Ocean Tracking Network (OTN) as a Fisheries Research Tool

A Joint Workshop of the Fishermen and Scientists Research Society (FSRS) & the Ocean Tracking Network (OTN)

February 25, 2010
Best Western Glengarry Hotel, Truro, NS

OCEAN TRACKING NETWORK

FISHERMEN & SCIENTISTS RESEARCH SOCIETY

NSERC CRSNG ATLANTIC ATLANTIQUE

Acknowledgements: The workshop would not have been possible without the cooperation of the Fishermen and Scientist Research Society and the Ocean Tracking Network, and the generous financial support of NSERC.

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Cover photos courtesy of OTN Multimedia Gallery, http://oceantrackingnetwork.org/media/index.html.

Disclaimer:
Presentations in this report may vary from the presentations given at the OTN Workshop due to work in progress information included in the presentations that are not currently available for public consumption.

The discussions following the presentations and the plenary discussions are presented as recorded and interpreted in the rappatours notes. While every effort was made to ensure accuracy, it is possible that errors or misinterpretations may have occurred. Some of the discussion questions and answers may have been edited for clarification.

ABSTRACT

The Ocean Tracking Network (OTN), headquartered at Dalhousie University in Halifax, Nova Scotia, Canada is a global partnership that tracks movements of fish and other marine species, identifies their critical habitat and studies how both are changing with altering environmental conditions. Technologies used include archival tags as detected by satellites and acoustic tags as detected by receivers on the ocean floor. Here we describe a one day workshop organized by the Fishermen and Scientists Research Society (FSRS) to explore and discuss ocean tracking as related to commercial fishing. Time was evenly split between presentations and discussion. The keynote address indicated that although better knowledge of fish distributions may reduce fuel and time consumed to capture fish, it must also be used to ensure sustainability and fairness. Three presentations described OTN as it was emerging globally (funded by Canada Foundation for Innovation - CFI), nationally (funded by National Science and Engineering Research Council - NSERC) and locally (supported by Dept of Fisheries and Oceans - DFO). An additional four presentations gave real examples of how scientists are using ocean tracking technology to study the behaviour of various species including: American lobster, Atlantic cod and salmon, and Grey seals in the NW Atlantic off Canada's east coast. Three break-out groups met separately and in plenary to discuss conservation, fisheries research and economic sustainability and to make recommendations on research priorities. Desire for early involvement by fishermen and concern over adverse affects of increased fishing power were the main issues raised. Adjusting the location of the upcoming Halifax line extension was suggested as a possibility for avoiding harmful interactions between fishing activity and ocean tracking infrastructure. Ideas for new research included inshore/offshore movement and stock depletion of lobster and crab. The need for more tags was generally recognized with several suggestions being made on what to tag, including porbeagle sharks, mackerel, herring, halibut, pollock and haddock.

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1.0 Introduction

The Fishermen and Scientists Research Society (FSRS), a non-profit organization, is an active partnership between fishermen and scientists developed with the overall objectives to promote effective communication between fishermen, scientists and the general public, and to establish and maintain a network of fishermen and scientists capable of conducting collaborative research and collecting information relevant and necessary to the long-term sustainability of marine fisheries. Since its inception in January 1994, the FSRS has brought together fishermen and scientists to work jointly on research projects that will help ensure the sustainability of marine fisheries, and has proven to be a successful model for effective collaboration. Working at the grassroots level, the FSRS has successfully created a network of fishermen and scientists who collaborate on important fisheries research, including joint initiatives with government, local and international fishermen's associations, and academia. These partnerships are the backbone of the FSRS and have enabled the FSRS to host and co-host a number of successful conferences and workshops, with the ***Ocean Tracking Network (OTN) as a Fisheries Research Tool Workshop*** being its latest collaboration.

The Ocean Tracking Network (OTN), headquartered at Dalhousie University in Halifax, Nova Scotia, Canada is a global partnership that tracks movements of fish and other marine species, identifies their critical habitat and studies how both are changing with altering environmental conditions. Technologies used include archival tags as detected by satellites and acoustic tags as detected by receivers on the ocean floor.

On February 25, 2010 the FSRS and the OTN held a joint ***Ocean Tracking Network (OTN) as a Fisheries Research Tool Workshop*** at the Best Western Glengarry Hotel in Truro, Nova Scotia. The objectives of the workshop were to:

- explore the potential benefits of and uses for the Ocean Tracking Network (OTN) and other ocean tracking initiatives to the fishing industry from conservation, fisheries research and economic sustainability perspectives, and
- identify fisheries research priorities that could utilize ocean tracking technology.

The objectives were achieved through presentations on the OTN and current projects for which OTN and other ocean tracking technology is being used, breakout group discussions, and a plenary session.

The keynote address by Ron O'Dor, Senior Scientist, Census of Marine Life, Consortium for Ocean Leadership, indicated that although better knowledge of fish distributions may reduce fuel and time consumed to capture fish, it must also be used to ensure sustainability and fairness. The next three presentations, given by Bob Branton, Director of Data Management, Ocean Tracking Network; Peter Smith, Ocean Sciences Division, Bedford Institute of Oceanography; and Sara Iverson, Professor, Department of Biology, Dalhousie University described OTN as it was emerging globally, nationally and locally. An additional four presentations gave real examples of how scientists are using ocean tracking technology to study the behaviour of various species, including American lobster, Atlantic cod and salmon, and Grey seals in the NW Atlantic off Canada's east coast. These presentations were given by Don Bowen, Research Scientist, Population Ecology Division, Fisheries and Oceans Canada; John

Brattey, Research Scientist, Fisheries and Oceans Canada, Groundfish; Hassan Moustahfid, Marine Scientist, NOAA Integrated Ocean Observations System (IOOS), National Ocean Service/NOAA; and Diane Cowan, Executive Director, The Lobster Conservancy. Contact information for the presenters can be found in Appendix I.

The presentations gave participants a good foundation for their breakout group discussions. Participants were divided into three groups, with each group starting their discussion on a different theme: conservation, fisheries research and economic sustainability. Each group was asked to: a) discuss expected benefits of ocean tracking technology to the fishing industry, b) comment on the current projects with regards to those benefits, and c) propose new research themes or projects. The groups were also asked to identify perceived gaps in relation to expected benefits and to make suggestions where ocean tracking in general might be strengthened.

The following report summarizes the presentations and discussions, as well as the results of the breakout group discussions presented in plenary. Desire for early involvement by fishermen and concern over adverse affects of increased fishing power were the main issues raised. Adjusting the location of the upcoming Halifax line extension was suggested as a possibility for avoiding harmful interactions between fishing activity and ocean tracking infrastructure. Ideas for new research included inshore/offshore movement and stock depletion of lobster and crab. The need for more tags was generally recognized with several suggestions being made on what to tag, including porbeagle sharks, mackerel, herring, halibut, pollock and haddock.

The *Ocean Tracking Network (OTN) as a Fisheries Research Tool Workshop* was a success and it is hoped it can serve as a model for collaborations in other locations. Communication was identified as a key factor in getting collaborators and increased support from others in the community, and workshops such as this one can be an effective means of increasing communication and awareness. One of the most important recommendations of this workshop was the reinforcement of the importance of having fishermen involved in the research projects from an early stage; improved communication is vital for this to happen.

1.1 Agenda

Ocean Tracking Network (OTN) as a Fisheries Research Tool
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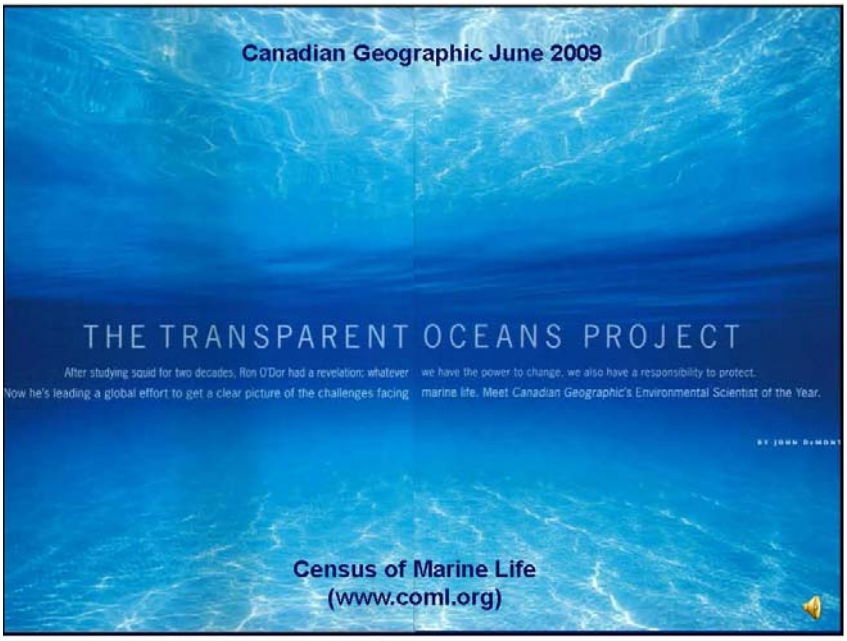
9:00 - 9:15	Welcome and Opening Remarks
9:15 - 10:15	**Keynote Address: The Transparent Oceans Project** - Ron O'Dor, OTN **OTN Global** - Bob Branton, OTN **OTN Operations on the Halifax Line** - Peter Smith, OTN/DFO **The OTN Canada Research Program** - Sara Iverson, OTN
10:15 - 10:30	Coffee Break
10:30 - 11:50	**Encounters at Sea: Grey Seal as Biological and Oceanographic Samplers** - Don Bowen, DFO **The Role of Ocean Tracking Technology in Recent Stock Assessments of Atlantic Cod Off Eastern Newfoundland**. - John Brattey, DFO **Using OTN Data to Improve Stock Assessment and Fishery Management** - Hassan Moustahfid, NOAA **Lobsters on the Move** - Diane Cowan, The Lobster Conservancy Q&A
11:50 - 12:00	Assign breakout groups and give them directions on what they will be doing.
12:00 - 1:00	Lunch (Provided)
1:00 - 3:00	**Break Groups** - participants will be divided into three groups and given questions to focus their discussions: • Explore the potential benefits for ocean tracking technology from a conservation, research and economic sustainability perspective. • Identify gaps in the current ocean tracking projects. • Identify new research projects for each of the three benefit areas from the gap analysis.
3:00 - 3:15	Coffee Break
3:15 - 4:30	**Plenary** - each breakout group will report back to the entire group and next steps and recommendations will be discussed.
4:30 - 5:00	Wrap Up/Conclusions

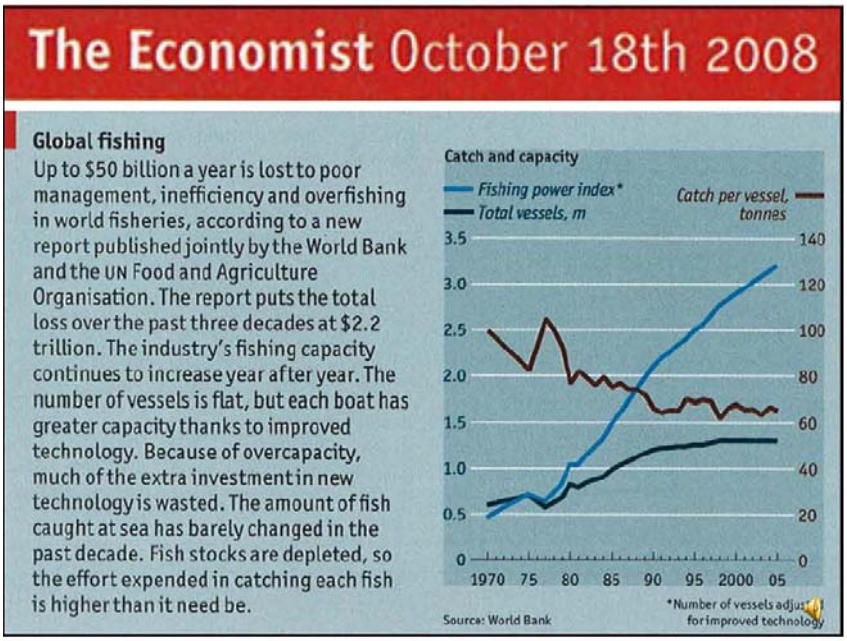
2.0 Presentations

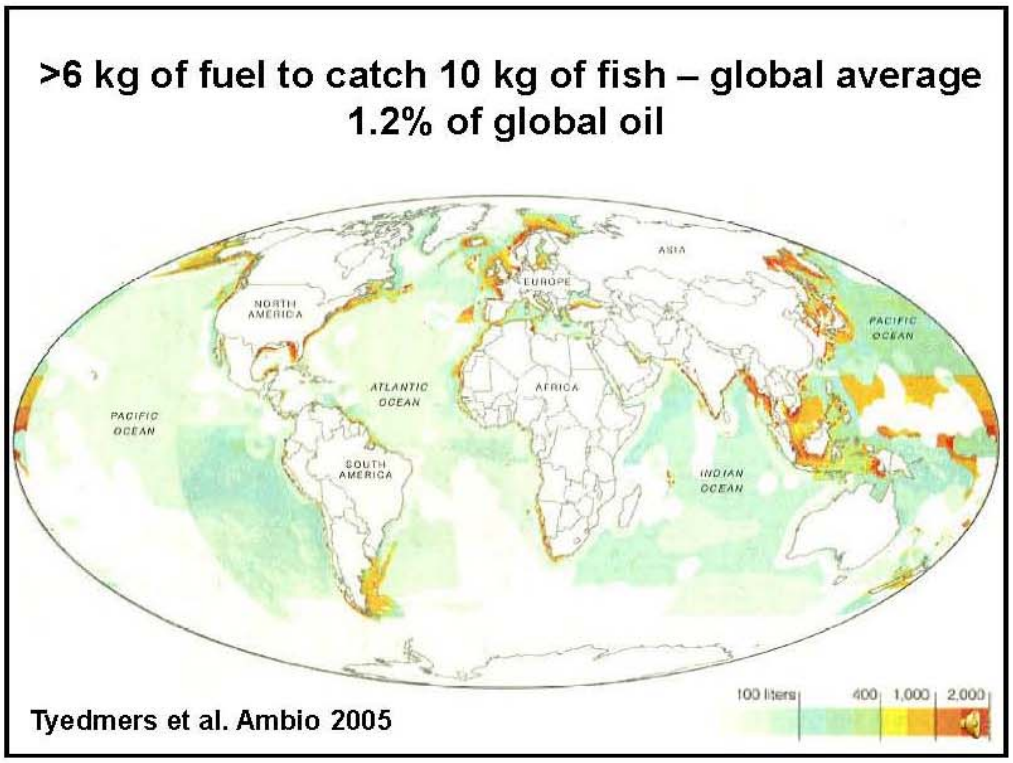
2.1. The Transparent Oceans Project

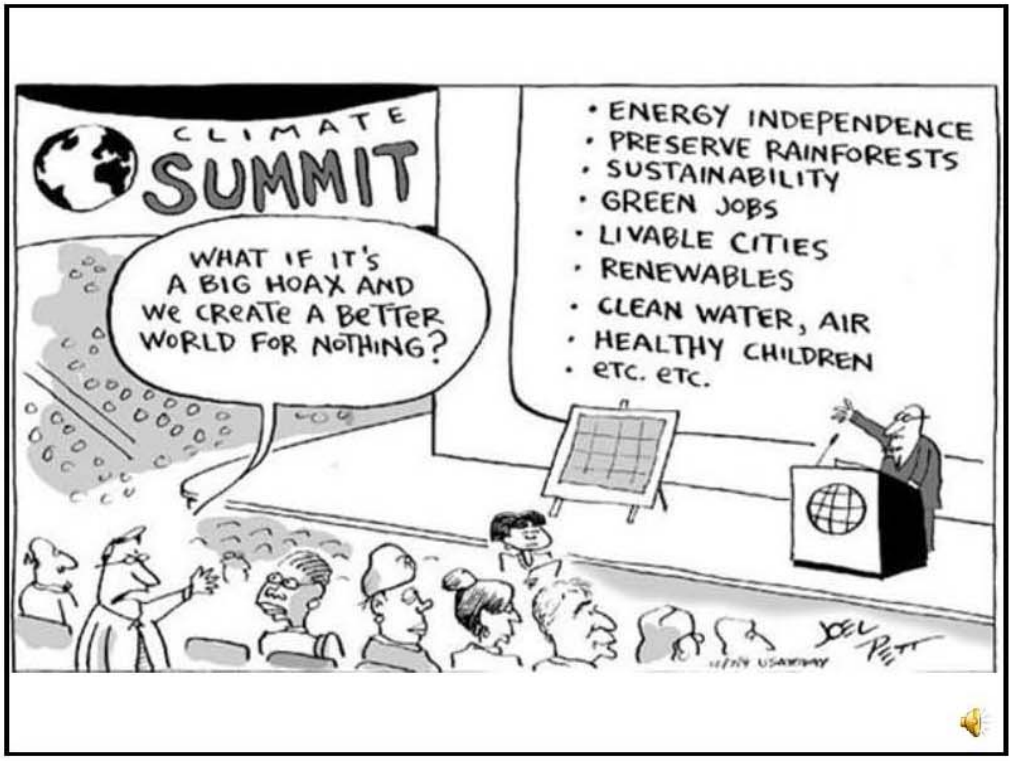
Ron O'Dor, Senior Scientist, Census of Marine Life, Consortium for Ocean Leadership

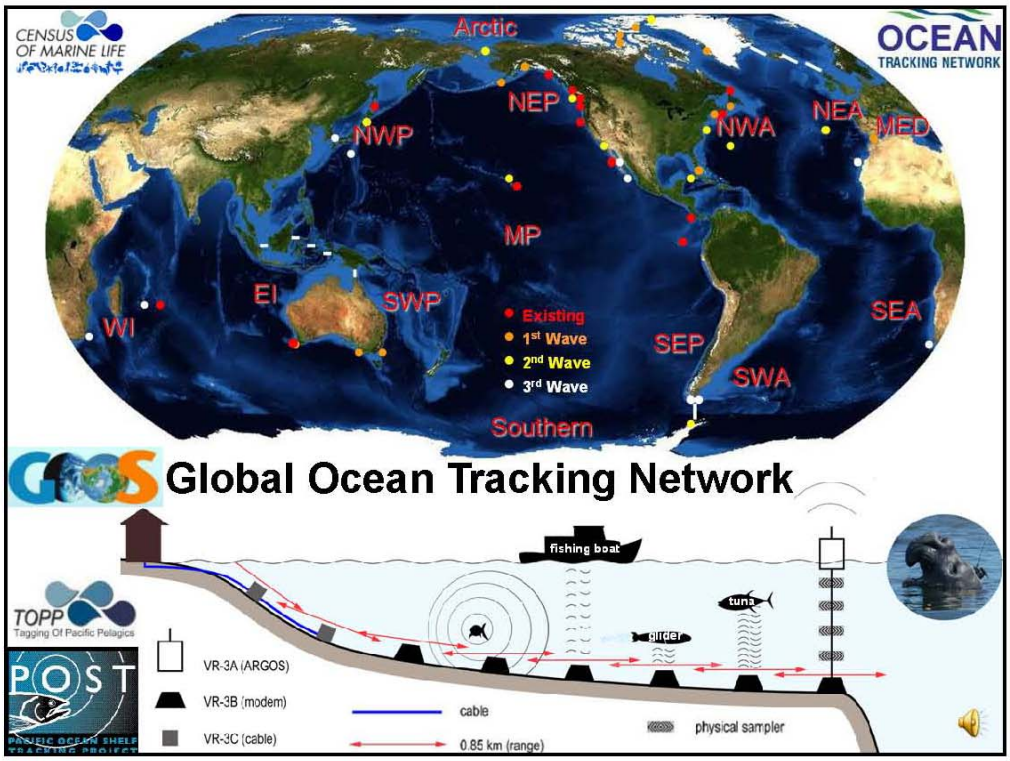
2.1.1 Presentation



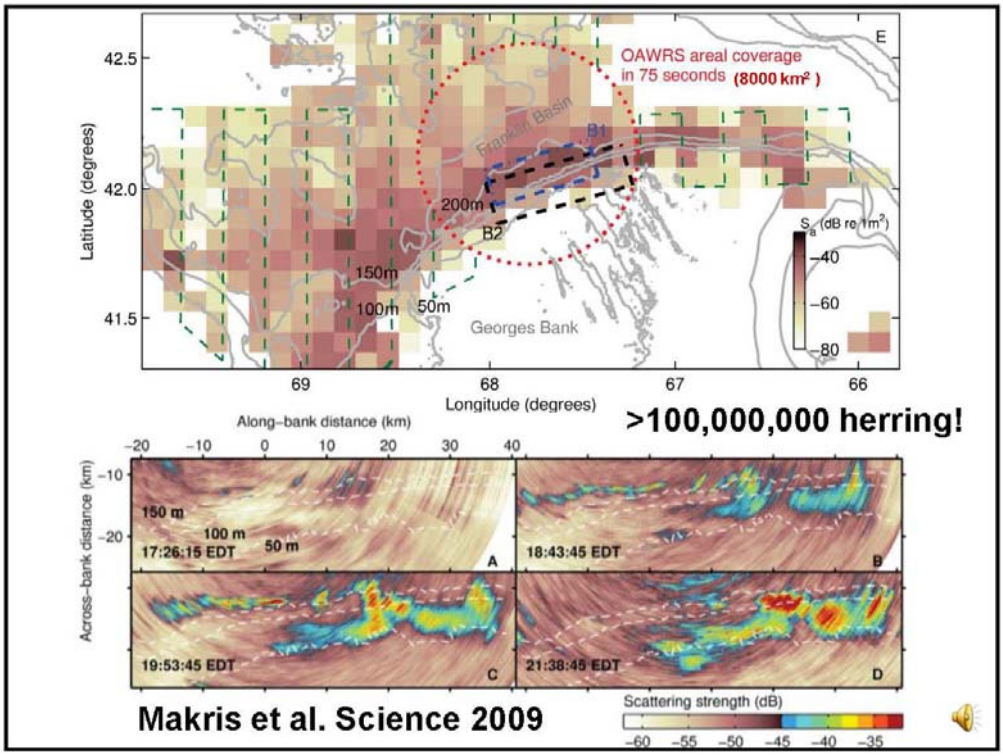


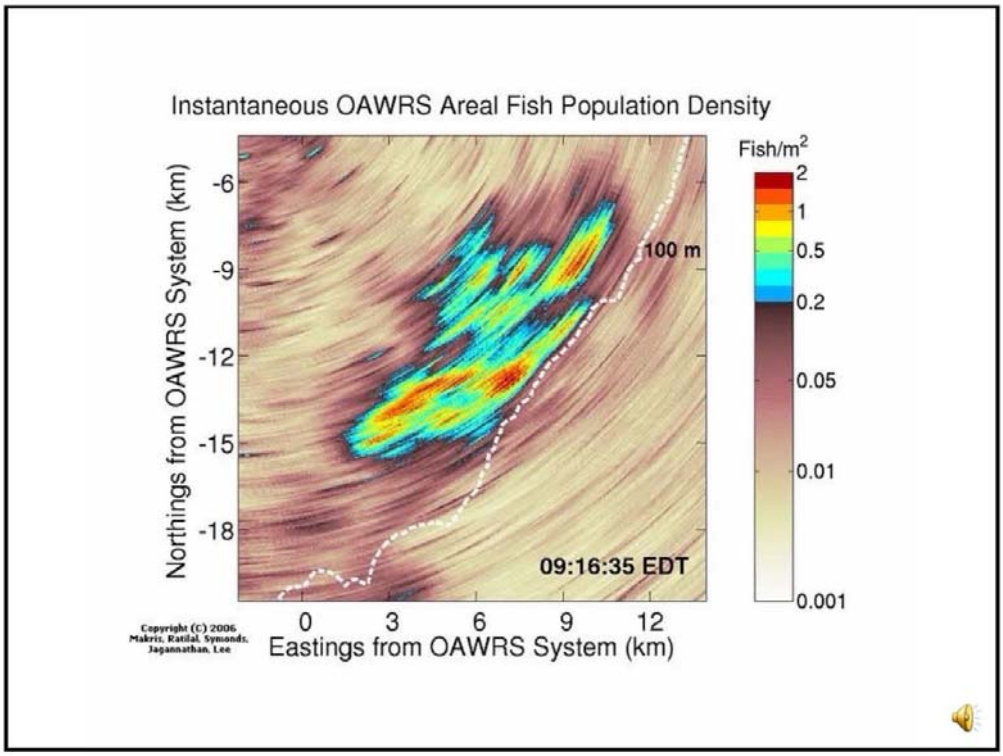

>6 kg of fuel to catch 10 kg of fish – global average
1.2% of global oil
ASIA
EUROPE
NORTH AMERICA
PACIFIC OCEAN
ATLANTIC OCEAN
AFRICA
PACIFIC OCEAN
SOUTH AMERICA
INDIAN OCEAN
100 liters
400
1,000
2,000
Tyedmers et al. Ambio 2005


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.


CENSUS OF MARINE LIFE
OCEAN TRACKING NETWORK
Arctic
NEP
NWP
NWA
NEA
MED
MP
EI
SWP
WI
SEP
SEA
SWA
Southern
Existing
1st Wave
2nd Wave
3rd Wave
Global Ocean Tracking Network
fishing boat
tuna
glider
TOPP
Tagging Of Pacific Pelagics
POST
VR-3A (ARGOS)
VR-3B (modem)
VR-3C (cable)
cable
0.85 km (range)
physical sampler


©2008 Google
Canada
Labrador
ASF - Strait of Belle Isle line
Newfoundland
Miramichi River
USA
Maine
Magaguadavic River
Penobscot River
Medway River
Nova Scotia
OTN - Cabot Strait line
DFO-MPO acoustic array
OTN - Halifax line
Fisheries and Oceans Canada
Pêches et Océans Canada
OCEAN TRACKING NETWORK
NOAA


OAWRS areal coverage
in 75 seconds (8000 km²)
Franklin Basin
B1
B2
200m
150m
100m
50m
Georges Bank
E
42.5
42.0
41.5
Latitude (degrees)
69
68
67
66
Longitude (degrees)
S_a (dB re 1m²)
−40
−60
−80
>100,000,000 herring!
Along−bank distance (km)
Across−bank distance (km)
150 m
100 m
50 m
17:26:15 EDT
A
18:43:45 EDT
B
19:53:45 EDT
C
21:38:45 EDT
D
Scattering strength (dB)
Makris et al. Science 2009


Instantaneous OAWRS Areal Fish Population Density
Fish/m²
2
1
0.5
0.2
0.05
0.01
0.001
100 m
09:16:35 EDT
Northings from OAWRS System (km)
-6
-9
-12
-15
-18
0
3
6
9
12
Eastings from OAWRS System (km)
Copyright (C) 2006
Makris, Ratilal, Symonds,
Jagannathan, Lee

2.1.2 Summary

The Census of Marine Life's decade long Transparent Oceans Project has created and demonstrated techniques that allow scientists to see what is going on in the ocean. The technologies used for the Transparent Oceans Project, such as the Ocean Tracking Network (OTN) can help the local fishing industry by making it more economically viable and sustainable.

The OTN is a global partnership that tracks movements of fish and other marine species, identifies their critical habitat and studies how both are changing with altering environmental conditions. Acoustic tags placed on small animals track their movement across listening lines. Larger animals that surface frequently can be equipped with satellite tags that allow scientist to locate them in near-real time. These technologies can be vital for the conservation of endangered species. The technology will also allow scientists and managers to determine stock structure of fishes in areas where fisheries already occur. This information is fundamental for development of conservation-oriented fishing plans. It may also be possible to create a more economical fishing industry if we have better knowledge of the seasonal shifts of fish distribution, as less fuel and time would be consumed to capture fish. However, such power will impose huge pressure on fish populations, and must be intricately coupled with proper management to ensure the sustainability of resources and the fairness of access to resources by all stakeholders.

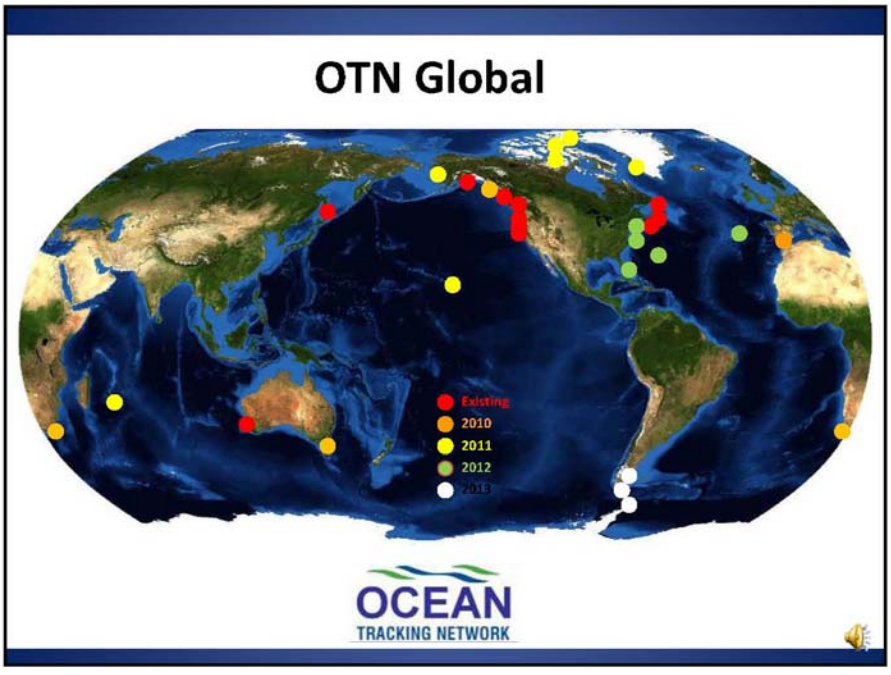
Technological advances in the fishing industry have greatly increased the ability of the industry to locate and catch fish. However, the time trend for the industry in general is that catch per unit effort (CPUE) continues to decline. Thus, we are spending more time and using more energy to capture the same or less amount of fish. Globally, we are using an average of 6 kg of fuel in order to capture 10 kg of fish. Fishing activity annually accounts for 1.2% of total global oil consumption. At a time when peak oil consumption is imminent, this is certainly a trend that needs be avoided. The Transparent Oceans Project has the potential to reduce this usage. As management improves and fish stocks become healthy we may be able to find fish closer to home and reduce time and effort, however, in order for the fisheries to remain sustainable, harvesting must be held at levels that do not deplete fish populations.

The North West Atlantic OTN infrastructure is growing rapidly. Of special note is the way it is building partnerships among international agencies, NGO's and the public who are all interested in restoring Atlantic salmon abundance. Once the infrastructure is in place, the cost of tagging additional species is minimal. The OTN is interested in working collaboratively with the fishing industry on the species that are important to study. New knowledge is required, because our traditional models for predicting fish location, timing and abundance are no longer performing as needed.

2.2 OTN Global

Bob Branton, Director of Data Management, Ocean Tracking Network

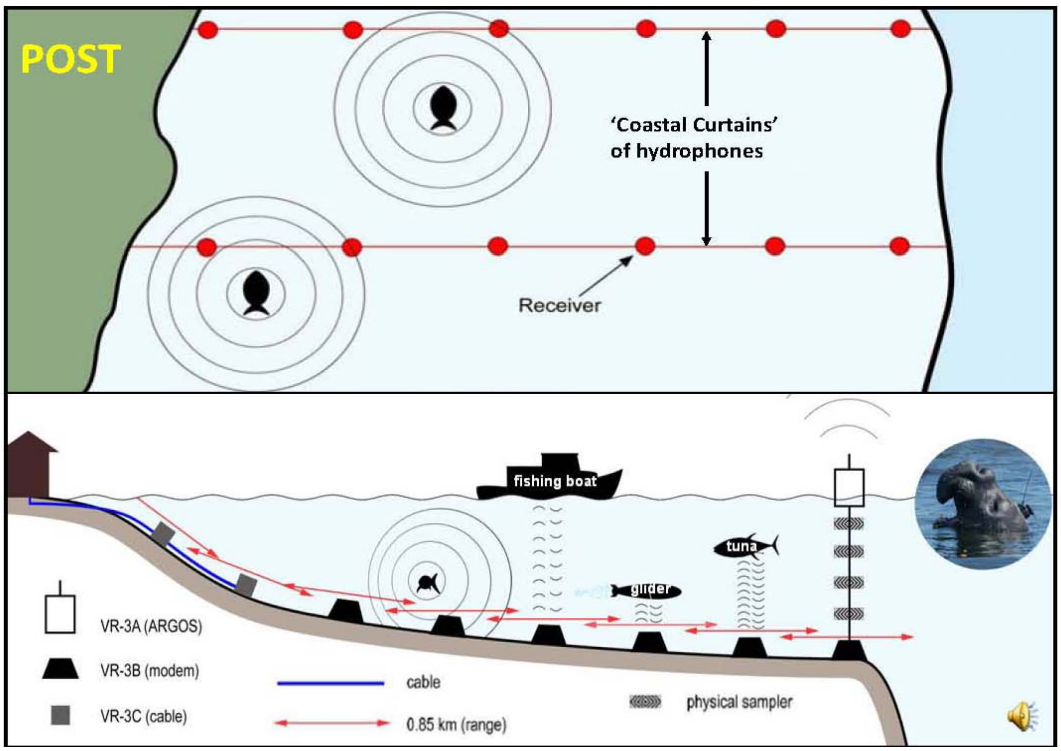
2.2.1 Presentation




OCEAN
TRACKING NETWORK
RESEARCH THEMES
Biology and behaviour of migrating marine life
Ocean physics modelling
Impact of climate change on first two
Resource management
International social and legal framework for oceans


Archival Tags
Wildlife Computer Mk10 PAT
Pop-up Archival Transmitting
Satellite Tag
Lotek Geolocating Archival Tag


Acoustic tags
copyright 2003 Dr.Chris Harvey-Clark all rights reserved
VEMCO R-code
Acoustic Tags


POST
'Coastal Curtains'
of hydrophones
Receiver
fishing boat
tuna
glider
VR-3A (ARGOS)
VR-3B (modem)
VR-3C (cable)
cable
0.85 km (range)
physical sampler

2.2.2 Summary

The Ocean Tracking Network (OTN) is a global conservation project headquartered at Dalhousie University. OTN Global is funded by the Canada Foundation for Innovation (CFI) and is part of the Global Ocean Observing System (GOOS), the marine component of the Global Earth Observing System (GEOS). It was created in 2006 by Ron O'Dor, senior scientist for the Census of Marine Life and Mike Stokesbury who were looking to unite physical oceanographers and animal trackers on a global scale. Their goal was to aid researchers in their ability to examine changes in animal movement and distribution, behaviour and survival rates, as well as relating these parameters to the changing ocean environment.

OTN is most active here in the Maritimes, on the Halifax and Cabot Strait lines in conjunction with DFO, and also in Australia on the Perth Line with Western Australia Fisheries. Another local line is operated by the Atlantic Salmon Federation on the Strait of Belle Isle. Future plans have lines considered for Alaska, Gibraltar Strait, Bass Strait and Cape of Good Hope. Following their completion, lines are also planned for the Arctic, Eastern USA and in the Southern Oceans.

The five main research themes that encompass OTN are as follows:

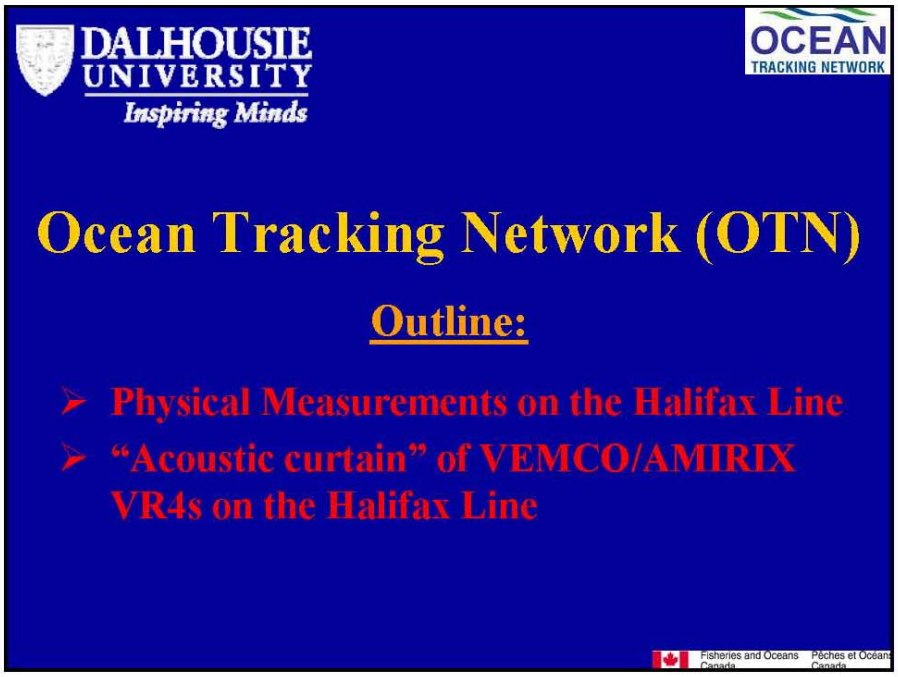
1. biology and behaviour of migrating marine life;
2. ocean physics modelling;
3. impact of climate change;
4. resource management; and
5. international social and legal frameworks for oceans.

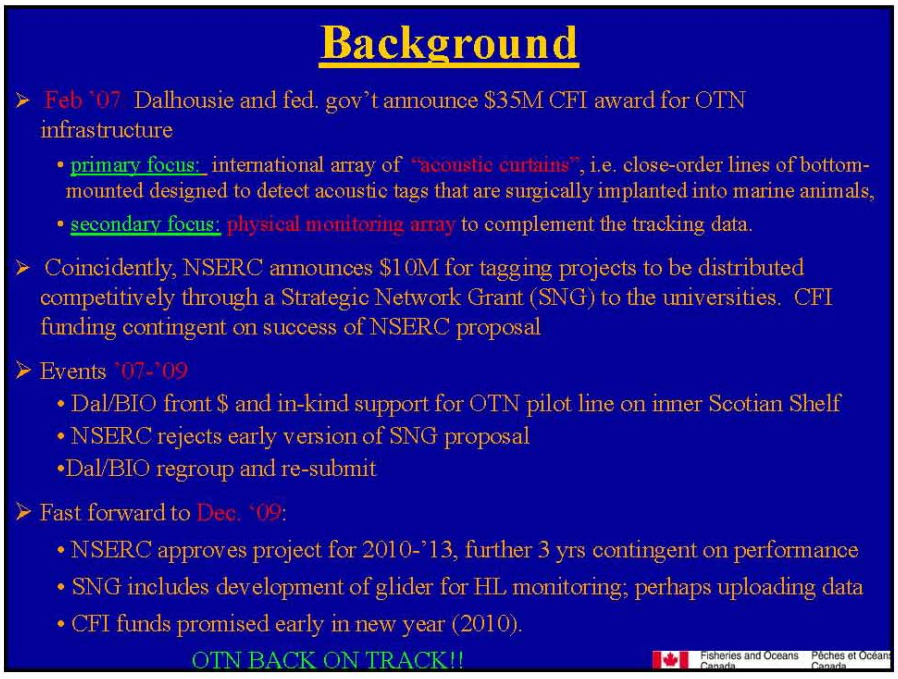
OTN uses both archival tags on the exterior of larger marine animals like sharks or seals and acoustic tags surgically implanted into smaller animals like salmon or crustaceans. Archival tags send data to satellites in space whereas acoustic tags send data to receivers on the ocean floor. Acoustic data is then either collected by recovering the receiver or by downloading to a research vessel using an acoustic modem. Other downloading alternatives being developed include: subsea gliders (roboprobes), business card tagged animals (bioprobes) and cabled observatories (daisy chaining). All OTN data regardless of how it is collected are expected to be stored in a central database at Dalhousie University and from there become publically and freely available on the Internet.

