dans sa volonté de faire avancer les choses représenterait un pas en arrière pour la Commission et ne s'apparente pas à une gestion responsable.

Tel que nous le concevons, ces réunions entre gestionnaires et scientifiques visent à fournir l'occasion d'établir un dialogue fructueux entre les scientifiques et les gestionnaires afin qu'ils se comprennent mieux les uns et les autres et qu'ils travaillent ensemble dans le but d'améliorer l'évaluation et la gestion. Toutefois, afin que la Commission reste crédible et adhère à une gestion fondée sur la science, une séparation claire entre la gestion et l'avis scientifique est nécessaire. Certaines parties des interventions d'hier nous ont semblé inquiétantes, car elles proposent d'estomper les lignes de responsabilité entre les scientifiques et les gestionnaires. À cet égard, nous appuyons les modifications proposées dans le document intitulé « Proposition de conclusions du point 7 de l’ordre du jour de la deuxième réunion du groupe de travail de gestionnaires des pêcheries et d'halieutes en appui à l'évaluation du stock de thon rouge de l'atlantique Ouest **» (Appendice 12)** qui contribuent à faire en sorte que les recommandations de ce groupe de travail ne soient pas trop contraignantes et ne portent pas atteinte à l'indépendance et la créativité du SCRS.