Atlantic Salmon Recovery Science

John F. Kocik, Chief

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NOAA FISHERIES

Northeast Fisheries Science Center

Part 2

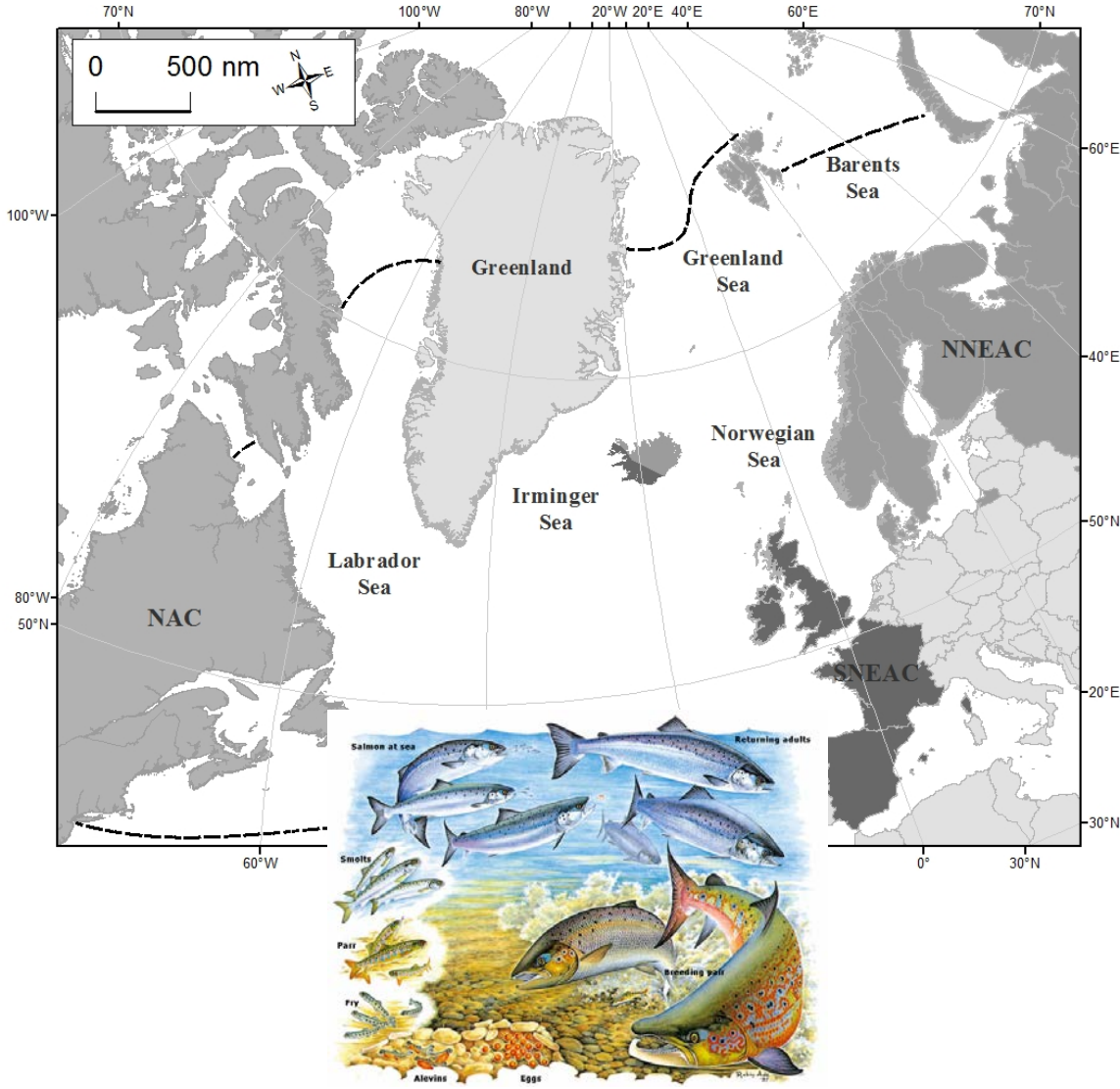
Prepared for NEFSC Protected Species Science Program Review April 13-16, 2015, Woods Hole, MA

Stock Assessment

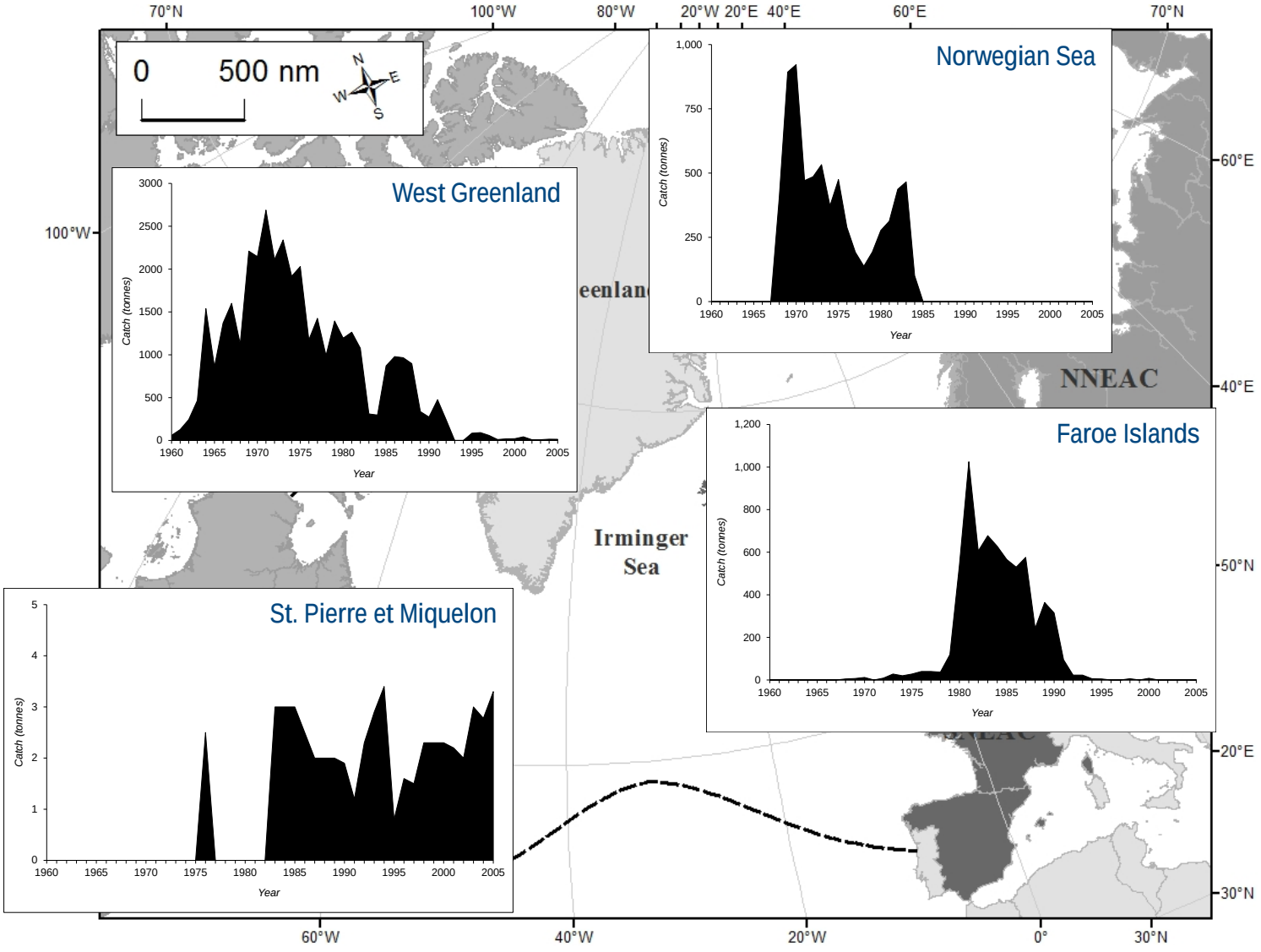
International

Unique challenges

- Wide ranging
- Diadromous
- Management foci
  - Domestic
  - International
  - Freshwater
  - Marine



Historical fisheries mixed-stock fisheries



North Atlantic Salmon Conservation Organization

- Convention for the Conservation of Salmon in the North Atlantic Ocean (1982)
  - To conserve, restore, enhance and rationally manage Atlantic salmon through international cooperation
- Parties
  - Canada, Denmark (in respect of Greenland and the Faroe Islands), European Union, Norway, Russian Federation, USA and *Iceland**
- Council
  - Forum for exchange and coordinate activities of the Commissions
- Three Commissions
  - North American, Northeast Atlantic and West Greenland
  - Forum for exchange and to propose regulatory measures

- Scientific advice requested from the International Council for the Exploration of the Seas

International Atlantic Salmon Research Board

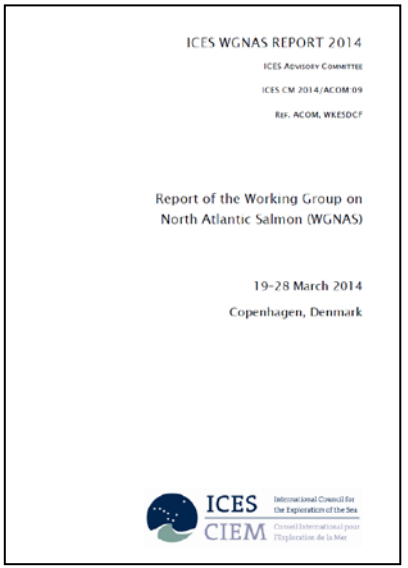
- Promote collaboration/cooperation on research into marine mortality of Atlantic salmon
  - Facilitate and coordinated, sometimes fund, collaborative international investigations into salmon mortality at sea
- SALSEA (*Salmon at Sea*) Programme
  - Coordinated marine sampling initiatives across the North Atlantic (2008-2010)
  - SALSEA North America, SALSEA-Merge and SALSEA Greenland
  - Salmon Summit
    - La Rochelle, France (2011)
    - ICES Journal of Marine Science: 69 (9)

International Council for the Exploration of the Seas

- Works through
  - Expert Groups (EG) generate primary information
  - Review Groups (RG) review EG products
  - Advisory Committee (ACOM) provides science back to clients
  - Science Committee (SCICOM) oversees all aspects of this process

Working Group on North Atlantic Salmon

- Addresses questions posed from NASCO to ICES
- Include scientists from all NASCO Parties
- Meets Annually
- Three primary foci:
  - Summary of the status of salmon stocks
  - Mixed-stock fisheries catch advice
  - Advise on issues related to the conservation, restoration, enhancement, and rational management
- Final report, advice, and all supporting input data, model codes, etc. are available online or upon request