2.3 OTN Operation on the Halifax Line

Peter Smith, Ocean Sciences Division, Bedford Institute of Oceanography

2.3.1 Presentation





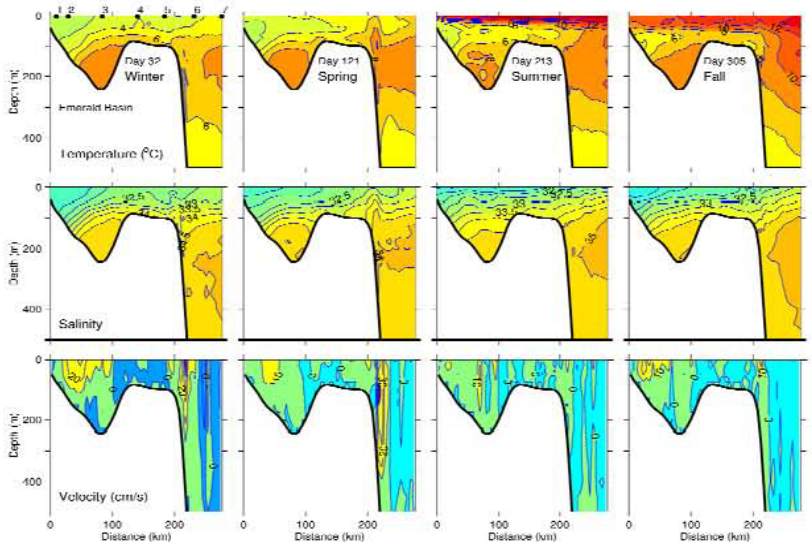
DFO Responsibilities for the Halifax Line:

- Deploy and maintain hydrophones @ ~0.8 km spacing of roughly 264 instruments; (~35 ship days over 3 years)
- Facilitate uploading of detection data from hydrophones on a regular basis; maintain array for at least 4 years (~20 days/year)
- Collection and analysis of data from physical oceanographic monitoring devices (e.g. ADCP, Microcat) on the inner ~50 km of the Line annually; maintain for at least 5 years (~3 days/year)
- Upgrade physical array at earliest convenience to retrieve data in near-real time and assimilate into regional ocean forecast model.
- Investigate and implement alternate means of uploading acoustic tag data, e.g.
  - "daisy chain" through acoustic modems,
  - upload to satellite, or
  - employ autonomous gliders (NSERC SNG)

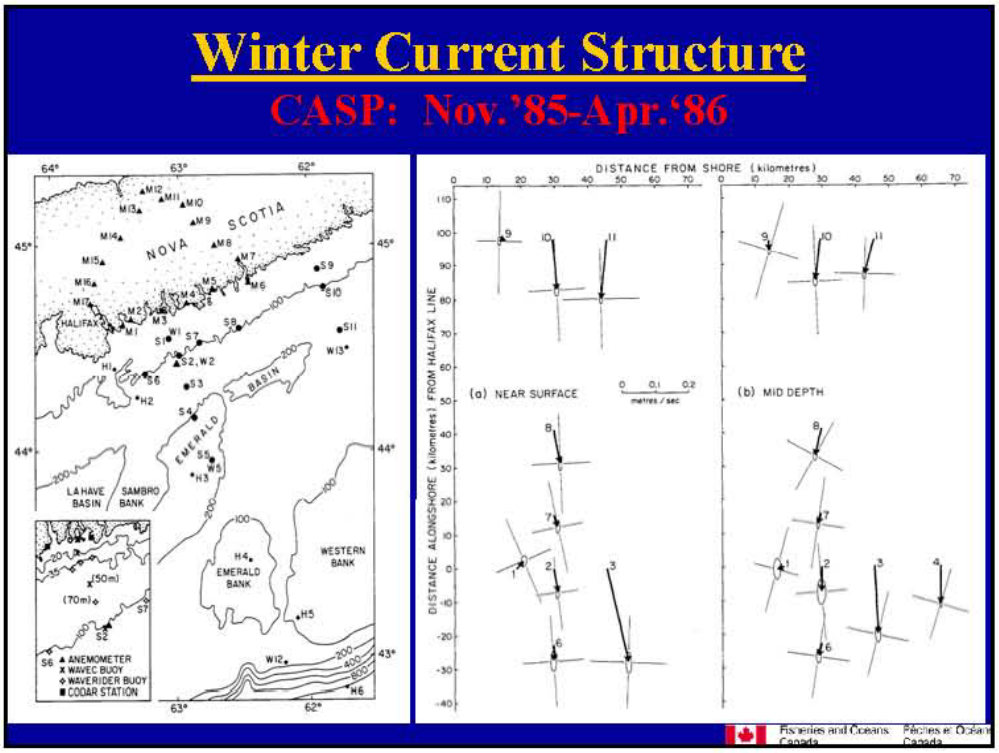
Fisheries and Oceans Canada Pêches et Océans Canada

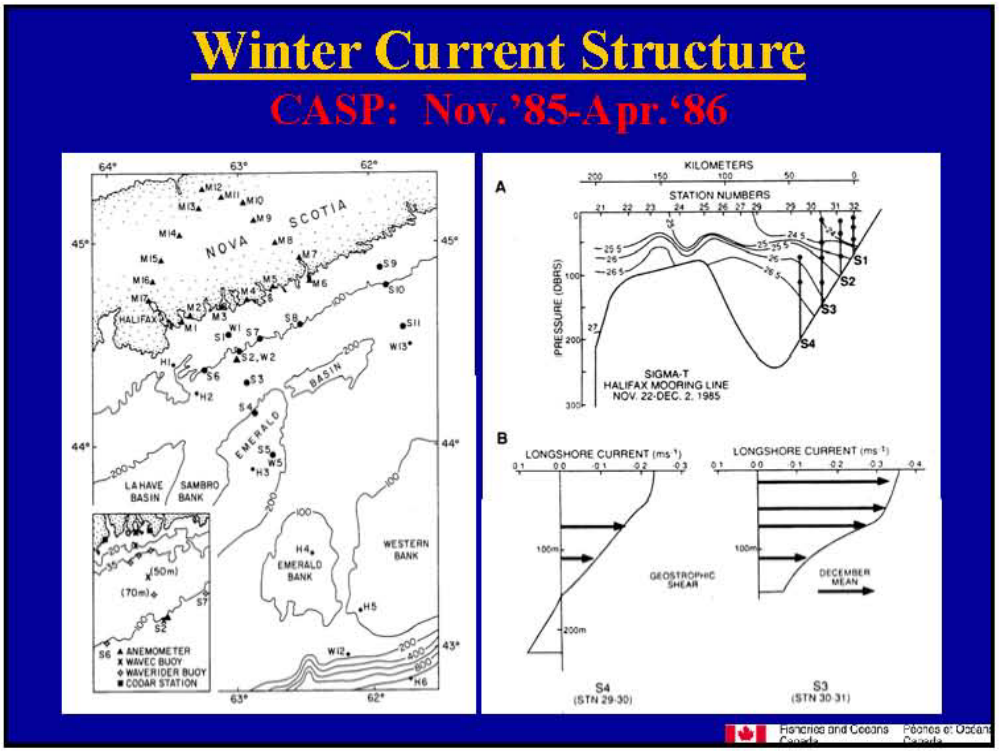
Seasonal Variability on Halifax Section

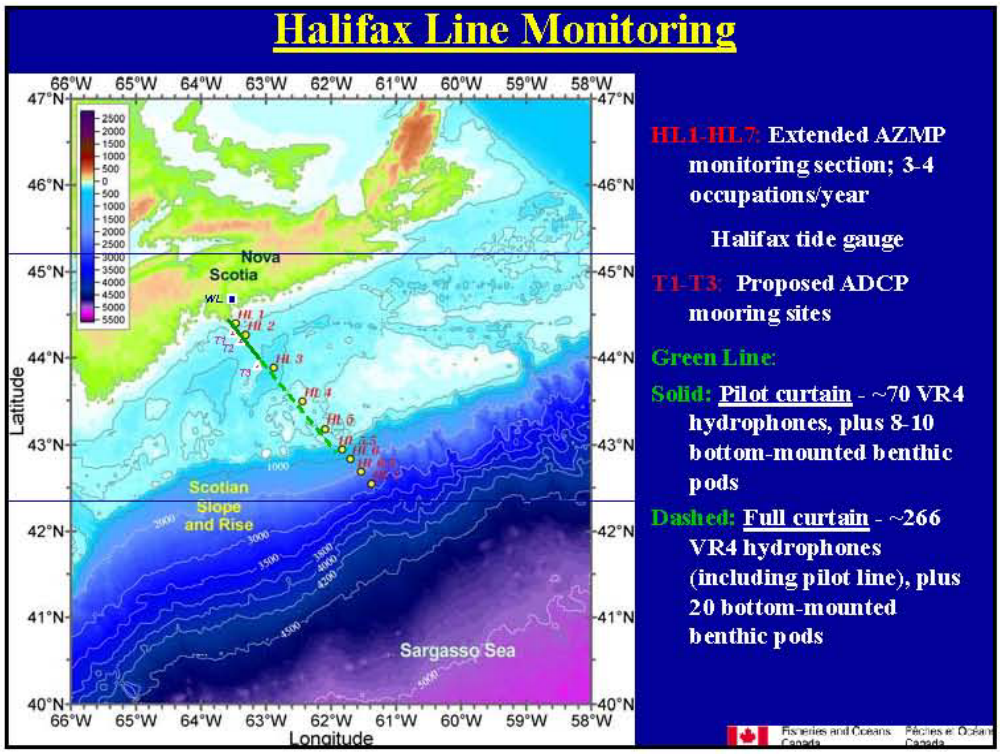
Loder, et al. (2003)

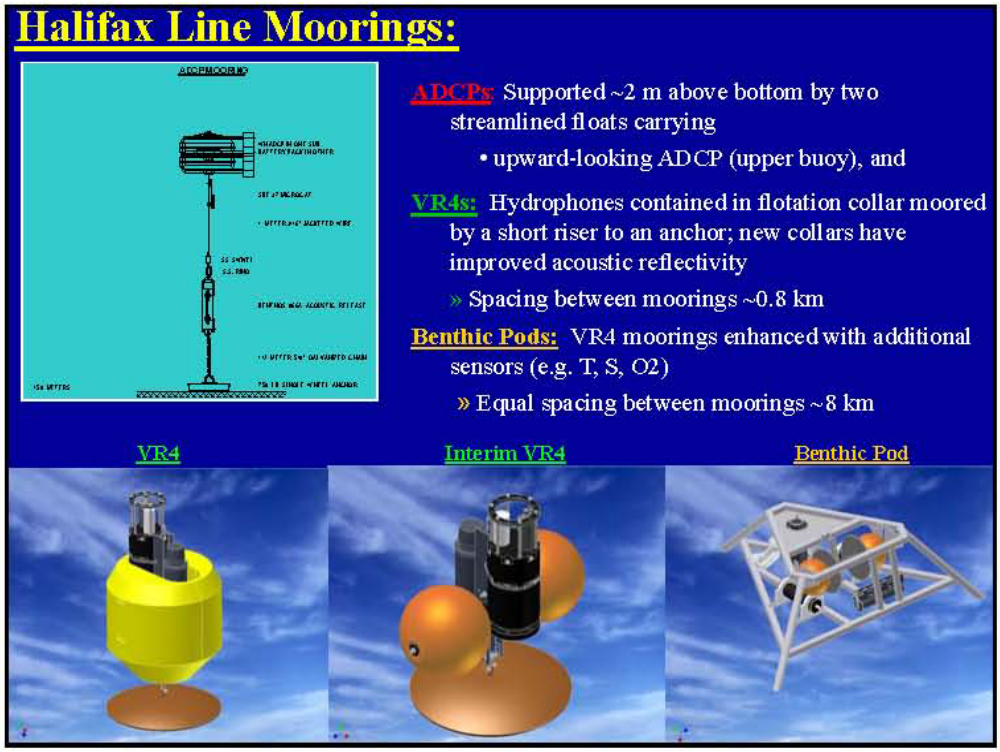


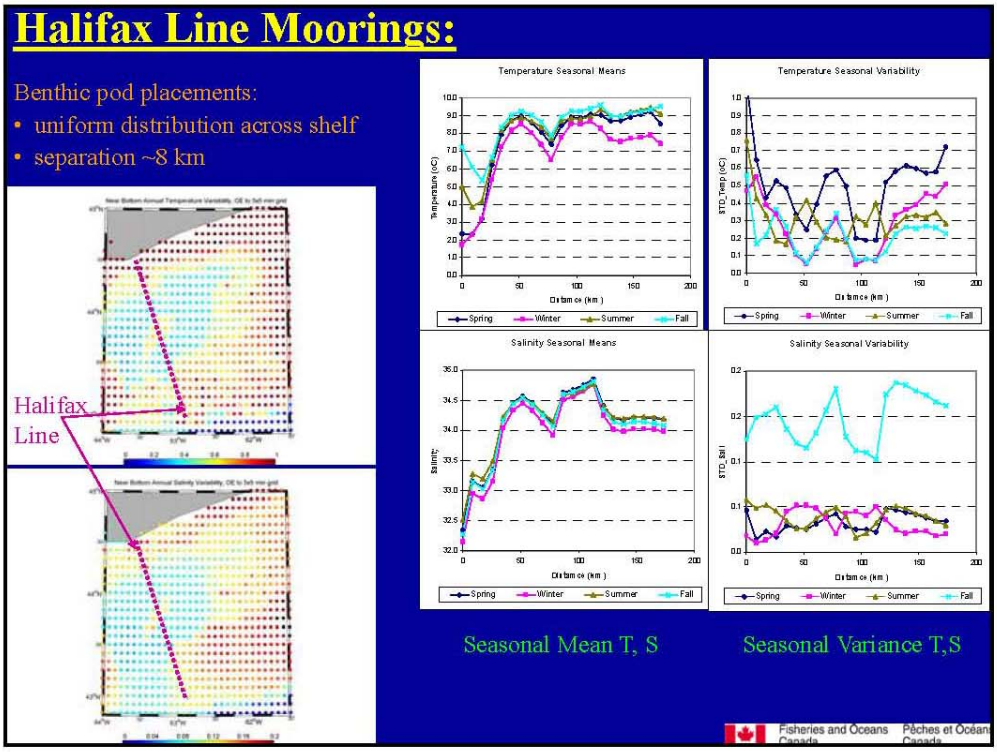
Fisheries and Oceans Canada Pêches et Océans Canada

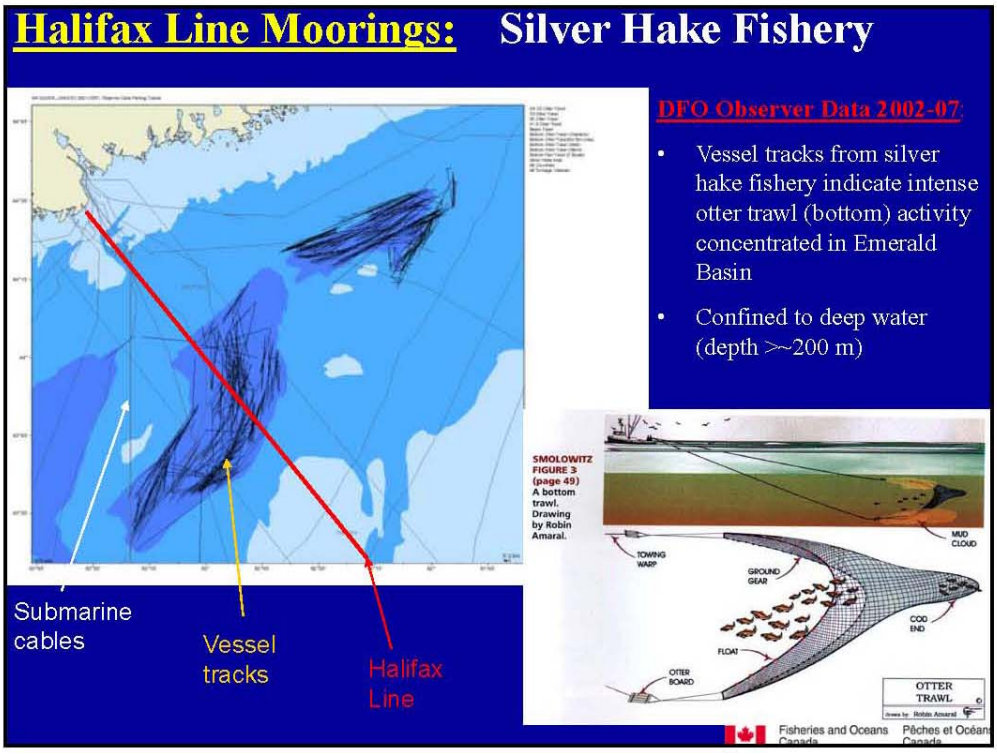

Winter Current Structure
CASP: Nov.'85-Apr.'86
NOVA SCOTIA
HALIFAX
LAHAVE BASIN
SAMBRO BANK
EMERALD BANK
WESTERN BANK
BASIN
(50m)
(70m)
S6 ANEMOMETER
X WAVEC BUOY
WAVERIDER BUOY
CODAR STATION
DISTANCE FROM SHORE (kilometres)
DISTANCE ALONGSHORE (kilometres) FROM HALIFAX LINE
(a) NEAR SURFACE
(b) MID DEPTH
metres / sec
Fisheries and Oceans Canada
Pêches et Océans Canada

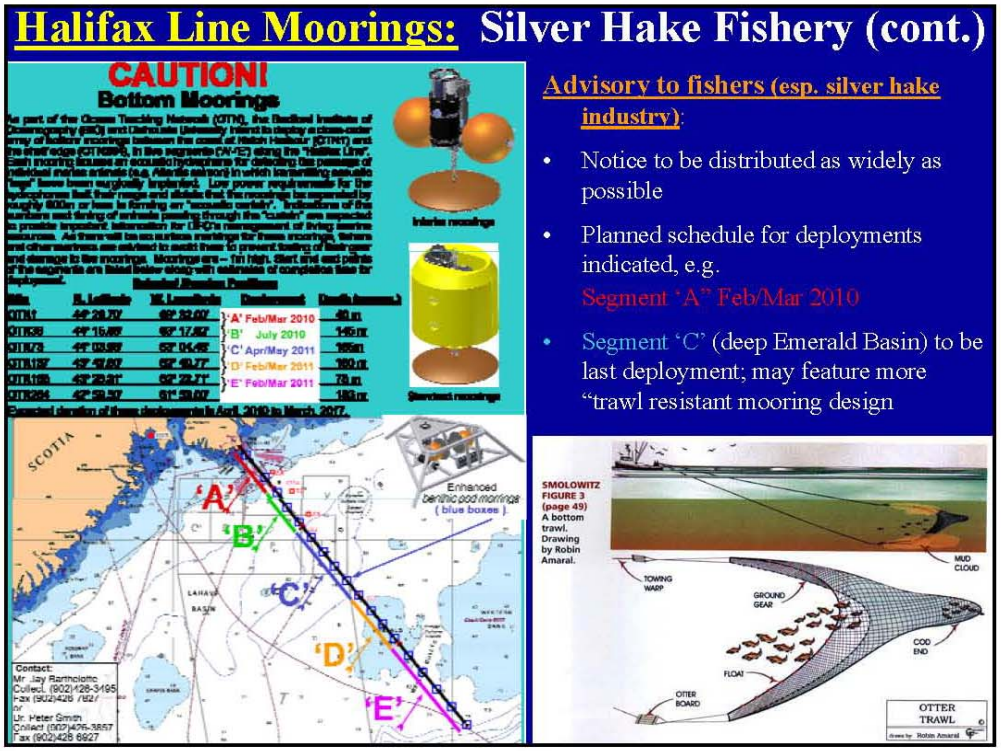

Winter Current Structure
CASP: Nov.'85-Apr.'86
NOVA SCOTIA
HALIFAX
LAHAVE BASIN
SAMBRO BANK
EMERALD BANK
WESTERN BANK
BASIN
(50m)
(70m)
S6 ANEMOMETER
X WAVEC BUOY
WAVERIDER BUOY
CODAR STATION
A
KILOMETERS
STATION NUMBERS
PRESSURE (DBRS)
S1
S2
S3
S4
SIGMA-T
HALIFAX MOORING LINE
NOV. 22-DEC. 2, 1985
B
LONGSHORE CURRENT (ms-1)
GEOSTROPHIC SHEAR
DECEMBER MEAN
S4
(STN 29-30)
S3
(STN 30-31)
Fisheries and Oceans Canada
Pêches et Océans Canada

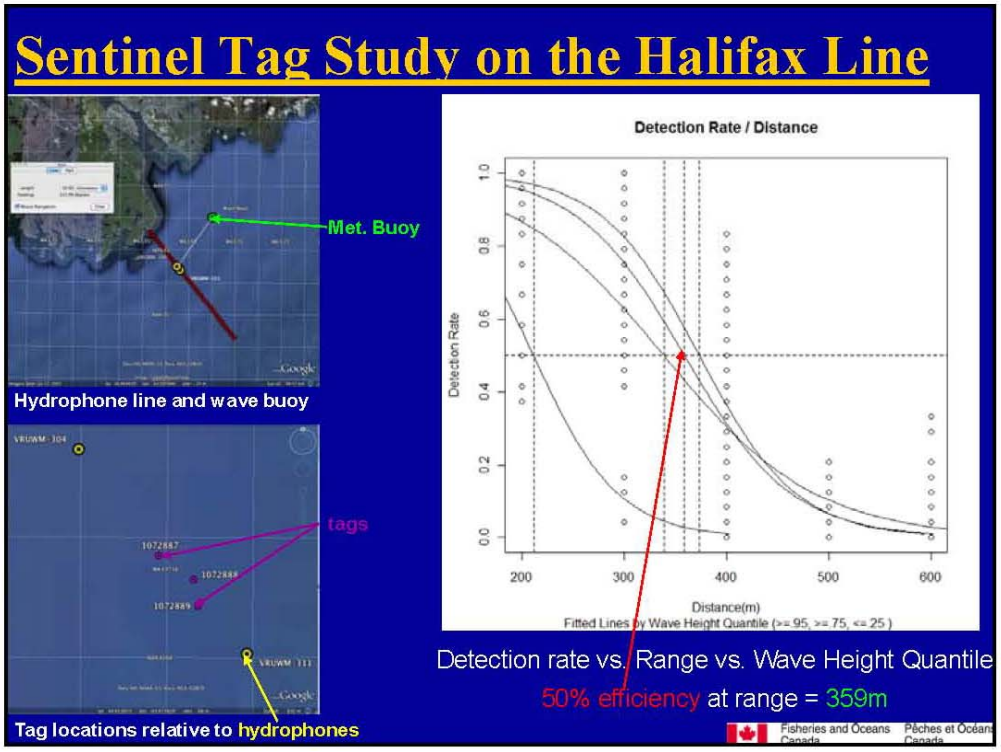

Halifax Line Monitoring
66°W 65°W 64°W 63°W 62°W 61°W 60°W 59°W 58°W
47°N 46°N 45°N 44°N 43°N 42°N 41°N 40°N
Latitude
Longitude
Nova Scotia
Scotian Slope and Rise
Sargasso Sea
HL1-HL7: Extended AZMP monitoring section; 3-4 occupations/year
Halifax tide gauge
T1-T3: Proposed ADCP mooring sites
Green Line:
Solid: Pilot curtain - ~70 VR4 hydrophones, plus 8-10 bottom-mounted benthic pods
Dashed: Full curtain - ~266 VR4 hydrophones (including pilot line), plus 20 bottom-mounted benthic pods

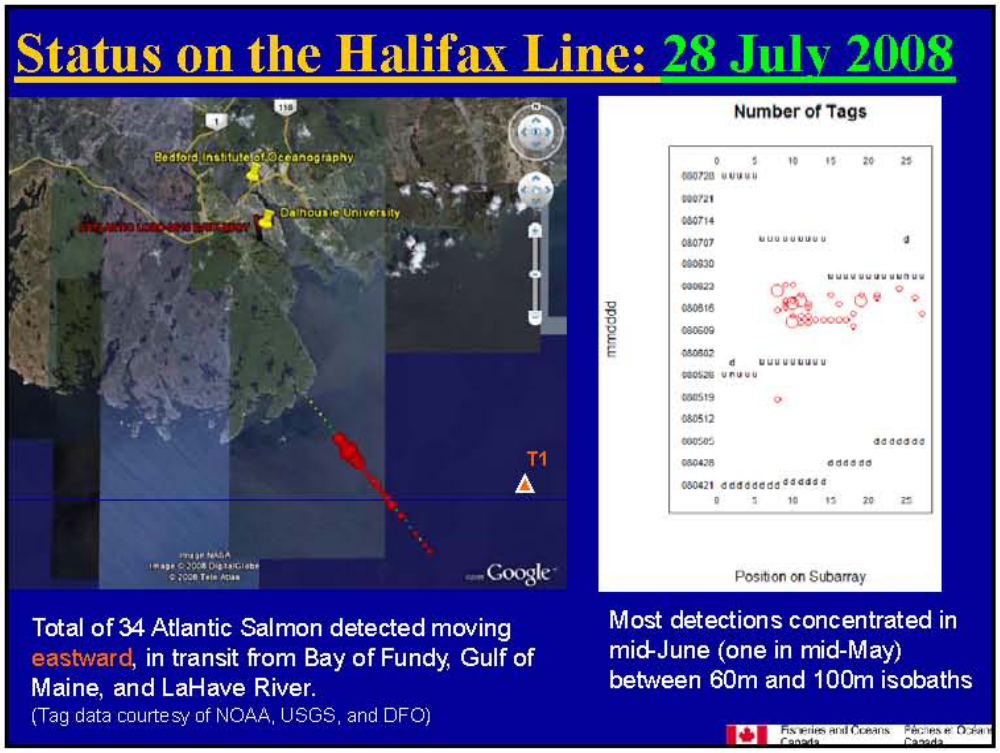

Halifax Line Moorings:
ADCPs: Supported ~2 m above bottom by two streamlined floats carrying
• upward-looking ADCP (upper buoy), and
VR4s: Hydrophones contained in flotation collar moored by a short riser to an anchor; new collars have improved acoustic reflectivity
» Spacing between moorings ~0.8 km
Benthic Pods: VR4 moorings enhanced with additional sensors (e.g. T, S, O2)
» Equal spacing between moorings ~8 km
VR4
Interim VR4
Benthic Pod

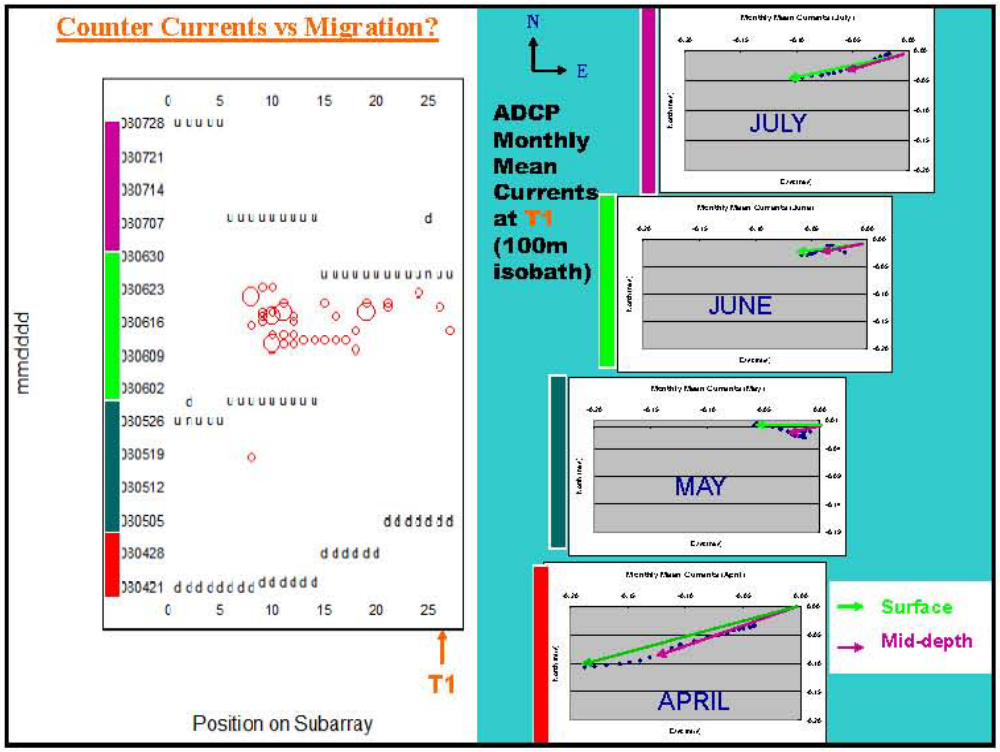

Halifax Line Moorings:
Benthic pod placements:
• uniform distribution across shelf
• separation ~8 km
Halifax Line
Temperature Seasonal Means
Temperature Seasonal Variability
Salinity Seasonal Means
Salinity Seasonal Variability
Spring
Winter
Summer
Fall
Seasonal Mean T, S
Seasonal Variance T,S
Fisheries and Oceans Canada
Pêches et Océans Canada

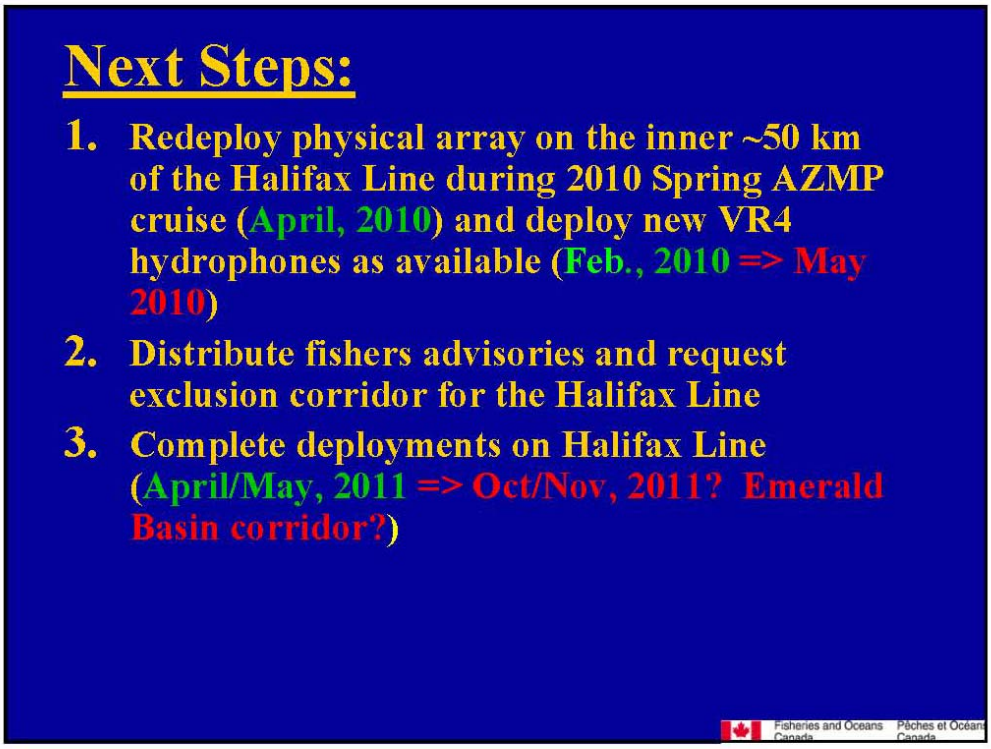

Halifax Line Moorings: Silver Hake Fishery
DFO Observer Data 2002-07:
• Vessel tracks from silver hake fishery indicate intense otter trawl (bottom) activity concentrated in Emerald Basin
• Confined to deep water (depth >~200 m)
Submarine cables
Vessel tracks
Halifax Line
SMOLOWITZ FIGURE 3 (page 49) A bottom trawl. Drawing by Robin Amaral.
MUD CLOUD
TOWING WARP
GROUND GEAR
COD END
FLOAT
OTTER BOARD
OTTER TRAWL
Fisheries and Oceans Canada
Pêches et Océans Canada


Halifax Line Moorings: Silver Hake Fishery (cont.)
CAUTION!
Bottom Moorings
'A' Feb/Mar 2010
'B' July 2010
'C' Apr/May 2011
'D' Feb/Mar 2011
'E' Feb/Mar 2011
Advisory to fishers (esp. silver hake industry):
Notice to be distributed as widely as possible
Planned schedule for deployments indicated, e.g.
Segment 'A" Feb/Mar 2010
Segment 'C' (deep Emerald Basin) to be last deployment; may feature more "trawl resistant mooring design
SCOTIA
'A'
'B'
'C'
'D'
'E'
Enhanced benthic cod moorings (blue boxes)
SMOLOWITZ FIGURE 3 (page 49) A bottom trawl. Drawing by Robin Amaral.
MUD CLOUD
TOWING WARP
GROUND GEAR
COD END
FLOAT
OTTER BOARD
OTTER TRAWL


Sentinel Tag Study on the Halifax Line
Met. Buoy
Hydrophone line and wave buoy
tags
Tag locations relative to hydrophones
Detection Rate / Distance
Detection Rate
Distance(m)
Fitted Lines by Wave Height Quantile (>= 95, >= 75, <= 25)
Detection rate vs. Range vs. Wave Height Quantile
50% efficiency at range = 359m
Fisheries and Oceans Canada
Pêches et Océans Canada


Status on the Halifax Line: 28 July 2008
Bedford Institute of Oceanography
Dalhousie University
T1
Google
Number of Tags
mmdddd
Position on Subarray
Total of 34 Atlantic Salmon detected moving eastward, in transit from Bay of Fundy, Gulf of Maine, and LaHave River.
(Tag data courtesy of NOAA, USGS, and DFO)
Most detections concentrated in mid-June (one in mid-May) between 60m and 100m isobaths


Counter Currents vs Migration?
mmdddd
T1
Position on Subarray
N
E
ADCP Monthly Mean Currents at T1 (100m isobath)
JULY
JUNE
MAY
APRIL
Surface
Mid-depth



2.3.2 Summary

The Halifax Line is the inaugural line of Canada's Ocean Tracking Network, composed of a growing number of VR3-4 hydrophones at 800m spacing beginning at Chebucto Head and ultimately extending to the shelf edge (~200m isobath). In February of 2007 the Canadian Foundation for Innovation (CFI) announced a $35M award to Dalhousie University for infrastructure to support OTN. OTN's long term vision is to have a worldwide array of "acoustic curtains", which are created by the bottom-mounted hydro-acoustic receivers, and will monitor the movements of marine animals by detecting electronic tags they carry when the pass through the "curtain". The program's goal is to observe migration patterns of different species as specific individuals pass through various curtains. In addition, DFO is also has installed physical oceanographic monitoring devices such as Acoustic Doppler Current Profiler's (ADCP) and bottom-mounted Microcats to monitor the Nova Scotia Current and record temperature and conductivity. Canada's Natural Sciences and Engineering Research Council (NSERC) is also providing $10M for other experiments using electronic tags on different species such as sharks, groundfish, and seals.

The Halifax pilot line has already provided insight into the migration patterns and behaviour of Atlantic salmon. Detections of salmon from the Gulf of Maine and LaHave River between April and July of 2008 have shown clusters of fish crossing the line in mid-June, between 60 and 100m isobaths. The fish were migrating eastwards, against the current, toward Newfoundland and information recorded by a nearby mooring showed that the opposing currents were weakest

at this time, due to the seasonal variation in the Nova Scotia Current. The salmon crossed the line at roughly the same time, thus there is speculation about a staging area where they group together and wait for a cue to begin the migration. This cue could very well be a reduction in current strength. The information provides insight into how changing environmental factors can affect the migration of marine species and how technology can be used to predict the time of these migrations in the future.

The biggest problem for the Halifax Line may potentially be the silver hake trawling industry which could pull up receivers in the fishing process. Fliers are being created with an advisory description of what equipment will be out and when, in the hope of minimizing any issues. There is a possibility of changing equipment design to be more trawl resistant and OTN researchers are currently taking suggestions regarding such a design. Direct consultation with the silver hake fishers will also be used to understand and mitigate potential problems.

The future of the Halifax Line, with help from the Department of Fisheries and Oceans, will be to deploy and maintain approximately 265 hydrophones (including pilot line) up until at least May of 2013. This will also include 20 bottom-mounted benthic pods with enhanced sensors to measure temperature, salinity and dissolved oxygen content. DFO will facilitate the uploading of data from hydrophones on a regular basis and will maintain the array for at least four years. Data from the ADCP's and Microcats on the inner 50 kilometres of the line will be obtained annually and maintained for at least five years. They will also research possible alternatives of retrieving data such as by 'daisy-chaining', satellite upload, or by use of self-directed gliders.

2.3.3 Discussion

Q: How far apart would each station be?
A: Eight hundred (800) meters. Hydrophones need to be 800 meters apart since the range of each is ~400 meters.

Comment: Fishermen can get locations of receivers so as to limit the chances of them being hauled up in the silver hake trawling.

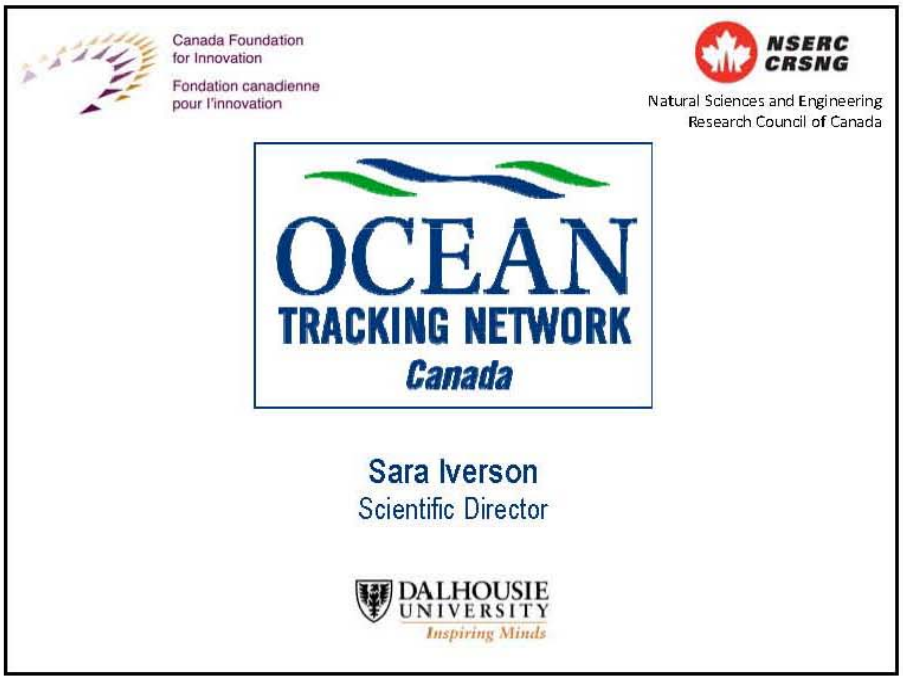
Q: Does heavy boat traffic affect efficiency?
A: It has not been looked at closely and there is no evidence to suggest so. Strong winds and breaking waves are probably the strongest deterrent to tag detection.

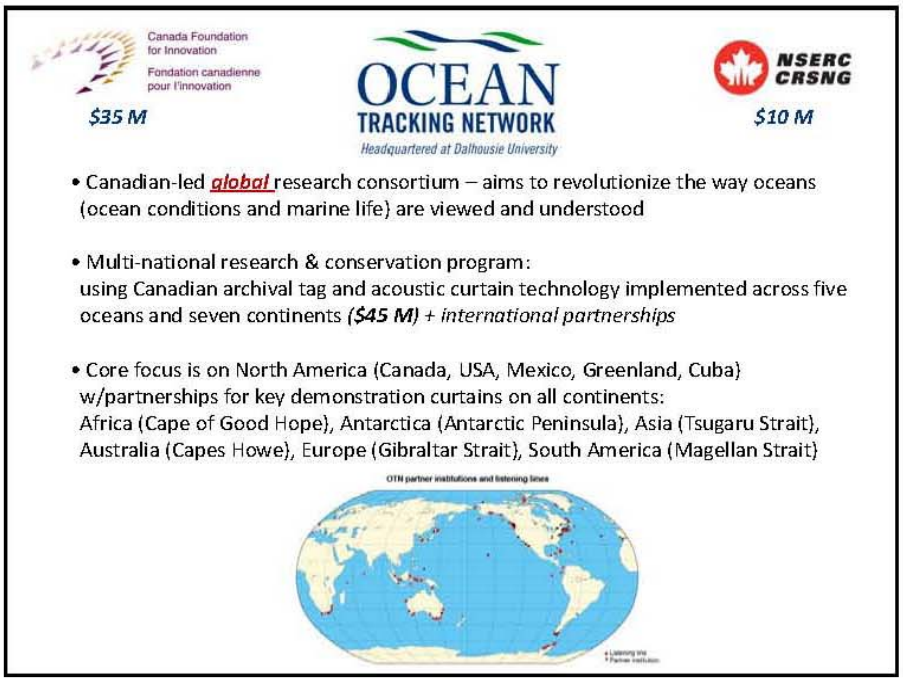
Q: How can you tell the direction of the fish/tagged mammals?
A: Because we know where they are tagged originally and have knowledge of their migration patterns.

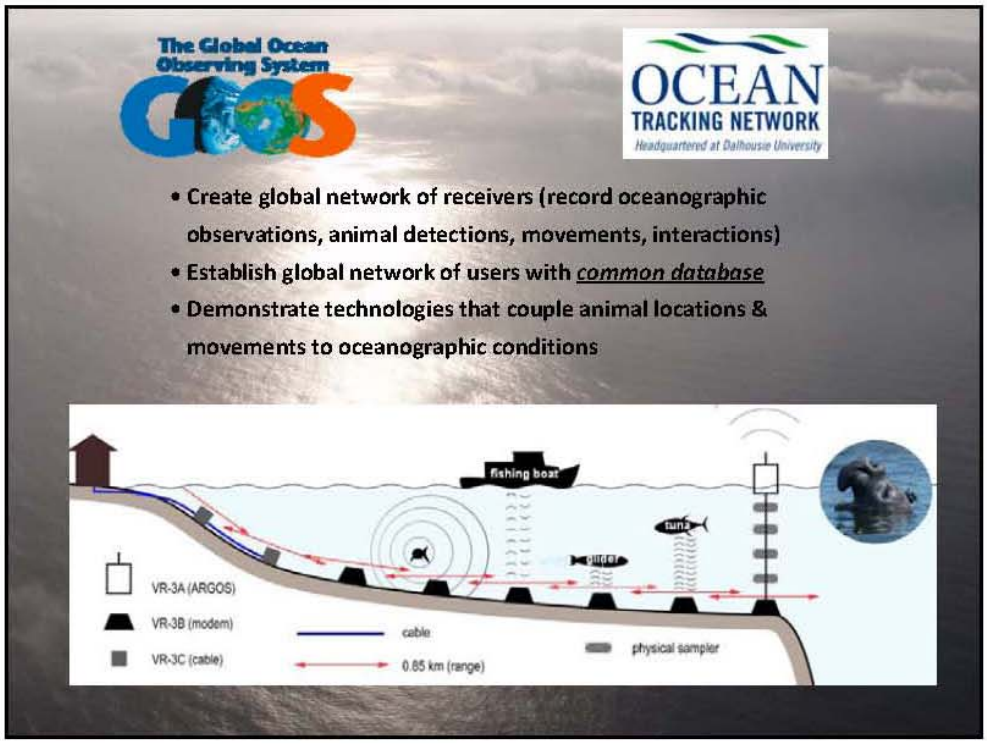
2.4 The OTN Canada Research Program

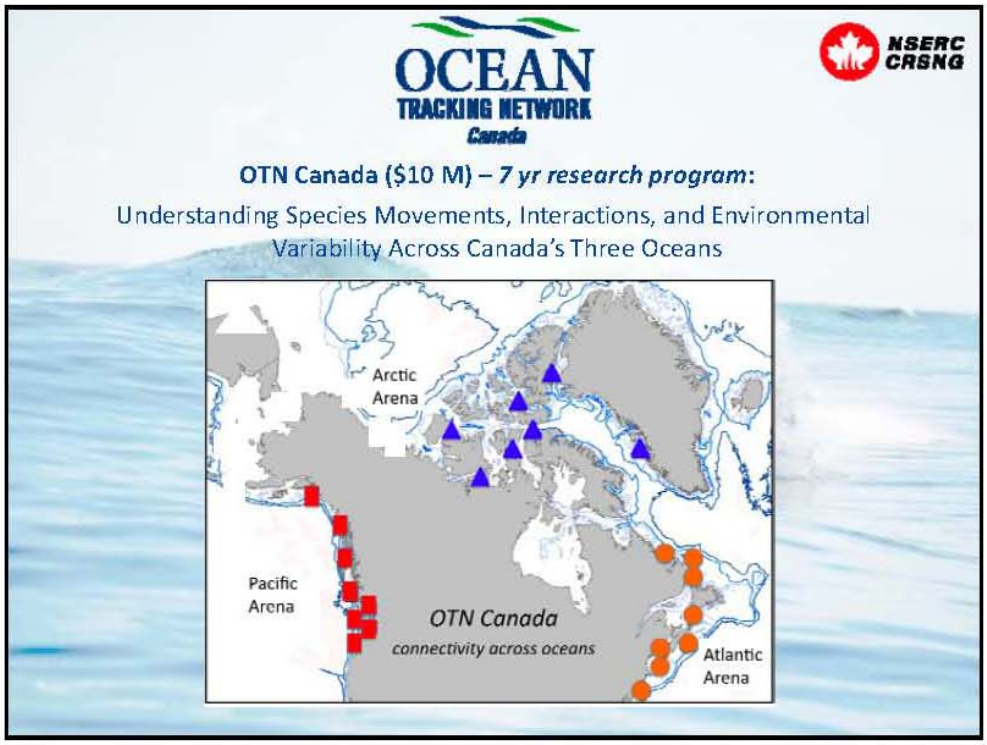
Sara Iverson, Professor, Department of Biology, Dalhousie University

2.4.1 Presentation






The Global Ocean Observing System
GOOS
OCEAN TRACKING NETWORK
Headquartered at Dalhousie University
• Create global network of receivers (record oceanographic observations, animal detections, movements, interactions)
• Establish global network of users with common database
• Demonstrate technologies that couple animal locations & movements to oceanographic conditions
fishing boat
tuna
VR-3A (ARGOS)
VR-3B (modem)
VR-3C (cable)
cable
0.85 km (range)
physical sampler


OCEAN TRACKING NETWORK
Canada
NSERC CRSNG
OTN Canada ($10 M) – 7 yr research program:
Understanding Species Movements, Interactions, and Environmental Variability Across Canada's Three Oceans
Arctic Arena
Pacific Arena
OTN Canada
connectivity across oceans
Atlantic Arena

OCEAN TRACKING NETWORK Canada

NSERC CRSNG

The Research Hub for all of OTN Global

Integrative research program:

- make use of OTN technologies and infrastructure to understand changing marine ecosystems across Canada,
- demonstrate a way in which we can learn about continental shelf ecosystems through cutting-edge research,
- contribute to global observation of coastal and oceanic ecosystems.

Goal:

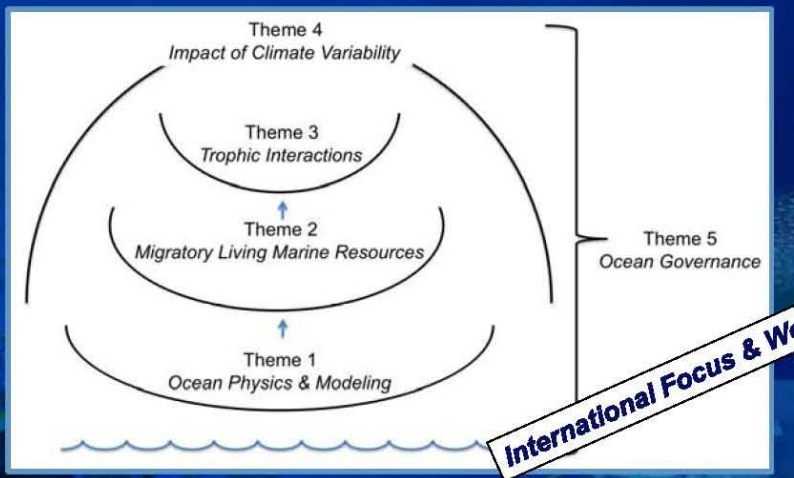
to better understand changing ocean dynamics & their impact on --

- ocean ecosystems,
- animal ecology, &
- ocean resources

-- with the aim to address critical issues in resource management and implications for ocean governance

OCEAN TRACKING NETWORK CANADA

RESEARCH THEMES



Overview of the Network

Arena Conceptual Organization - remains a useful organizational framework under which to plan research strategies and budgetary frameworks

Arctic Arena

priority for OTN Canada:

integrate questions and research strategies both **within** and **across** Arenas

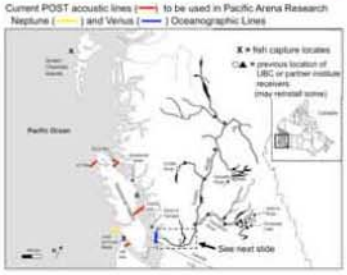
Pacific Arena

Organizational Framework: "Arenas"

initial proposed receiver lines / buoys (CFI-IJVP & partners)

Atlantic Arena

Pacific Arena



BC Salmon

Focus on environmental transition zones:
Continental Shelf & Salish Sea

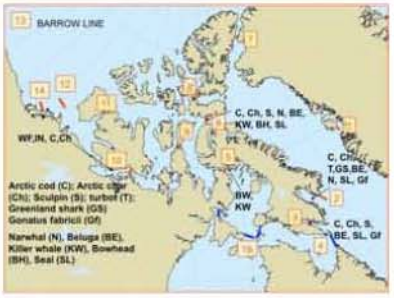
1) What are the physical, chemical, and biological oceanographic linkages that determine the population structure, dynamics, movement and critical habitat of **Pacific salmonids?**

2) How will climate variability, change and anthropogenic activities affect the distribution and abundance of salmonids and other marine organisms?

Arctic Arena

NSERC CRSNG

Major goals:



- describe movement of fish and mammals in the Eastern and central Canadian Arctic
- describe marine food chains, food webs and predator - prey interactions
- oceanographic regional model on changes in flows, salinity and temperature in the Arctic relative to interactions with Pacific and Atlantic Oceans and modeling of local physical affects on biota (coelenterates, fish and mammals)
- test new technologies and innovative application to aid our understanding of animal /environment interactions, under severe Arctic conditions, and
- community education and training

OCEAN TRACKING NETWORK Canada

Atlantic Arena

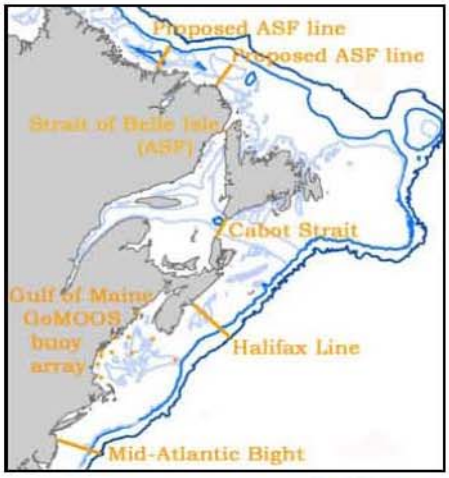
NSERC CRSNG

Lead Universities:

Acadia University
Cape Breton University
Dalhousie University
Memorial University
Université Laval
University of New Brunswick

Lead Collaborating Institutions:

Atlantic Salmon Federation
Bedford Institute of Oceanography-DFO
Institute Maurice Lamantagne-DFO



OCEAN TRACKING NETWORK Canada

Atlantic Arena – Theme 1

NSERC CRSNG

Objectives:

- Develop an integrated platform that combines multidisciplinary observation and modeling systems
- Provide three-dimensional, time-dependent characterization of the physical, chemical & biological marine environment
- Foundation for the integration of a range of OTN activities with the oceanographic environment (physical, chemical & biological)

Atlantic Arena – Theme 2

NSERC CRSNG

Atlantic Salmon -- Migration Routes, Survival and Links with Ocean Environments

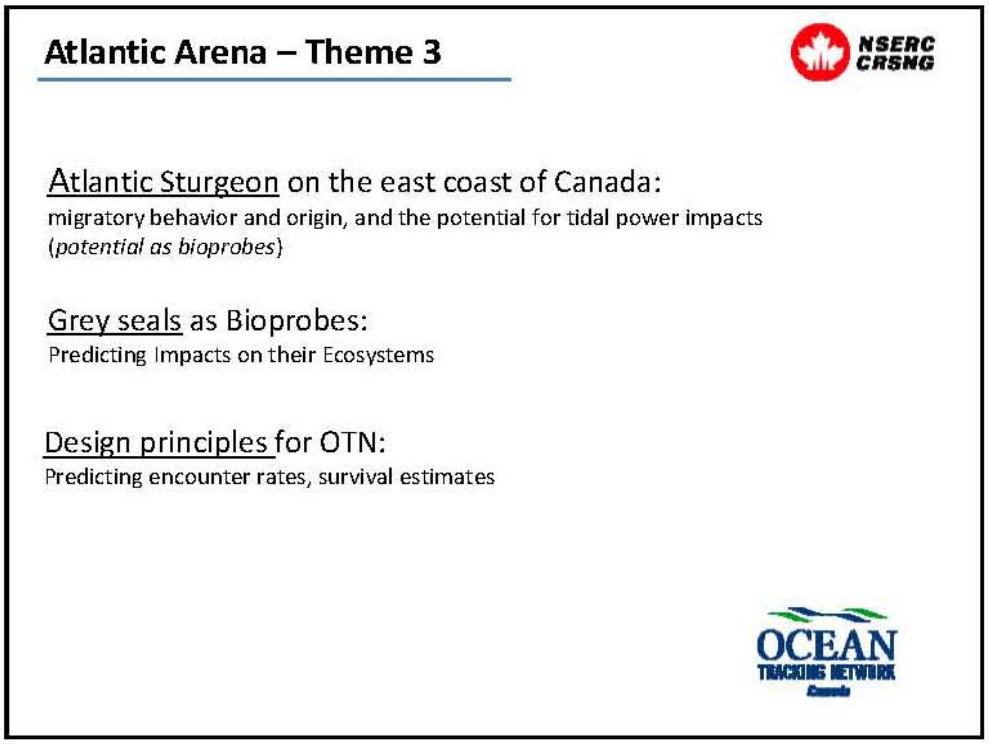
Dramatic declines - endangered/at risk; great economic importance

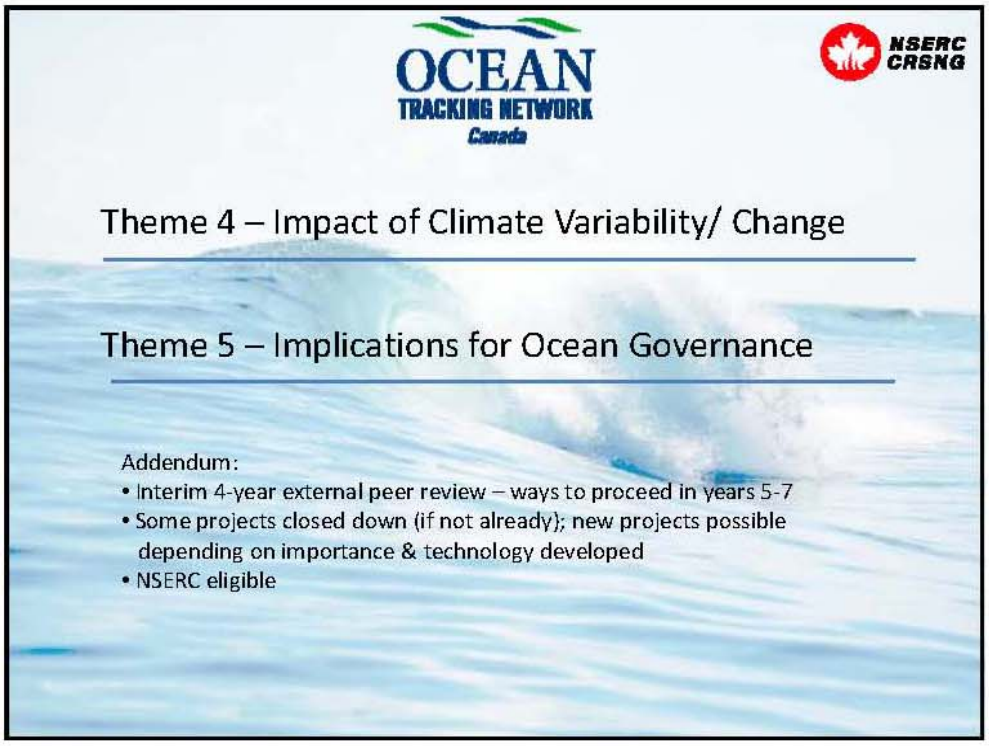
Estuarine and oceanic migrations of the juvenile & reproductive stages of the American eel

Catadromous eels perform one of the most amazing long-distance migration of all fishes, with a deep-water spawning in the Sargasso Sea followed by a larval drift migration to continental waters, a growth period on the continent, and a return spawning migration of adults to the Sargasso Sea.

Dramatic declines - endangered/at risk

OCEAN TRACKING NETWORK Canada


Atlantic Arena – Theme 3
NSERC CRSNG
Atlantic Sturgeon on the east coast of Canada:
migratory behavior and origin, and the potential for tidal power impacts
(potential as bioprobes)
Grey seals as Bioprobes:
Predicting Impacts on their Ecosystems
Design principles for OTN:
Predicting encounter rates, survival estimates
OCEAN TRACKING NETWORK Canada


OCEAN TRACKING NETWORK Canada
NSERC CRSNG
Theme 4 – Impact of Climate Variability/ Change
Theme 5 – Implications for Ocean Governance
Addendum:
• Interim 4-year external peer review – ways to proceed in years 5-7
• Some projects closed down (if not already); new projects possible depending on importance & technology developed
• NSERC eligible

2.4.2 Summary

OTN Canada is by a $10M integrative research program funded by the Natural Sciences and Engineering Research Council (NSERC) of Canada over a seven-year period. The project will make use of existing OTN Global technology and infrastructure to focus research on Canadian marine ecosystems. OTN Canada's goals are to understand species movements, interactions, and environmental variability across Canada's three oceans. It will also be used to better understand changing ocean dynamics and their impact on ocean ecosystems, animal ecology, and ocean resources with the aim to address critical issues in resource management and implications for ocean governance. OTN Canada will allow us to better understand changing marine ecosystems across the country, demonstrate a way in which we can learn about Continental Shelf ecosystems through cutting edge research, and also contribute to global observations of coastal and oceanic environments. It represents the research hub for all of OTN global and aims to promote synergy among all Canadian participants as well as international partnerships.

The research projects and teams have been organized into three Arenas: the Atlantic, Arctic, and Pacific, however, a priority is to integrate questions and research strategies both within and across these arenas. Though each arena does have its own unique areas of interest, there are similar themes for all three. Each arena will have an ocean physics and modelling component, which will combine multidisciplinary observations of ocean characteristics and numerical modeling systems, provide three-dimensional information on ecosystems to provide linkages with animal movements, and allow better prediction of past and future ocean states. Each arena will also study the biology and behavior of marine life by focusing on keystone species and species at risk, and try to understand their movements in relation to oceanographic features and environmental variability. Finally, the arenas will study trophic interactions by having larger predators act as bioprobes to sample their ecosystem, provide feedback on other tagged species they interact with, and to test a number of predator/prey interaction hypotheses.

The Pacific Arena will focus its attention on British Columbia salmon with regard to environmental transition zones on the Continental Shelf and Salish Sea. It will study physical, chemical, and biological properties that determine population structure, dynamics, movement and critical habitat of Pacific salmonids while also examining climate variability and human influence on salmon populations.

The Arctic Arena will describe fish and mammal movement, trophic interactions, changes in oceanographic characteristics, and test new technologies, while simultaneously educating and training members of the community.

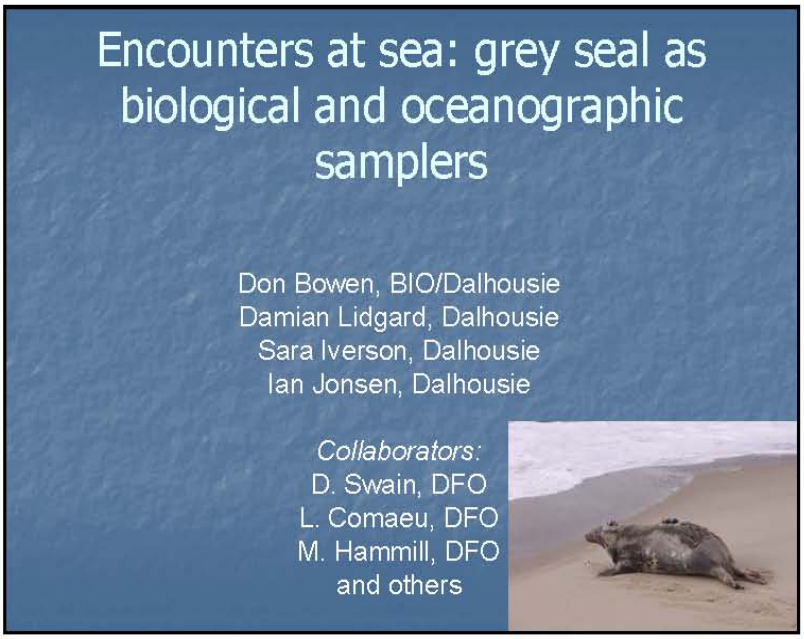
Finally, the Atlantic Arena is comprised of a number of different projects including characterizing oceanographic features and improving ocean prediction models, studies of Atlantic salmon and American eel migration routes and survival links, use of Atlantic sturgeon and grey seals as bioprobes to test interaction theories and movements. It will also include studies of climate change impacts on all aspects being studied and lastly will explore implications for ocean governance.

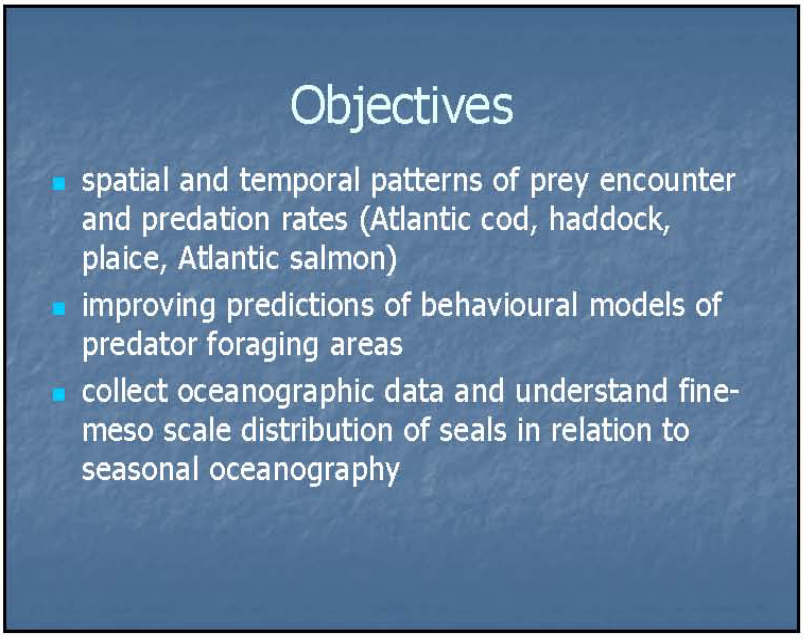
In each region, research is focused at academic institutions, with a number of key research partnerships, the most important of which are with DFO institutions and researchers. New projects may emerge over the course of time and with development of new insight and technology, and would potentially be eligible for NSERC funding.

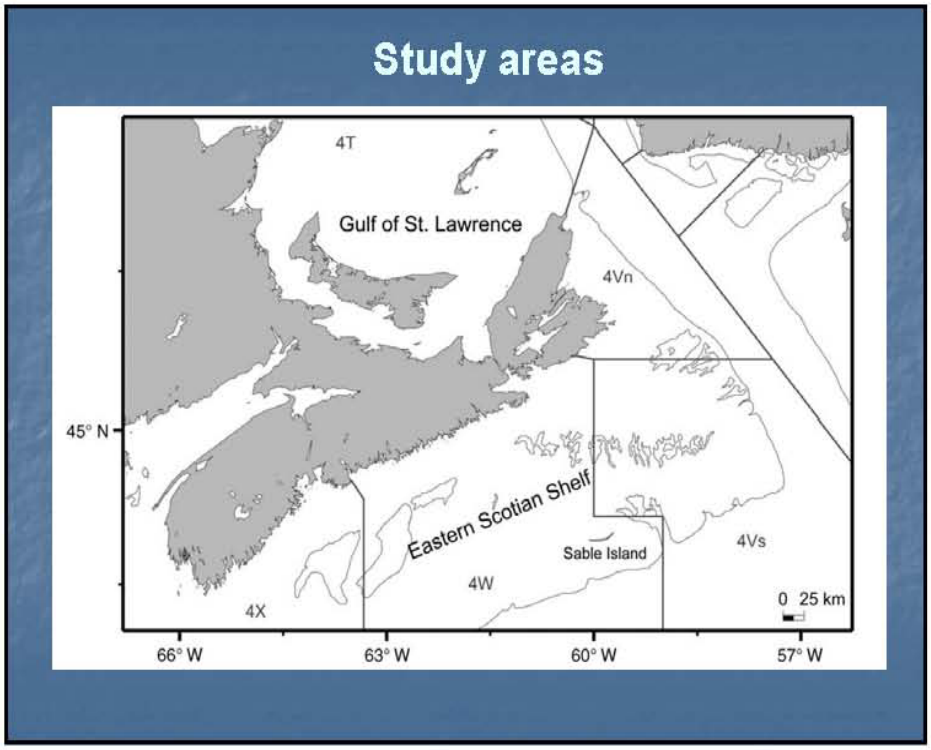
2.5 Encounters at Sea: Grey Seal as Biological and Oceanographic Samplers

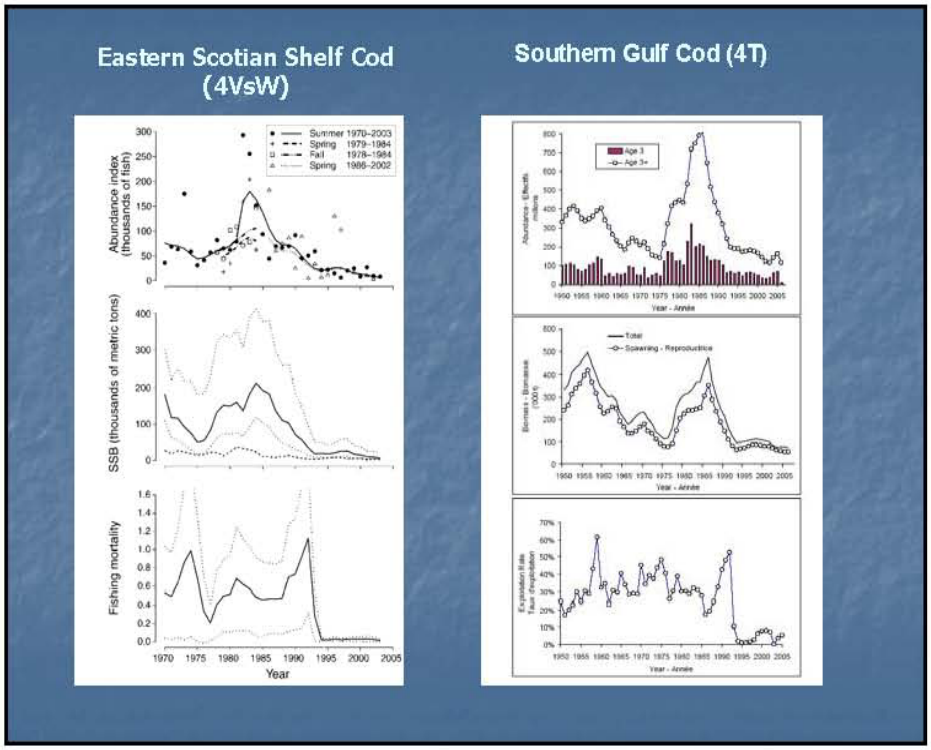
Don Bowen, Research Scientist, Fisheries and Oceans Canada, Population Ecology Division

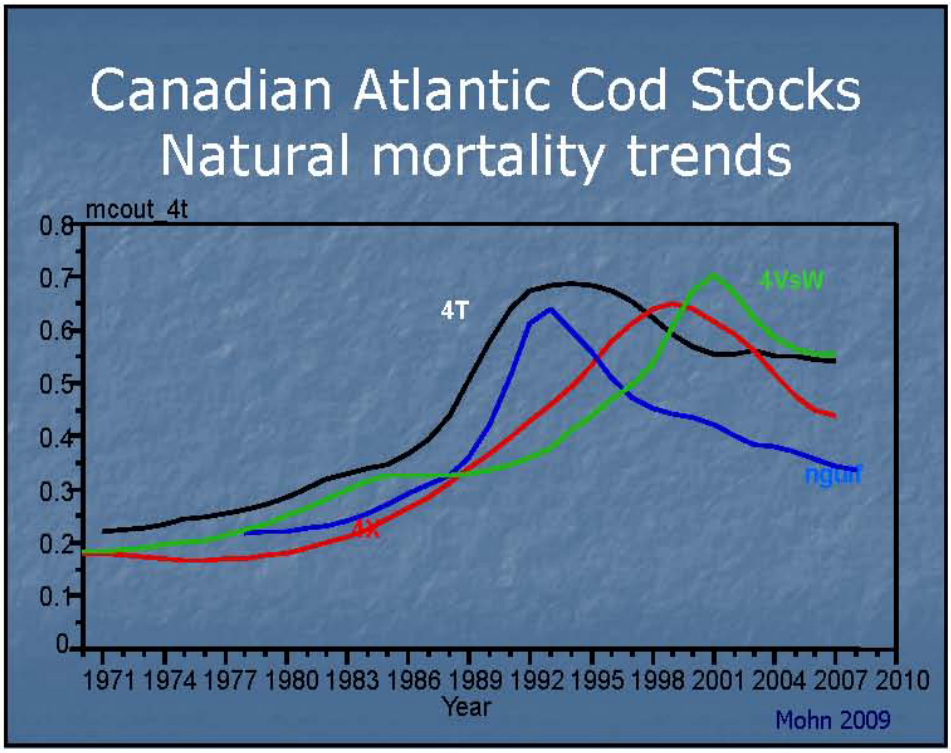
2.5.1 Presentation

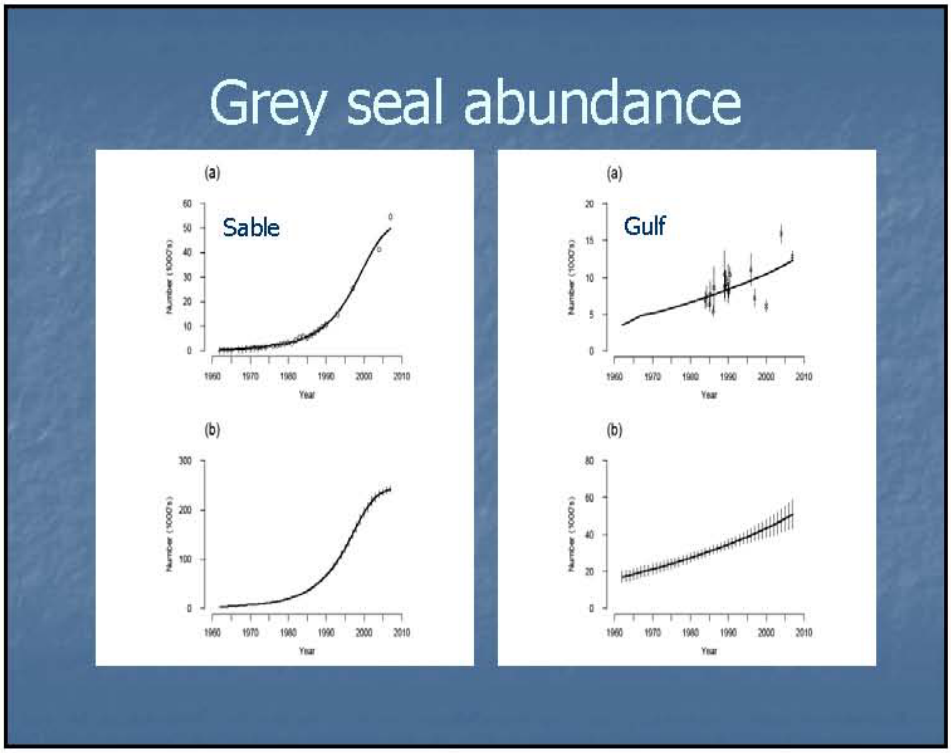


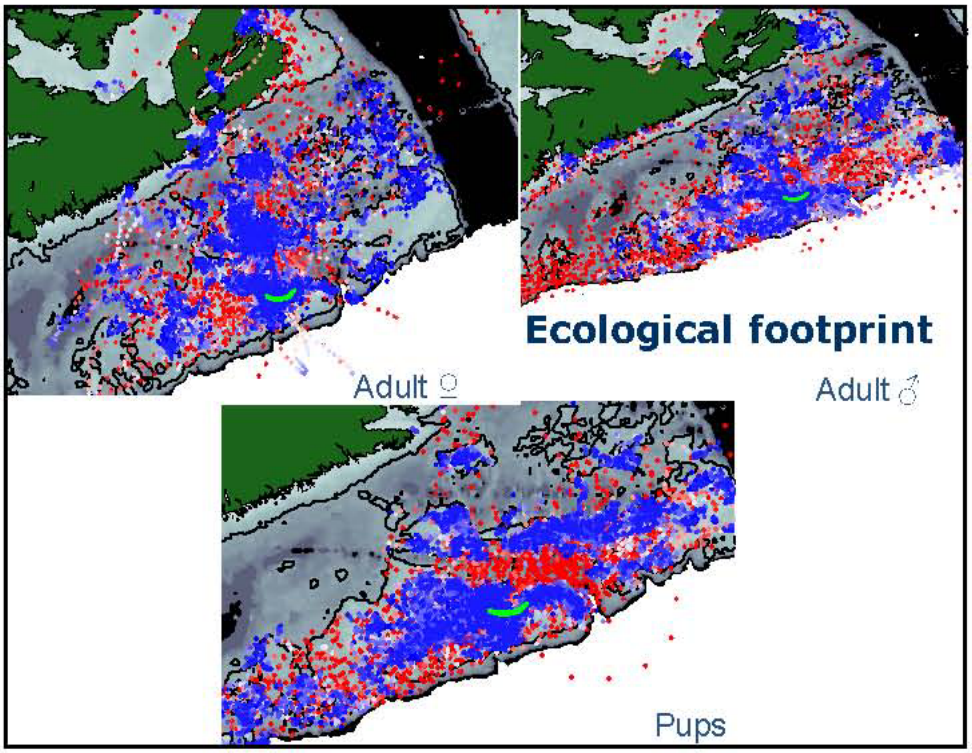



Study areas
4T
Gulf of St. Lawrence
4Vn
45° N
Eastern Scotian Shelf
Sable Island
4Vs
4W
4X
0 25 km
66° W
63° W
60° W
57° W


Eastern Scotian Shelf Cod (4VsW)
Abundance index (thousands of fish)
Summer 1970–2003
Spring 1979–1984
Fall 1978–1984
Spring 1986–2002
SSB (thousands of metric tons)
Fishing mortality
Year
Southern Gulf Cod (4T)
Age 3
Age 3+
Total
Spawning - Reproducteur
Year - Année


Canadian Atlantic Cod Stocks
Natural mortality trends
mcout_4t
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4T
4VsW
4X
ngtm
1971 1974 1977 1980 1983 1986 1989 1992 1995 1998 2001 2004 2007 2010
Year
Mohn 2009

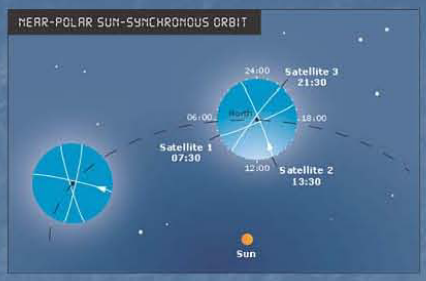

Grey seal abundance
(a)
Sable
(b)
(a)
Gulf
(b)



Grey seal predation on cod

- Both stocks M is high and particularly on larger fish
- Grey seals consume some cod but generally smaller sizes
- Business card tag provides the first opportunity to test hypothesis that seals are preying on these large cod, particularly in over-wintering or spawning concentrations

Satellite-linked telemetry



- three satellites are in phased polar orbits at 850 km
- at the poles, the satellites see each transmitter on every pass, approximately 14 times per day per satellite
- period during which the satellite can receive messages from a platform is 10 minutes
- about 20,000 PTTs are being tracked each yr

Business card tags and OTN

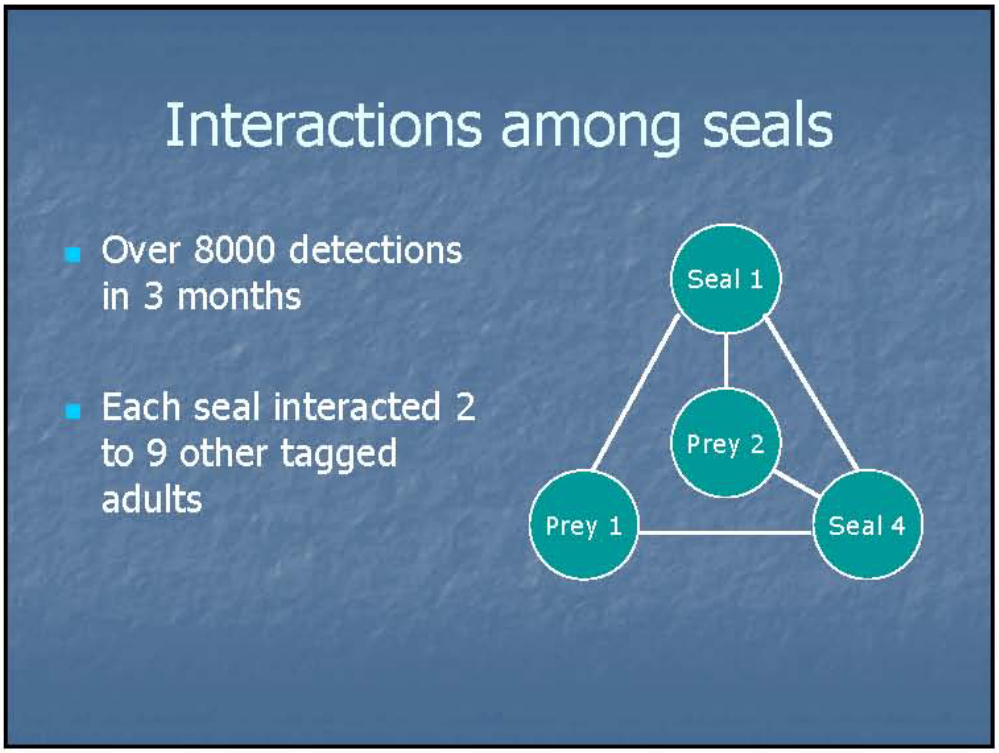
- deployment of business tags/GPS satellite tags (~20-25/yr) on grey seals at Sable Island (next 3 yr)
- cod tagged by DFO researchers annually in three cod stocks (4T, 4VsW, 4X)
- employ Chat technology to allow deployment of business tags on grey seals in Gulf
- critical to have fish tagged!!!

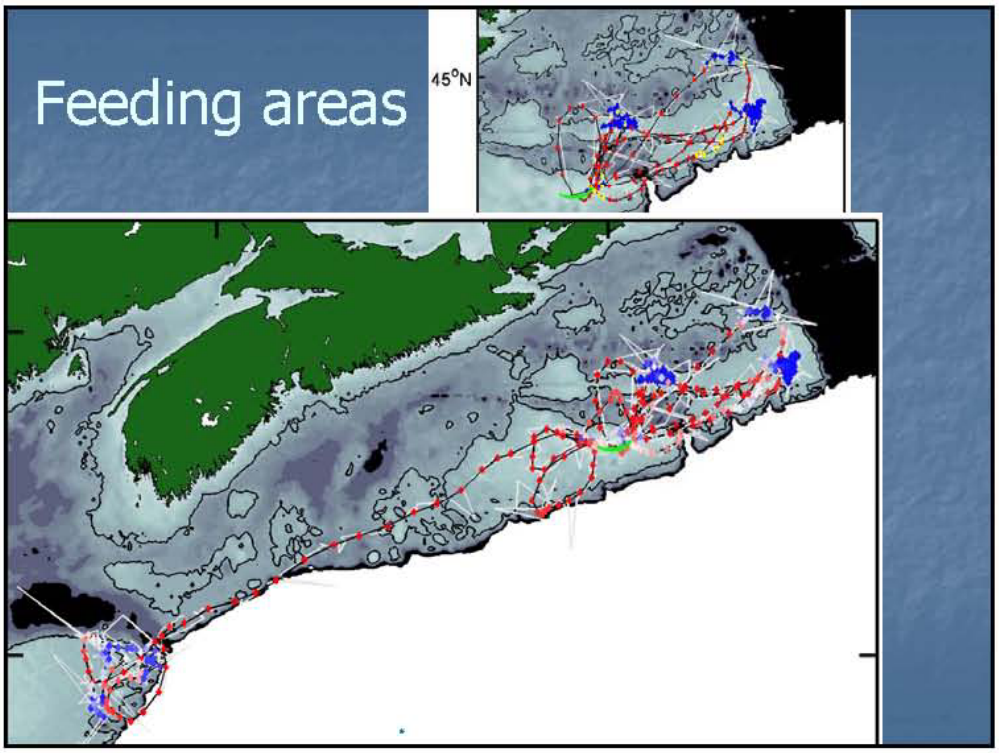
Grey seals and cod

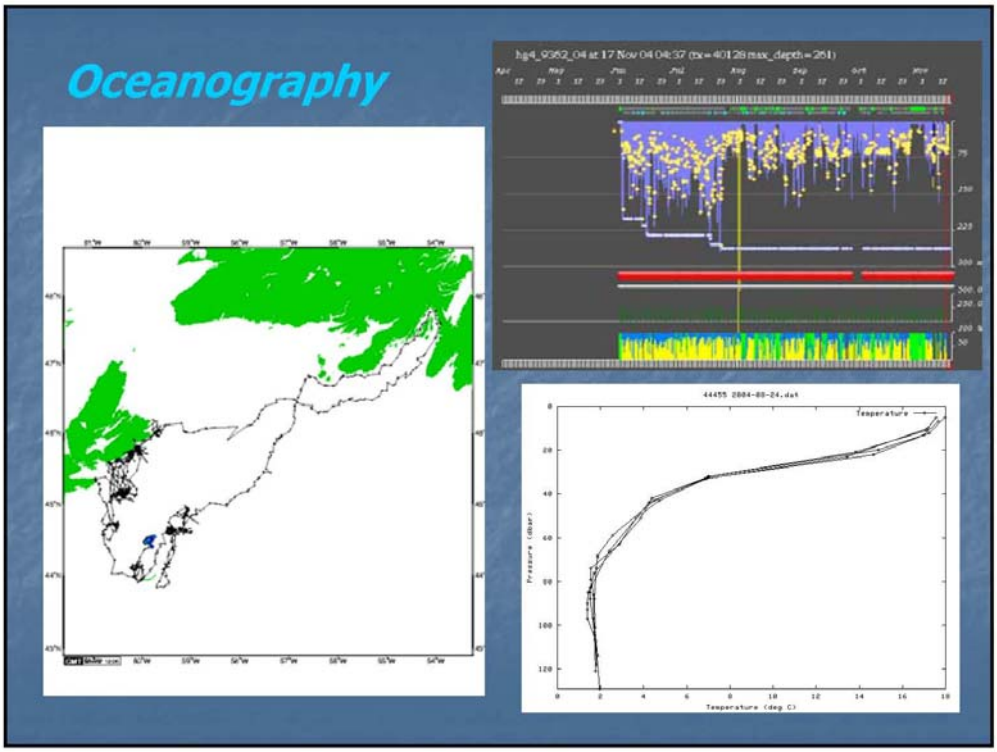
- May 2009 100 cod tagged in the southern Gulf with V13 acoustic tags (3-4 yr life)
- Oct 2009 15 grey seals fitted with integrated Argos Sat/GPS tags and BCT
- Jan 2010 13 of 15 seals recaptured and BCT downloaded
- Blubber samples and skin taken at initial capture and recapture to estimate the diet of each seal using fatty acid signature analysis and stable isotopes

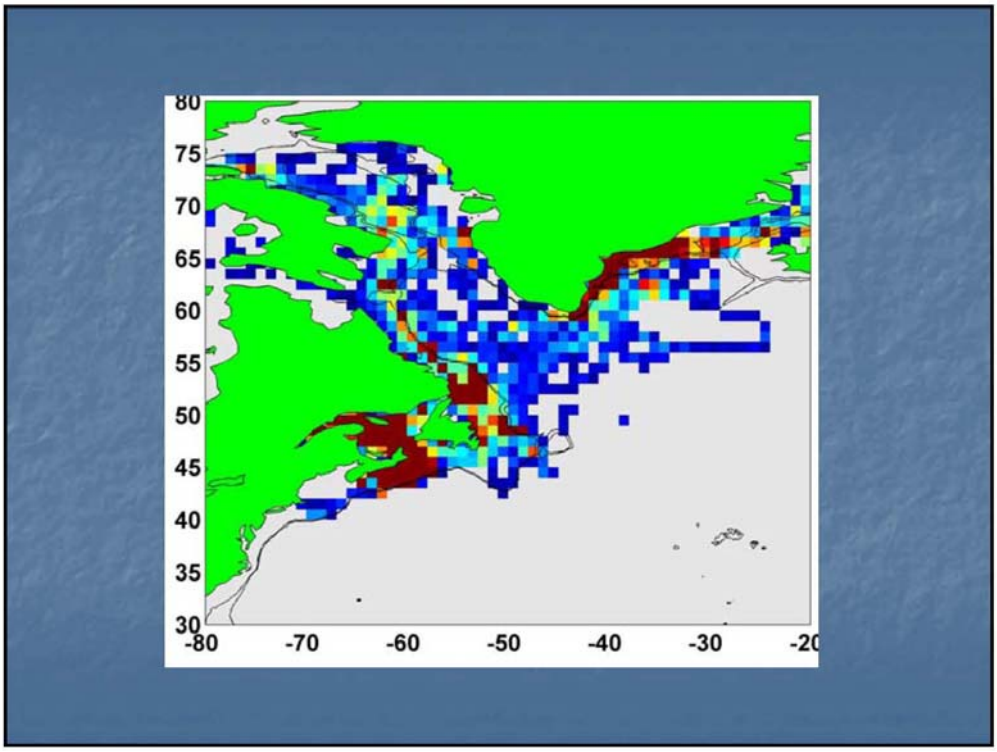
Grey seal 2009 deployment results

- recovered 13 of 15 business card tags/GPS satellite tags in Jan 2010
- detections of coded acoustic tags on all grey seal business card tags, from several hundred to over 2000
- also may have detected one of the cod in Cabot Strait


Interactions among seals
Over 8000 detections in 3 months
Each seal interacted 2 to 9 other tagged adults
Seal 1
Prey 2
Prey 1
Seal 4


Feeding areas
45°N


Oceanography


80
75
70
65
60
55
50
45
40
35
30
-80
-70
-60
-50
-40
-30

Oceanography and seasonal habitat use by grey seals

- What oceanographic features correspond with areas of high grey seal use?
- How do these feature vary seasonally?
- What inferences can we make regarding prey?