ICES WGNAS REPORT 2014

ICES Advisory Committee

ICES CM 2014/ACOM:09

Ref. ACOM, WKESDCF

Report of the Working Group on North Atlantic Salmon (WGNAS)

19–28 March 2014

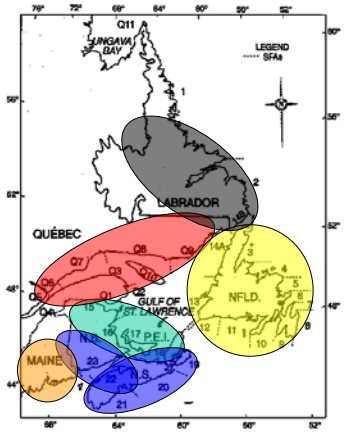
Copenhagen, Denmark

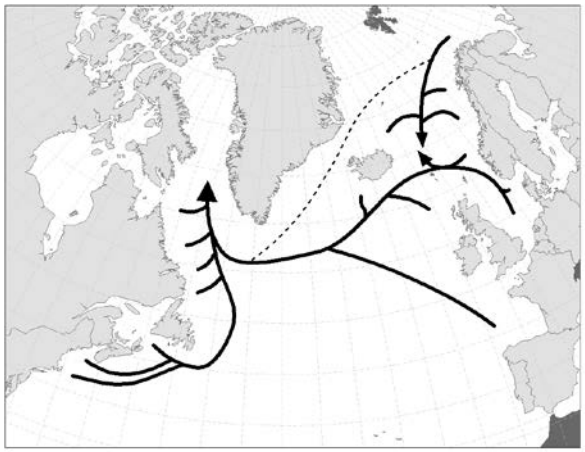
ICES International Council for the Exploration of the Sea

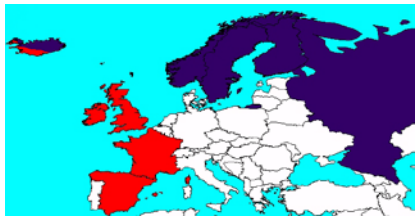
CIEM Conseil International pour l'Exploration de la Mer

Stock Status and Management Advice

- Six North American regions
- All contribute to West Greenland fishery
  - In addition to southern Europe complex
  - Fishery exploits non-maturing 1SW fish (~95%, eventual two sea winter returns)

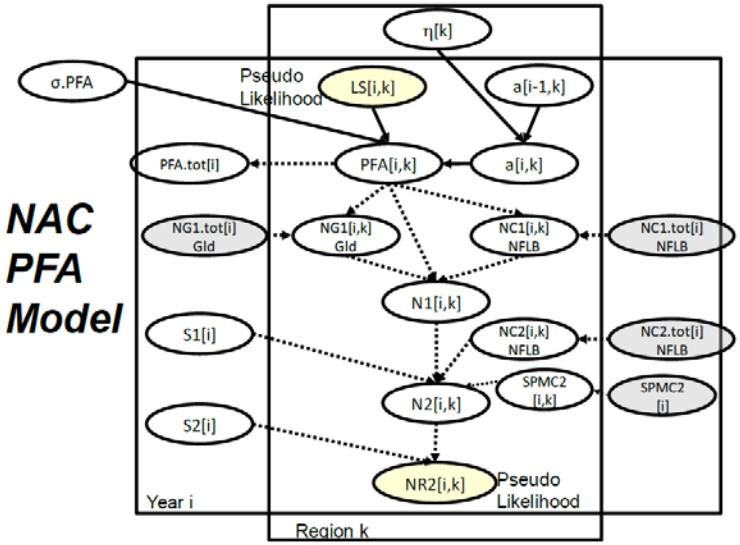


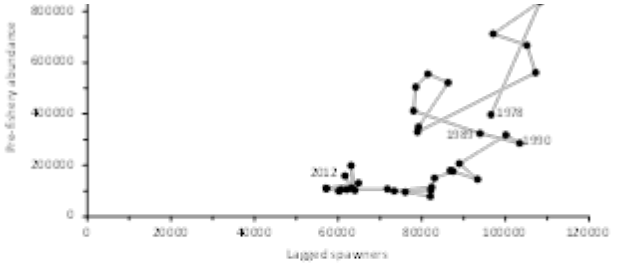


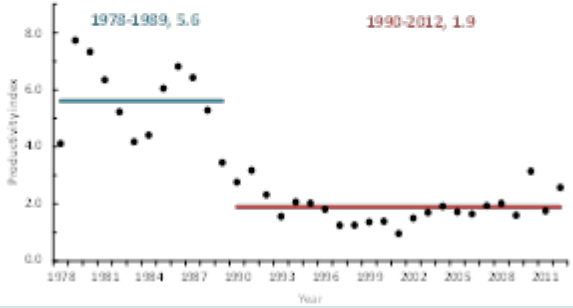


Five Component Risk Analysis Framework

1. Historic pre-fishery abundance (PFA)
   - **Returns** used to estimate PFA
2. Historic spawning stock
   - **Spawners** are lagged forward (**lagged-spawners**) by smolt year
3. Spawning requirements
   - **Conservation limits** (adults) to maximize yield
4. Forecast of PFA
   - **PFA estimates** assumed proportional to lagged-spawners
5. Consequences based on management objectives
   - Levels of harvest removed from forecasted PFA and projected returns matched against management objectives