Implications

- Contribute to resolution of reasons for failure of depleted cod stocks (and potential other depleted species) to recover
- Contribute to understanding of ecosystem functioning and development of ecosystem management
- Contribute to development of new tracking instruments that feature Canadian companies

2.5.2 Summary

This research study is aimed at better understanding the ecological function of large marine predators in Continental Shelf ecosystems by using Grey seals and OTN's acoustic tagging technology. First it will look at spatial and temporal patterns of prey encounters by a mobile, large marine predator and will then look at predator movements and foraging behaviour in relation to seasonal oceanography in Eastern Canada. This project pairs the usage of business card tags and satellite tags on grey seals and acoustic tagging on cod. Cod was chosen as the focal prey species due to huge reductions in its biomass in recent years. The project objectives are to use technology to get spatial and temporal maps of seal and cod relationships, improve predictions of where seals forage, and have them carry instruments used to get oceanographic information.

It is a possibility that Grey seals are predating heavily on the cod stocks however, in the past seals have been known to consume only smaller cod. Natural mortality rate of larger cod is high and seal populations are increasing in most areas. The business card tag is providing the first opportunity to test a hypothesis that seals are now preying on larger cod, particularly in over-wintering and/or spawning regions. Over the next three years 20-25 Grey seals will be tagged annually at Sable Island with business card/GPS satellite tags. It is planned that cod will also be tagged annually by DFO researchers in the 4T, 4VsW, and 4X areas. Researchers are also currently developing Chat technology which they hope to use to remotely retrieve data from tagged seals in the Gulf of St. Lawrence.

In May of 2009, 100 cod were tagged in the Southern Gulf with acoustic tags and in June, 15 Grey seals were fitted with Argos satellite/GPS tags or business card tags (BCT). In the following January, 13 of the seals were recaptured and BCT information was downloaded. Blubber and skin samples were also taken at initial capture and again at recapture of the seals to get an estimate of their diet by using fatty acid signature analysis and stable isotopes. All Grey seal tags contained information from several hundred to over two-thousand coded acoustic tags from cod and over 8000 detections were recorded in the three month study period. Each seal was also found to interact with between two and nine other tagged adults that may indicate that they are feeding in the same locations.

The future of the project will look at what oceanographic features correspond with areas of high seal usage and how these features vary seasonally. They will also look into what assumptions can be made regarding prey. This information may be used to contribute to a resolution of reasons for failure of depleted cod stocks and to aid in the recovery process. It can also be used to contribute to the understanding of ecosystem functioning and development of better management practises while also contributing to the development of new instruments from local Canadian companies.

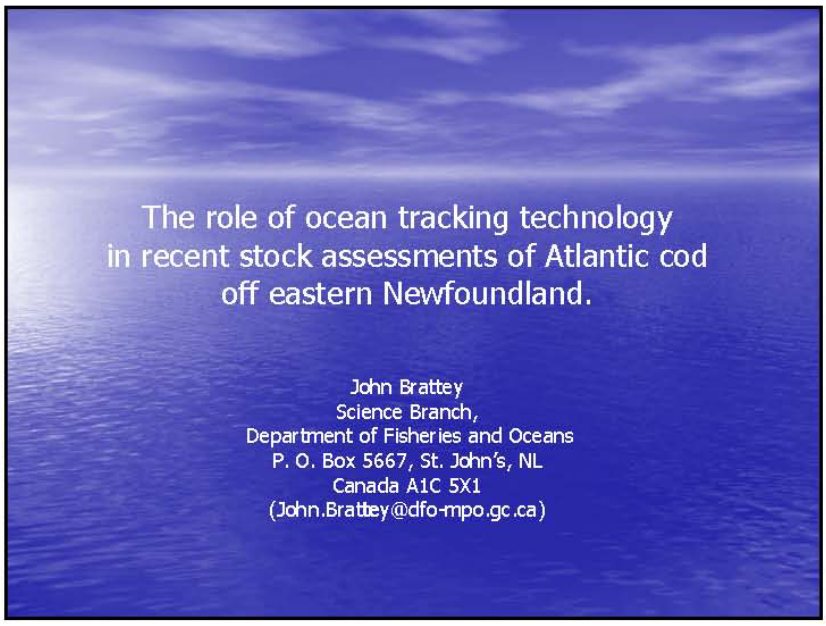
2.5.3 Discussion

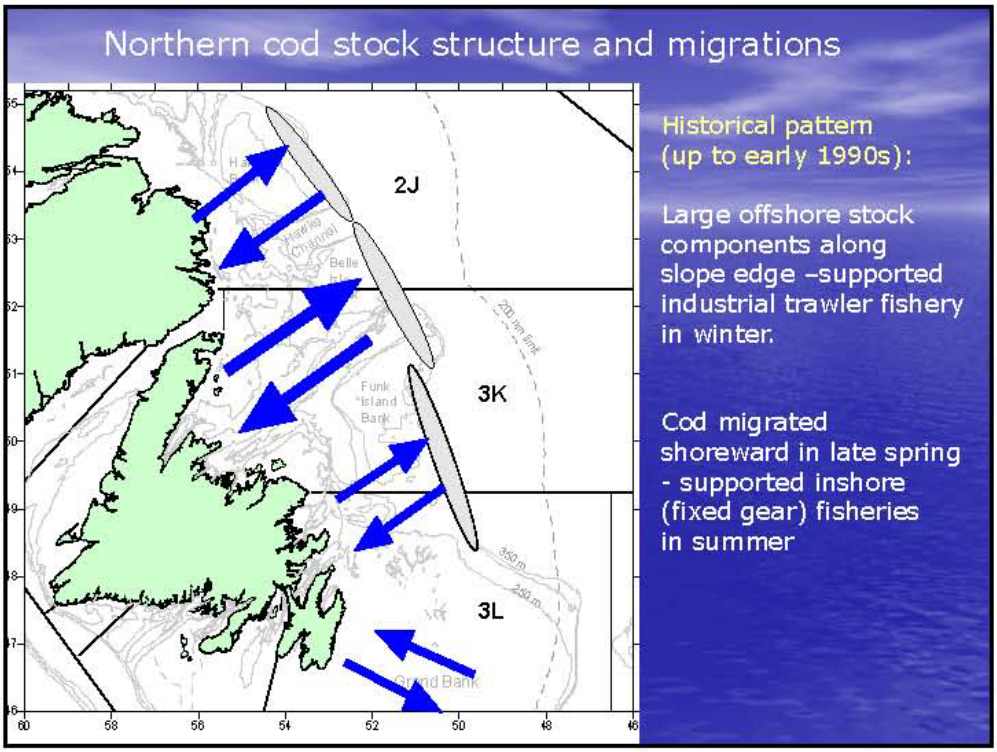
Q: Are the animals seen in Southwest Nova Scotia the same animals that are being tagged?
A: Yes, some use broader areas of the ocean. They feed in particular areas that have a large concentration of prey.

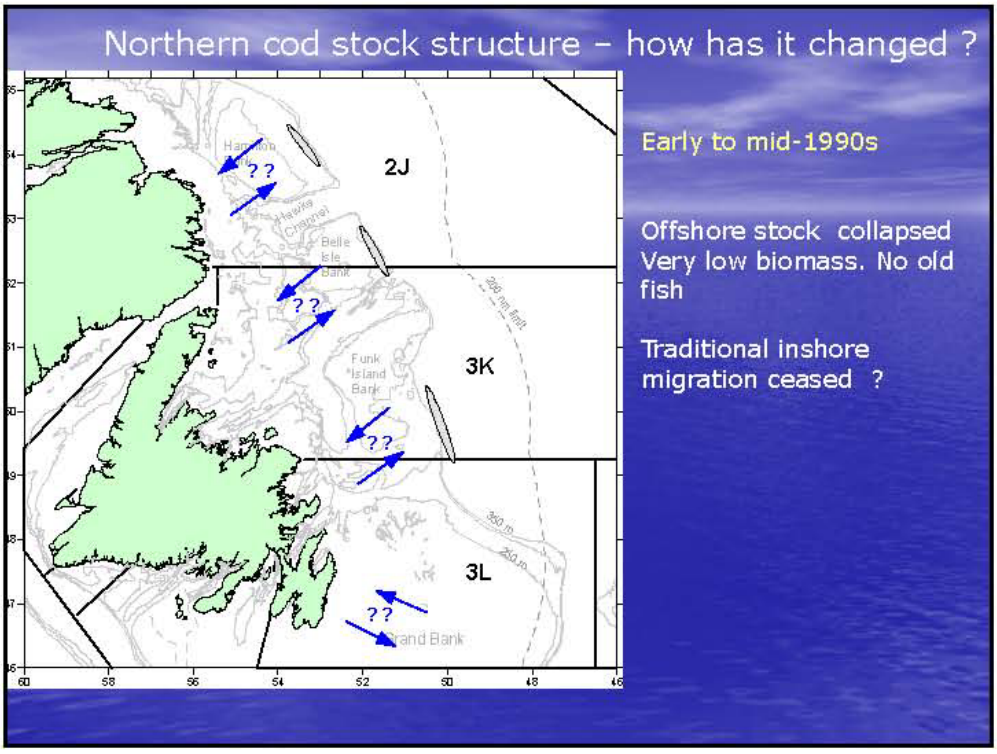
2.6 The Role of Ocean Tracking Technology in Recent Stock Assessments of Atlantic Cod off Eastern Newfoundland

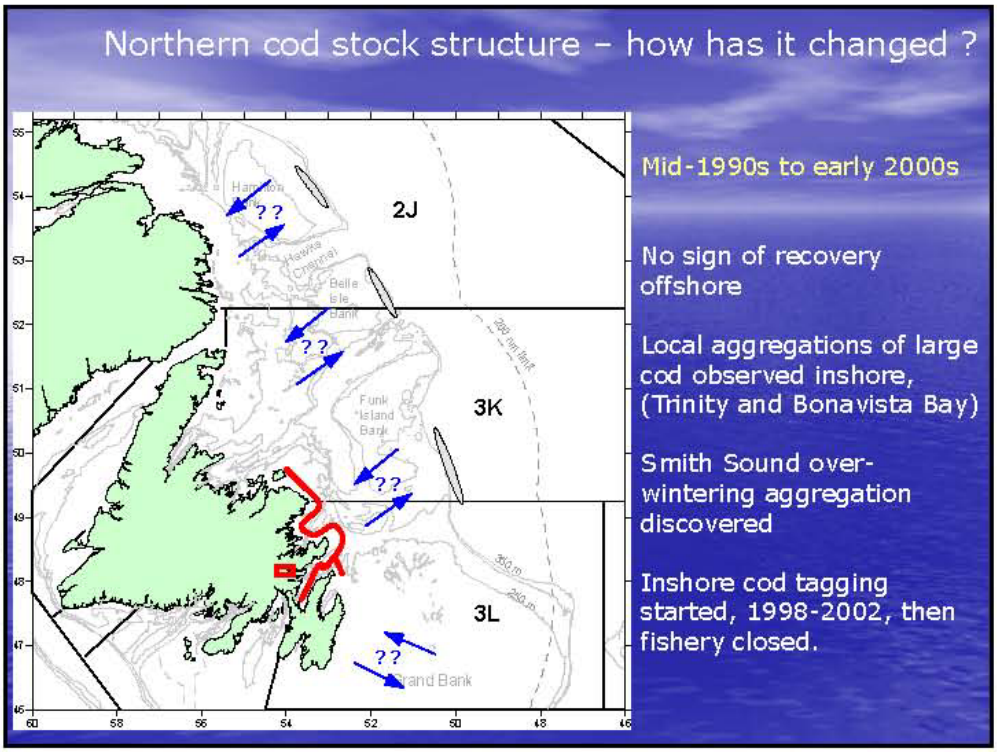
John Brattey, Research Scientist, Fisheries and Oceans Canada, Groundfish

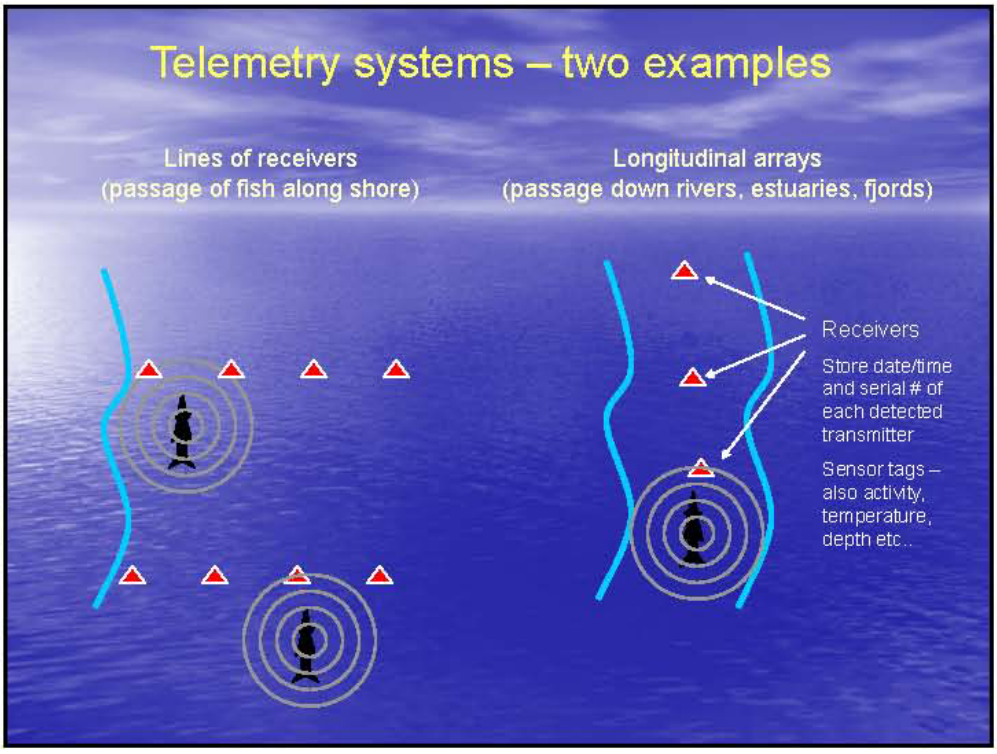
2.6.1 Presentation

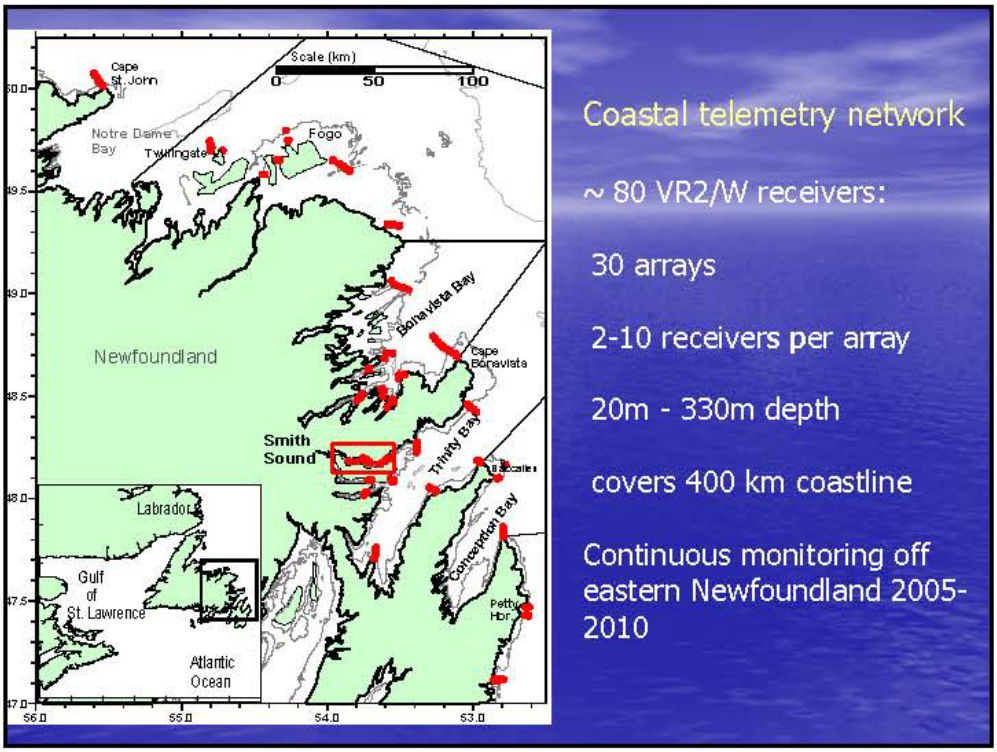


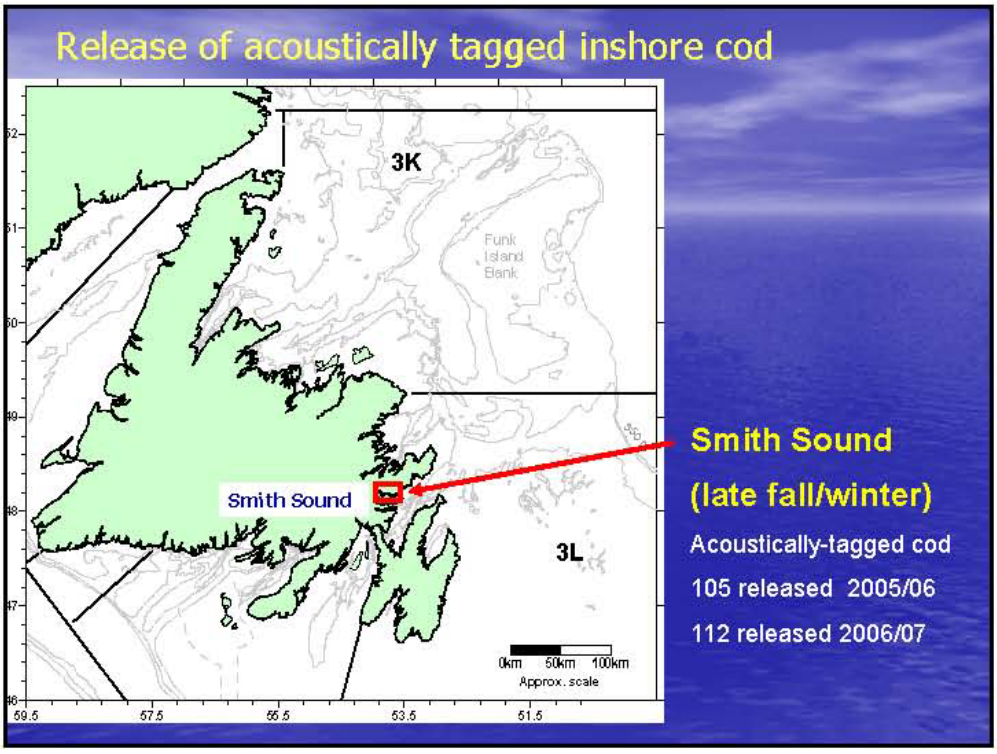

Northern cod stock structure and migrations
2J
3K
3L
Historical pattern (up to early 1990s):
Large offshore stock components along slope edge –supported industrial trawler fishery in winter.
Cod migrated shoreward in late spring - supported inshore (fixed gear) fisheries in summer

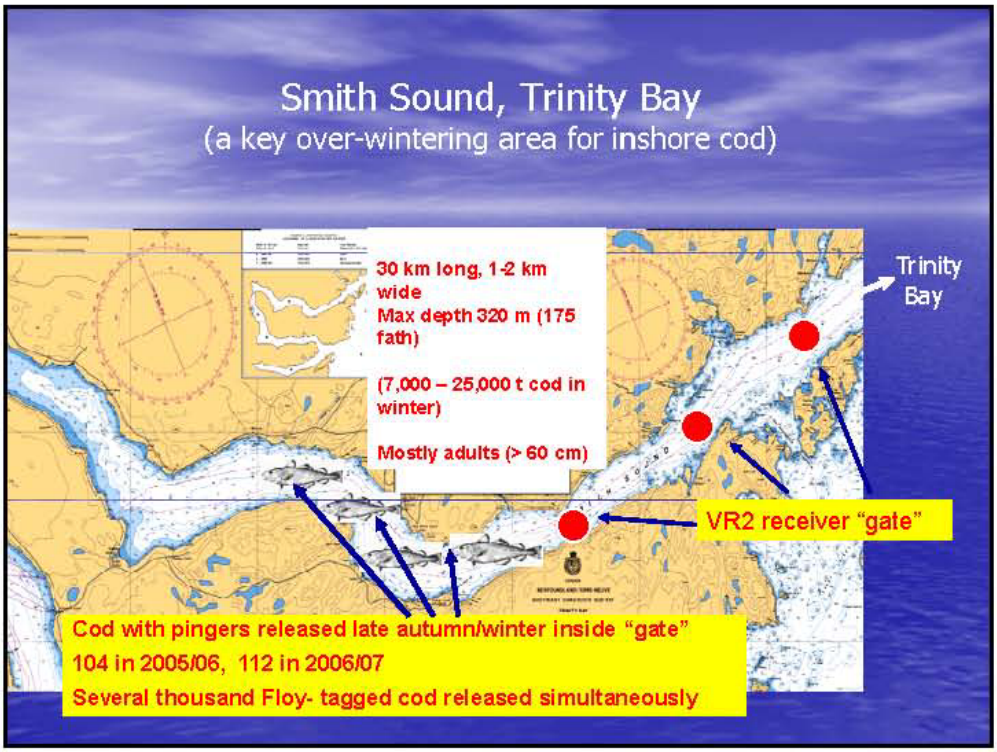

Northern cod stock structure – how has it changed ?
2J
3K
3L
??
Early to mid-1990s
Offshore stock collapsed Very low biomass. No old fish
Traditional inshore migration ceased ?

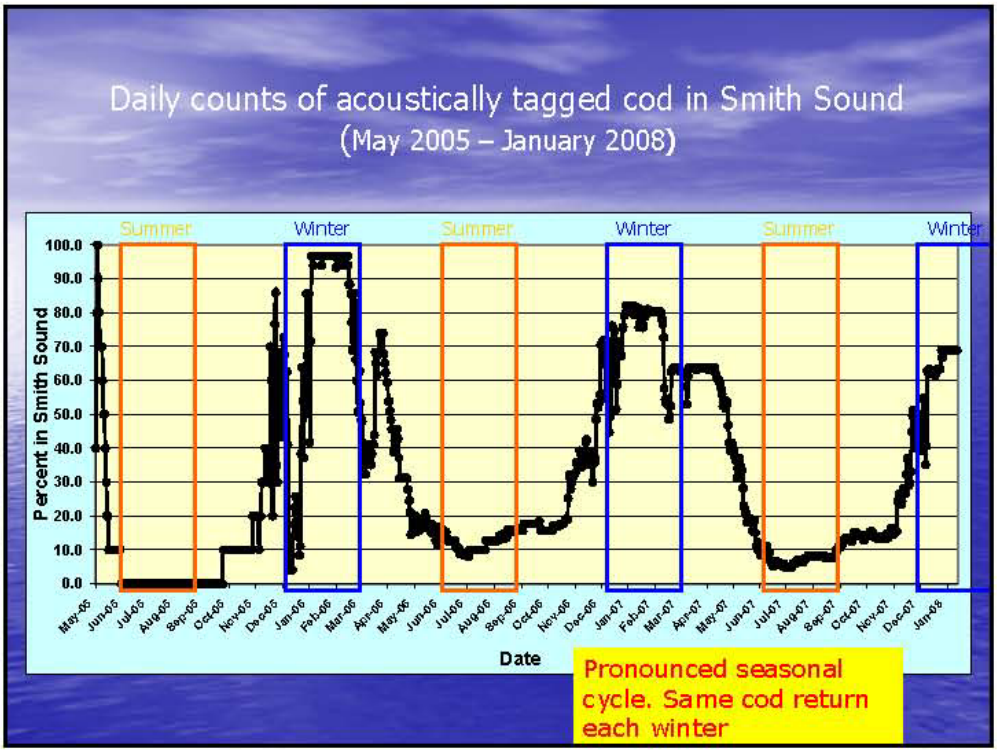

Northern cod stock structure – how has it changed ?
2J
3K
3L
Funk Island Bank
Grand Bank
Mid-1990s to early 2000s
No sign of recovery offshore
Local aggregations of large cod observed inshore, (Trinity and Bonavista Bay)
Smith Sound over-wintering aggregation discovered
Inshore cod tagging started, 1998-2002, then fishery closed.

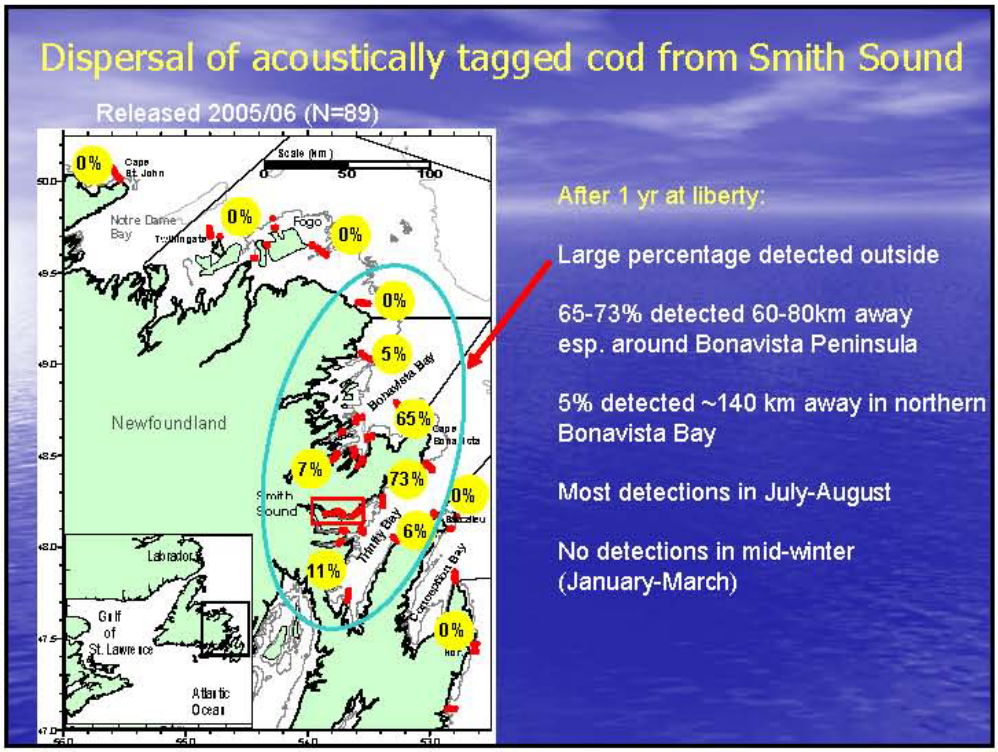

Telemetry systems – two examples
Lines of receivers
(passage of fish along shore)
Longitudinal arrays
(passage down rivers, estuaries, fjords)
Receivers
Store date/time and serial # of each detected transmitter
Sensor tags – also activity, temperature, depth etc..

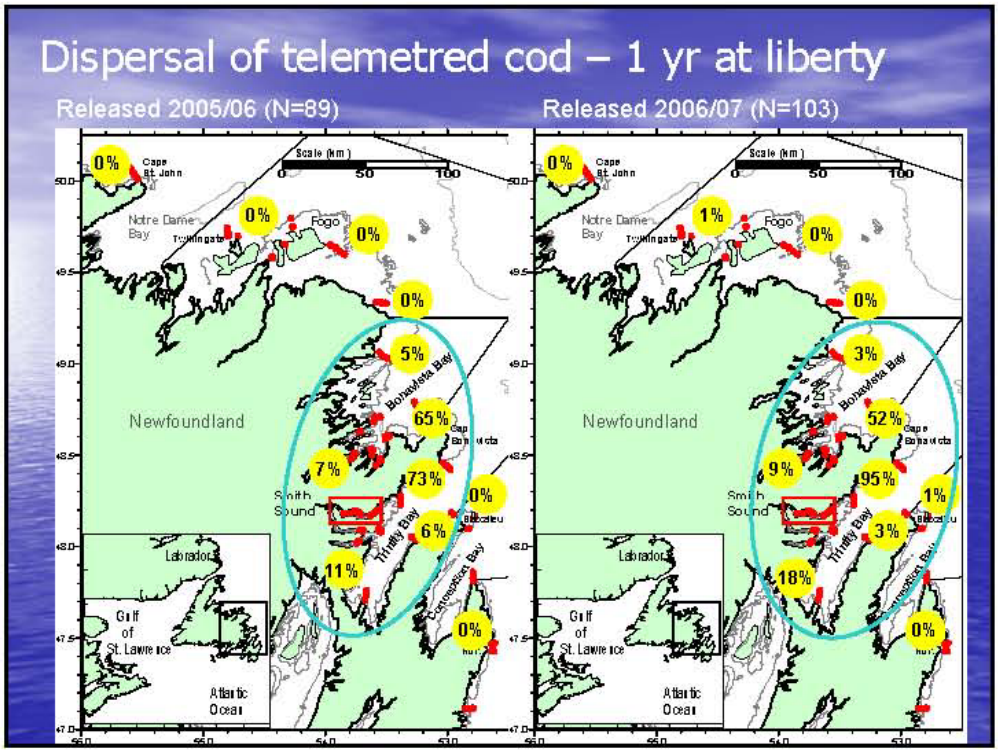

Cape St. John
Scale (km)
0
50
100
Notre Dame Bay
Twillingate
Fogo
Newfoundland
Bonavista Bay
Cape Bonavista
Smith Sound
Trinity Bay
Conception Bay
Labrador
Gulf of St. Lawrence
Atlantic Ocean
Coastal telemetry network
~ 80 VR2/W receivers:
30 arrays
2-10 receivers per array
20m - 330m depth
covers 400 km coastline
Continuous monitoring off eastern Newfoundland 2005-2010

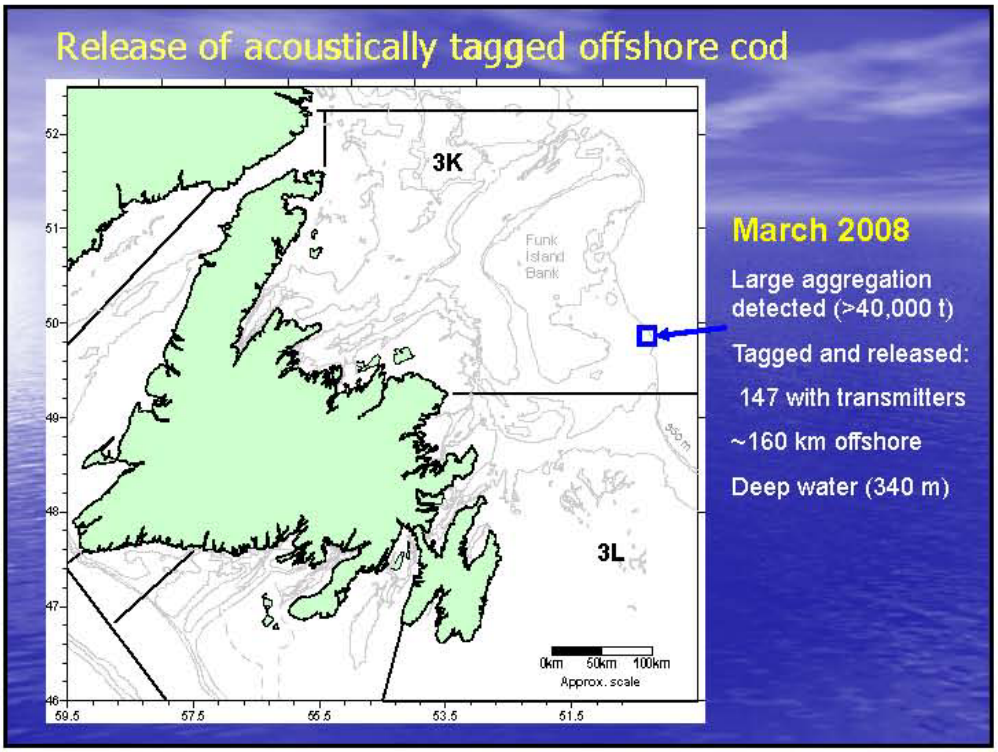

Release of acoustically tagged inshore cod
3K
Funk Island Bank
Smith Sound
3L
0km 50km 100km
Approx. scale
Smith Sound
(late fall/winter)
Acoustically-tagged cod
105 released 2005/06
112 released 2006/07

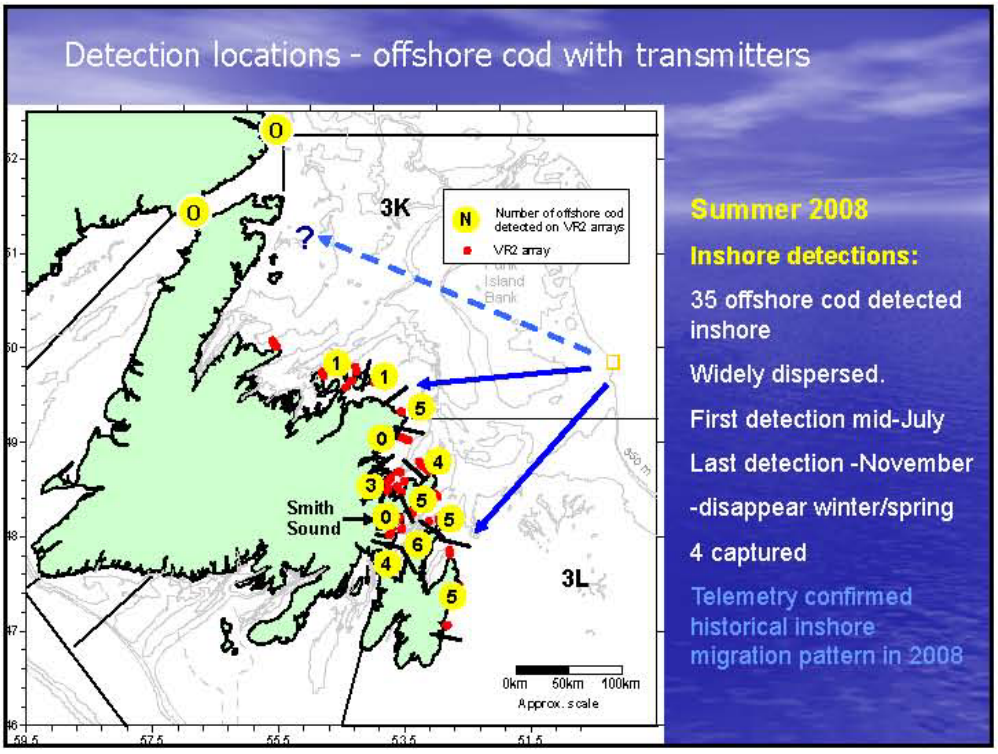

Smith Sound, Trinity Bay
(a key over-wintering area for inshore cod)
30 km long, 1-2 km wide
Max depth 320 m (175 fath)
(7,000 – 25,000 t cod in winter)
Mostly adults (> 60 cm)
Trinity Bay
VR2 receiver "gate"
Cod with pingers released late autumn/winter inside "gate"
104 in 2005/06, 112 in 2006/07
Several thousand Floy- tagged cod released simultaneously


Daily counts of acoustically tagged cod in Smith Sound
(May 2005 – January 2008)
Summer
Winter
Summer
Winter
Summer
Winter
Percent in Smith Sound
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
May-05 Jun-05 Jul-05 Aug-05 Sep-05 Oct-05 Nov-05 Dec-05 Jan-06 Feb-06 Mar-06 Apr-06 May-06 Jun-06 Jul-06 Aug-06 Sep-06 Oct-06 Nov-06 Dec-06 Jan-07 Feb-07 Mar-07 Apr-07 May-07 Jun-07 Jul-07 Aug-07 Sep-07 Oct-07 Nov-07 Dec-07 Jan-08
Date
Pronounced seasonal cycle. Same cod return each winter

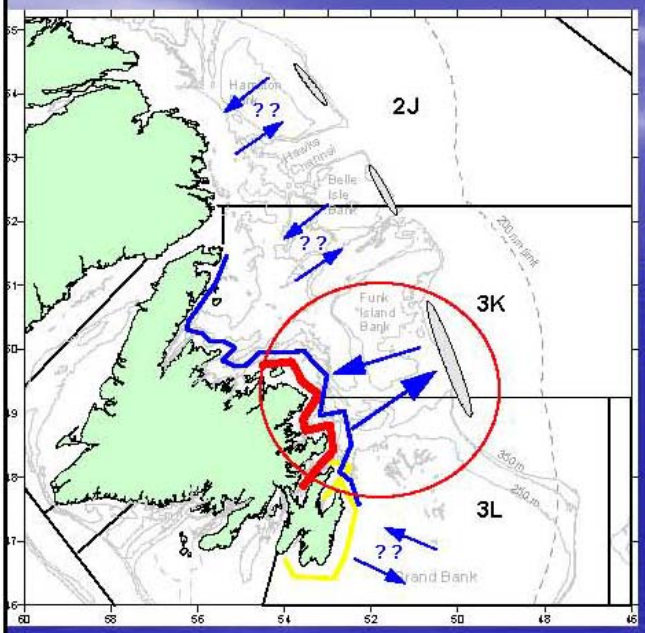

Dispersal of acoustically tagged cod from Smith Sound
Released 2005/06 (N=89)
Scale (km)
0
50
100
0%
0%
0%
0%
5%
65%
7%
73%
0%
6%
11%
0%
Cape St. John
Notre Dame Bay
Fogo
Bonavista Bay
Newfoundland
Smith Sound
Trinity Bay
Labrador
Gulf of St. Lawrence
Atlantic Ocean
After 1 yr at liberty:
Large percentage detected outside
65-73% detected 60-80km away esp. around Bonavista Peninsula
5% detected ~140 km away in northern Bonavista Bay
Most detections in July-August
No detections in mid-winter (January-March)


Dispersal of telemetred cod – 1 yr at liberty
Released 2005/06 (N=89)
Released 2006/07 (N=103)
Scale (km)
0
50
100
0%
0%
0%
0%
5%
65%
7%
73%
0%
6%
11%
0%
1%
0%
0%
3%
52%
9%
95%
1%
3%
18%
0%
Cape St. John
Notre Dame Bay
Fogo
Bonavista Bay
Newfoundland
Smith Sound
Trinity Bay
Labrador
Gulf of St. Lawrence
Atlantic Ocean


Release of acoustically tagged offshore cod
3K
3L
Funk Island Bank
0km 50km 100km
Approx. scale
March 2008
Large aggregation detected (>40,000 t)
Tagged and released:
147 with transmitters
~160 km offshore
Deep water (340 m)


Detection locations - offshore cod with transmitters
3K
3L
Smith Sound
N Number of offshore cod detected on VR2 arrays
VR2 array
0km 50km 100km
Approx. scale
Summer 2008
Inshore detections:
35 offshore cod detected inshore
Widely dispersed.
First detection mid-July
Last detection -November
-disappear winter/spring
4 captured
Telemetry confirmed historical inshore migration pattern in 2008

A new perspective on northern cod stock structure



Telemetry revealed 3 subcomponents:

1. Offshore 3K
2. Coastal (Smith Snd)
3. Migrants from 3Ps

Traditional inshore migration taking place 2008.

Moratorium no longer protecting offshore stock

~6% offshore tagged cod captured inshore 2008

What role can fishers play in the use of OTN-type technology ?

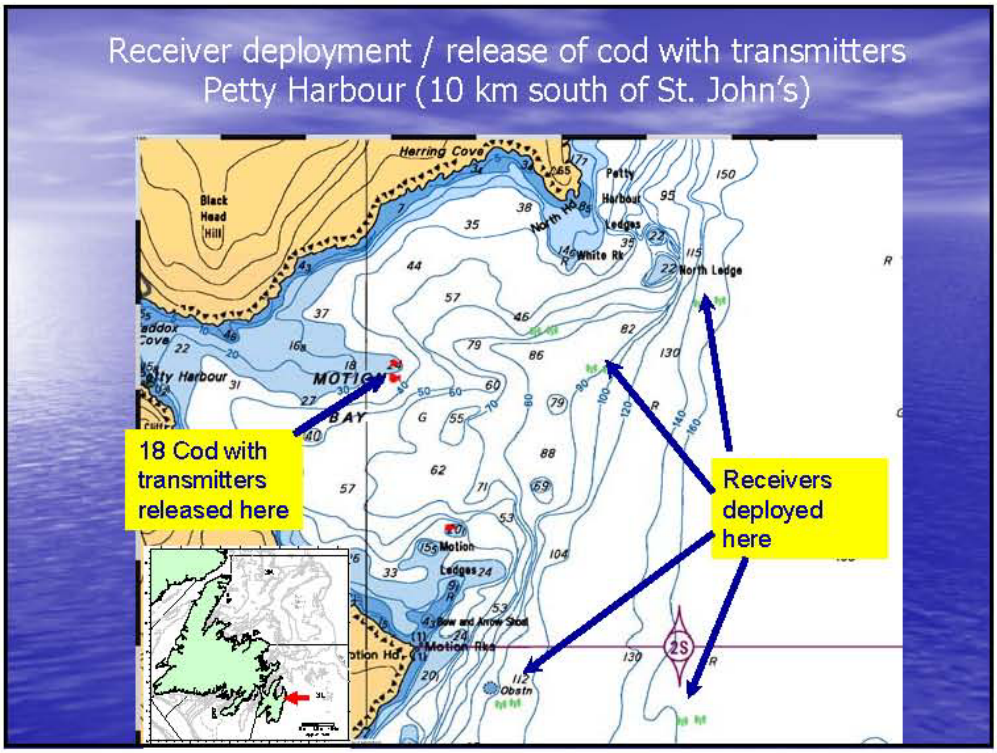
Provide advice on:

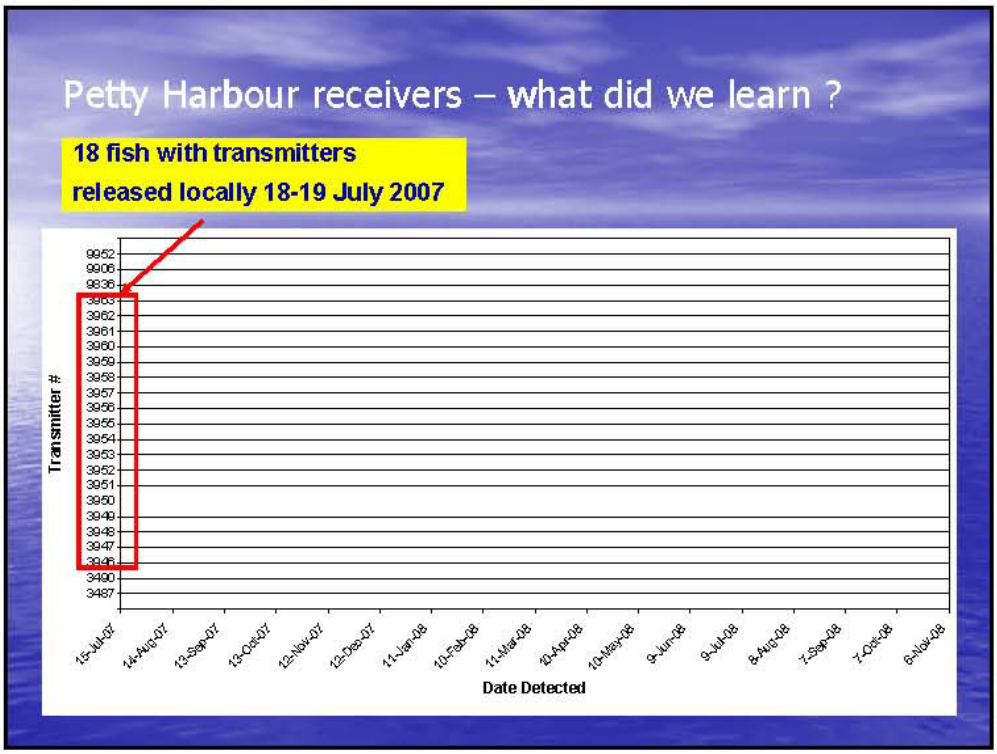
- Sources of animals for transmitters.
- Optimum location of acoustic telemetry arrays
  - where best to intercept migrating animals.
  - avoid conflict between receiver arrays and fishing activity.
- Design of moorings for receivers.