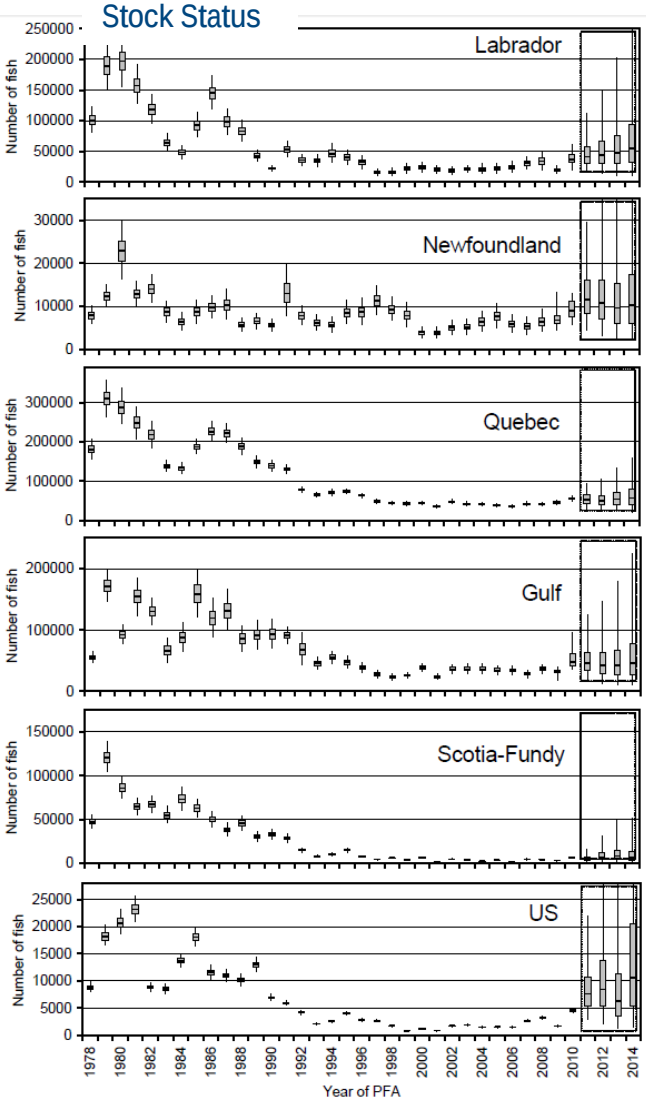




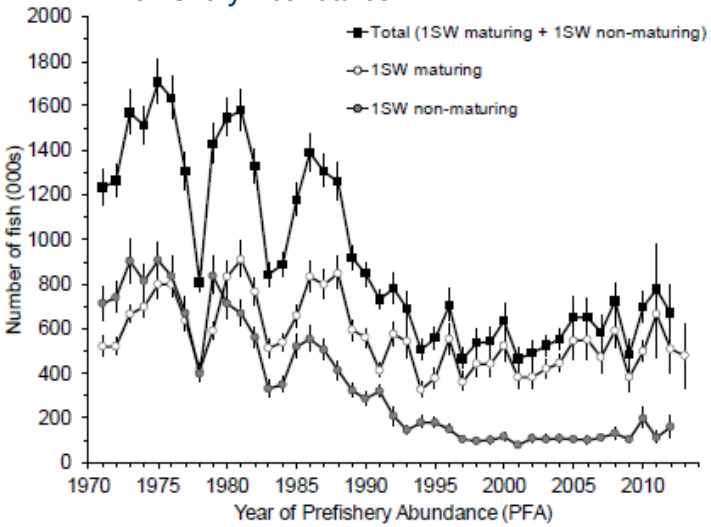


Advice to NASCO

Stock Status



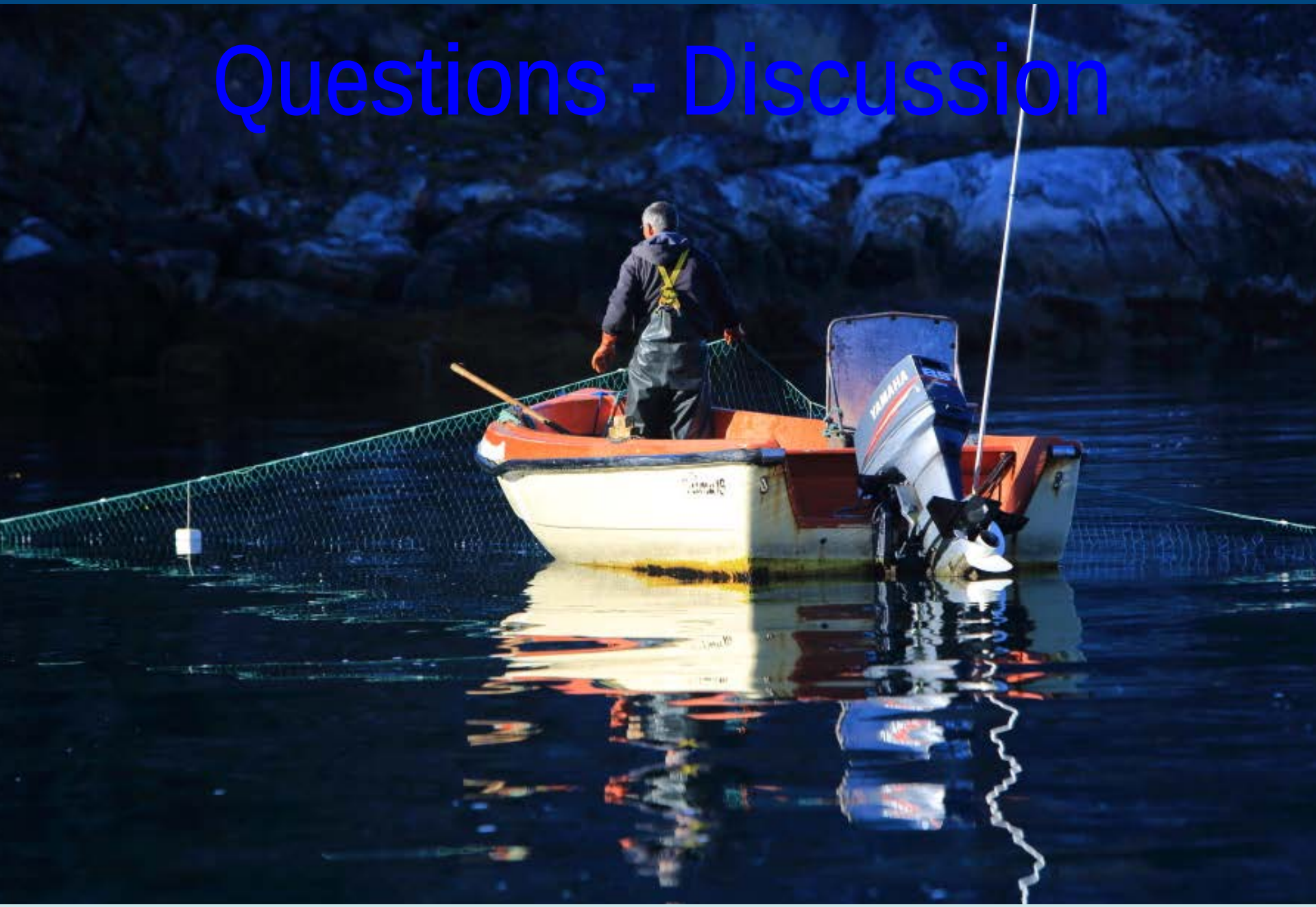
Pre-fishery Abundance



Catch Advice

2014 Catch option	Probability of meeting or exceeding region-specific management objectives							
	LAB	NFLD	QC	GULF	SF	USA	S-NEAC	ALL
0	0.56	0.78	0.75	0.55	0.20	0.86	0.94	0.08
10	0.55	0.77	0.73	0.53	0.20	0.85	0.94	0.08
20	0.53	0.75	0.70	0.51	0.19	0.84	0.94	0.07
30	0.52	0.73	0.67	0.49	0.18	0.83	0.94	0.07
40	0.50	0.71	0.64	0.47	0.17	0.82	0.94	0.06
50	0.48	0.69	0.62	0.46	0.17	0.81	0.94	0.06
60	0.46	0.67	0.59	0.44	0.16	0.79	0.94	0.06
70	0.45	0.65	0.56	0.42	0.16	0.77	0.94	0.05
80	0.43	0.63	0.54	0.41	0.15	0.76	0.94	0.05
90	0.42	0.61	0.51	0.39	0.14	0.74	0.94	0.05
100	0.40	0.59	0.49	0.38	0.14	0.72	0.94	0.05

Questions - Discussion



Successes In Research

What are the major successes in protected species research and how should they be supported?

Major Successes

- Marine Survival
  - Better understanding of when, where, why
- Dam Impacts
  - Science support for management
- Ecosystem Approach to Recovery Science
  - Focus on restoration of diadromous community ecosystem services

Successes In Research

Marine Survival

Demographic Knowledge

Pre-1995

Large parr estimate → Assumed overwinter survival → Adult returns

Pre-1995

- Monitoring efforts were focused on:
  - A few rivers
  - Freshwater
  - Large parr and returning adult abundance
- Initial ASRCT efforts focused on:
  - Improving freshwater monitoring
  - Incrementally moving further out to sea

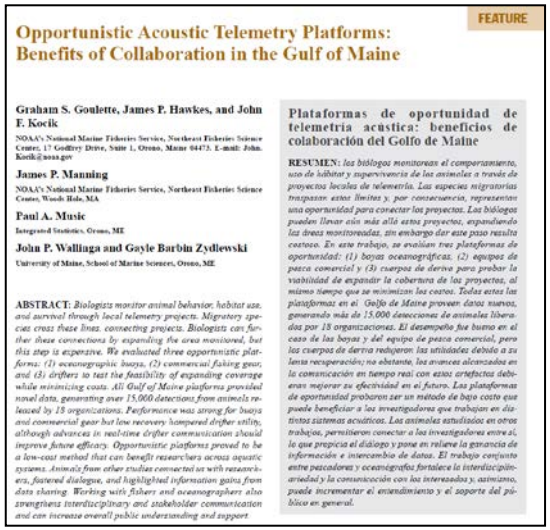
Freshwater Parr and Smolts

- Development of stratified sampling design
  - Improved large parr abundance estimates
- Smolt monitoring via rotary screw traps
  - Abundance measures of marine recruits
  - Improved over-winter mortality estimates

Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Nearshore Smolts and Postsmolts

- Migration monitoring via ultrasonic telemetry
  - Infrastructure evolution and maintenance
    - Atlantic salmon
    - Atlantic sturgeon
    - Shortnose sturgeon
    - Alewive
    - American eel



FEATURE

Opportunistic Acoustic Telemetry Platforms: Benefits of Collaboration in the Gulf of Maine

Graham S. Goulette, James P. Hawkes, and John F. Kocik
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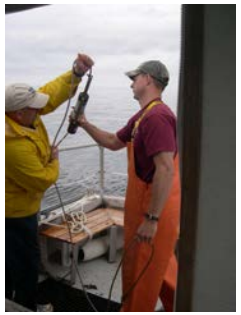
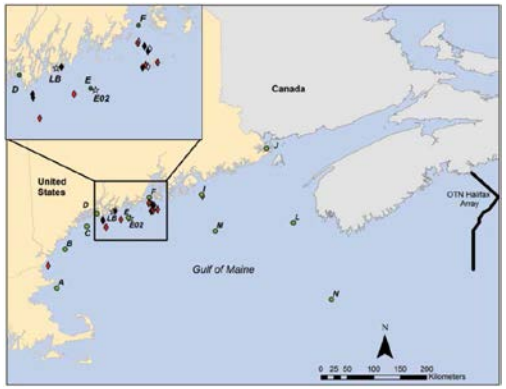
ABSTRACT: Biologists monitor animal behavior, habitat use, and survival through local telemetry projects. Migratory species cross these lines, connecting projects. Biologists can further these connections by expanding the area monitored, but this step is expensive. We evaluated three opportunistic platforms: (1) oceanographic buoys, (2) commercial fishing gear, and (3) drifters to test the feasibility of expanding coverage while minimizing costs. All Gulf of Maine platforms provided novel data, generating over 15,000 detections from animals released by 15 organizations. Performance was strong for buoys and commercial gear but low recovery hampered drifter utility, although advances in real-time drifter communication should improve future efficacy. Opportunistic platforms proved to be a low-cost method that can benefit researchers across aquatic systems. Animals from other studies connected us with researchers, fostered dialogue, and highlighted information gains from data sharing. Working with fishers and oceanographers also strengthens interdisciplinary and stakeholder communication and can increase overall public understanding and support.

Plataformas de oportunidad de telemetría acústica: beneficios de colaboración del Golfo de Maine

RESUMEN: los biólogos monitorean el comportamiento, uso de hábitat y supervivencia de los animales a través de proyectos locales de telemetría. Las especies migratorias traspasan estos límites y, por consecuencia, representan una oportunidad para conectar los proyectos. Los biólogos pueden llevar aún más allá estos proyectos, expandiendo las áreas monitoreadas, sin embargo dar este paso resulta costoso. En este trabajo, se evalúan tres plataformas de oportunidad: (1) boyas oceanográficas, (2) equipos de pesca comercial y (3) cuerpos de deriva para probar la viabilidad de expandir la cobertura de los proyectos, al mismo tiempo que se minimizan los costos. Todas estas las plataformas en el Golfo de Maine proveen datos nuevos, generando más de 15,000 detecciones de animales liberados por 15 organizaciones. El desempeño fue bueno en el caso de las boyas y del equipo de pesca comercial, pero los cuerpos de deriva redujeron las utilidades debido a su lenta recuperación; no obstante, los avances alcanzados en la comunicación en tiempo real con estos artefactos deberán mejorar su efectividad en el futuro. Las plataformas de oportunidad probaron ser un método de bajo costo que puede beneficiar a los investigadores que trabajan en distintos sistemas acuáticos. Los animales estudiados en otros trabajos, permitieron conectar a los investigadores entre sí, lo que propicia el diálogo y pone en relieve la ganancia de información e intercambio de datos. El trabajo conjunto entre pescadores y oceanógrafos fortalece la interdisciplinariedad y la comunicación con los interesados y, asimismo, puede incrementar el entendimiento y el soporte del público en general.





Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Nearshore Smolts and Postsmolts

- Migration monitoring via ultrasonic telemetry
  - Migration dynamics
  - Habitat use
  - Partitioned survival through nearshore
  - Hatchery product performance

American Fisheries Society Symposium 69:293–310, 2009

Assessing Estuarine and Coastal Migration and Survival of Wild Atlantic Salmon Smolts from the Narraguagus River, Maine Using Ultrasonic Telemetry

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American Fisheries Society 2012
ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2012.688916

Transactions of the American Fisheries Society

ARTICLE

Swimming Depth, Behavior, and Survival of Atlantic Salmon Postsmolts in Penobscot Bay, Maine

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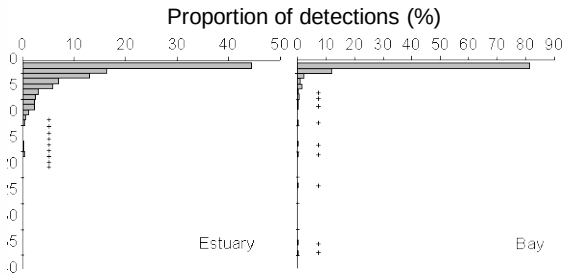

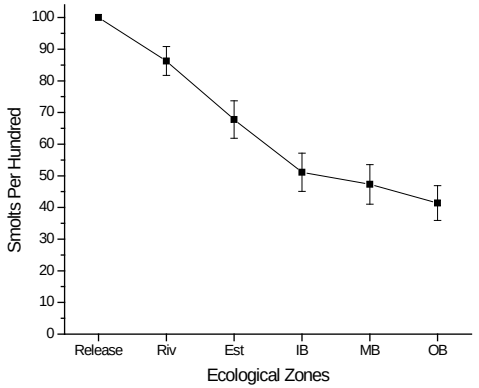

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Nearshore Smolts and Postsmolts

- Telemetry/PIT tagging - hydroelectric facility impacts
  - Smolt mortality estimates at dams
  - Dam-related (latent) estuarine mortality
  - Adult selection impacts

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DOI: 10.1080/00028487.2011.618356

ARTICLE

Survival of Migrating Atlantic Salmon Smolts through the Penobscot River, Maine: a Prerestoration Assessment

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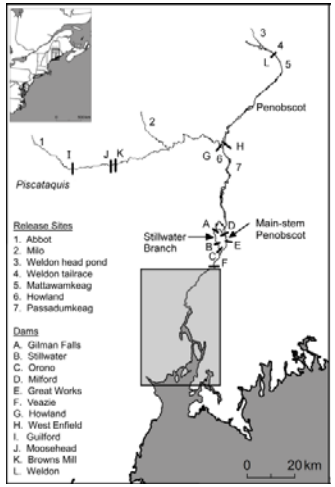
Joseph Zydlewski
U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, 5755 Nutting Hall, University of Maine, Orono, Maine 04469, USA



Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Early Marine Postsmolts

- Marine migration dynamics over 200 marine miles
- Modelling Gulf of Maine migration

FISHERIES OCEANOGRAPHY
FISHERIES OCEANOGRAPHY Fish. Oceanogr. 23:2, 172–189, 2014

Migration model of post-smolt Atlantic salmon (*Salmo salar*) in the Gulf of Maine

CARRIE J. BYRON,[1,2,*] ANDREW J. PERSHING,[2,3] JASON D. STOCKWELL,[4] HUIJIE XUE[3] AND JOHN KOCIK[5]

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[2]*Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 04101, U.S.A.*
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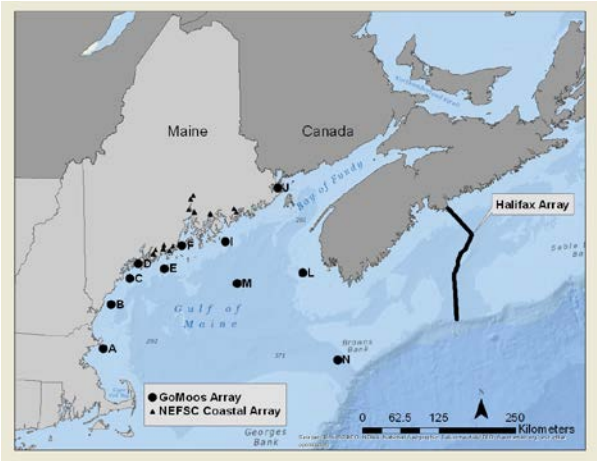
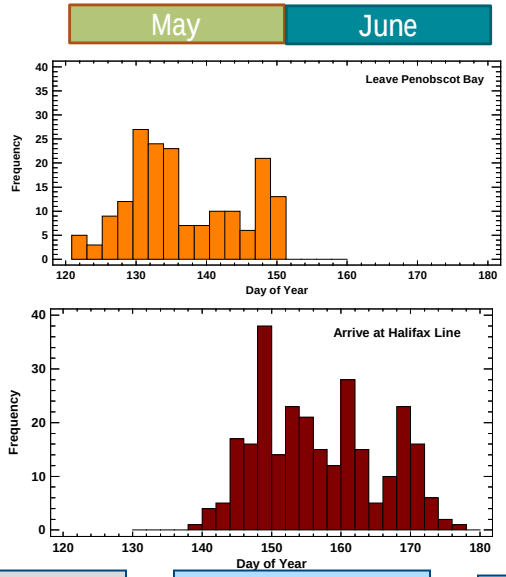
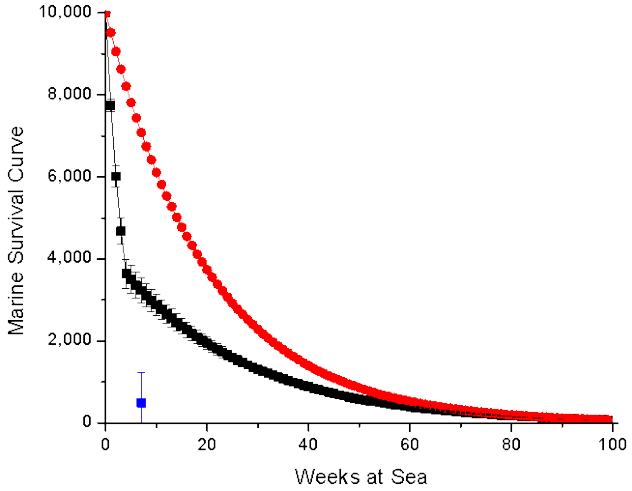
[4]*Rubenstein Ecosystem Science Laboratory, University of Vermont, 3 College Street, Burlington, VT, 05405, U.S.A.*
[5]*NOAA Fisheries Maine Field Station, Northeast Fisheries Science Center, 17 Godfrey Drive, Suite 1, Orono, ME, 04473, U.S.A.*

dramatically influenced post-smolt salmon migration success. There was a trade-off between arriving at the destination quickly but at a small size and not arriving at the destination at all. Fish that took a long time to migrate had more opportunities to feed and encountered warmer summer waters, increasing their overall growth.

Key words: bioenergetics, coastal currents, individual-based model, oceanographic variability, sea surface temperature







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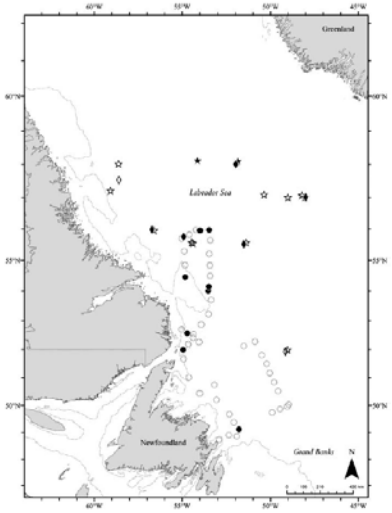
Marine Phase Salmon

- Marine trawl surveys
  - Postsmolt Trawl Survey
    - Nearshore ecology
  - SALSEA North America
    - Ocean ecology



Journal of FISH BIOLOGY

Journal of Fish Biology (2011) **79**, 374–398
doi:10.1111/j.1095-8649.2011.03025.x, available online at wileyonlinelibrary.com

Surface trawl survey for U.S. origin Atlantic salmon *Salmo salar*

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Journal of FISH BIOLOGY

Journal of Fish Biology (2011) **79**, 356–373
doi:10.1111/j.1095-8649.2011.03020.x, available online at wileyonlinelibrary.com

Feeding ecology of early marine phase Atlantic salmon *Salmo salar* post-smolts

M. D. Renkawitz* and T. F. Sheehan

National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543, U.S.A.

NRC Research Press

ARTICLE

Physiological and endocrine changes in Atlantic salmon smolts during hatchery rearing, downstream migration, and ocean entry

Stephen D. McCormick, Timothy F. Sheehan, Björn Thrandur Björnsson, Christine Lipsky, John F. Kocik, Amy M. Regish, and Michael F. O'Dea

ICES Journal of Marine Science

ICES CIEM

ICES Journal of Marine Science (2012), 69(9), 1580–1588. doi:10.1093/icesjms/fss052

SALSEA North America: a pelagic ecosystem survey targeting Atlantic salmon in the Northwest Atlantic

Timothy F. Sheehan[1]*, David G. Reddin[2], Gérald Chaput[3], and Mark D. Renkawitz[1]

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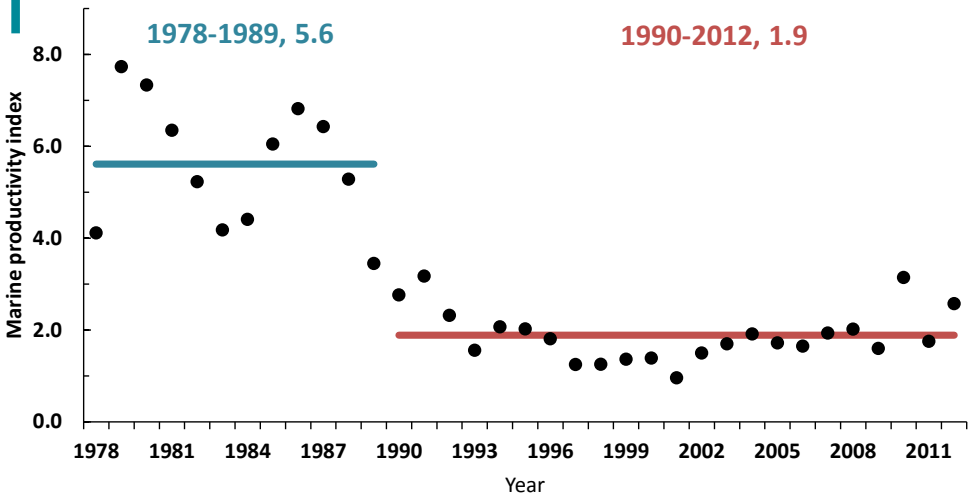
Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Marine Phase Salmon

- Phase-shift in marine productivity
  - Decrease in recruits per spawner
  - Mechanisms not identified



ICES Journal of Marine Science, 62: 131–143 (2005)
doi:10.1016/j.icesjms.2004.10.006

Available online at www.sciencedirect.com
SCIENCE DIRECT

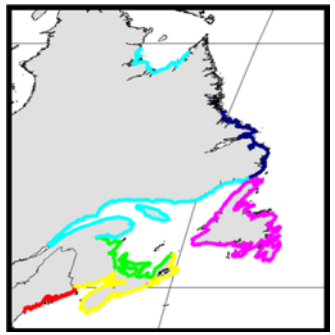
Provision of catch advice taking account of non-stationarity in productivity of Atlantic salmon (*Salmo salar* L.) in the Northwest Atlantic