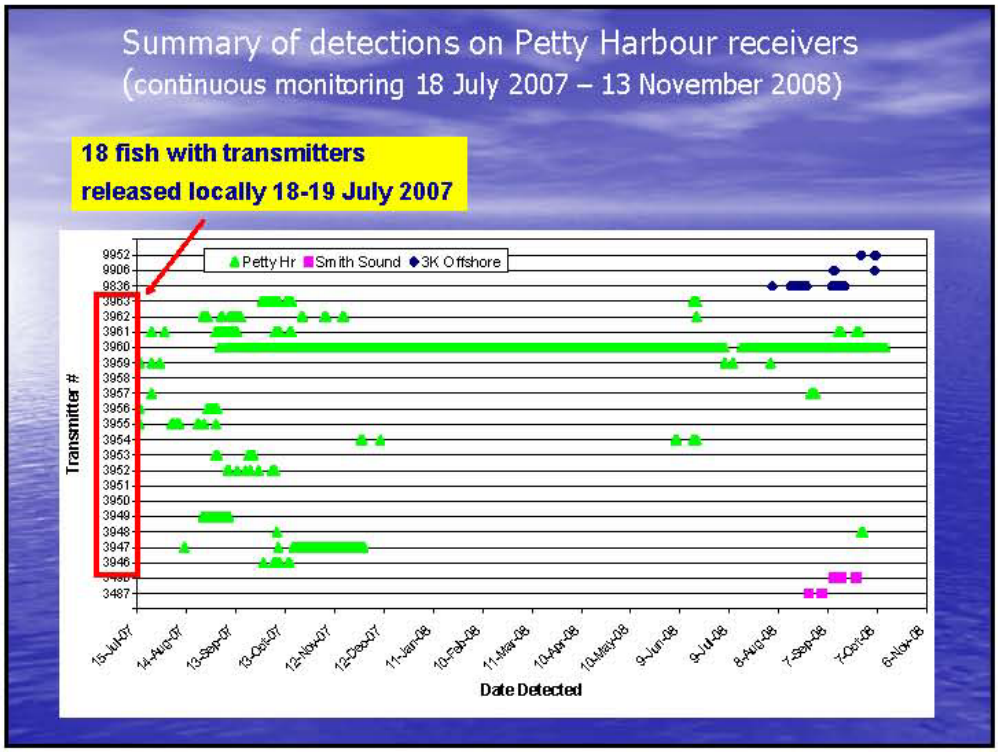
Active roles:

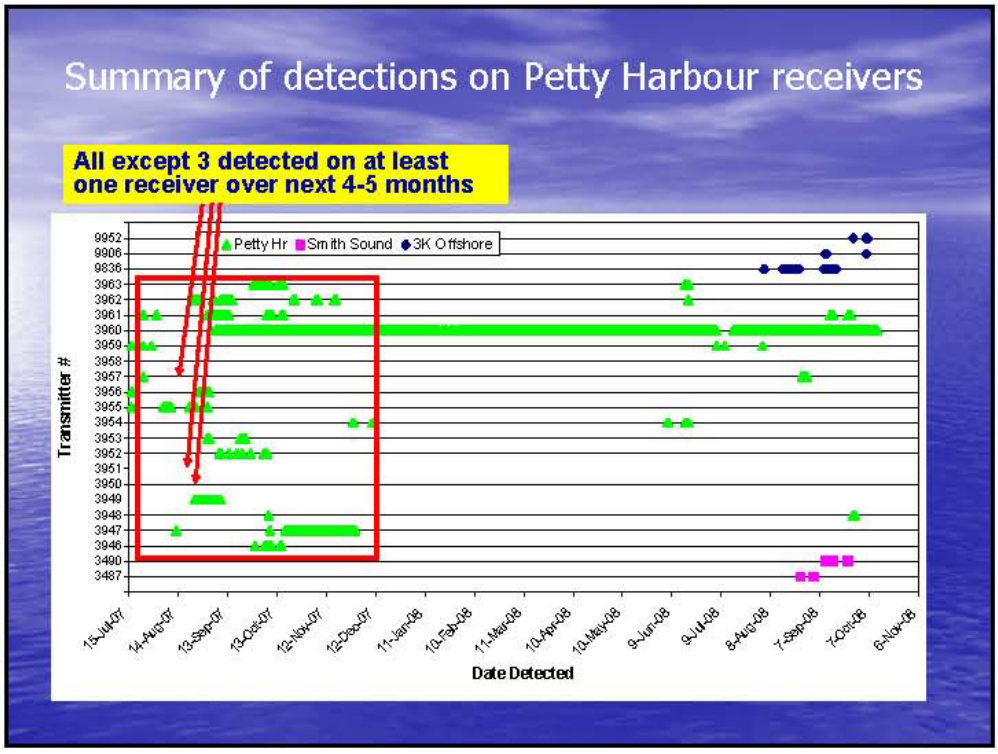
- Capture of animals for telemetry.
- Provide platforms for deployment/ retrieval of receivers.
- Assume full responsibility for local receiver arrays
  (i.e. deployment, retrieval, battery changes, data uploading, redeployment)

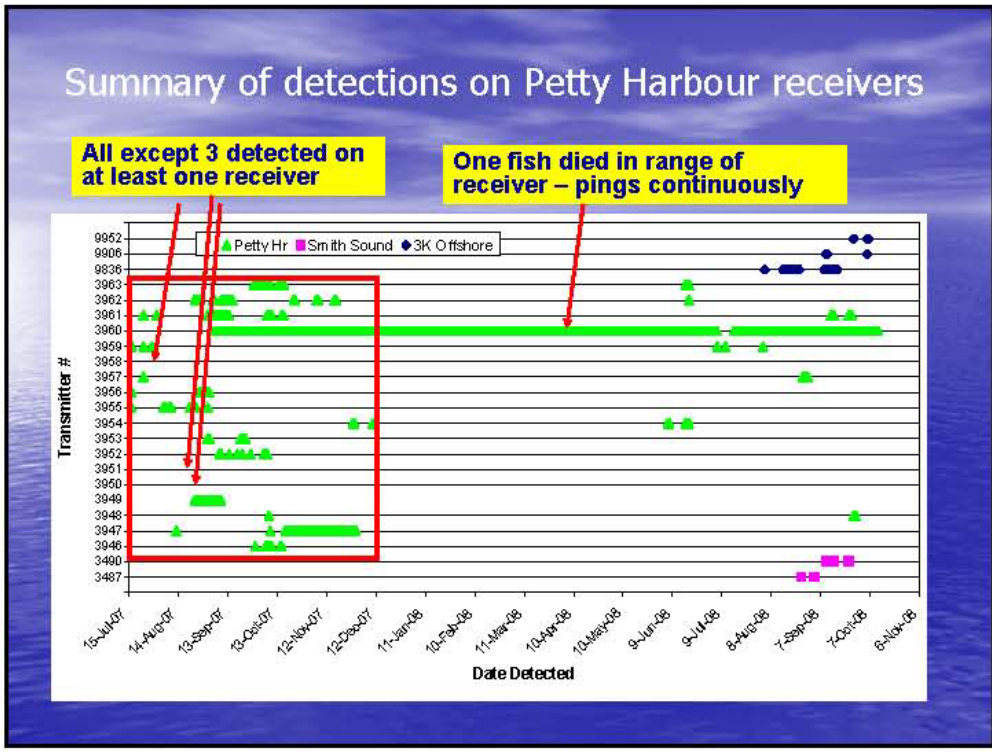
.....an example from Petty Harbour, NL

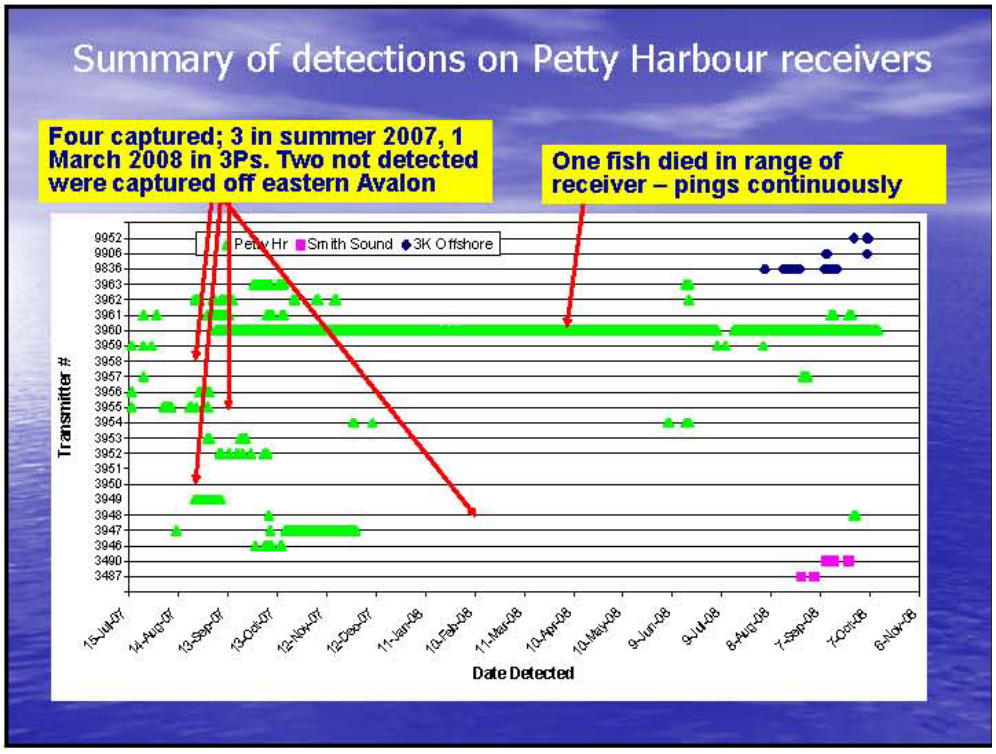

Receiver deployment / release of cod with transmitters
Petty Harbour (10 km south of St. John's)
18 Cod with transmitters released here
Receivers deployed here
Herring Cove
Petty Harbour
North Ledge
White Rk
Ledges
Motion
Obstn

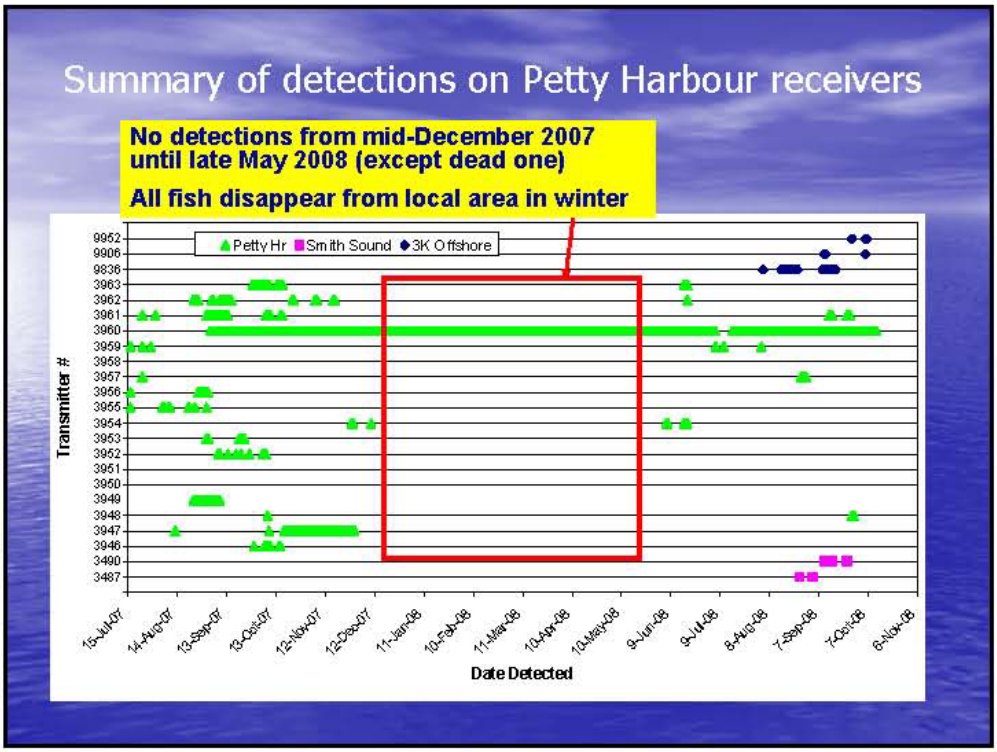

Petty Harbour receivers – what did we learn ?
18 fish with transmitters released locally 18-19 July 2007
Transmitter #
Date Detected
15-Jul-07
14-Aug-07
13-Sep-07
13-Oct-07
12-Nov-07
12-Dec-07
11-Jan-08
10-Feb-08
11-Mar-08
10-Apr-08
10-May-08
9-Jun-08
9-Jul-08
8-Aug-08
7-Sep-08
7-Oct-08
6-Nov-08

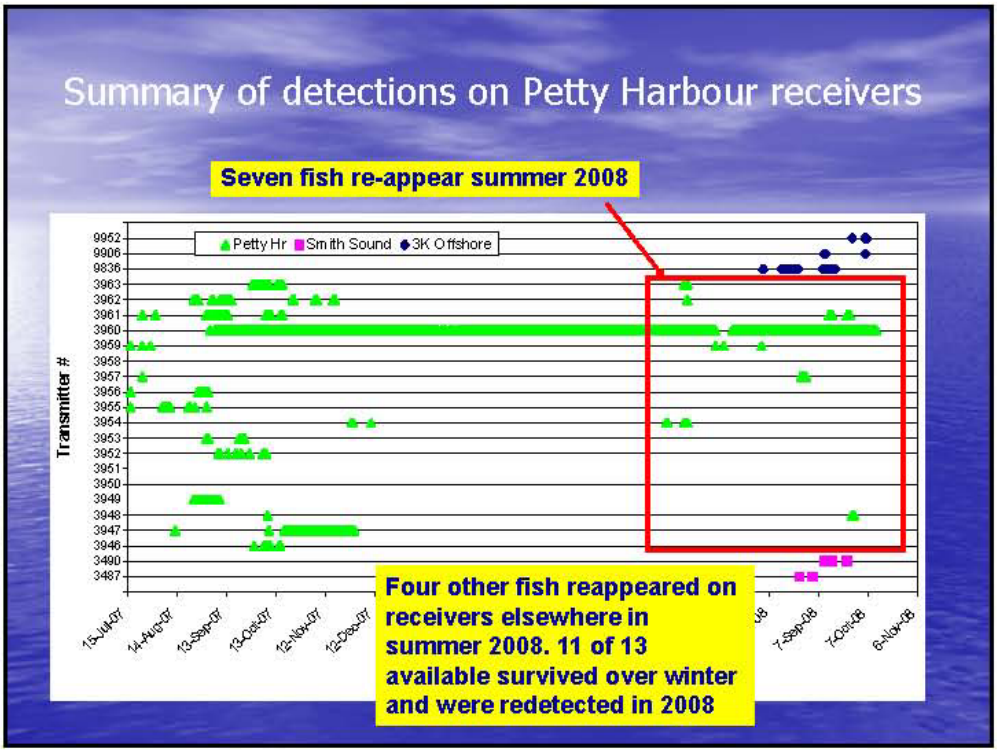

Summary of detections on Petty Harbour receivers
(continuous monitoring 18 July 2007 – 13 November 2008)
18 fish with transmitters
released locally 18-19 July 2007
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected

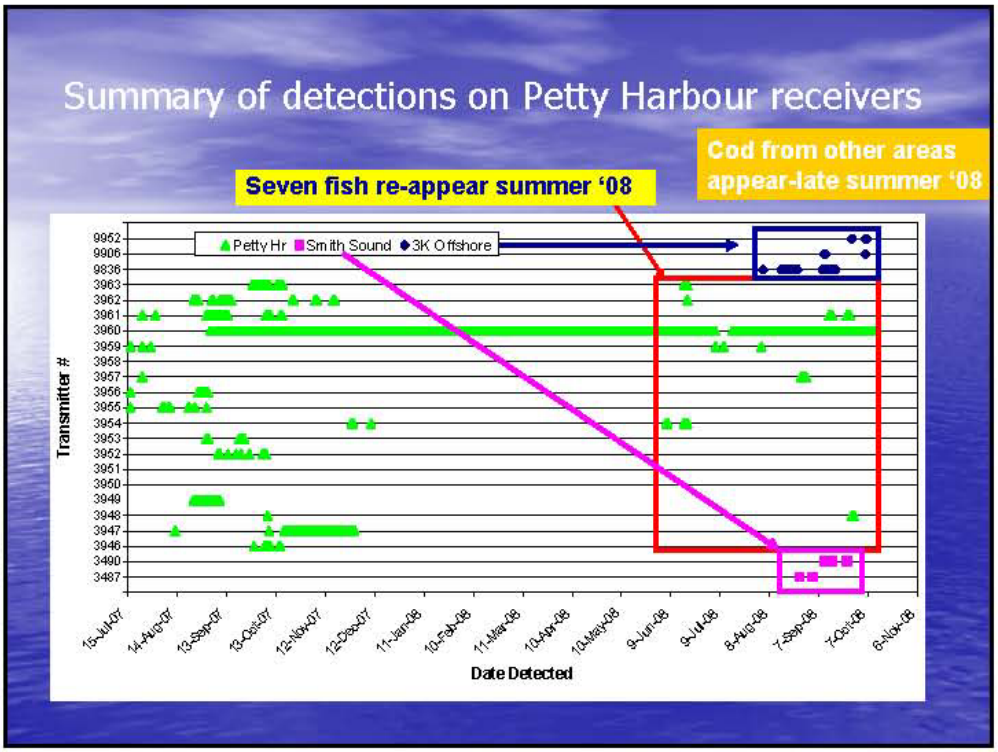

Summary of detections on Petty Harbour receivers
All except 3 detected on at least
one receiver over next 4-5 months
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected

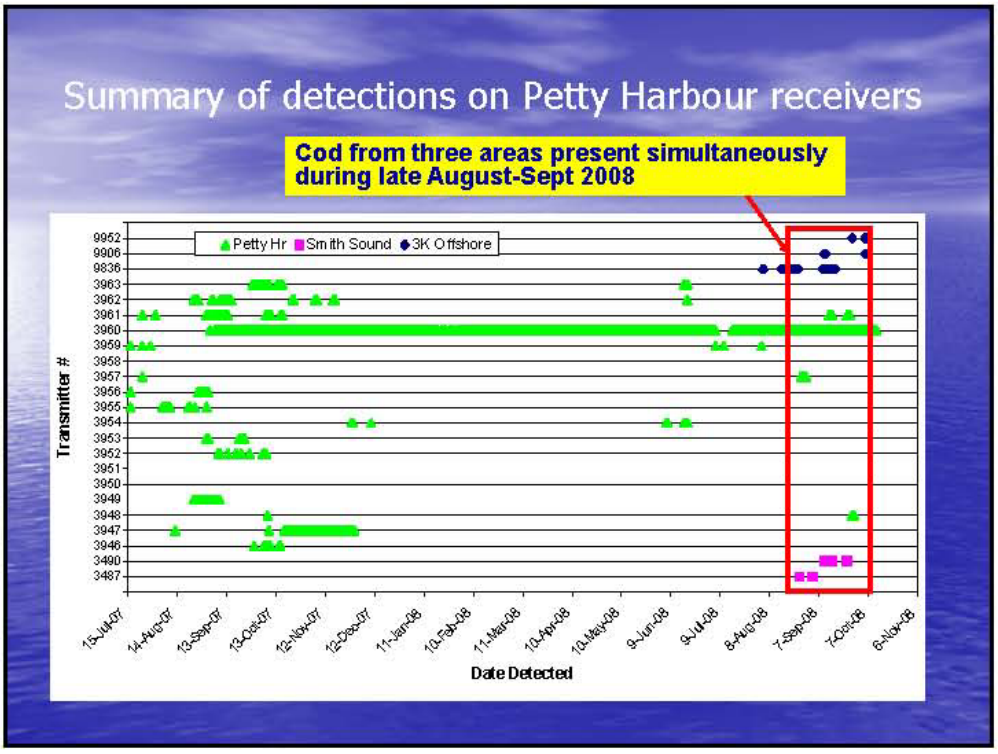

Summary of detections on Petty Harbour receivers
All except 3 detected on at least one receiver
One fish died in range of receiver – pings continuously
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected

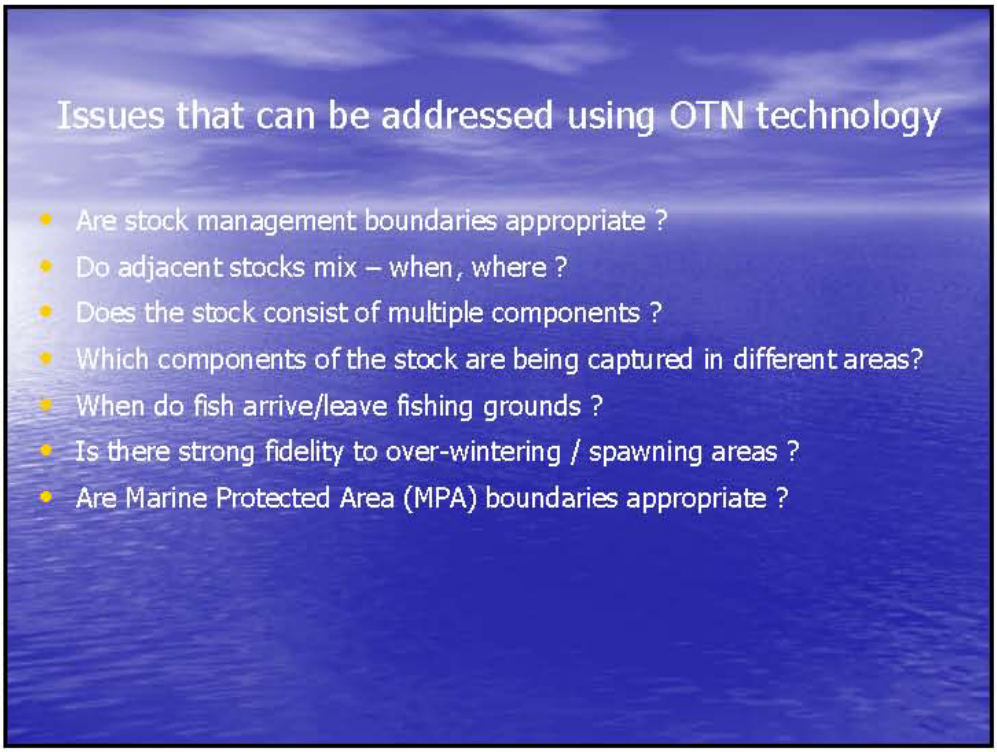

Summary of detections on Petty Harbour receivers
Four captured; 3 in summer 2007, 1 March 2008 in 3Ps. Two not detected were captured off eastern Avalon
One fish died in range of receiver – pings continuously
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected

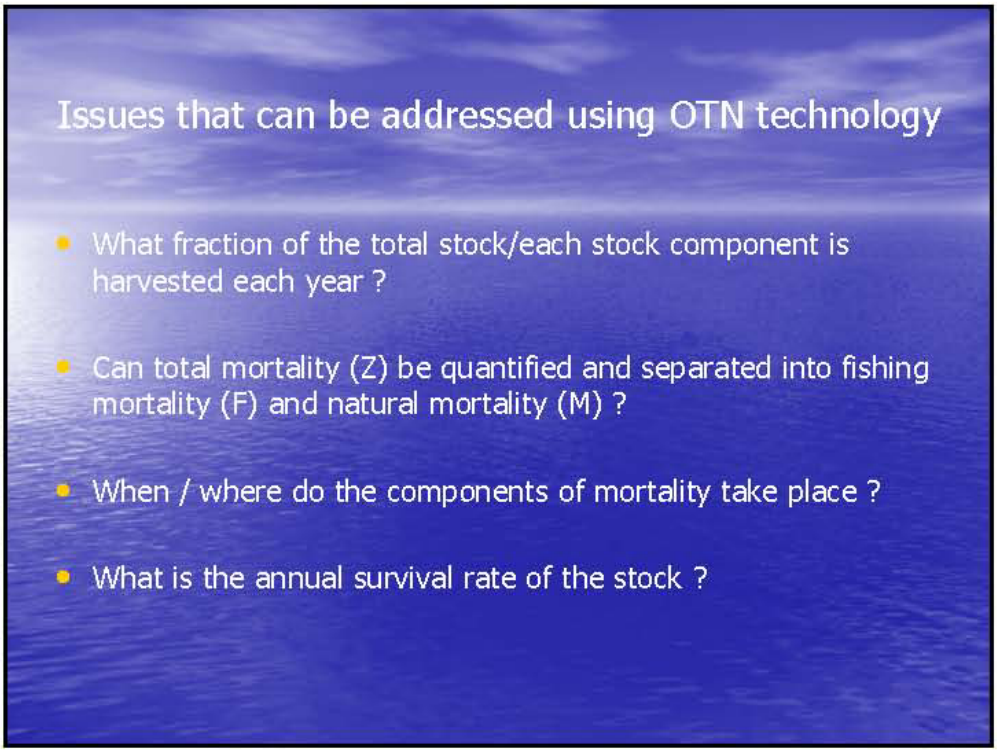

Summary of detections on Petty Harbour receivers
No detections from mid-December 2007 until late May 2008 (except dead one)
All fish disappear from local area in winter
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected


Summary of detections on Petty Harbour receivers
Seven fish re-appear summer 2008
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Four other fish reappeared on receivers elsewhere in summer 2008. 11 of 13 available survived over winter and were redetected in 2008


Summary of detections on Petty Harbour receivers
Seven fish re-appear summer '08
Cod from other areas appear-late summer '08
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected


Summary of detections on Petty Harbour receivers
Cod from three areas present simultaneously during late August-Sept 2008
Petty Hr
Smith Sound
3K Offshore
Transmitter #
Date Detected


Issues that can be addressed using OTN technology
Are stock management boundaries appropriate ?
Do adjacent stocks mix – when, where ?
Does the stock consist of multiple components ?
Which components of the stock are being captured in different areas?
When do fish arrive/leave fishing grounds ?
Is there strong fidelity to over-wintering / spawning areas ?
Are Marine Protected Area (MPA) boundaries appropriate ?


Issues that can be addressed using OTN technology
What fraction of the total stock/each stock component is harvested each year ?
Can total mortality (Z) be quantified and separated into fishing mortality (F) and natural mortality (M) ?
When / where do the components of mortality take place ?
What is the annual survival rate of the stock ?

Acknowledgements

Many DFO Science colleagues have provided input which I gratefully acknowledge

Staff of the groundfish, sentinel, shellfish, commercial sampling sections esp. Dan Porter, Clyde George (retired), Paul Higdon, Todd Paddle, Corey Morris.

Fishers in several communities, esp Tom Best, Paul Goodyear, Dennis Ivany, Cyril and George Dalley, Lloyd Sullivan, Roger Tucker.

Funding from:

- DFO Science Strategic Program
- SARCEP / SARA
- Fisheries Science Collaborative Program
- Fish Food & Allied Workers

2.6.2 Summary

Cod stocks in Eastern Newfoundland began to show a decline in the late 80's and early 90's and the 2J3KL stock was under moratorium (offshore) or exposed to only small scale fisheries (inshore) by the mid 90's. The massive decline established the need to study cod stocks and better understand what was going on with these populations. Between the early 1990s and the early 2000's local aggregations of large cod were discovered inshore near Trinity and Bonavista Bay, Newfoundland. An over-wintering aggregation of cod was also discovered in Smith Sound and tagging of these groups of inshore cod commenced during a period of limited inshore fishing from 1998 to 2002 until the fishery closed again in 2003. With no fishing, the amount of data available from tagging was limited. In 2005/2006 inshore fishing re-opened and funding from DFO allowed for continued tagging and monitoring using newer telemetry technology along the north-eastern coast of the province In the first two years of telemetry, 105 and 112 (respectively) cod were tagged with acoustic pingers and released in Smith Sound. Acoustic receivers were placed along a 350 km stretch of coastline in 30 different coastal locations. Long term monitoring from VR2 acoustic receivers placed in Smith Sound confirmed that cod returned there in the winter months and left by mid spring. Also, after the first year a large percentage of the tagged cod (65-73%) were detected 60-80 km away near Bonivista Peninsula; mostly between July and August.

In March of 2008 a large group (greater than 40,000 tonnes) of offshore cod was detected approximately 160 km from the coast. Tag and release efforts were expanded and 147 individuals were captured and released with transmitters. In the summer of 2008, 35 of these offshore cod were detected inshore and were very widely dispersed. This confirmed a historical inshore migration pattern and a mixing of cod stocks. The study confirmed that not only are there both inshore and offshore groups of cod but also that offshore migrants come inshore in the summer months.

Fishermen can play a key role in using OTN technology and a number of studies similar to this one could be undertaken. Fishers can provide advice on sources of animals to be tagged, optimum locations to place receiver arrays based on known migration routes and to avoid conflict with active fishing, and also to help design moorings for receivers. They can also take an active role by capturing animals for tagging, help with deployment and retrieval of receivers, and assume full responsibility for local receiver arrays.

OTN technology can be used to determine stock management boundaries, figure out when fish arrive and leave fishing grounds, learn about mixing of adjacent stocks, and determine if marine protected area boundaries are appropriate for present migration routes. It can also answer important questions such as:

- What fraction of total stock is harvested each year?
- Can we separate fishing mortality from natural mortality?
- Where do they take place?
- What is the annual survival rate of the stock?

2.6.3 Discussion

Q: Did you just tag the large fish?
A: Fish 60 cm and up were tagged since it is the minimum you can go with the large tags used, but we have also used smaller V13 tags in cod as small as 40 cm. The batteries in the smaller tags don't last as long but still function for at least a year.

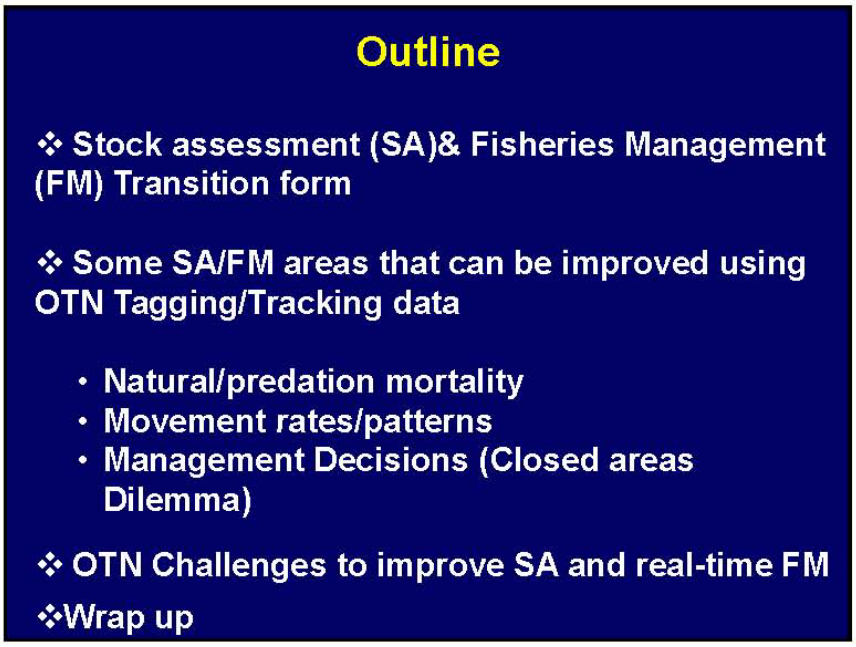
Q: Have you had a chance to apply this to stock assessment?
A: Yes, in the case of estimating exploitation rates and understanding movements.

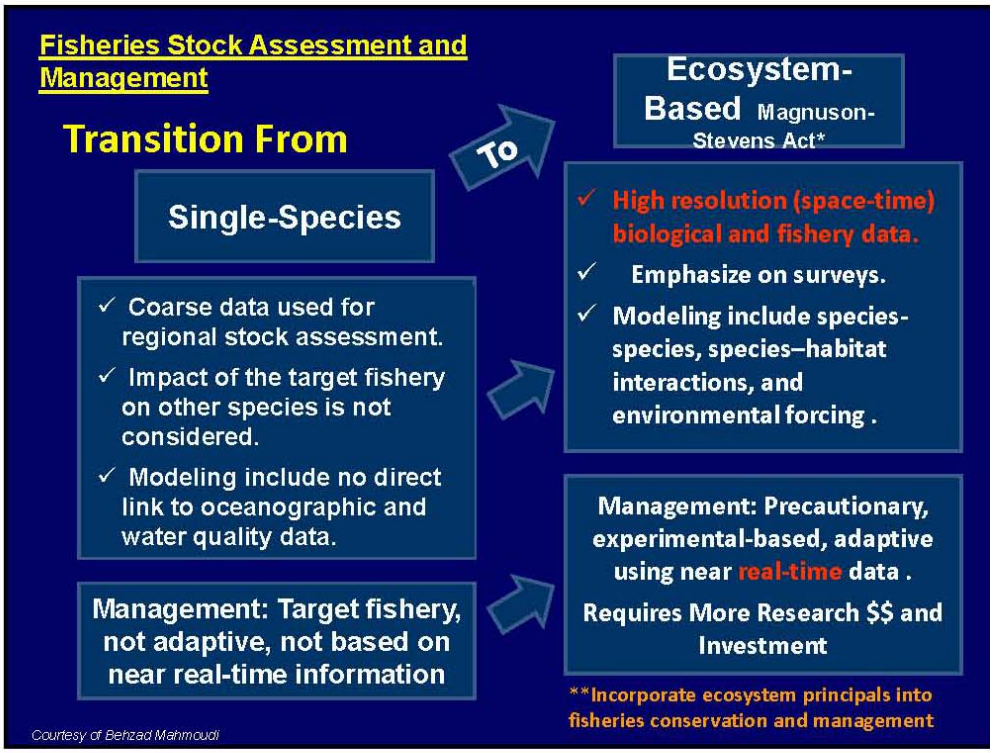
Q: Since cod stay in the Sound in winter do they spawn right there?
A: We know that some do, but many seem to leave Smith Sound and spawn widely around the coast into Bonavista Bay

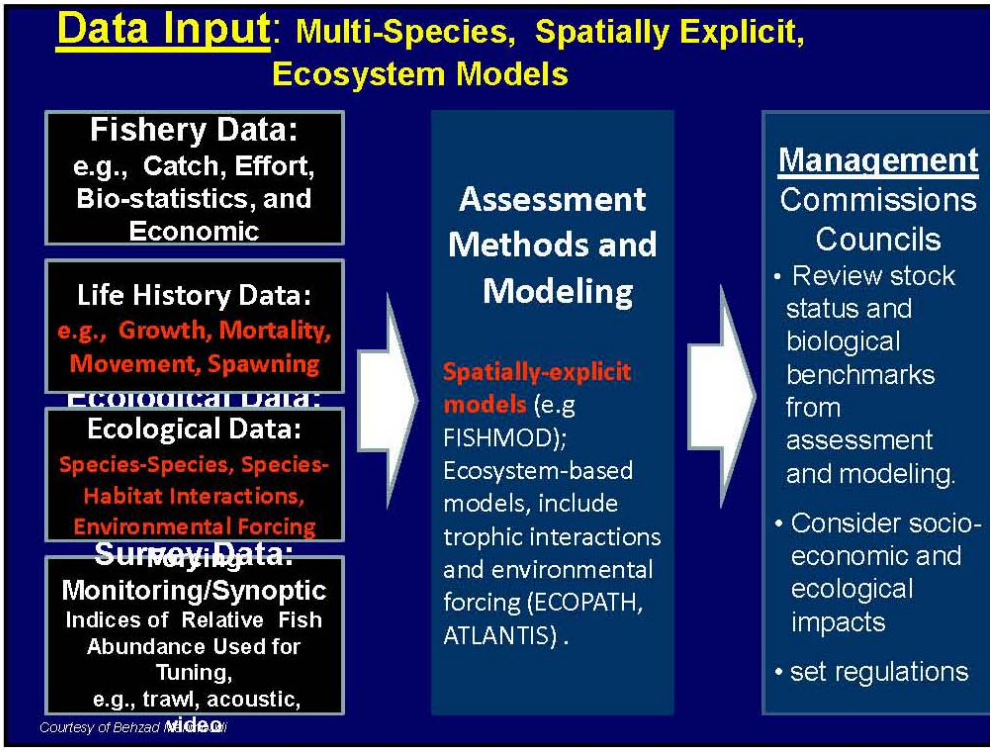
2.7 Using OTN Data to Improve Stock Assessment and Fishery Management

Hassan Moustahfid, Marine Scientist, NOAA Integrated Ocean Observations System (IOOS), National Ocean Service/NOAA

2.7.1 Presentation




Fisheries Stock Assessment and Management
Transition From
Single-Species
To
Ecosystem-Based Magnuson-Stevens Act*
✓ Coarse data used for regional stock assessment.
✓ Impact of the target fishery on other species is not considered.
✓ Modeling include no direct link to oceanographic and water quality data.
Management: Target fishery, not adaptive, not based on near real-time information
✓ High resolution (space-time) biological and fishery data.
✓ Emphasize on surveys.
✓ Modeling include species-species, species–habitat interactions, and environmental forcing .
Management: Precautionary, experimental-based, adaptive using near real-time data .
Requires More Research $$ and Investment
**Incorporate ecosystem principals into fisheries conservation and management
Courtesy of Behzad Mahmoudi


Data Input: Multi-Species, Spatially Explicit, Ecosystem Models
Fishery Data:
e.g., Catch, Effort, Bio-statistics, and Economic
Life History Data:
e.g., Growth, Mortality, Movement, Spawning
Ecological Data:
Species-Species, Species-Habitat Interactions, Environmental Forcing
Survey Data:
Monitoring/Synoptic
Indices of Relative Fish Abundance Used for Tuning,
e.g., trawl, acoustic, video
Assessment Methods and Modeling
Spatially-explicit models (e.g FISHMOD); Ecosystem-based models, include trophic interactions and environmental forcing (ECOPATH, ATLANTIS) .
Management
Commissions
Councils
• Review stock status and biological benchmarks from assessment and modeling.
• Consider socio-economic and ecological impacts
• set regulations
Courtesy of Behzad Mahmoudi

1689

North American Journal of Fisheries Management 29:1555–1566, 2009
American Fisheries Society 2009
DOI: 10.1577/M08-221.1

[Article]

Accounting Explicitly for Predation Mortality in Surplus Production Models: an Application to Longfin Inshore Squid

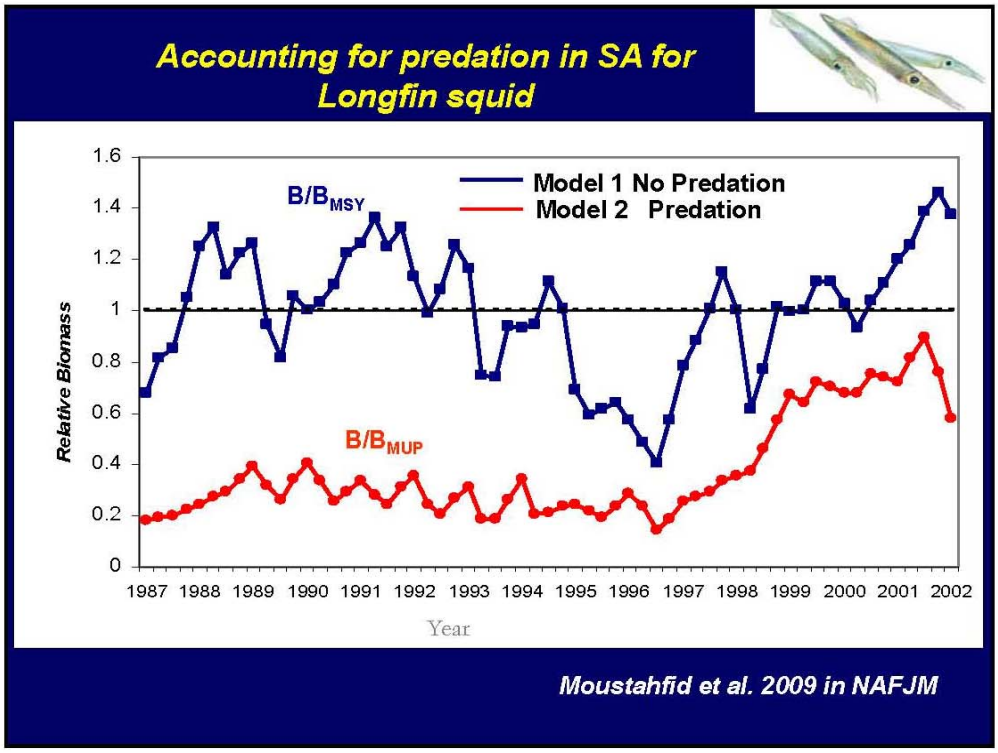
ICES Journal of Marine Science Advance Access published January 16, 2009