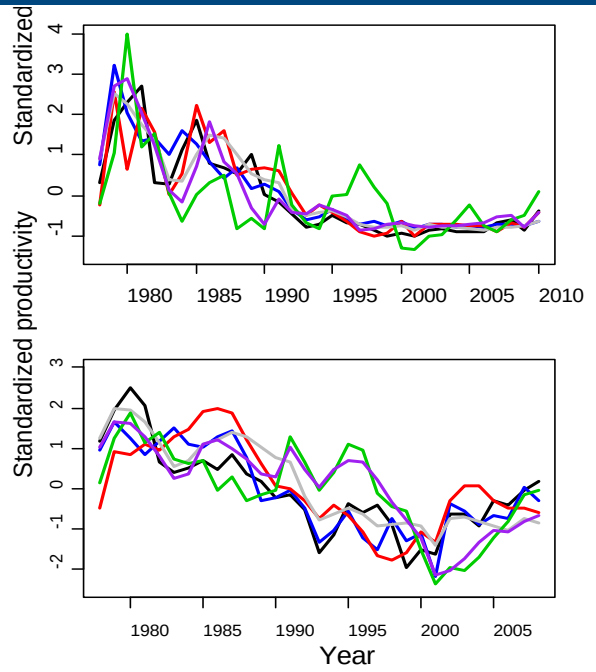
G. Chaput, C. M. Legault, D. G. Reddin, F. Caron, and P. G. Amiro

Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Marine Phase Salmon

- Wide spread coherence
- Ecosystem connections
  - Mechanisms proposed





Global Change Biology

Global Change Biology (2013) **19**, 3046–3061, doi: 10.1111/gcb.12298

Climate and ecosystem linkages explain widespread declines in North American Atlantic salmon populations

KATHERINE E. MILLS*†, ANDREW J. PERSHING*†, TIMOTHY F. SHEEHAN‡ and DAVID MOUNTAIN§

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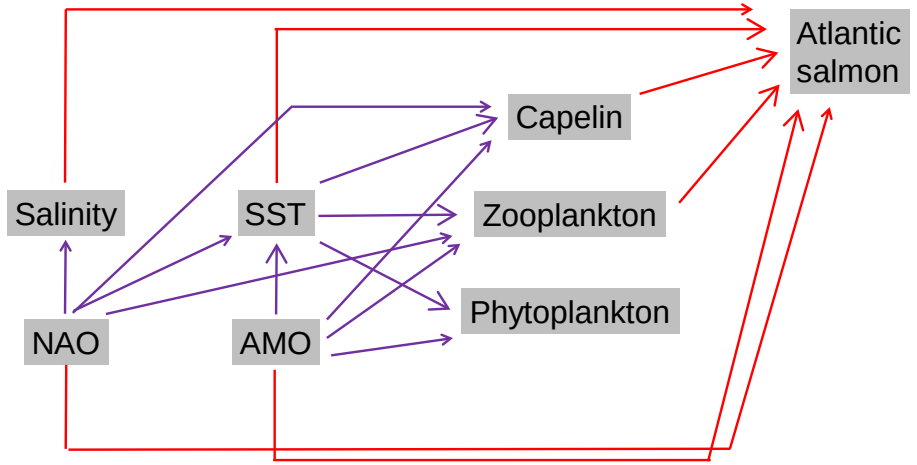
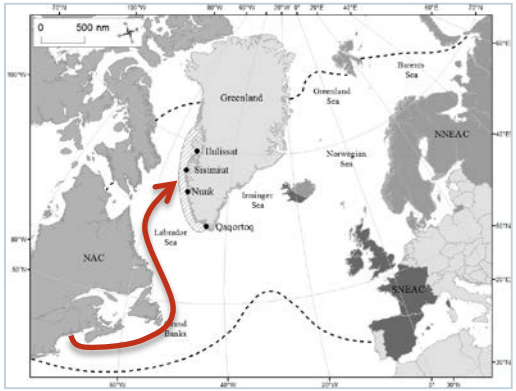
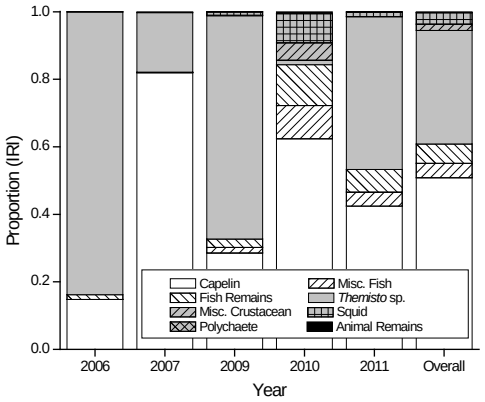


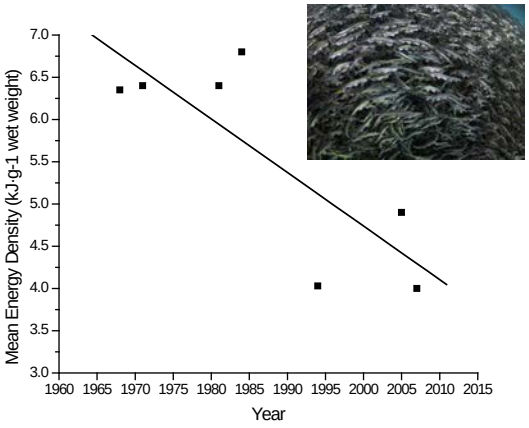
Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

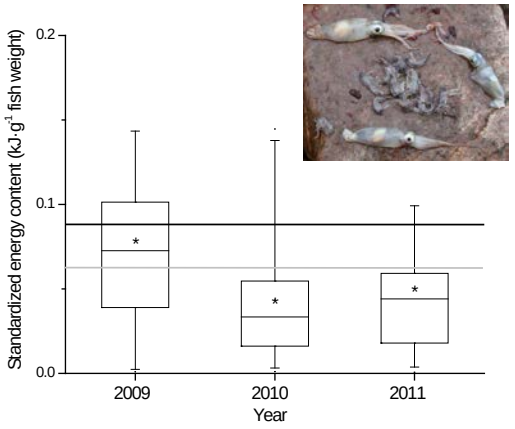
Marine Phase Salmon

- Mechanisms further developed
  - Cascading ecosystem impacts altering food quality







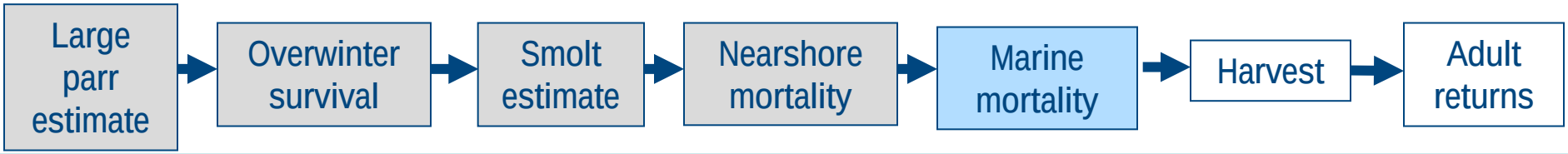


Renkawitz et al. (*in review*)

Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

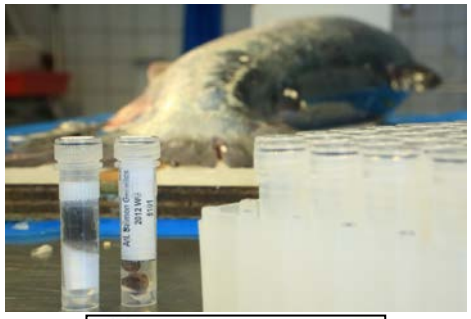
Marine Phase Salmon

- Next Steps (*ongoing*)
- NEC-Gulf of Maine Research Institute collaboration
- Three primary objectives:
  - Evaluate marine growth over time
  - Evaluate ecosystem influences
  - Model energy flow on growth, survival, and productivity



Mixed-stock Fisheries

- Monitoring of harvest at West Greenland
  - Biological Characteristics to support international stock assessment
  - Sampling platform for ecological investigations
    - e.g. SALSEA West Greenland
  - Improved accounting of harvest



Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Mixed-stock Fisheries

- Stock Contributions
  - West Greenland
  - Labrador
  - St Pierre et Miquelon

Probabilistic-based genetic assignment model: assignments to subcontinent of origin of the West Greenland Atlantic salmon harvest

Timothy F. Sheehan, Christopher M. Legault, Timothy L. King, and Adrian P. Spidle

Sheehan, T. F., Legault, C. M., King, T. L., and Spidle, A. P. 2010. Probabilistic-based genetic assignment model: assignments to subcontinent of origin of the West Greenland Atlantic salmon harvest. – ICES Journal of Marine Science, 67: 537–550.

A multistock Atlantic salmon (*Salmo salar*) fishery operates off the coast of West Greenland and harvests fish of North American and European origin. Annual landings peaked in 1971 at 2700 t, but declined to 22 t in 2003. Biological data are collected to characterize the catch and its stock composition. Multilocus genotypes, generated via microsatellite DNA analysis, are used to derive statistics on continent of origin and less accurate finer-scale assignments. We developed a probabilistic-based genetic assignment (PGA) model to

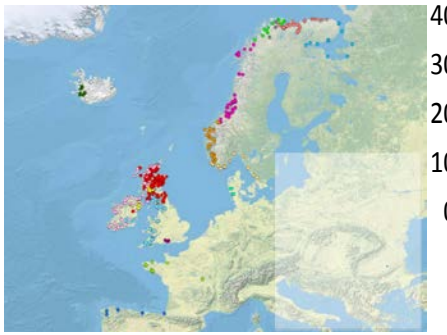
NRC Research Press

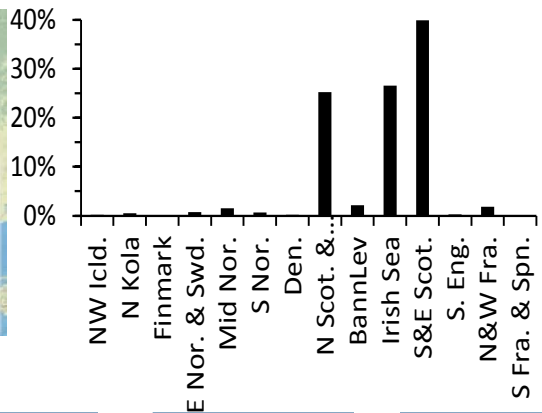
ARTICLE

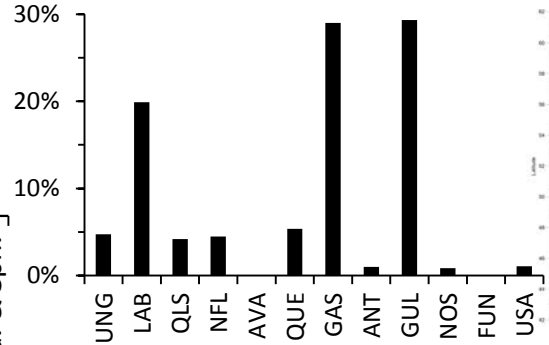
Genetic evidence of local exploitation of Atlantic salmon in a coastal subsistence fishery in the Northwest Atlantic

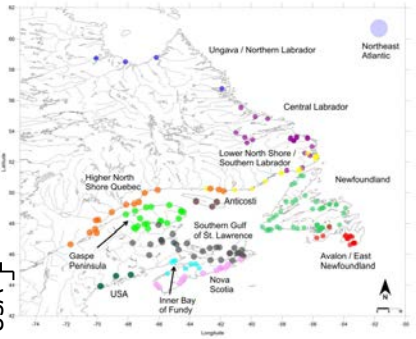
Ian R. Bradbury, Lorraine C. Hamilton, Sara Rafferty, David Meerburg, Rebecca Poole, J. Brian Dempson, Martha J. Robertson, David G. Reddin, Vincent Bourret, Mélanie Dionne, Gerald Chaput, Timothy F. Sheehan, Timothy L. King, John R. Candy, and Louis Bernatchez

Abstract: Fisheries targeting mixtures of populations risk the overutilization of minor stock constituents unless harvests are monitored and managed. We evaluated stock composition and exploitation of Atlantic salmon (*Salmo salar*) in a subsistence fishery in coastal Labrador, Canada, using genetic mixture analysis and individual assignment with a microsatellite baseline (15 loci, 11 829 individuals, 12 regional groups) encompassing the species' western Atlantic range. Bayesian and maximum likelihood mixture analyses of fishery samples over 6 years (2006–2011; 1772 individuals) indicate contributions of adjacent stocks of 96%–97%. Estimates of fishery-associated exploitation were highest for Labrador salmon (4.2%–10.6% per year) and generally <1% for other regions. Individual assignment of fishery samples indicated nonlocal contributions to the fishery (e.g., Quebec, Newfoundland) were rare and primarily in southern Labrador, consistent with migration pathways utilizing the Strait of Belle Isle. This work illustrates how genetic analysis of mixed stock Atlantic salmon fisheries in the Northwest Atlantic using this new baseline can disentangle exploitation and reveal complex migratory behaviours.









Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Adult Returns

- Monitoring adult returns
  - Traps
  - Redd counts
- Compiled and reports to USASAC, ICES and NASCO

ANNUAL REPORT OF THE U.S. ATLANTIC SALMON ASSESSMENT COMMITTEE

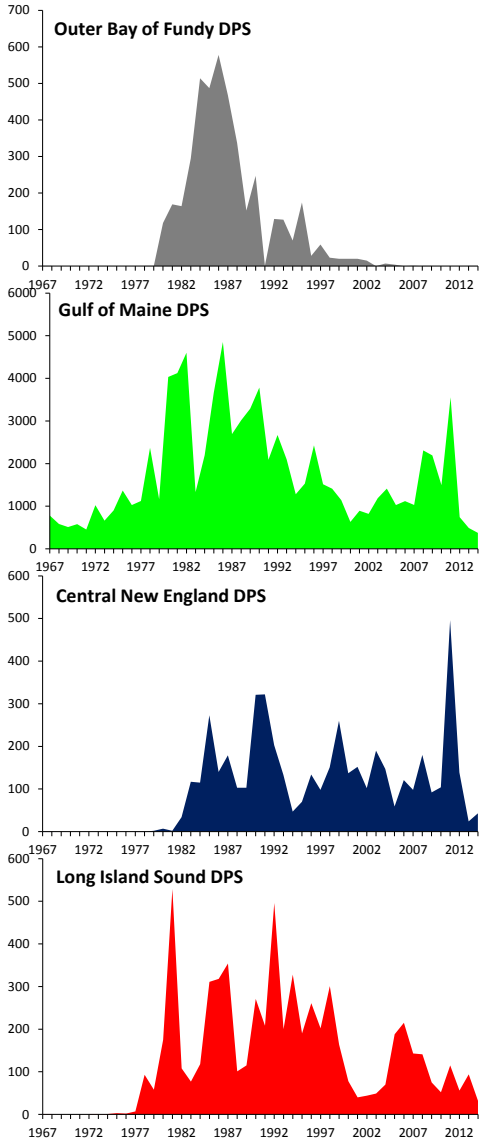
REPORT NO. 25 - 2012 ACTIVITIES

Old Lyme, Connecticut
February 25-28, 2013

25th Anniversary
U.S. Atlantic Salmon Assessment Committee
1987 2012

PREPARED FOR

U.S. SECTION TO NASCO



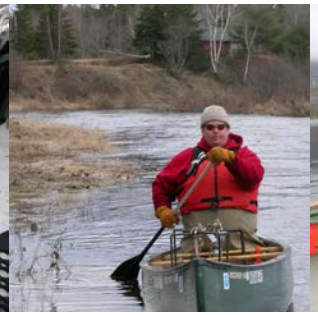
Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Significant Gains in Demographic Knowledge

Pre-1995

Large parr estimate → Assumed overwinter survival → Adult returns






Present

Large parr estimate → Overwinter survival → Smolt estimate → Nearshore mortality → Marine mortality → Harvest → Adult returns

Questions - Discussion

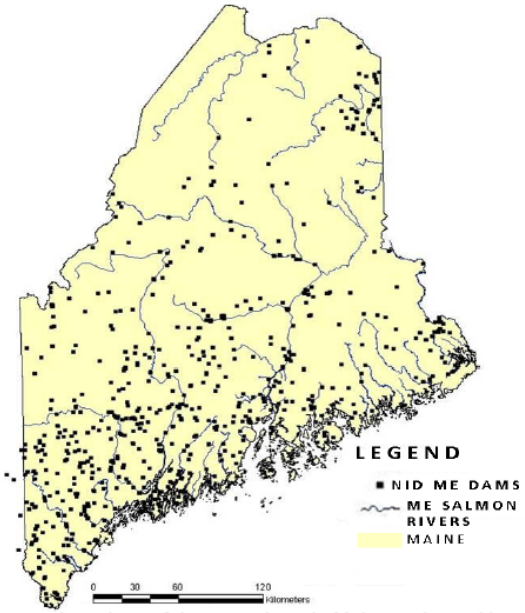
Photo credit: Audun Rikardsen

Successes In Research

Dams

Dam Impacts

- Ubiquitous across the NE landscape
- A primary threat to Atlantic salmon
- Significantly impact diadromous species dynamics and productivity
  - Injure or kill (direct, indirect and latent)
  - Reduced connectivity
  - Limit habitat access
  - Alter hydraulics
  - Alter habitat type
- Impacts were (generally) known
  - Monitoring was limited to the responsibility of the dams owners
  - Focused primarily on fish passage

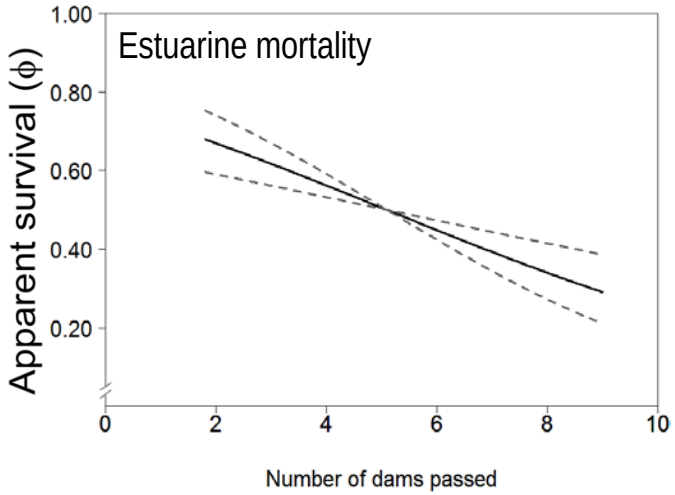


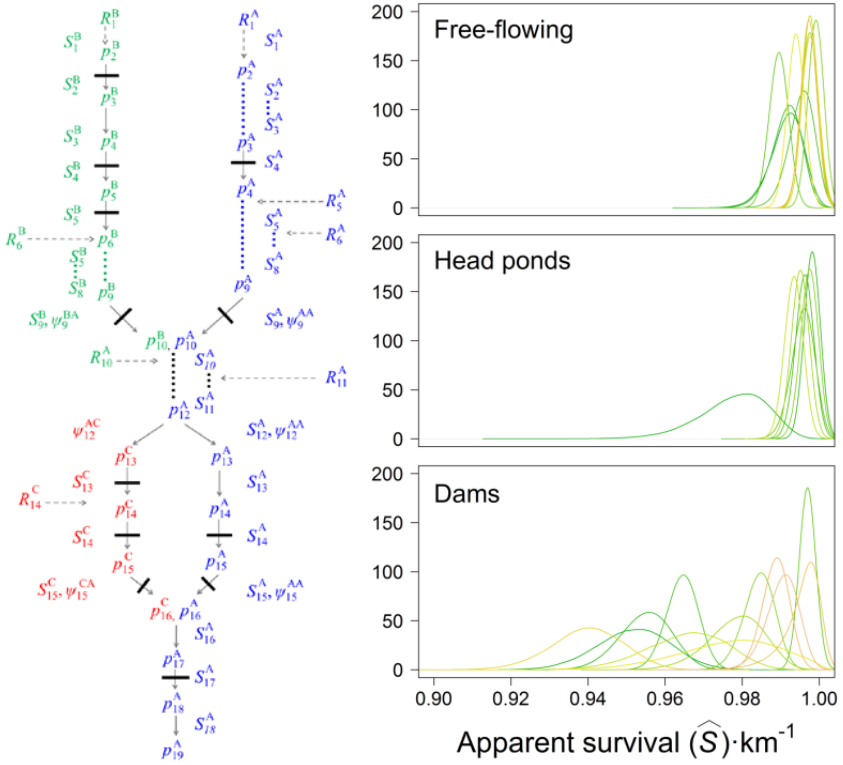
Locations of the 600+ dams in Maine registered in the National Inventory of Dams (NID)(http://geo.usace.army.mil).

Locations of the 600+ dams in Maine registered in the National Inventory (> 4 ft.). Majority were constructed prior to the 1920's.