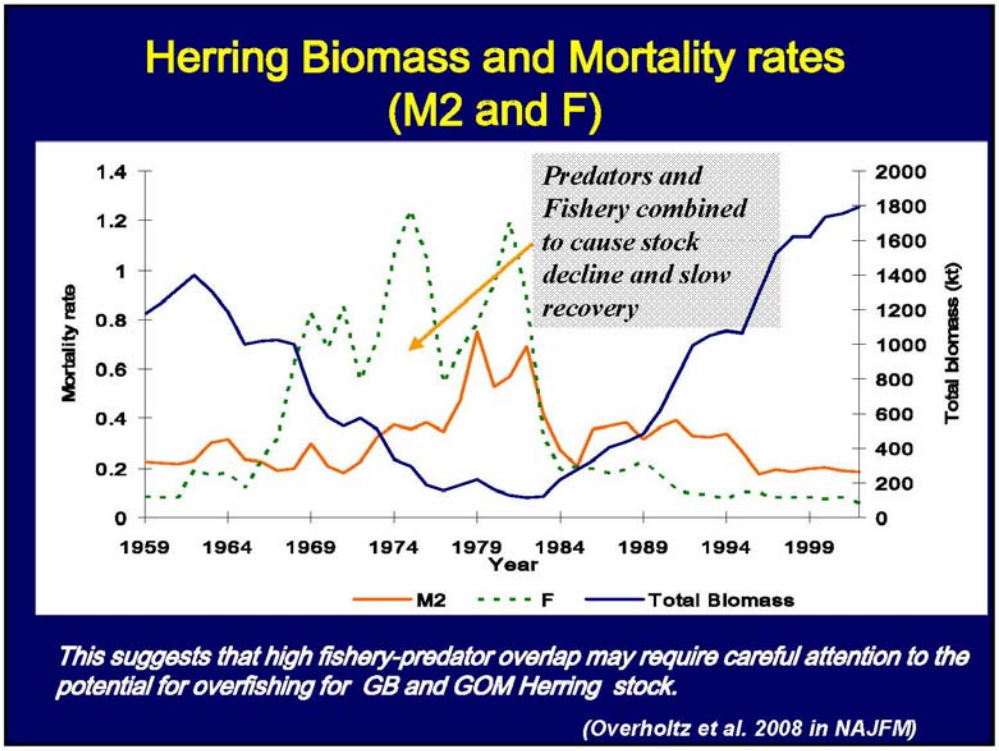
The advantage of explicitly incorporating predation mortality into age-structured stock assessment models: an application for Atlantic mackerel

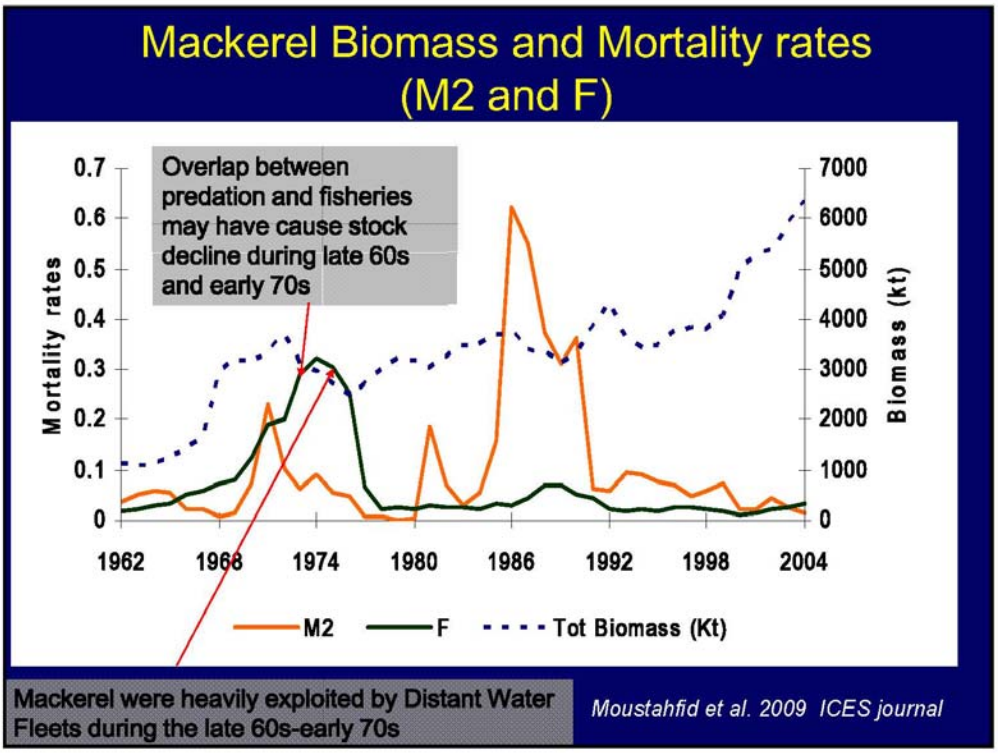
H. Moustahfid, J. S. Link, W. J. Overholtz, and M. C. Tyrrell

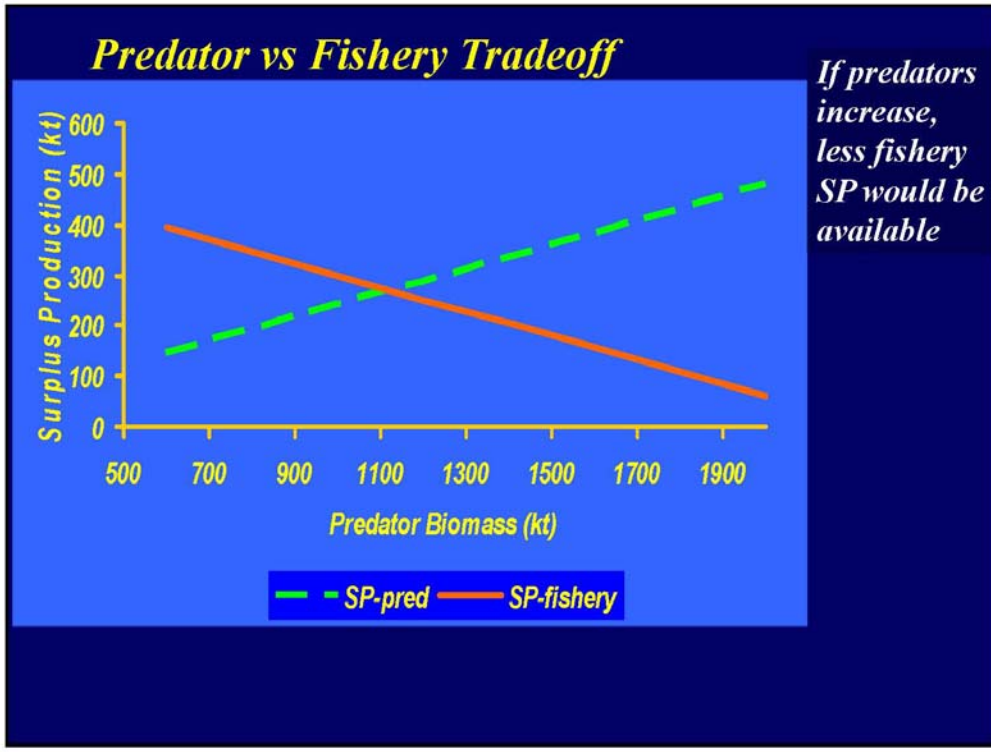
Moustahfid, H., Link, J. S., Overholtz, W. J., and Tyrrell, M. C. 2009. The advantage of explicitly incorporating predation mortality into age-structured stock assessment models: an application for Atlantic mackerel. – ICES Journal of Marine Science, 66: 000–000.

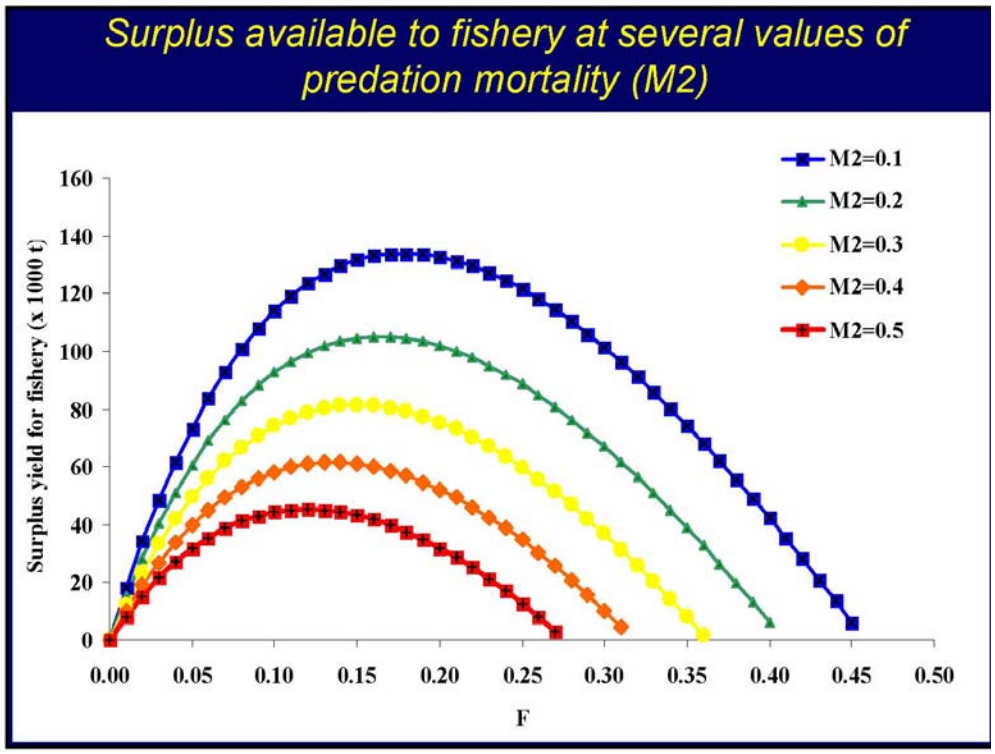
An age-structured assessment programme (ASAP) that explicitly incorporates predation mortality was applied to Atlantic mackerel (*Scomber scombrus*) in the Northwest Atlantic. Predatory removals were modelled in the same manner as fishing mortality, with a comparable set of time-series, to produce estimates of predation mortality at age and for each year. Results from the analysis showed that incorporating predation into a mackerel stock assessment model notably altered model outputs. When excluding explicitly modelled rates of predation, the model underestimated the magnitude and uncertainty in spawning-stock biomass (SSB) and recruitment. Further, the rates of predation mortality varied across time and were higher for younger fish. Predation mortality was higher than fishing mortality for fish aged 1 year, approximately equal for 2-year-olds, and lower for older fish (3 years and older). Biological reference points for Atlantic mackerel differed considerably when predation mortality was included. For example, SSB_{MSY} was more than twice as high in the model where predation was incorporated than in the fisheries-only model. Although there are several caveats to the predation model outputs, chief of which is that the estimates are conservative because some mackerel predators were excluded, the results demonstrate the feasibility of executing such an approach with an extant tool. The approach presented here ultimately has the advantage of detecting, and upon detection parsing out, the impact of predators relative to fisheries and has the potential to provide useful information to those interested in small pelagic fish and their associated fisheries.

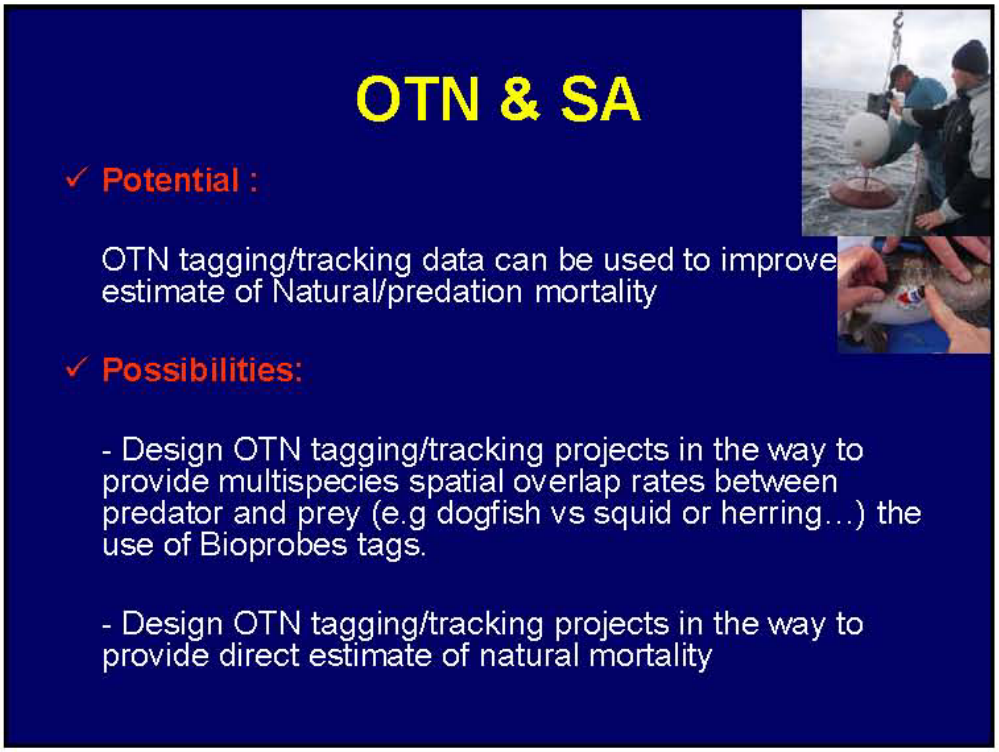


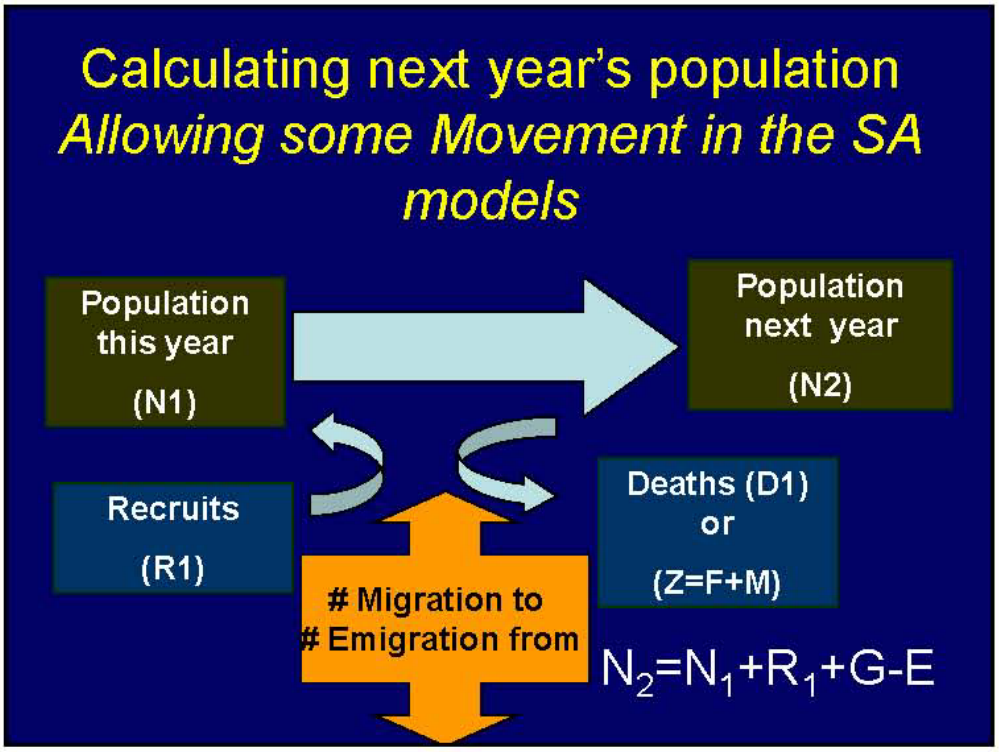

Herring Biomass and Mortality rates
(M2 and F)
Predators and Fishery combined to cause stock decline and slow recovery
Mortality rate
Total biomass (kt)
Year
M2
F
Total Biomass
This suggests that high fishery-predator overlap may require careful attention to the potential for overfishing for GB and GOM Herring stock.
(Overholtz et al. 2008 in NAJFM)

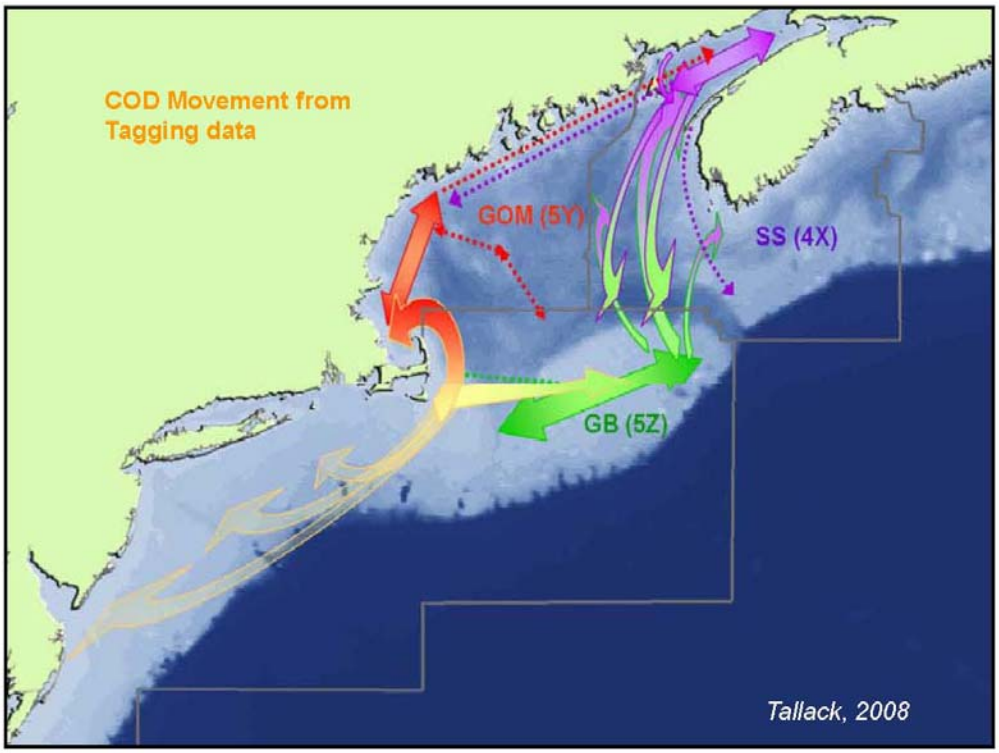

Mackerel Biomass and Mortality rates
(M2 and F)
Overlap between predation and fisheries may have cause stock decline during late 60s and early 70s
Mortality rates
Biomass (kt)
M2
F
Tot Biomass (Kt)
Mackerel were heavily exploited by Distant Water Fleets during the late 60s-early 70s
Moustahfid et al. 2009 ICES journal

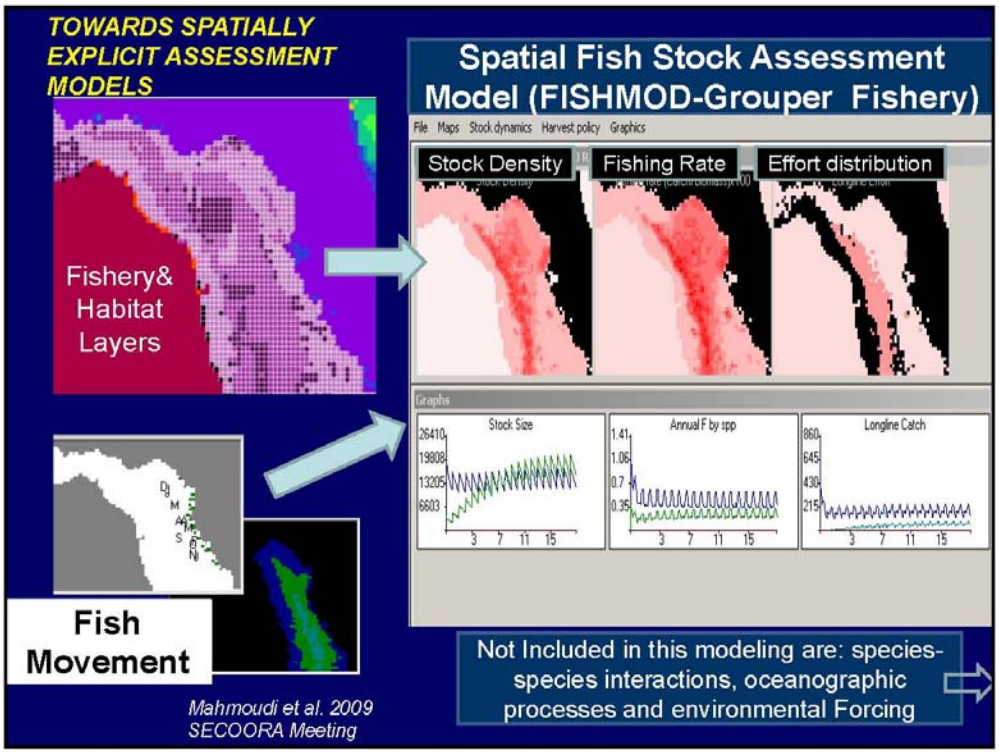

Predator vs Fishery Tradeoff
If predators increase, less fishery SP would be available
Surplus Production (kt)
600
500
400
300
200
100
0
500
700
900
1100
1300
1500
1700
1900
Predator Biomass (kt)
SP-pred
SP-fishery


Surplus available to fishery at several values of predation mortality (M2)
M2=0.1
M2=0.2
M2=0.3
M2=0.4
M2=0.5
Surplus yield for fishery (x 1000 t)
160
140
120
100
80
60
40
20
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
F


OTN & SA
✓ Potential :
OTN tagging/tracking data can be used to improve estimate of Natural/predation mortality
✓ Possibilities:
- Design OTN tagging/tracking projects in the way to provide multispecies spatial overlap rates between predator and prey (e.g dogfish vs squid or herring…) the use of Bioprobes tags.
- Design OTN tagging/tracking projects in the way to provide direct estimate of natural mortality


Calculating next year's population
Allowing some Movement in the SA models
Population this year (N1)
Population next year (N2)
Recruits (R1)
Migration to
Emigration from
Deaths (D1) or (Z=F+M)
$N_2=N_1+R_1+G-E$


COD Movement from
Tagging data
GOM (5Y)
SS (4X)
GB (5Z)
Tallack, 2008


TOWARDS SPATIALLY
EXPLICIT ASSESSMENT
MODELS
Spatial Fish Stock Assessment
Model (FISHMOD-Grouper Fishery)
File Maps Stock dynamics Harvest policy Graphics
Stock Density
Fishing Rate
Effort distribution
Fishery&
Habitat
Layers
Graphs
Stock Size
Annual F by spp
Longline Catch
Fish
Movement
Not Included in this modeling are: species-species interactions, oceanographic processes and environmental Forcing
Mahmoudi et al. 2009
SECOORA Meeting

OTN- SA

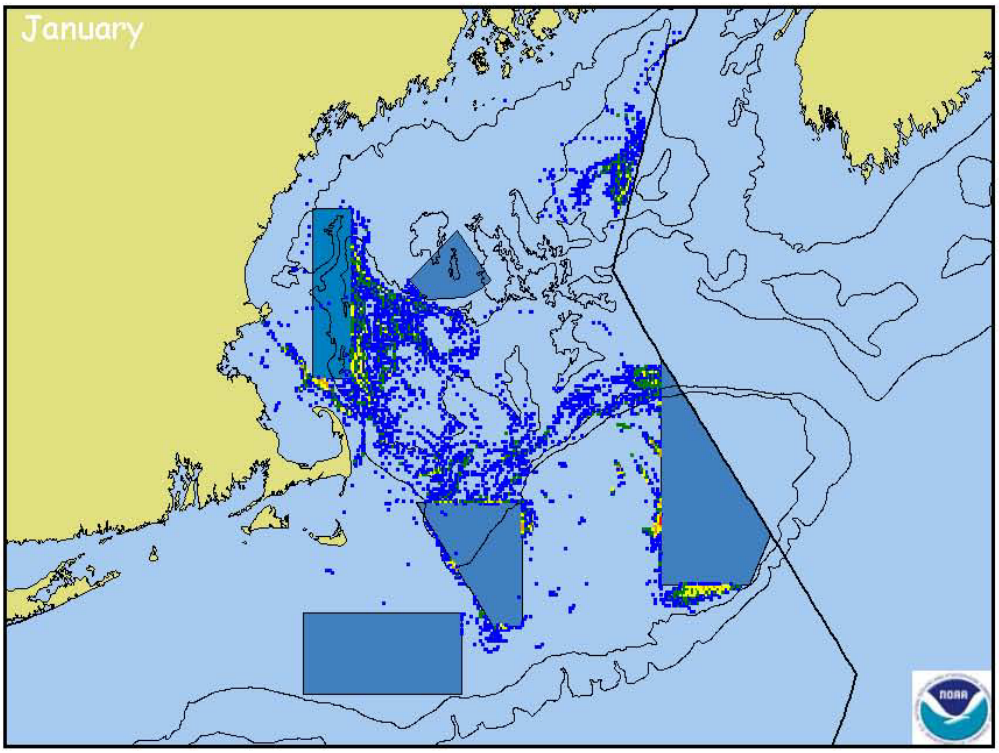
✓ **Potential :**

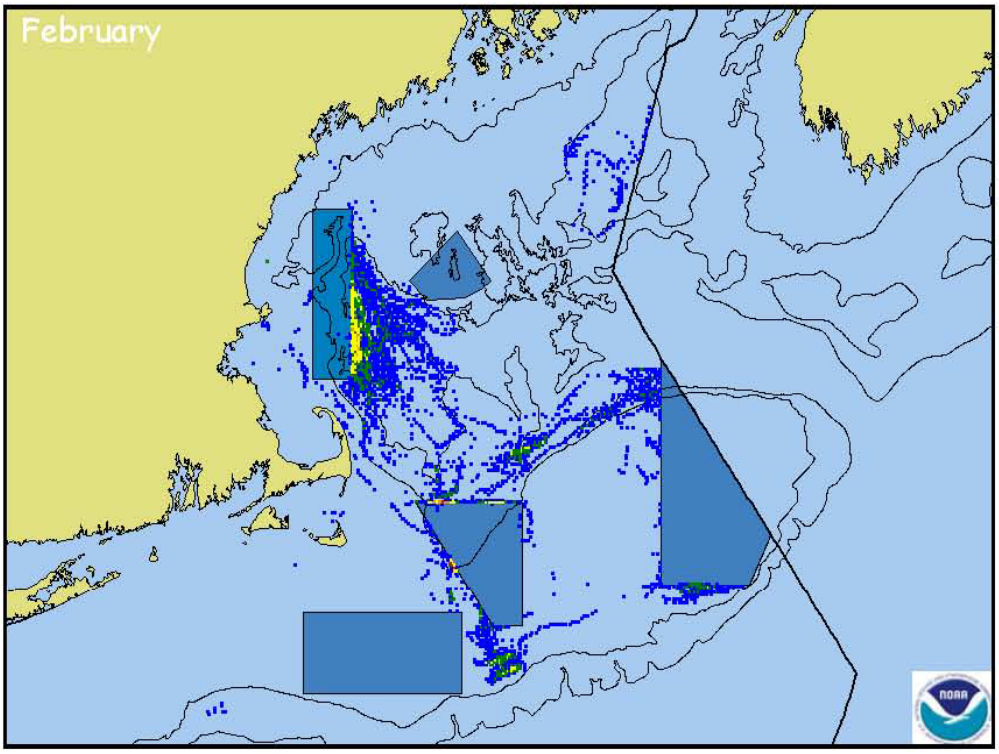
OTN tagging/tracking data can be used to estimate Movement patterns and Movement rates

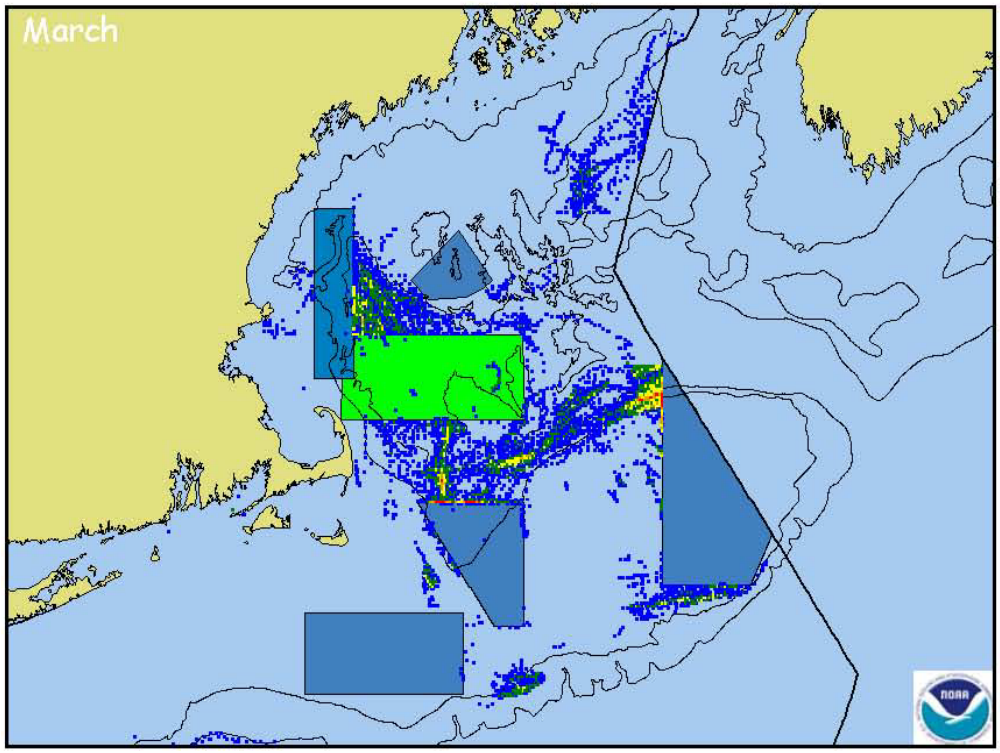
✓ **Action:**

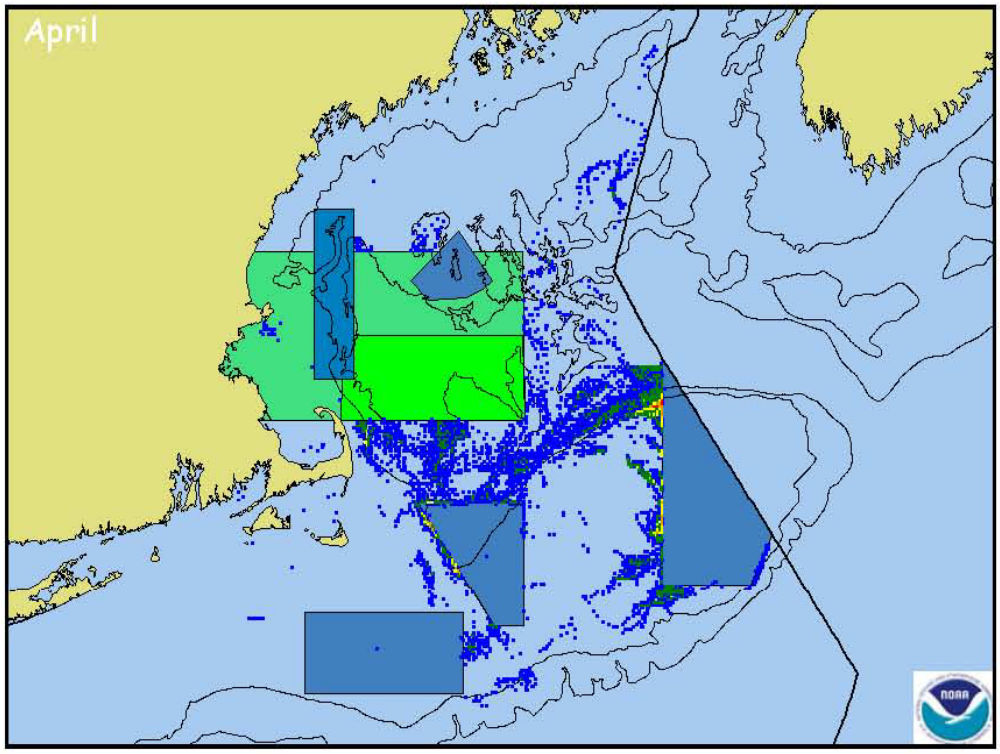
- Design OTN projects to focus on fish movement between stocks
- Expand coverage through regional coordination

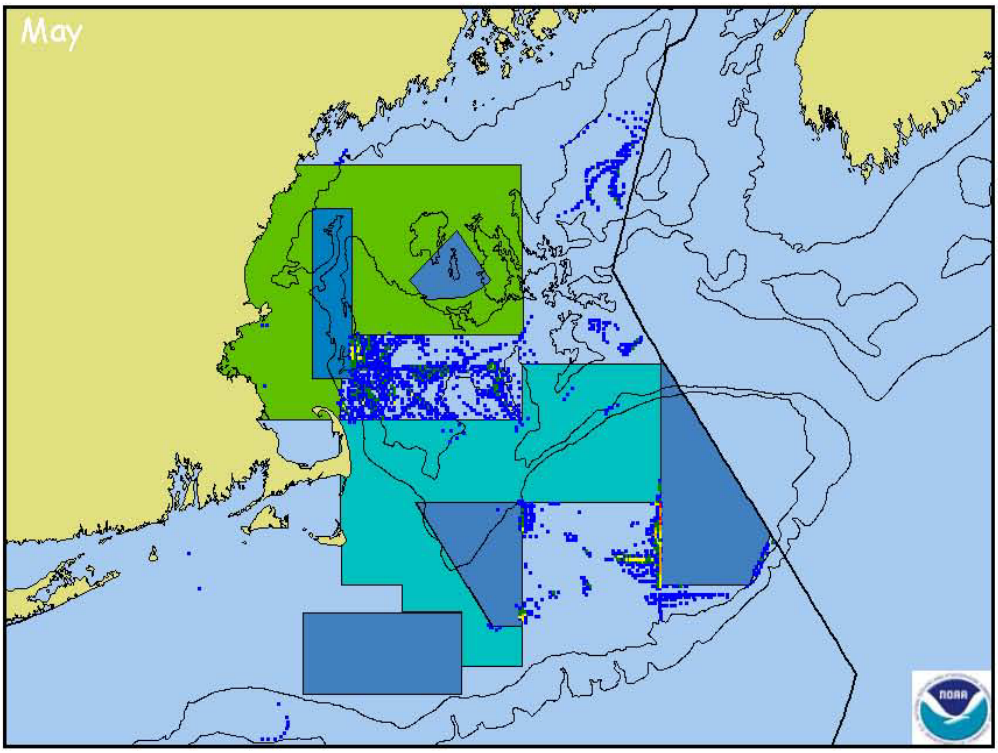
Management Decisions
Closed Areas(CA)/MA/MPA etc…
US northeast CA/MA