Dam Mortality Studies

- Telemetry studies to evaluate dam impacts
  - Baseline mortality estimates
  - Dam-specific mortality
  - Cumulative and latent mortality





Journal of FISH BIOLOGY
fsbi

Journal of Fish Biology (2014)
doi:10.1111/jfb.12483, available online at wileyonlinelibrary.com

Survival of Atlantic salmon *Salmo salar* smolts through a hydropower complex

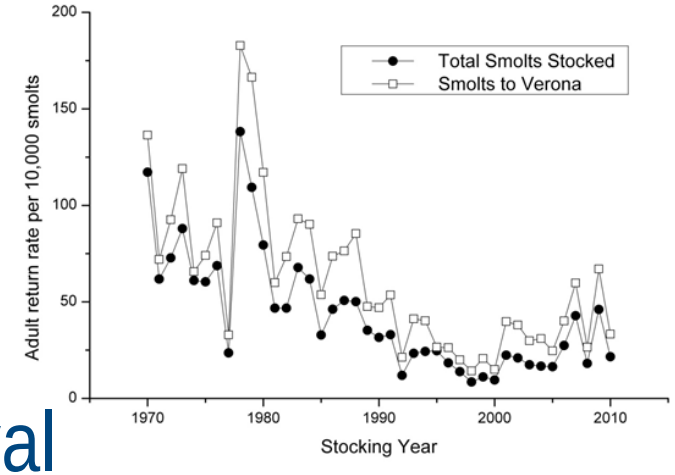
D. S. Stich*†, M. M. Bailey‡ and J. D. Zydlewski*§

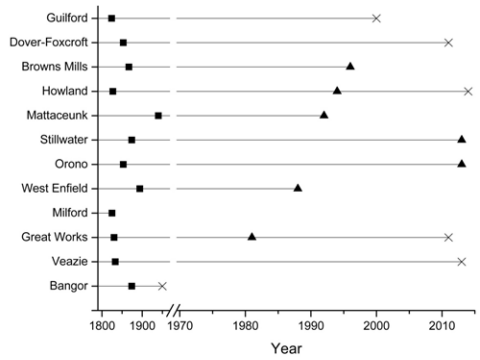
*Department of Wildlife Ecology, 5755 Nutting Hall, University of Maine, Orono, ME 04469, U.S.A., ‡U.S. Fish and Wildlife Service, Central New England Fishery Resource Office, Nashua, NH 03063, U.S.A. and §U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, 5755 Nutting Hall, University of Maine, Orono, ME 04469, U.S.A.

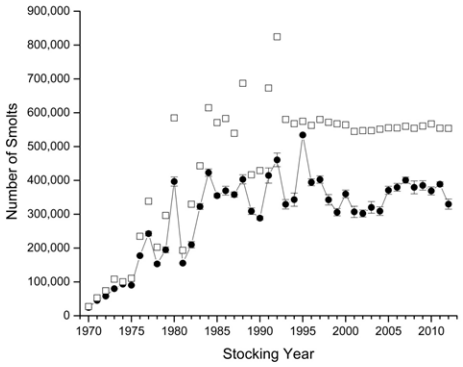
PenPass – a Retrospective Survival Model

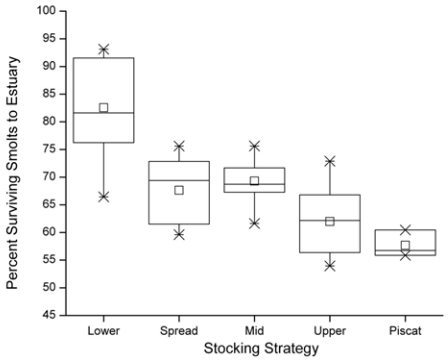
- Modelled the effect of downstream dam passage on hatchery smolt survival
  - Smolt stocking location
  - Year-specific flows
- 1970-2012, 54-93% (68%) survival

Stevens et al. (*in review*)





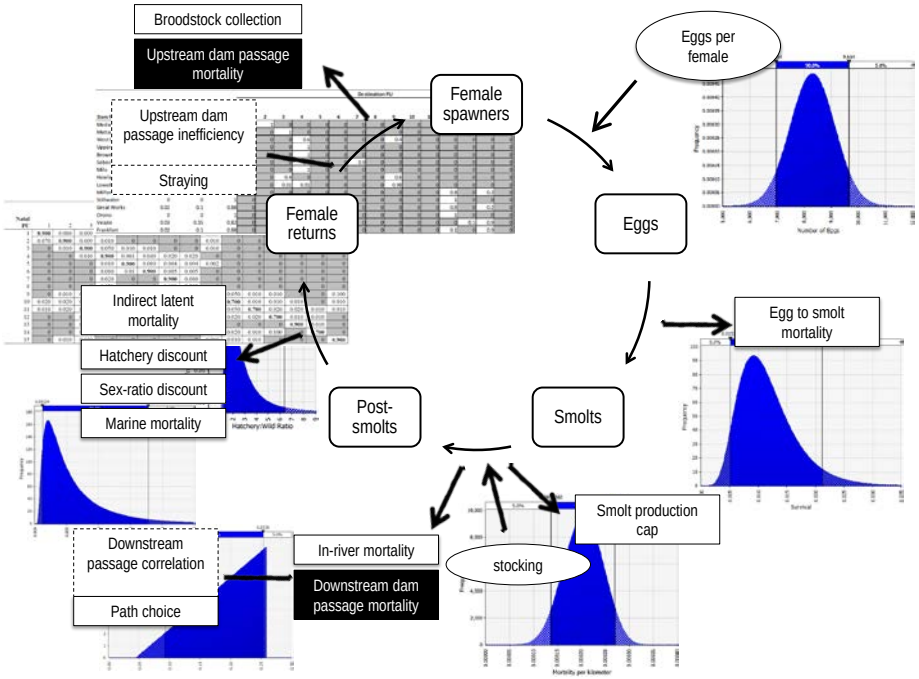


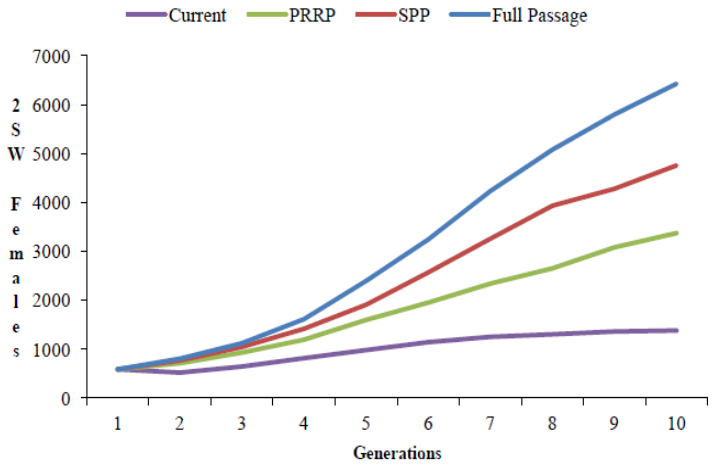


Dam Impact Analysis

- Life cycle model to support FERC permitting
  - Used to support performance standards

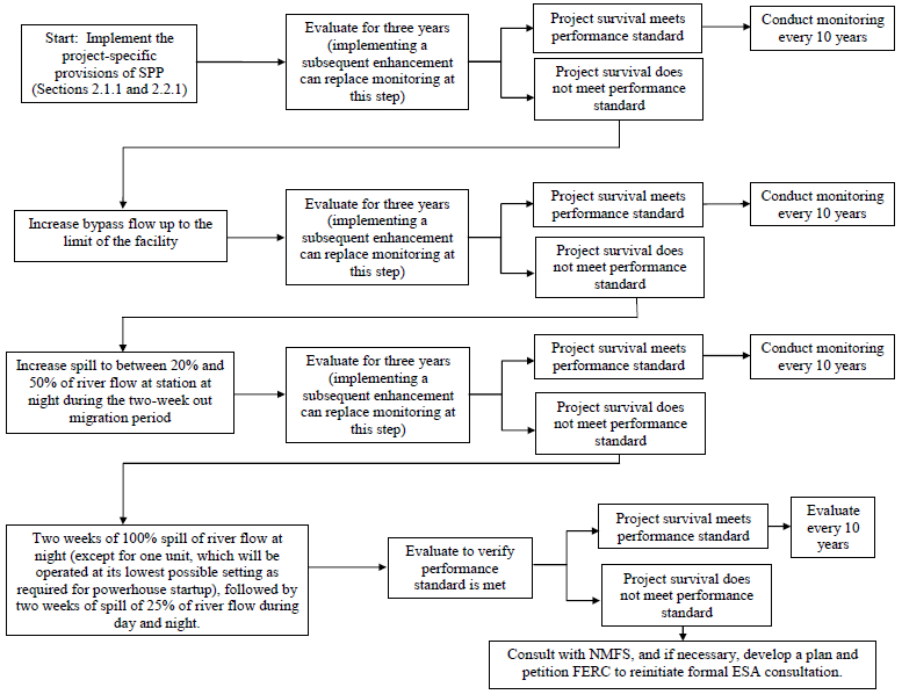
Nieland et al. (*in review*)





Performance Standards

- ESA Section 7 consultation and support
- Upstream/downstream passage survival need to achieve conservation goals
  - Accounting for direct, indirect and cumulative mortality
- Supported the development, implementation and monitoring of Species Protection Plan



Questions - Discussion

Successes In Research

Ecosystem Approach

Ecosystem processes

- Restoration beyond hatcheries
- Goal: restore the overall structure and function of healthy diadromous ecosystems
- Benefits:
  - Habitat conditioning
  - Increased fish abundance and diversity
  - Prey buffering
  - Marine-derived nutrients

COURTESY OF THE BANGOR DAILY NEWS; USED WITH PERMISSION

A successful day of Atlantic salmon fishing on the Penobscot River in 1926.

FEATURE:
ENDANGERED SPECIES

Maine's Diadromous Fish Community: Past, Present, and Implications for Atlantic Salmon Recovery

Rory Saunders
Michael A. Hachey
Clem W. Fay

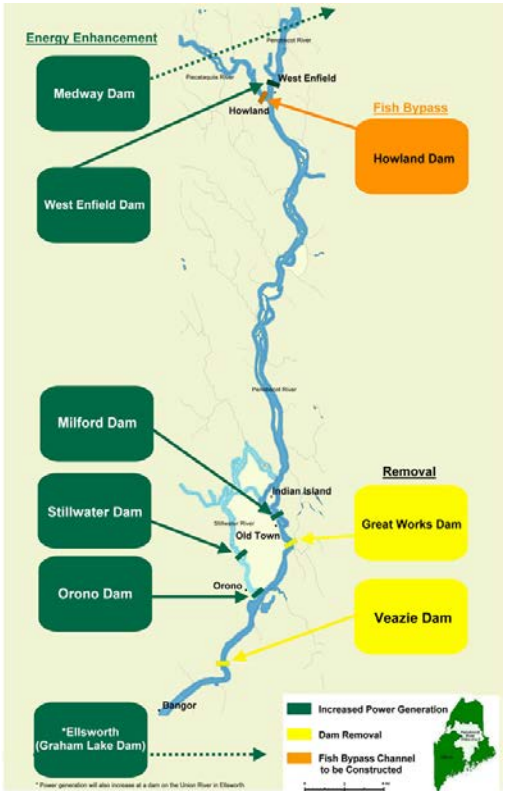
Saunders is a fishery biologist, NOAA's National Marine Fisheries Service, Orono, Maine and can be reached at Rory.Saunders@noaa.gov. Hachey is an environmental technician, NOAA's National Marine Fisheries Service, Orono, Maine. Fay was a fisheries manager, for the Penobscot Nation, Department of Natural Resources, Indian Island, Maine.