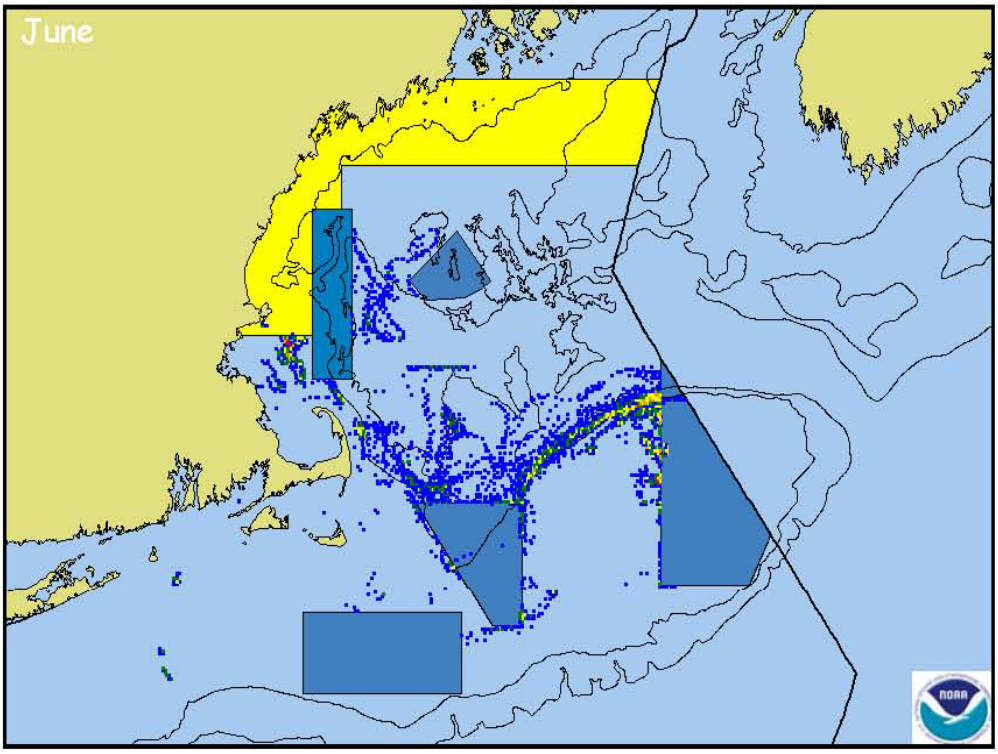

January

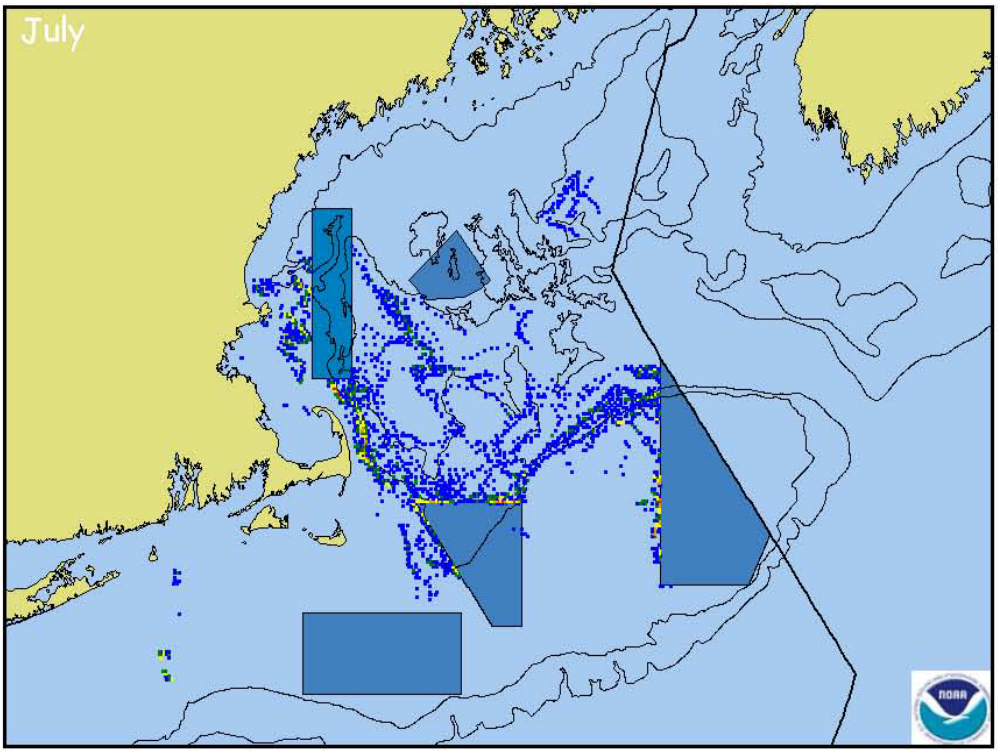

February

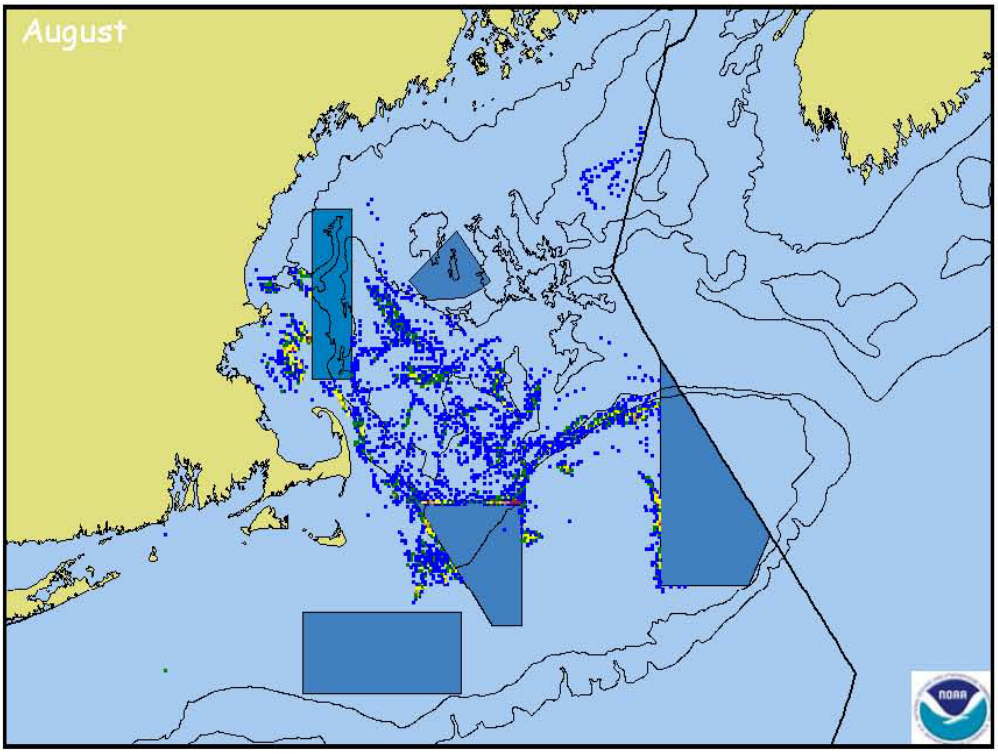

March

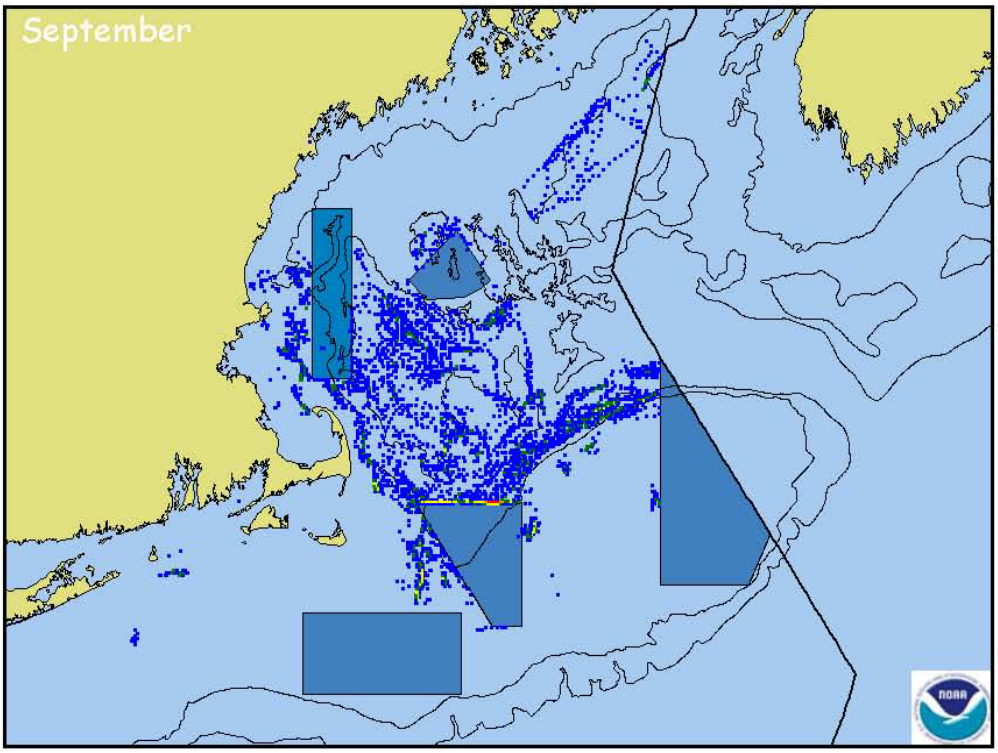

April

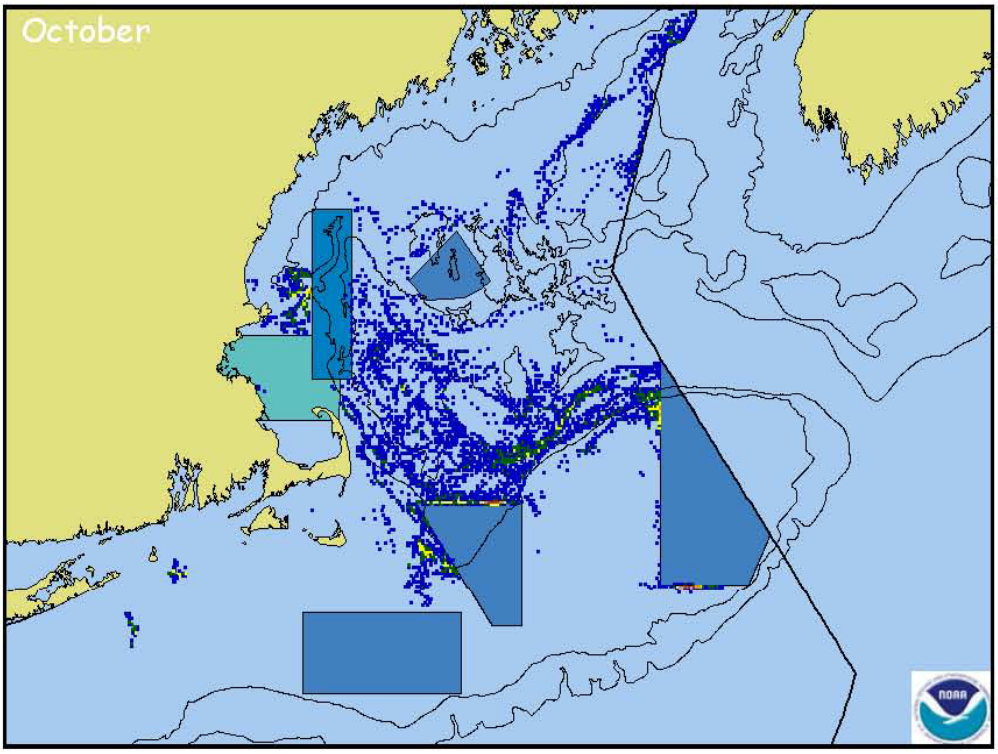

May

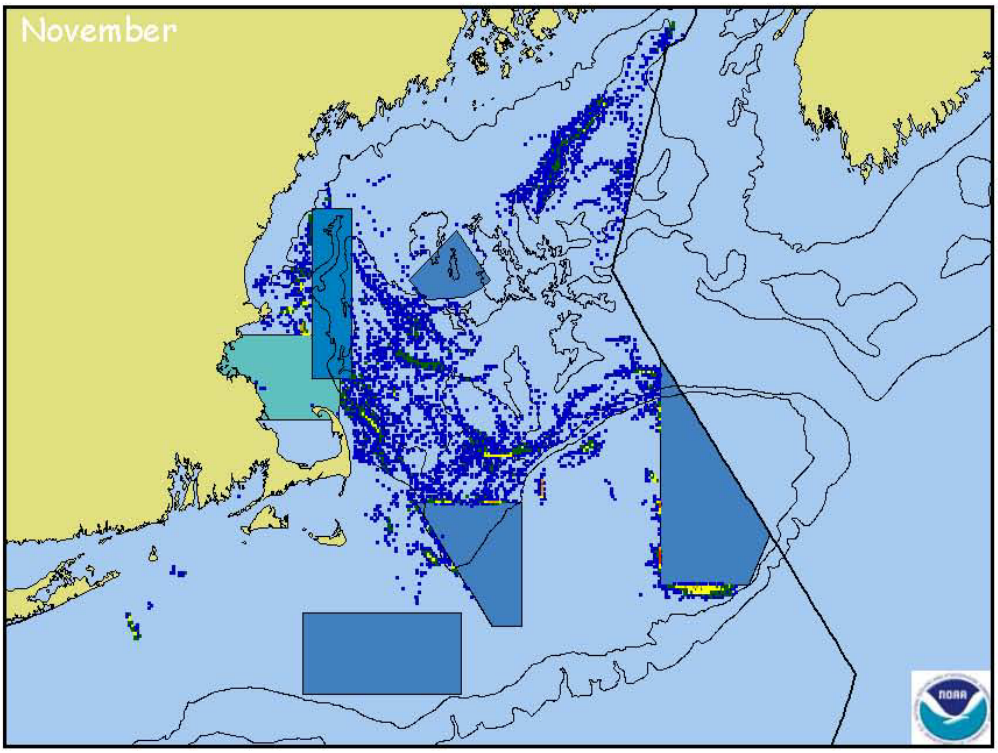

June

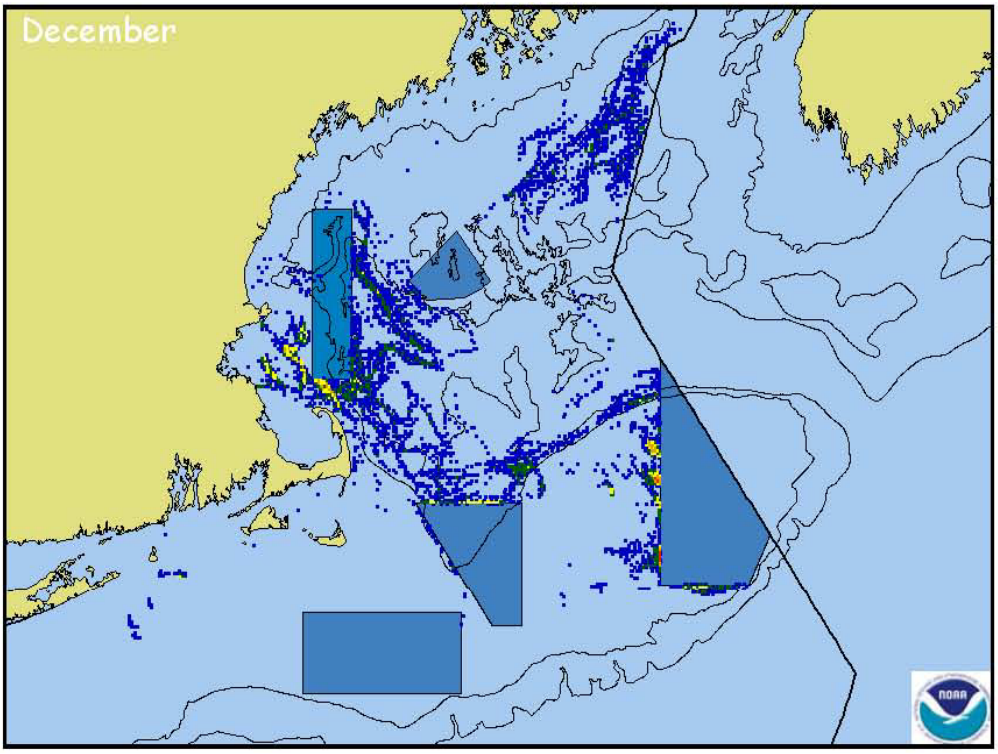

July


August


September

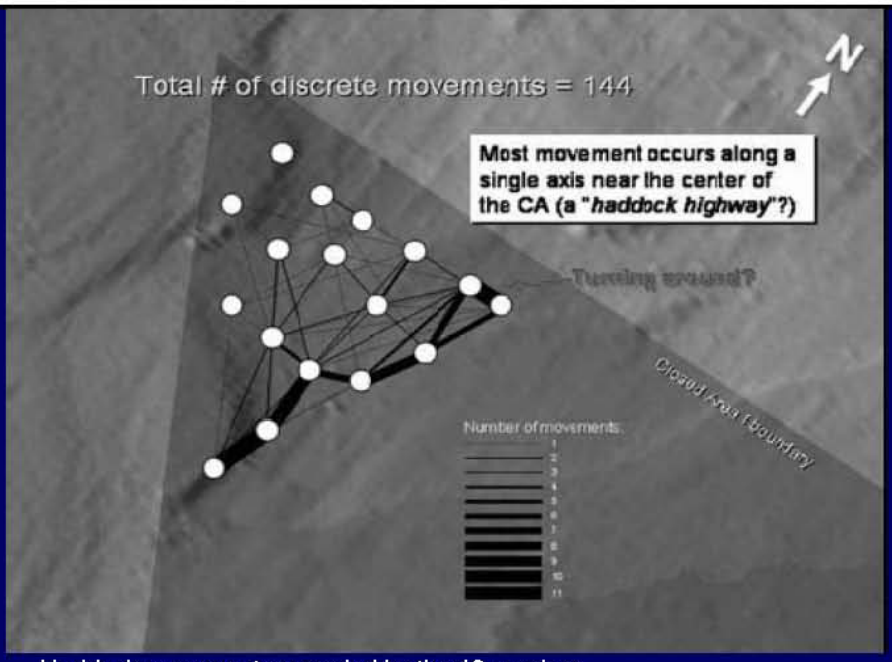

October


November


December

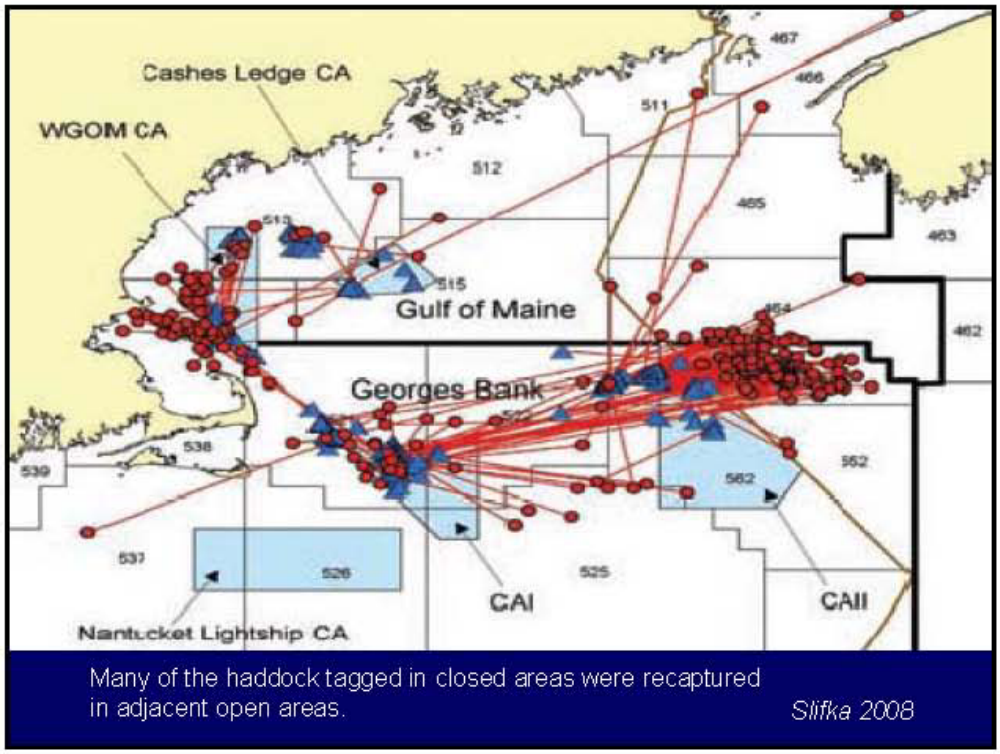
"Fish does not recognize boundaries"

"*The reality is that those fish don't necessarily follow our management calendar, and so here is the potential place for improvement*". Tom Nies New England Fishery Management Council

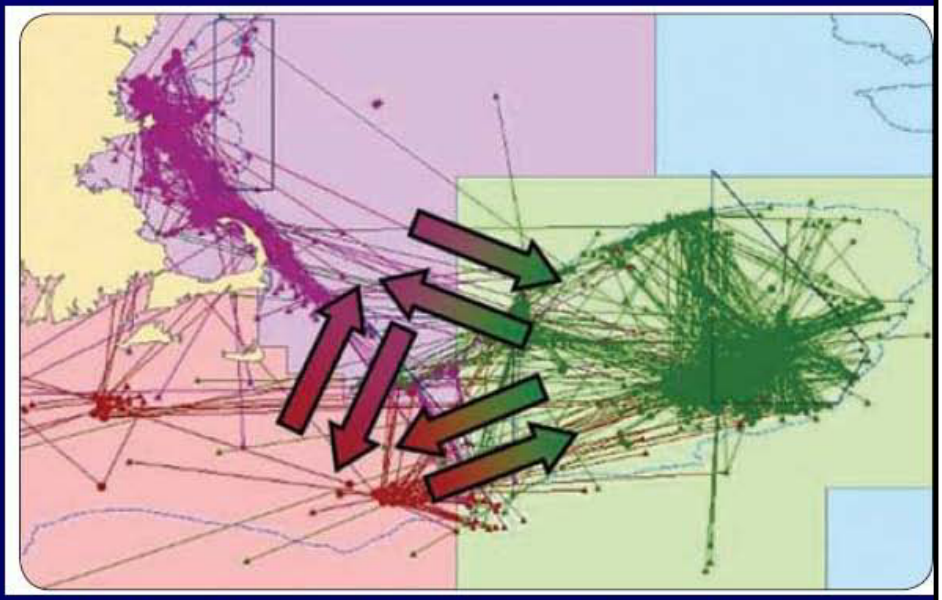


Haddock movements recorded by the 19-receiver array in CA I indicate a corridor of movement.

Sherwood 2008



Many of the haddock tagged in closed areas were recaptured in adjacent open areas. *Slifka 2008*



Yellowtail flounder movements within and across management boundaries. *Cardin et al. 2008*

OTN & MD

✓ **Potential :**

- OTN data can be used to evaluate pre-existing management decisions
- OTN data can be used to enable Marine Spatial Planning
- OTN data can become a tool for real-time decision (e.g. triggered closures)

✓ **OTN Action:**

- Develop case studies to evaluate and design Marine Protected Areas (MPAs) that works best for fish.

OTN – Fishermen

- Fishermen are highly knowledgeable about finding fish
- Fishermen are critical to the success of tagging projects
- Communication and dialogue between fishermen and scientists, managers and the public is essential

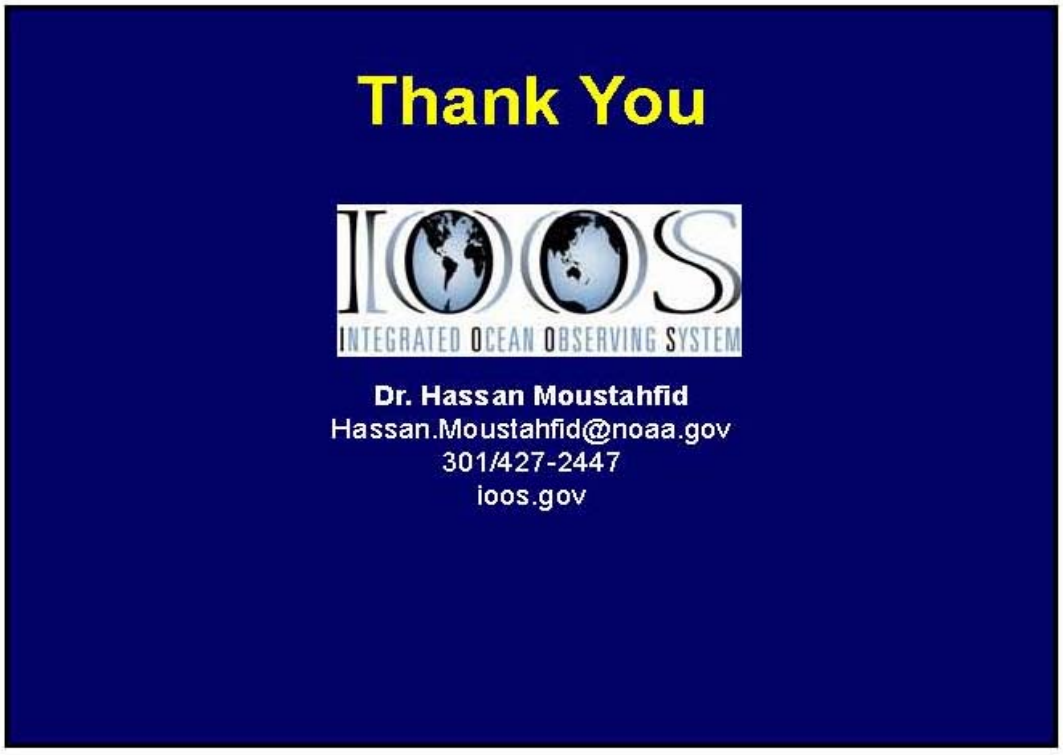
✓ OTN action- Facilitate collaboration between fishermen, scientists and managers through tagging/tracking projects

OTN Challenges to Improve SA & FM

- Integrated data from different tagging/tracking studies in the region =OTN regional data management Infrastructure. Will help avoid duplication
- Make newest acoustic tagging/tracking technology to be more cost-effective
- Facilitate collaboration between Fishermen and Scientists
- Develop Visualization tools for FM
- Develop tagging/tracking design not only to know broad Mvt patterns (mixing rates) but also knowing where fish are at certain times, so managers could make real-time decisions

WRAP UP

With Careful study design, OTN tagging/tracking data can indeed be used with other independent and dependent fisheries data to improve Stock Assessments and provide unique perspectives on challenging fishery issues.



2.7.2 Summary

Improved tagging and tracking methodologies has lead to the development of statistical models that incorporate this type of data into fishery stock assessments. Stock assessments and fisheries management are currently in a transition form and can be improved using Ocean Tracking Network (OTN) tagging and tracking information.

The transition involves moving from a single species view to a more ecosystem based holistic look at "all things" that incorporate space-time data and consider ecological interactions and environmental changes.

OTN information improves stock assessment by providing estimates of natural and predation mortality on fish species and estimating movement patterns and movement rates of these species. OTN uses data from multiple tagging projects to: 1) benefit fisheries management, 2) use the information to evaluate pre-existing management actions, and 3) allow for real-time decision making.

Closed and protected areas were given their status based on commercial catch information before there were any tagging studies conducted. These regions should be revisited and

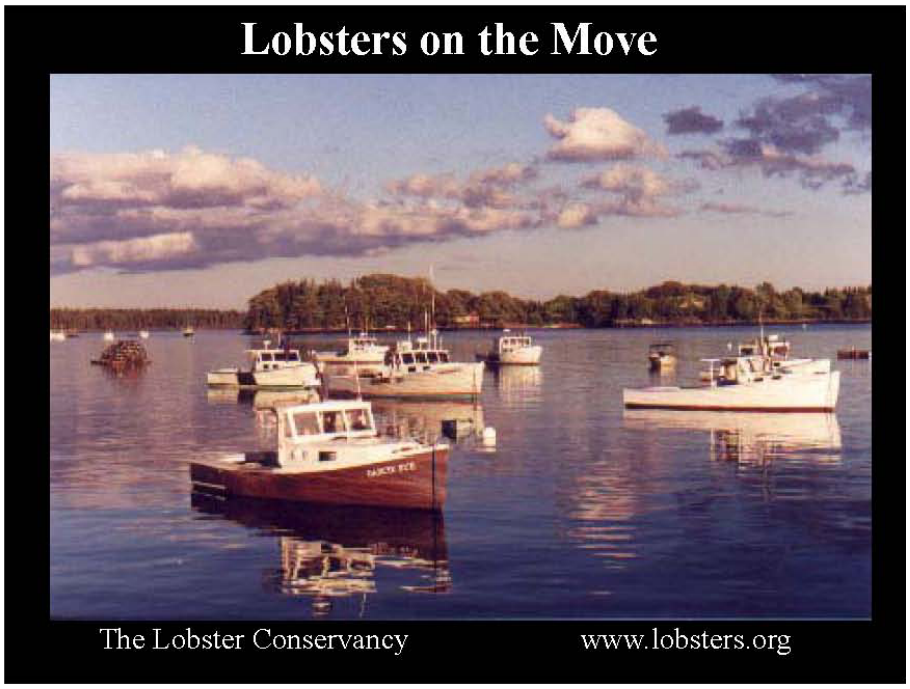
properly assessed with OTN technology to make sure they are serving their purpose and acting as a benefit to fish stocks. Multi-species and multi-stock interactions are necessary to better understand fish movements and behaviours and develop a better fisheries management plan.

Developing partnerships with fishermen is essential to better management of marine protected areas and tagging projects as a whole. They are highly knowledgeable about finding fish. Communication between fishermen, scientists, industry managers, and the public is necessary to ensure that tagging projects are successful and that the marine environment benefits from them. As we continue to advance towards employing spatial management, the tagging and tracking data is a valuable asset to improving stock assessments and fisheries management as a whole.

2.8 Lobsters on the Move

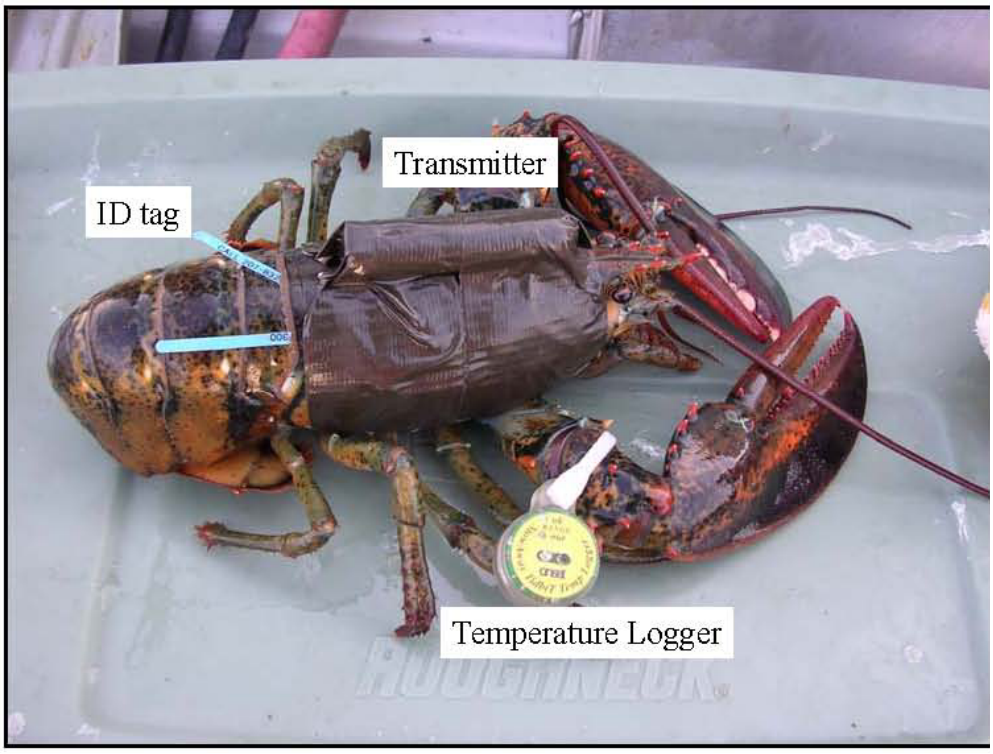
Diane Cowan, Executive Director, The Lobster Conservancy

2.8.1 Presentation

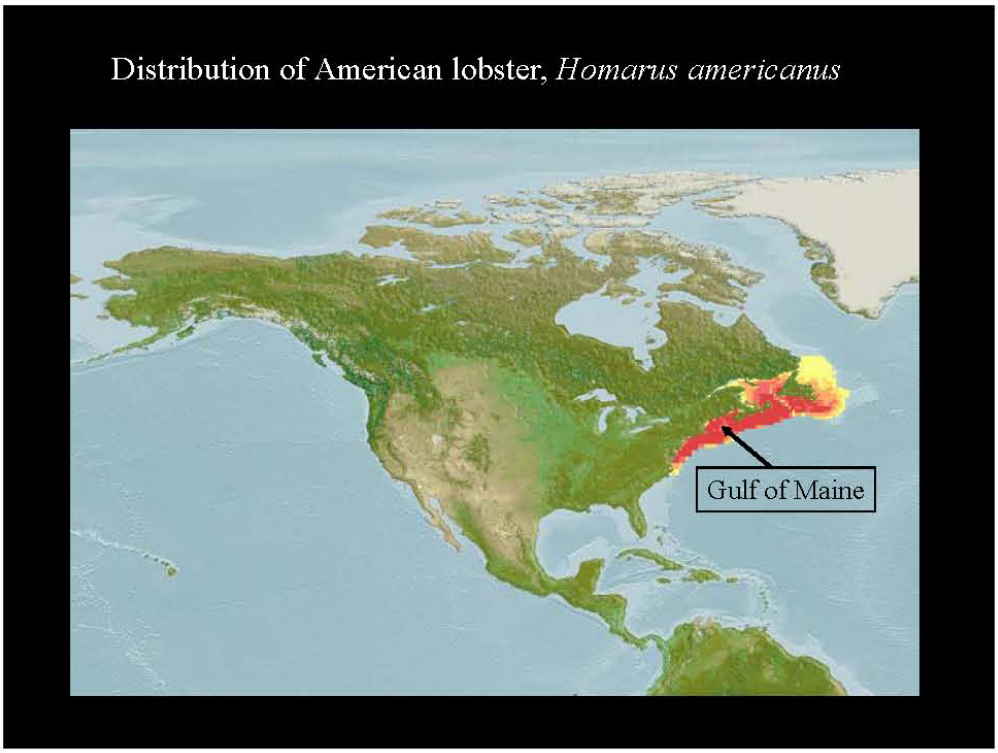


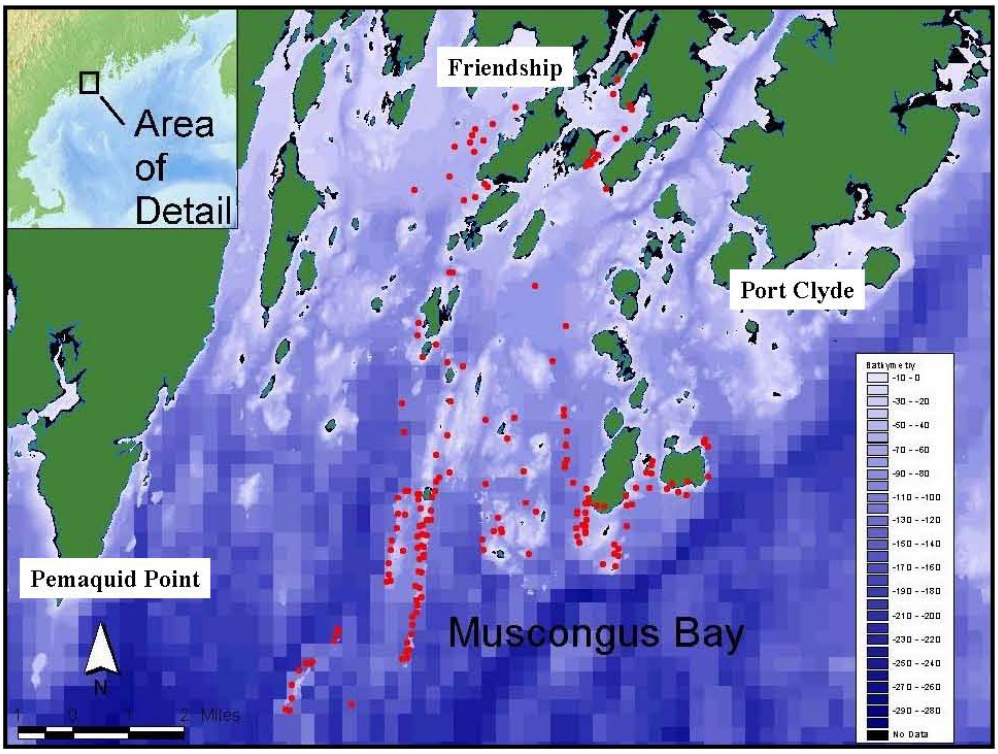
WHICH LOBSTERS DID WE TAG & WHY?

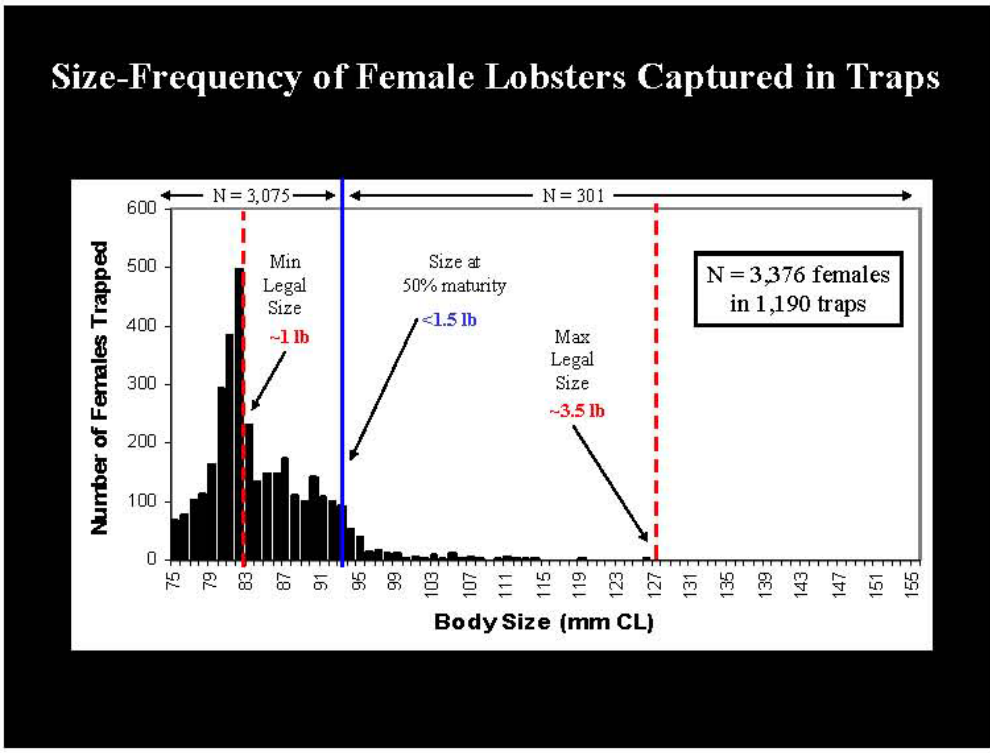
HOW DID WE TAG THE LOBSTERS?

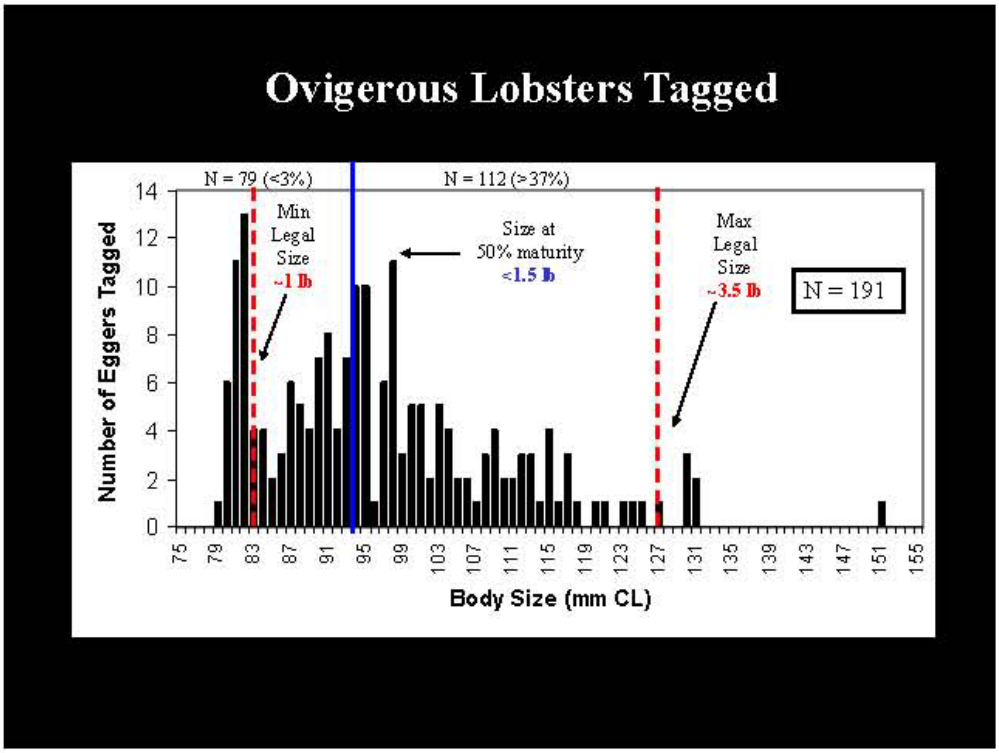


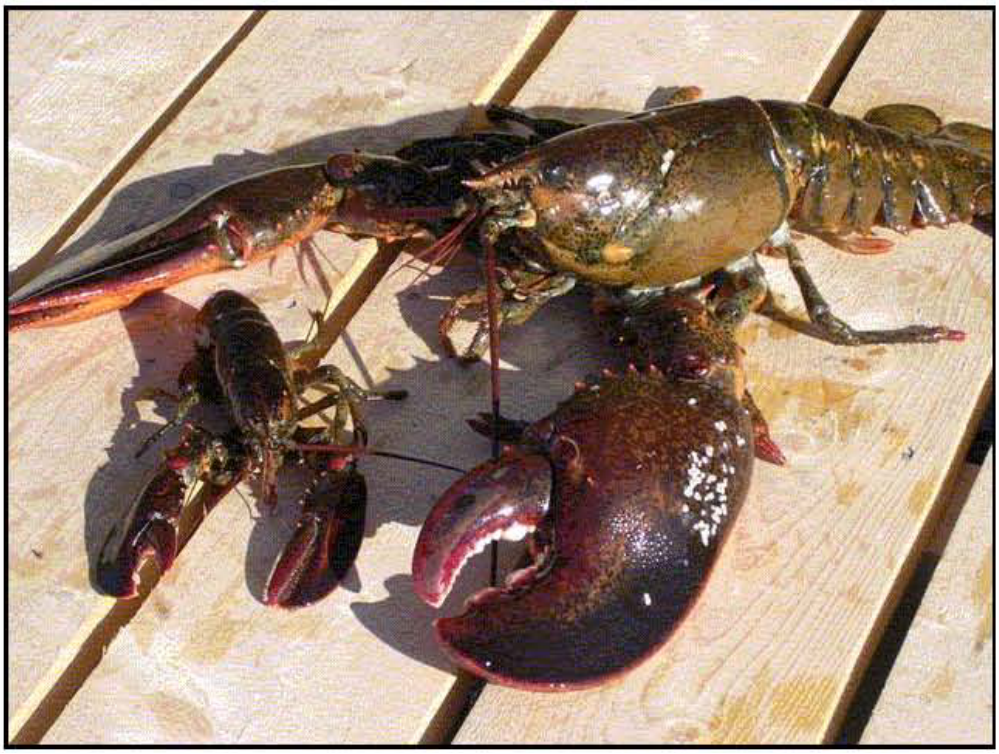
WHEN & WHERE DID WE CAPTURE THE TAGGED LOBSTERS?


Distribution of American lobster, *Homarus americanus*
Gulf of Maine


Area of Detail
Friendship
Port Clyde
Pemaquid Point
Muscongus Bay
N
Miles


Size-Frequency of Female Lobsters Captured in Traps
N = 3,075
N = 301
Number of Females Trapped
600
500
400
300
200
100
0
Min Legal Size ~1 lb
Size at 50% maturity <1.5 lb
Max Legal Size ~3.5 lb
N = 3,376 females in 1,190 traps
75 79 83 87 91 95 99 103 107 111 115 119 123 127 131 135 139 143 147 151 155
Body Size (mm CL)


Ovigerous Lobsters Tagged
N = 79 (<3%)
N = 112 (>37%)
Min Legal Size ~1 lb
Size at 50% maturity <1.5 lb
Max Legal Size ~3.5 lb
N = 191
Number of Eggers Tagged
Body Size (mm CL)



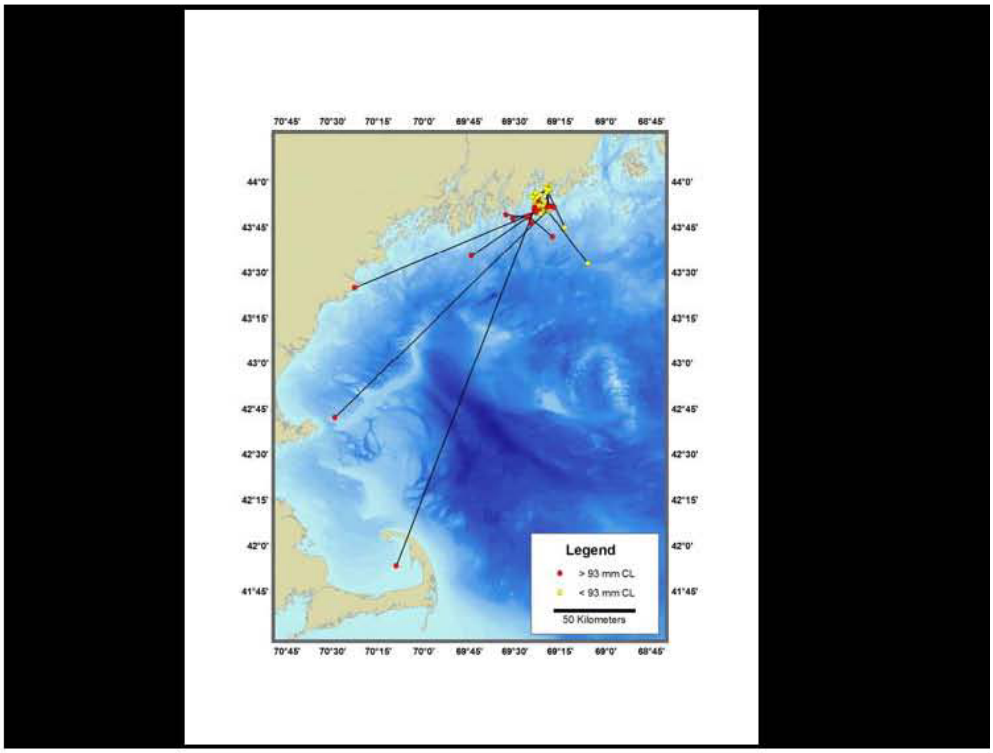
HOW DID WE KEEP TRACK OF THE LOBSTERS?

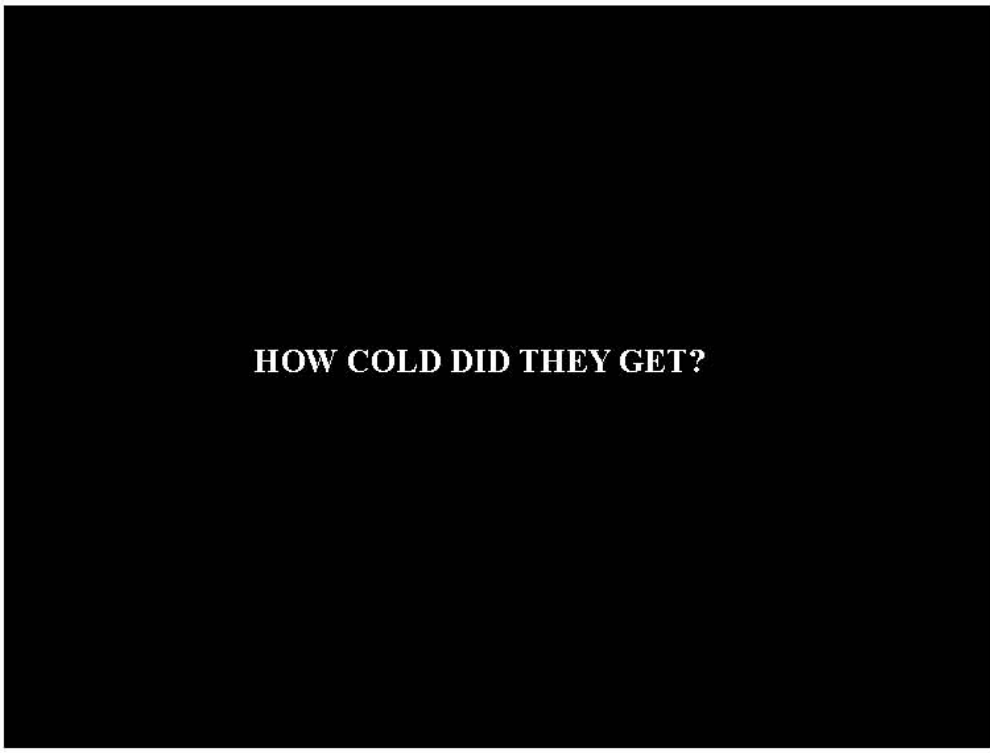
Relocating Tagged Lobsters

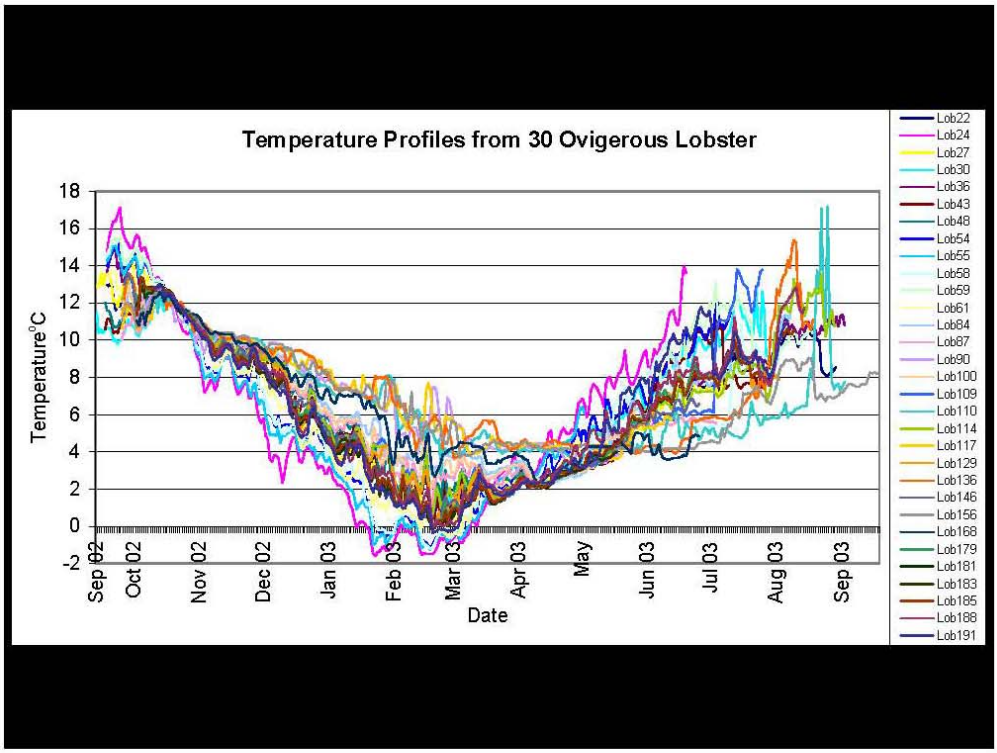
Hydrophone, Receiver and Headphones

Traditional Recaptures

Dive Recaptures


70°45'
70°30'
70°15'
70°0'
69°45'
69°30'
69°15'
69°0'
68°45'
44°0'
43°45'
43°30'
43°15'
43°0'
42°45'
42°30'
42°15'
42°0'
41°45'
Legend
> 93 mm CL
< 93 mm CL
50 Kilometers


HOW COLD DID THEY GET?


Temperature Profiles from 30 Ovigerous Lobster
Temperature°C
18
16
14
12
10
8
6
4
2
0
-2
Sep 02
Oct 02
Nov 02
Dec 02
Jan 03
Feb 03
Mar 03
Apr 03
May
Jun 03
Jul 03
Aug 03
Sep 03
Date
Lob22
Lob24
Lob27
Lob30
Lob36
Lob43
Lob48
Lob54
Lob55
Lob58
Lob59
Lob61
Lob84
Lob87
Lob90
Lob100
Lob109
Lob110
Lob114
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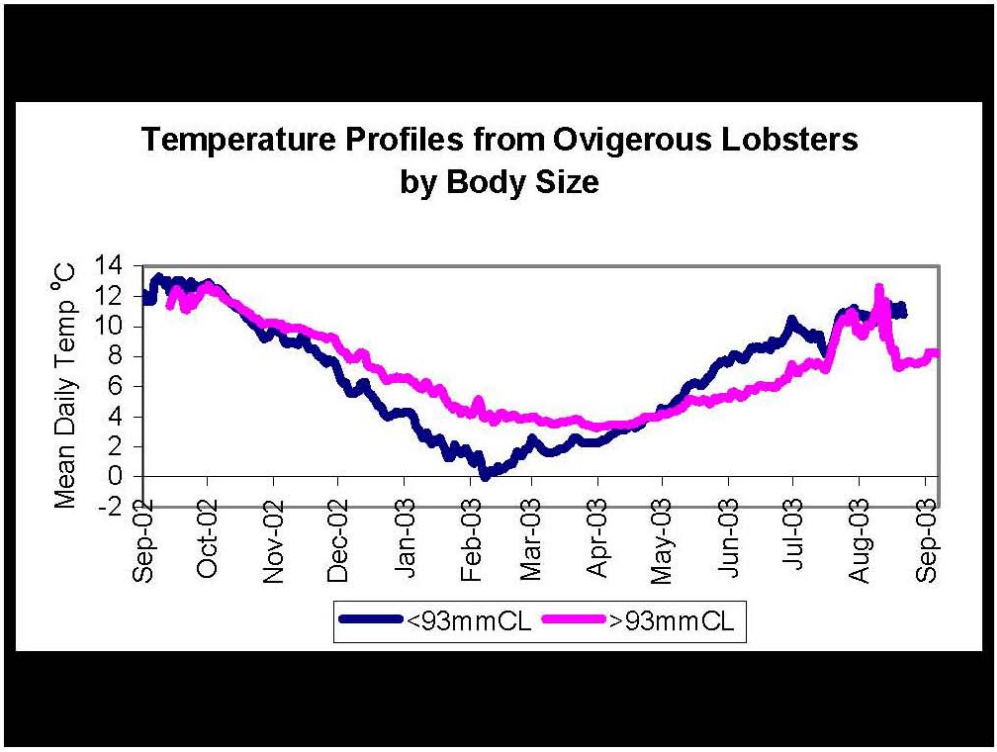
Lob156
Lob168
Lob179
Lob181
Lob183
Lob185
Lob188
Lob191


Temperature Profiles from Ovigerous Lobsters by Body Size
Mean Daily Temp °C
14
12
10
8
6
4
2
0
-2
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
<93mmCL
>93mmCL

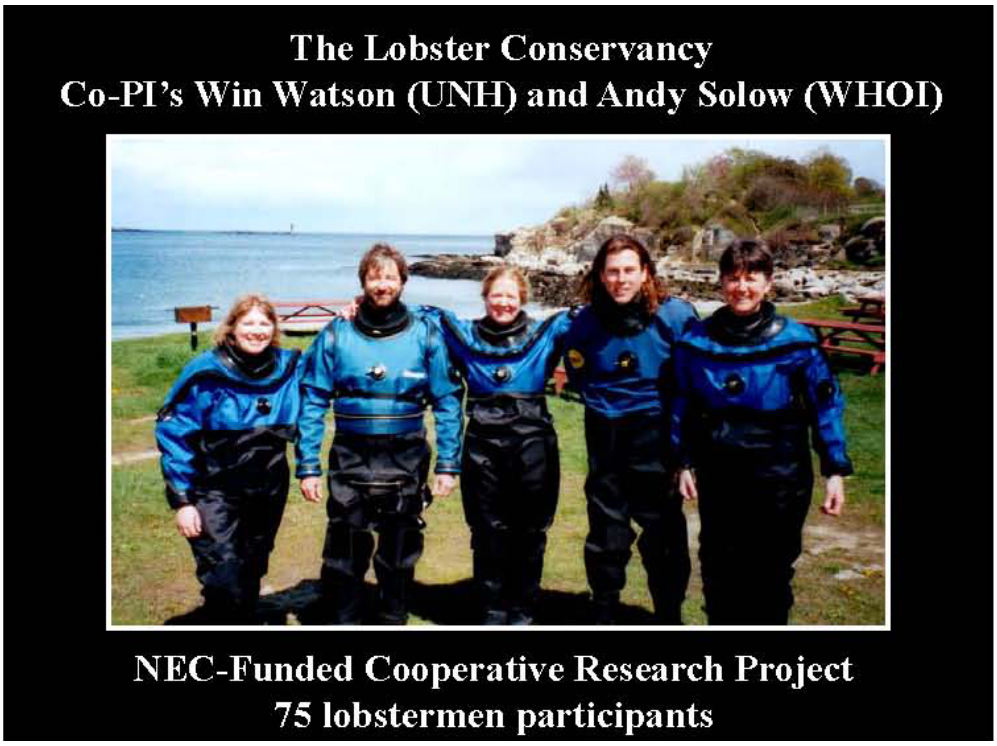
So what?

–TEMPERATURE

- degree-days for embryonic development
- cold temperatures for ovarian maturation

–MOVEMENTS

- hatching and larval dispersal
- gene flow



2.8.2 Summary

For more than a century, fishermen and scientists have been devising clever ways to follow lobster movements. Data from previous tagging studies showed that eggers generally migrate to deeper, warmer waters in winter to maintain temperatures suitable for brooding eggs. Several years ago, Diane realized acoustic tags could be used to investigate whether lobsters stayed in one place. While mark/recapture studies that depend on lobster traps to capture lobsters require that lobsters be motivated to crawl into traps, acoustic telemetry works even if lobsters don't move. Together, The Lobster Conservancy and local lobster fishermen from Friendship, Maine created the Lobster Sonar Tracking Project to investigate the relationships between temperature, movements and body size of eggers.

Trying to study long-term movements by attaching external tags to lobsters poses a problem because external tags are lost when lobsters shed. Another problem with trying to study lobster movements is removal by harvest. We maximized our tracking time to the 12-month life of the pingers (acoustic tags) by taking advantage of the 9-13 month brooding period during which lobsters generally do not molt and are protected from harvest.

A total of 191 freshly extruded berried females were tagged with a pinger, ID tag and temperature logger. Of the 191 lobster, 79 were small, weighing less than 1.5 lbs and the other 112 were considered large (>1.5 lbs). Additional smaller females would have been tagged however of more than 3,000 small females captured only 79 were eggers. They used three

methods for retrieving data: (1) detection of transmitters using handheld hydrophone deployed from lobster boats, (2) traditional recaptures in lobster traps, and (3) diver recaptures. Of the 191 tagged lobster 156 (82%) were detected at least once after release and nearly half were recaptured (at least once) and had their temperature data downloaded. Only 35 individuals (5 small and 30 large) were never heard from again.

The results showed that the known deep water migrations were only a small part of the story. About one third of the lobster remained in a 2 km radius of where there were originally caught and tagged and thus experience the coldest of the temperatures recorded. Another third remained in a 30 km radius and experienced the warmest temperatures while the remainder travelled even greater distances (as much as 240 km to Cape Cod, Massachusetts) and experienced intermediate temperatures.

Based on the data collected they then grouped the lobsters into three categories; movers, return trips, and non-movers. Non-movers move less than 10 km, return trip makers moved generally short distances and then returned to the capture site, while movers travelled further than this and did not return. The data showed that larger lobsters were usually 'movers' and travelled to warmer waters while the smaller females tended to stay in the same area and experienced colder temperatures. The two most important things to come from The Lobster Conservancy's Lobster Sonar Tracking Project were the temperature results and evidence that many eggers hardly move at all. In light of these results, it seems the larger "long-distance" travelers are more likely to seed distant locations while both larger and smaller "non-movers" reseed local areas. This is just one more of the many ways in which larger eggers contribute to the future generations of lobsters in a superior way. The more we can learn about the movement of lobsters the more we can help keep their populations sustainable by using hard data.

2.8.3 Discussion

Q: What are your suspicions about the lost ones?
A: They are out there somewhere. Not entirely sure but it is unlikely that they have been eaten.

3.0 Breakout Groups

Participants were divided into three breakout groups, with each group starting their discussion on a different theme: Group 1 - conservation, Group 2 - fisheries research and Group 3 - economic sustainability. Each group were required to:

a. discuss expected benefits of ocean tracking technology to the fishing industry,
b. comment on the current projects with regards to those benefits, and
c. propose new research themes or projects.

The groups were also asked to identify perceived gaps in relation to expected benefits and to make suggestions where ocean tracking in general might be strengthened. The results of the group discussions are highlighted in this section and a copy of each group's completed tables can be found in Appendix III. Each group presented the results of their group's discussions in a plenary session; a summary of the main points from these presentations and the conclusions are included in the next section.

3.1 Summaries

3.1.1 Group 1: Conservation

Co-leads: Paul Macnab and Randy Boutilier

The group expressed a broad agreement on the "conservation" definition offered and related OTN potential/benefits. Initial discussions revealed considerable misunderstanding about the role and scope of OTN. Future presentations to industries should make it clear that the first phase of infrastructure (i.e., Halifax and Cabot lines) is largely settled and that initial tagging projects are already established. It is also important to clarify the importance of getting more animals and a greater variety of species tagged with transmitters. While it's fine to suggest future receiver lines and research questions, participants will need to find scientific collaborators and funding sources.

Many gaps in the Sable Island seal project were pointed out and suggestions offered. One suggestion was to try tagging different species and apply tags in other locations (e.g., islands off Cape Breton). Be especially careful when drawing conclusions about diet, particularly when seals are studied on Sable. Fishers are most interested in foraging preferences when seals are feeding some months earlier in coastal Cape Breton waters. A point was made to have the lessons and learning from the Sable Island seals be used as a demonstration project, one that could be replicated elsewhere.

Closed areas monitoring was discussed with reference to tracking studies underway in New England closures. Participants acknowledged the potential for similar studies in the Haddock Box, Browns Bank lobster closure and nursery areas, but the interest was somewhat limited. By comparison, there was very strong interest in questions surrounding Gulf of Saint Lawrence to Sydney Bight migrations of cod and cross Laurentian Channel movements and mixing of halibut and mackerel.

Communication with industry and opportunities for future cooperation were major topics of discussion. Practical suggestions were offered for seabed mooring conflict avoidance and tag return. Participants stressed the importance of having industries better understand the OTN so that it could become more fully involved in field components (e.g., tagging support) as well as hypothesis formulation and research design in collaboration with researchers and the OTN. All of these topics were underscored by the information shared at this workshop and the key facilitation role played today and into the future by the FSRS.

3.1.2 Group 2: Fisheries Research

Co-leads: Josh Fricker and Bruce Hatcher

This group started off by briefly discussing the different presentations of the morning. In terms of OTN global some worried about the effect that it might have on the ability of other nations to target certain species in times when they shouldn't be fishing them (such as during times of breeding). They talked about potentially changing the direction of the Halifax line and wondered what the benefits of this might be. The group felt that the use of OTN on stock assessment and fishery management was a good idea and that the more advanced the technology becomes the better it will be at helping make management decisions. A couple of benefits regarding the use of seals as biological and oceanographic samplers were discussed. First of all they agreed that knowing where seals go to feed will help fishermen be more sustainable in their time and effort, but also the information would be useful if the need to control seal populations arises. The more localized usage of OTN, as in the case of cod off of Eastern Newfoundland, was acknowledged by the group who were impressed by the quality of data the project produced. In the end, the group stated that fishermen and scientists are interested in knowing where the lobsters will crawl to and when they will make these journeys.

The group then moved on to discussing some of the expected benefits of using OTN technology. In regards to using a vessel tracking service (VTS) to track fishing vessels and stock, they worried that it could ultimately lead to over-fishing. They also talked about how OTN is currently being lead by professors and universities for academic purposes and not DFO management. Thus, they suggested that OTN may have positive goals to benefit fisheries and science and help DFO management make their decisions. They felt that the technology would bring better knowledge of connections and mixing of stocks along the shelf. However, there is still the issue regarding the ability to resolve cross-shelf connectivity so they suggested oblique lines across the shelf and others along the shelf to be incorporated. OTN will provide critical information about commercially important species, however there is the issue of delineation of lobster and snow crab inshore and offshore stocks. A solution would be to engage fishermen to tag these species and have receiver lines placed further out.

Some other questions they brought to the table included the level of privacy of information if DFO begins to work with OTN. Should OTN adopt similar privacy rules such as the FSRS uses for data? Will fishing information have a more negative impact?

3.1.3 Group 3: Economic Sustainability

Co-leads: Eugene O'Leary and Sara Ellis

Several fishermen started off the discussion by voicing their primary concerns regarding OTN. First and foremost, they feared that too much information about the exact locations of large aggregations of fish may lead to over-fishing by some. They also feared that the information would be counterproductive towards smaller boat fisheries if larger corporations began taking advantage of the technology. There was also a bit of concern as to what would happen when the individuals who received the information first had a better opportunity to fish more efficiently on their end and contribute to over-fishing of the stock. The responses to these concerns were centered on the effectiveness of OTN for the fishing industry. The receivers are effective at telling you when a fish crosses a certain line, however, it is not set up to tell you everywhere that a fish travels in real time. There is also currently an approximate one or more year delay in the collection of data and there will likely always be a delay in the release of data. Some fishermen suggested that the information be released annually or at specific intervals so that a general idea of recent fish behaviour and location can be noted without giving away exact locations.

The fishermen noted that many of the presentations suggested the use of OTN to gather information on trans-boundary fisheries. They worried that this could lead to international regulations that would reduce or close their fisheries.

Overall they were generally supportive of the concept and believed the technology could be used to collect necessary data to help improve fisheries science and address issues of concern to fishermen. A number of benefits and gaps were noted;

Benefits

- OTN will allow for better estimates of natural mortality which would make stock assessments much more accurate. This would also aid fisheries in seeking Marine Stewardship Council certification.
- Newer data could be used to alter regulations that some feel are misinformed. An example of such an issue is that of the "Haddock Box" and many feel that it has been placed in the wrong location. Newer, more concrete data on haddock movements could help test this theory. Also, if receivers were placed in a Marine Protected Area (MPA) that data could illustrate whether or not the area is serving its purpose.
- It could also be useful to increase our understanding of predatory-prey interactions as was demonstrated by Don Bowen with Grey seals and cod.

Gaps

- The Halifax line may prove ineffective to capture inshore/offshore movements of lobsters since they may move parallel to the line and may rarely come into close enough contact.
    - Suggestion: Localized studies using short listening lines could be place across the mouth of a bay or similar area.

- So far there do not appear to be enough lines in the planning process to cover the region. It might prove to be beneficial to get input from stakeholders.
    - Suggestions for line locations:
        - Eastern coast of Newfoundland
        - Off of Canso
        - Within one of the proposed MPA's of Nova Scotia

4.0 Plenary

4.1 Summaries

4.1.1 Group 1: Conservation

- Focused most of their discussion on the need for more lines and more tagged species for OTN to reach its full potential and have a greater contribution to the conservation of marine species.
- They commented on the use of OTN to monitor small and large scale migration patterns of pelagics such as bluefin tuna and salmon.
- The group was adamant regarding the use of fishermen to tag species and operate the necessary technology as the best method of getting many different species tagged and in larger quantities (up until a determined maximum limit). They mentioned that the FSRS could be used as a training resource for fishermen interested in doing so.
- They found that the idea of sending out a notice to mariners regarding the OTN infrastructure was a good idea but that it should also contain information about the project itself to help raise awareness and potentially get others involved in the effort.
- The group raised a question regarding tagging different schools of fish. They wondered if it was best to tag many individuals from one school or to tag a few from a number of different locations to look for common trends in behaviour.
- They also stressed that more research questions need to be posed and fishermen should be involved in project proposals to ensure that finances are available to have more species being monitored.

4.1.2 Group 2: Fisheries Research

- The overall concept of OTN was well received by the group. They felt that fishermen need to be engaged and become a valuable partner by being spoken to early on and spoken to often.
- They did not feel that the FSRS should be the only liaison between OTN and the fishermen, and that more direct lines of communication need to be established.
- A contribution to stock assessment was seen as the core value of OTN.
- They noted that the largest problem facing the commercial fishery at this time was the grey seal population.
- Try to eliminate putting lines in that will intersect with high traffic fishing areas and attempt to let as many people as possible know where hydrophones are located.

- The Halifax line is an okay place to start but needs to include oblique or parallel lines to better understand boundary crossings.
- Spoke of the need to implement a policy on data sharing with fishermen.
- They then brought to attention the fact that there is not currently a lobster component in the OTN study and the lobster fishery accounts for 50% of Nova Scotia fisheries.

4.1.3 Group 3: Economic Sustainability

- The idea of having the fishermen tag the fish themselves was discussed and noted that it would not work because of an early problem with halibut tagging by fishermen. It was not accepted as being done properly due to lack of certification to do the work, thus an observer was and would be needed on board to monitor the effort.
- The idea of instituting a tax on fishermen to help pay for tags was not well received.
- It was suggested that fishermen's logbooks would be a simple and effective way to help spread the OTN information but it was noted by some that the logbooks are already quite complicated.

4.2 Summary of All Groups' Final Suggestions

1) Ideas for new research and or species to tag:
    - Sharks, especially porbeagle sharks
    - Lobster, to look at inshore/offshore movements
    - Snow crabs, if tagged after their last moult (terminal moult) they could retain a tag for longer than lobsters
    - Leatherback turtles
    - Mackerel, cod, herring, halibut, pollock, haddock
    - Whales
    - Measure cross-shelf movement
    - Conduct stock depletion experiments

2) Identify ways to increase fishermen's participation in ocean tracking research:
    - It was recommended that fishermen be included in all stages of planning to make it a truly collaborative effort. Their input could be useful in the design of receiver moorings to make them trawl resistant, recommend locations based on local knowledge, and their vessels could be used as platforms to set moorings and collect data.
    - If fishing boats are used then charter fees would be welcome. Fishermen are generally good to volunteer their time as long as their expenses are covered. Use a standardized rate of reimbursement.

- It would be important to share data and all results with individuals who do participate in the research aspect in any way.
- Communication is a key aspect in getting collaborators and increased support from others in the community. Groups such as the Eastern Fishermen's Federation, the Maritime Fishermen's Union, FSRS, the Guysborough County Inshore Fishermen's Association, Sou'Wester newspaper, or a fisheries-related radio program would all be considered good communication venues. A mailing list sign up on the OTN website may also be useful to some fishermen.
- Several fishermen working with the FSRS noted that there is often a level of resistance to new fishermen and scientist collaboration but over time existing members have been able to convince others of the research value.
- Smaller scale community-based lines integrated with OTN could involve fishermen in multiple aspects.
- Enforce safety standards vigorously.

3) Identify potential interactions between fishing activity and ocean tracking infrastructure and describe ways to resolve or reduce them:
   - Placing receivers inside an MPA would help reduce conflict between OTN gear and fishermen.
   - In regards to silver hake trawling, and other fishing in general, it was felt that a notice sent to mariners would not likely be an effective way to spread word about the location of receivers. Outreach via fisheries associations, individuals, media, as well as posting notices on wharves would be more effective.
   - Adjust the location of the Halifax line in consultation with fishermen.
   - Involve fishermen in all aspects of the research. Talk with them often and focus research on areas where you do not agree.

4.3 Conclusions

The objectives of the workshop were to explore the potential benefits of and uses for the OTN and other ocean tracking initiatives to the fishing industry from conservation, research and economic/sustainability perspectives, and identify fisheries research priorities that could utilize the OTN. The objectives were achieved through presentations on the OTN and current projects for which it is being used, breakout group discussions, and a plenary session.

The workshop was well attended and we were able to achieve the desired mix of participants, including industry, the academic community, the private sector and government. The workshop was by invite only as we wanted to keep the workshop size small to ensure productive size breakout groups and full participation in the discussions by all participants. With the workshop only being one day, it was felt the smaller groups would be more productive. This approached proved successful. However, once the fishing industry, academic community and government scientists started to become aware that the event was occurring, there was more interest than expected, particularly by the fishing industry. This suggests that it would be valuable to hold a

larger event to better inform stakeholders about the OTN and ocean tracking technology and how it is being used, and to discuss the interest in additional projects which could utilize the technology.

The presentations were found to be very informative and provided a good foundation for the breakout group discussions that followed. A number of ideas for new research and species to tag were identified, including:

- Sharks, especially porbeagle sharks
- Lobster, to look at inshore/offshore movements
- Snow crabs
- Leatherback turtles
- Mackerel, cod, herring, halibut, pollock, haddock
- Whales
- Conduct stock depletion experiments
- Smaller scale community based lines integrated with OTN could involve fishermen in multiple aspects of the research.

Finding ways to increase fishermen's participation in ocean tracking research was identified as an important issue. It was recommended that fishermen be included in all stages of planning to make it a truly collaborative effort. Their input could be useful on the design of receiver moorings to make them trawl resistant, to recommend locations based on local knowledge, and their vessels could be used as platforms to set moorings and collect data. Sharing data and all results with individuals who participate in the research in any way was also identified as important. Communication was identified as a key factor in getting collaborators and increased support from others in the community.

The *Ocean Tracking Network (OTN) as a Fisheries Research Tool Workshop* was a success and it is hoped it can serve as a model for collaborations in other locations. As noted, communication was identified as a key factor in promoting collaboration and increasing support for ocean tracking initiatives, and workshops such as this one can be an effective means of increasing communication and awareness. One of the most important recommendations of this workshop was the reinforcement of the importance of having fishermen involved in the research projects from an early stage; improved communication is vital for this to happen.

APPENDIX I - Presenters' Contact Information

Presenter	Title	Organization	Address	E-mail	Phone
Robert Branton	Director of Data Management	Ocean Tracking Network	1355 Oxford Street, Room 7089, LSC, Dalhousie University, Halifax NS Canada B3H 4J1	bob.branton@dal.ca	902-949-7560
Peter Smith	Research Scientist	Fisheries and Oceans Canada	PO Box 1006, Challenger Drive, Dartmouth NS Canada B2Y 4A2	peter.smith@dfo-mpo.gc.ca	902-426-3474
Sara Iverson	Scientific Director	Ocean Tracking Network Canada	Dept of Biology, Dalhousie University, Halifax NS Canada B3H 4J1	sara.iverson@dal.ca	902-422-4399
Don Bowen	Research Scientist	Fisheries and Oceans Canada	PO Box 1006, Challenger Drive, Dartmouth NS Canada B2Y 4A2	don.bowen@dfo-mpo.gc.ca	902-426-8909
John Brattey	Research Scientist	Fisheries and Oceans Canada	Science Branch, Northwest Atlantic Fisheries Centre, PO Box 5667, St. John's NL Canada A1C 5X1	john.brattey@dfo-mpo.gc.ca	709-772-2891
Hassan Moustahfid	Marine Scientist	NOAA Integrated Ocean Observations System (IOOS), Na-	1100 Wayne Ave, Suite 1225, Silver Spring MD USA 20910	hassan.moustahfid@noaa.gov	301-427-2447
Diane Cowan	Executive Director	The Lobster Conservancy	PO Box 235, Friendship ME USA 04547	dcowan@lobsters.org	207-542-9781
Ron O'Dor	Senior Scientist	Census of Marine Life, Consortium for Ocean Leadership	Suite 420, 1201 New York Ave. NW Washington DC USA 20005	rodor@oceanleadership.org	202-332-0063 x1233

APPENDIX II - Participant List

First Name	Last Name	Title	Organization	OTN (1-3)
David	Baker	Fisherman	Tancook Island, NS	1
Duncan	Bates	Technical Officer	Ocean Tracking Network	1
Raymond	Beliveau	President	Charlesville Fisheries Ltd.	2
Hubert B.	Boutilier	Fisherman	Mushaboom	3
Randy	Boutilier	Fisherman	Mushaboom	1
Don	Bowen	Research Scientist	Fisheries and Oceans Canada	1
Eric	Branton	Field Technician	AVC Lobster Science Centre	2
Robert	Branton	Director of Data Management	Ocean Tracking Network	0
John	Brattey	Research Scientist	Fisheries and Oceans Canada	3
Jonathan	Carr	Biologist	Atlantic Salmon Federation	1
Cecil	Cashin	Fisherman	Port Felix	1
Roderick	Cashin	Fisherman	Port Felix	3
Bernie	Chisholm	Fisherman	Malignant Cove	2
Robert	Courtney	President	North of Smokey Fishermen's Association	1
Diane	Cowan	Executive Director	The Lobster Conservancy	2
Susan	Dufault	Data Manager	Ocean Tracking Network	2
Sara	Ellis	Program Manager and Biologist	GoM Census of Marine Life & GoM Lobster Foundation	3
Jeanna	Fletcher	Volunteer	Fishermen and Scientists Research Society	3
Josh	Fricker	Fisherman	Neil's Harbour	2
Edmund	Halfyard	Biologist	Atlantic Salmon Federation	1
Bruce	Hatcher	Chair in Marine Ecosystem Research	Cape Breton University	2
Bob	Henneberry	Fisherman	Sambro	3
Sara	Iverson	Scientific Director	Ocean Tracking Network Canada	3
Mark	Jeffrey	Fisherman	Sandy Cove	2
Bruce	Keus	Fisherman	North Lake, PEI	1
Ross	Keus	Fisherman	Naugrage, PEI	3
Stephane	Kirchhoff	Technical Officer	Ocean Tracking Network	3
Barry	Levy	Fisherman	Lunenburg	2
Krista	MacEachern	Fisheries Technician	Fishermen and Scientists Research Society	1

First Name	Last Name	Title	Organization	OTN (1-3)
Krista	MacEachern	Fisheries Technician	Fishermen and Scientists Research Society	1
Steve	MacInnis	Fisherman	Arisaig, NS	2
Paul	Macnab	Oceans Biologist	Fisheries and Oceans Canada	1
Rodney	Manthorne	Fisherman	Drum Head	2
Marta	Mihoff	Database Developer	Ocean Tracking Network	2
Hassan	Moustahfid	Senior Scientist	NOAA/IOOS	1
Doug	Pezzack	Biologist	Fisheries and Oceans Canada	3
Arthur	Richardson	Fisherman	Mitchell Bay, NS	2
Sheila	Richardson	Fisherman	Mitchell Bay, NS	1
Jesus	Rivera Martinez	Tracker	OTN-Instituto Español de Oceanografia	1
Anna	Sanchez Vidal	Tracker	OTN-University of Barcelona, Spain	3
Shannon	Scott-Tibbetts	Research Biologist	Fishermen and Scientists Research Society	0
Peter	Smith	Research Scientist	Fisheries and Oceans Canada	2
Wilford	Smith	Fisherman	Port La Tour	1
Ken	Snow	Fisherman	Canso	3
Aaron	Spares	PhD. Candidate	Ocean Tracking Network	2
Richard	Vallée	VP Sales and Marketing	VEMCO	3

APPENDIX III - Breakout Group Tables

Group 1: Conservation

Ocean Tracking Network (OTN) as a Fisheries Research Tool - *Instructions to breakout group*

Name of your group: #1 Conservation

You will be divided into 3 groups, with each group starting their discussion off on a different theme: a) conservation, b) fisheries research and c) economic sustainability. This way all groups do not have to cover all themes. Each group will do essentially the same thing, that is: a) discuss expected benefits of ocean tracking technology to the fishing industry b) comment on the current projects with regards to those benefits and c) propose new research themes or projects. As for comments on the projects, use them as a basis for identifying perceived gaps in relation to expected benefits and to make suggestions where ocean tracking in general might be strengthened. You are not being asked to critique the individual projects.

Name of Group	Common definition	Give alternative definition if you don't like this one
1) conservation	preservation and careful management of the environment and of natural resources	No objections
2) fisheries research	a multidisciplinary science, which draws on the disciplines of oceanography, marine biology, marine conservation, ecology, population dynamics, economics and management to attempt to provide an integrated picture of fisheries	
3) economic sustainability	utilizing marine resources in an economically viable manner while ensuring that conservation objectives are also being met	

Name of your group: #1 Conservation

Presentations
1) OTN Global
2) OTN Operations on the Halifax Line
3) The OTN Canada Research Program
4) Using OTN Data to Improve Stock Assessment and Fishery Management
5) Encounters at Sea: Grey Seal as Biological and Oceanographic Samplers Participants suggested that the location of the seal research should be spread out more widely to include tagging efforts and receiver arrays in the Gulf as well as on St. Paul's and Hay Islands (i.e. clear gaps in the program). It was believed that more cod would be revealed in the seals' diet if animals were examined closer to these coastal feeding areas. It is not clear that traces of cod from coastal feeding areas will remain present months later when these animals are re-sampled on Sable. Participants strongly believed that the Sable project needs to be replicated in other areas.
6) The Role of Ocean Tracking Technology in Recent Stock Assessments of Atlantic Cod Off Eastern Newfoundland
7) Lobsters on the Move

Name of your group: #1 Conservation

Expected Benefits	Perceived Gaps	Suggestions	Relevant Presentation #s	Relevant Theme #s
		Future presentations to industry should make it clear that the first phase of infrastructure is already established. It is also important to clarify the importance of getting more animals and a greater variety of species tagged with transmitters.		
	The Atlantic facing side of Nova Scotia appeared to be well served but that the Gulf side was lacking. Furthermore, one line off Halifax only tells us that fish have passed; it does not reveal much more about movement, behaviour, etc..	Fishers already know a lot about migration so their input would be helpful in terms of planning future lines.		

Name of your group: #1 Conservation

Expected Benefits	Perceived Gaps	Suggestions	Relevant Presentation #s	Relevant Theme #s
	Concerns about only tagging multiple fish from a single school.	Tags should be widely dispersed to get a better picture of movements, etc..		
The technology appears to show great promise for studying sites like the Haddock Box, the Browns Bank lobster closure and various marine protected areas to determine if the closed areas are working.				

Name of your group: #1 Conservation

Question	Suggestions	Relevant Presentation #s	Relevant Theme #s
1)Ideas for new research and or species to tag.	– Migrations of mackerel across the Straights and movements of cod from traditional grounds in Sydney Bight into deeper waters.		
2) Identify ways to increase fishermen participation in ocean tracking research.	– Important to have industry better understand the OTN so that it can be more fully involved in field components (e.g., tagging support) as well as hypothesis formulation and research design in collaboration with researchers and the OTN. – Getting word out to fishers on the technology and potential applications was described as critical. Such opportunities enable fishers to become educated and better prepared to collaborate on research ideas and to build jointly-sponsored projects with OTN researchers.		
3) Identify potential interactions between fishing activity and ocean tracking infrastructure and describe ways to resolve or reduce them.	– Using GPS coordinates to let fishermen know where OTN equipment is located. – Use notices to also explain what the gear is used for and describe any early findings. – Instructions of what to do with recovered tags (info sheets, envelopes).		

Group 2: Fisheries Research

Ocean Tracking Network (OTN) as a Fisheries Research Tool - ***Instructions to breakout group***

Name of your group: #2 Fisheries Research

You will be divided into 3 groups, with each group starting their discussion off on a different theme: a) conservation, b) fisheries research and c) economic sustainability. This way all groups do not have to cover all themes. Each group will do essentially the same thing, that is: a) discuss expected benefits of ocean tracking technology to the fishing industry b) comment on the current projects with regards to those benefits and c) propose new research themes or projects. As for comments on the projects, use them as a basis for identifying perceived gaps in relation to expected benefits and to make suggestions where ocean tracking in general might be strengthened. You are not being asked to critique the individual projects.

Name of Group	Common definition	Give alternative definition if you don't like this one
1) conservation	preservation and careful management of the environment and of natural resources	
2) fisheries research	a multidisciplinary science, which draws on the disciplines of oceanography, marine biology, marine conservation, ecology, population dynamics, economics and management to attempt to provide an integrated picture of fisheries	A multidisciplinary science, which draws on the disciplines of oceanography, marine biology, marine conservation, ecology, population dynamics, economics, and management to demonstrate the causal relationships among fish, their environment, and the people who hunt them.
3) economic sustainability	utilizing marine resources in an economically viable manner while ensuring that conservation objectives are also being met	

Group 2: Fisheries Research

Presentations
OTN Global The group saw it as important that the OTN Canada is embedded in the global arena. Issues were raised about the risk of sharing sensitive data about fish location (e.g. tuna). People identified the need for policies and guidelines on data sharing. A two year embargo may not be long enough in some cases.
2) OTN Operations on the Halifax Line The group would have liked there to have been more early consultation on the installation of this line. There is real potential for interference by fishing activities, not just trawlers. No obvious relocation could be seen to significantly reduce conflict. A corridor was discussed and discussed. The cross shelf priority was challenged.
3) The OTN Canada Research Program The group saw the merits in the Canadian program, but felt that the design of sampling arrays would miss some important movement patterns (onshore-offshore). The species coverage neglects the two most valuable species, lobsters and snow crab.
4) Using OTN Data to Improve Stock Assessment and Fishery Management The group acknowledged the great potential of the OTN results to improve the calibration of both analytical and numerical fishery models
5) Encounters at Sea: Grey Seal as Biological and Oceanographic Samplers This was seen as extremely important research, as it would prove or disprove the case for seal-induced mortality on ground fish stock recovery, and help guide the seal hunt. The small sample size caused people to question the maps of feeding areas
6) The Role of Ocean Tracking Technology in Recent Stock Assessments of Atlantic Cod Off Eastern Newfoundland The group was extremely impressed with this work. They felt that it was the most powerful and convincing demonstration of the value of the tools and techniques of OTN.
7) Lobsters on the Move There was considerable discussion of the results of this study, which highlighted the variability in behavior among lobsters, and the difficulties in tagging and tracking them. Suggestions were made about how to use internal tags in lobster of different sizes and moult stages.

Group 2: Fisheries Research

Expected Benefits	Perceived Gaps	Suggestions	Relevant Presentation #s	Relevant Theme #s
Better knowledge of connections and mixing of stocks along shelf.	Little ability to resolve cross-shelf connectivity.	More transects obliquely across shelf, and others along shelf.	2-7	1-3
Critical information about commercially important species and stocks.	Lobster, snow crab, delineation of inshore and offshore stocks.	Engage fishermen to tag lobster and crab. Place receiver lines along the 50 fm line.	2,3,4,7	1-3
Improved stock assessments – Stock delineation – Estimates of mortality	Virgin stock assessments using stock depletion experiments, e.g. lobster stock discovered in the emerging Jonah Crab fishery.	– Conduct a series of stock depletion experiments using tagged sub-samples within a line of receivers. – Surround an NIFR with receivers and research tagged species within it.	4,6	1,2

Group 2: Fisheries Research

Question	Suggestions	Relevant Presentation #s	Relevant Theme #s
1)Ideas for new research and or species to tag.	– Measure cross-shelf movement. – Measure spill over from NIFR's. – Conduct stock depletion experiments. – Study lobster, snow crab, pollock (stock depletion), haddock (Effectiveness of haddock box), and Halibut (long range movements).		
2) Identify ways to increase fishermen participation in ocean tracking research.	– Don't work only with the FSRS fishermen. – Pay the fishermen's true costs (only expect their time for free). – Use a standardized rate of reimbursement. – Enforce safety standards rigorously.		
3) Identify potential interactions between fishing activity and ocean tracking infrastructure and describe ways to resolve or reduce them.	– Adjust the location of the Halifax Line in consultation with fishermen. – Watch out for the ammunition dump – use it for protection. – Negotiate a fishery exclusion zone with compensation for catch forgone. – It is important to involve fishermen in all aspects of the research. Talk with them often, find out where you don't agree, and focus research on that area. – The fact that the OTN is an academic network, not a DFO project, is seen as beneficial to research collaboration.		

Group 3: Economic Sustainability

Ocean Tracking Network (OTN) as a Fisheries Research Tool - ***Instructions to breakout group***

Name of your group: #3 Economic Sustainability

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Group 3: Economic Sustainability

Presentations
1) OTN Global
2) OTN Operations on the Halifax Line
3) The OTN Canada Research Program
4) Using OTN Data to Improve Stock Assessment and Fishery Management
5) Encounters at Sea: Grey Seal as Biological and Oceanographic Samplers
6) The Role of Ocean Tracking Technology in Recent Stock Assessments of Atlantic Cod Off Eastern Newfoundland
7) Lobsters on the Move

Group 3: Economic Sustainability

Expected Benefits	Perceived Gaps	Suggestions	Relevant Presentation #s	Relevant Theme #s
Will help locate fish.	Will want to fish greater amounts if they know how much and where fish are (greed coming with knowledge).	– Time lapse release. – Only scientists to have the data.		
Password protection.	Safe guarded data that is acquired.			
Better estimates of natural mortality would help make stock assessments more accurate, and could be useful for fisheries seeking Marine Stewardship Council certification.	There do not appear to be enough lines planned to cover the region.	Suggested line locations: – Eastern coast of Newfoundland – Off Canso – Within one of the proposed MPA's off Nova Scotia		

Group 3: Economic Sustainability

Expected Benefits	Perceived Gaps	Suggestions	Relevant Presentation #s	Relevant Theme #s
New data could be used to respond to an unpopular regulation. E.g. Many think the 'haddock box' has been placed in the wrong location.		Lines placed in an MPA could show if the MPA was working or not.		
OTN research can help improve our understanding of predator-prey interactions, e.g. grey seals and groundfish (especially if that work can be expanded beyond Sable Island after the demonstration project is finished there).				
	The Halifax line will not capture inshore/offshore movements of lobsters.	Conduct localized studies that can use short listening lines placed across the mouth of a bay.		

Group 3: Economic Sustainability

Question	Suggestions	Relevant Presentation #s	Relevant Theme #s
1)Ideas for new research and or species to tag.	– Sharks: especially porbeagle sharks (several people noted that these sharks appear to be increasing in abundance in their fishing areas. – Lobster: especially to look at inshore/offshore movements (may be an issue of short tag retention due to molting). – Leatherback turtles, mackerel, cod, herring, whales, snow crab.		
2) Identify ways to increase fishermen participation in ocean tracking research.	– Through Eastern Shore marine protected area. – Assembly with fishermen to explain and educate. – Include them in all stages of planning to make all efforts truly collaborative. Fishermen could have useful input on designs of receiver moorings, recommend locations, and their vessels could be used as platforms to set moorings and collect data. – Important to share data with any individual who does participate – Communication is key to getting collaborators, and to help increase buy-in from others in the community. Industry groups such as the Guysborough County Inshore Fishermen's Association and so on would be good communication venues, as would be the Sou'Wester newspaper and fisheries related radio programs (e.g. in NFLD). A mailing list sign up on the OTN webpage would be useful to some fishermen, but not a majority. – The experience of several fishermen who had worked with FSRS was that there is often resistance to new fishermen/scientists collaborations, but over time participating fishermen can help convince non-participants of the value of the research. – Community based listening lines on a smaller scale than the main OTN lines, but integrated with OTN, could involve fishermen in multiple aspects as shown by Jim Brattey's work in NFLD.		

Group 3: Economic Sustainability

Question	Suggestions	Relevant Presentation #s	Relevant Theme #s
3) Identify potential interactions between fishing activity and ocean tracking infrastructure and describe ways to resolve or reduce them.	– Put a line through a marine protected area. – Increase communication. – The notice to mariners is not likely to be a very effective way to spread the word about the locations of receivers. Outreach efforts through fisheries associations, individuals, and media as well as posting notices on wharves would be more effective.		