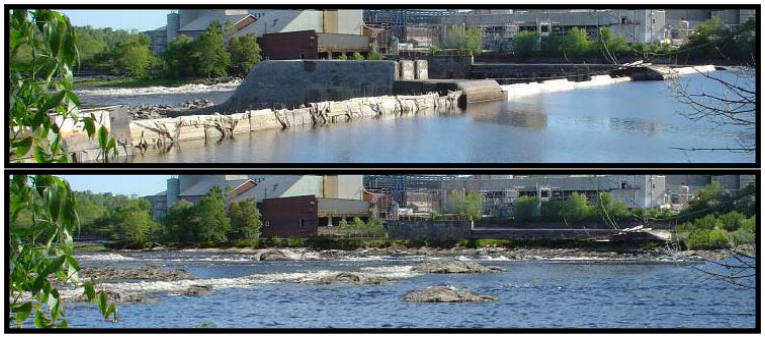
Ecosystem Services

- Salmon need healthy habitats and healthy diadromous communities
  - Alewives
    - Prey buffer juvenile salmon and marine derived nutrients
  - American shad
    - Prey buffer for adult salmon
  - Sea lampreys
    - Nutrient cycling, invertebrate production and habitat conditioning
  - Rainbow smelt
    - Prey buffer for smolts and food for kelts

Ecosystem Monitoring of Dam Removal

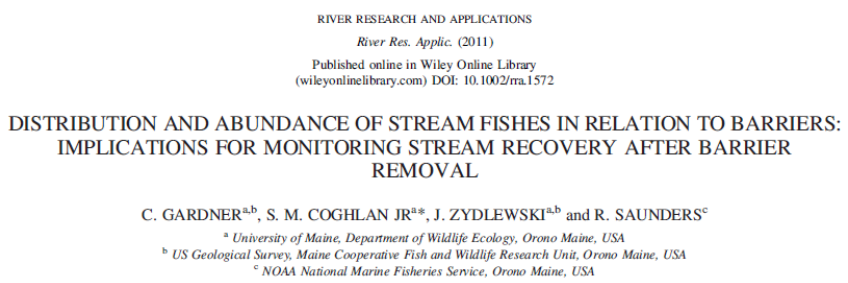
- Penobscot River Restoration Project
  - Nine studies (2009-ongoing)
  - BACI design
    - Geomorphology
    - Water quality and benthic inverts
    - Upstream and downstream fish passage
    - Sturgeon dynamics
    - Fish community and biomass
    - Wetlands and riparian habitat
    - Marine-derived Nutrients
- Quantify ecological benefits and consequences





Habitat Conditioning

- Impacts of barriers and legacy effects of forestry, agriculture, and urbanization
  - Increased siltation/embeddedness
- Investigations into diadromous species restoration dynamics
  - Impacts of dam removal upon these factors
- Sedgeunkedunk Stream - two low-head dams removed
    - Pre and post-monitoring (ongoing)
  - Positive responses by diadromous fishes
    - Atlantic salmon, alewife, sea lamprey, sea lamprey and rainbow smelt
  - Sea lamprey nest building
    - Habitat conditioning and increased invertebrate/fish production



RIVER RESEARCH AND APPLICATIONS

River Res. Applic. (2011)

Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.1572

DISTRIBUTION AND ABUNDANCE OF STREAM FISHES IN RELATION TO BARRIERS: IMPLICATIONS FOR MONITORING STREAM RECOVERY AFTER BARRIER REMOVAL

C. GARDNER[a,b], S. M. COGHLAN JR[a]*, J. ZYDLEWSKI[a,b] and R. SAUNDERS[c]

[a] *University of Maine, Department of Wildlife Ecology, Orono Maine, USA*
[b] *US Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, Orono Maine, USA*
[c] *NOAA National Marine Fisheries Service, Orono Maine, USA*

Freshwater Biology

Freshwater Biology (2014) 59, 1294–1307 doi:10.1111/fwb.12349

Anadromous sea lampreys (*Petromyzon marinus*) are ecosystem engineers in a spawning tributary

ROBERT S. HOGG*, STEPHEN M. COGHLAN JR*, JOSEPH ZYDLEWSKI† AND KEVIN S. SIMON‡

**University of Maine, Department of Wildlife Ecology, Orono, Maine, USA*
†U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, Maine, USA
‡The University of Auckland, School of Environment, Auckland, New Zealand

Increased fish abundance and diversity

- Restricted diadromous species distribution
- Immediate distribution increases post-removal
  - **River herring** in Blackman Stream and **American shad** above Milford – first time in 100+ years
  - **River herring** counts improved from 12,000 to >300,000
  - Benefits expected to cascade throughout the ecosystem as sub-watersheds continue to be seeded with spawning adults

RIVER RESEARCH AND APPLICATIONS
River Res. Applic. (2014)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.2738

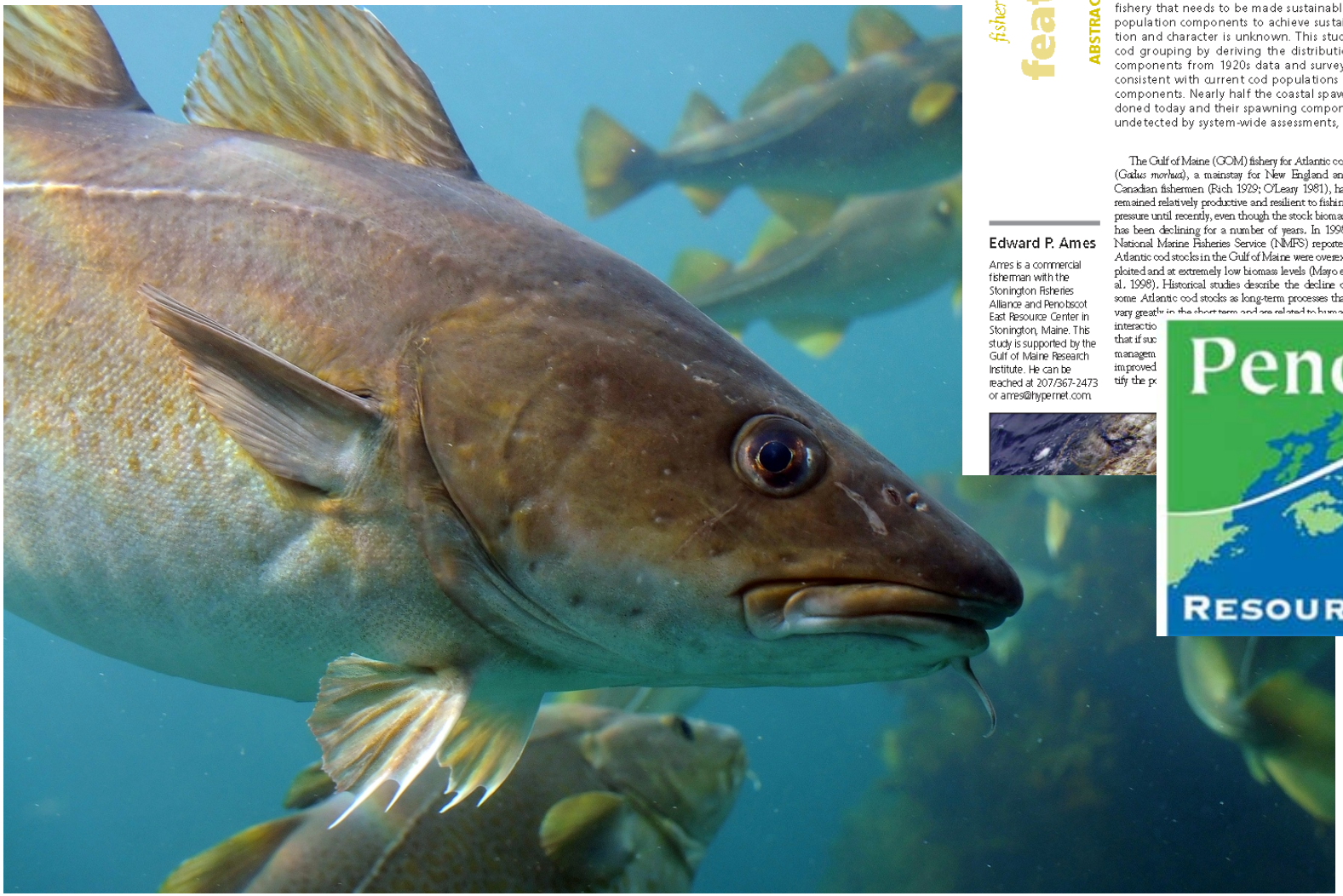
AN ASSESSMENT OF FISH ASSEMBLAGE STRUCTURE IN A LARGE RIVER

I. A. KIRALY[a*], S. M. COGHLAN JR.[a], J. ZYDLEWSKI[a,b] AND D. HAYES[c]
[a] *Department of Wildlife Ecology, University of Maine, Orono, Maine, USA*
[b] *US Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, Maine, USA*
[c] *Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan, USA*

Increased fish abundance and diversity

- NEC monitoring to understand changes in the structure and function of the Penobscot estuary
  - 12 of the 12 historical diadromous species documented
  - Multiple year classes of alewives
  - American shad spawning documented
- Leveraging resources, collaborating and increasing ecosystem view
  - Shortnose and Atlantic sturgeon ecology
  - Mysid distribution and dynamics

Beyond Atlantic salmon



fisheries research **feature**

Atlantic Cod Stock Structure in the Gulf of Maine

ABSTRACT

Atlantic cod (*Gadus morhua*) in the Gulf of Maine provide an important but depleted fishery that needs to be made sustainable. However, restoring and maintaining robust population components to achieve sustainability is made difficult when their distribution and character is unknown. This study clarifies the structure of the Gulf of Maine cod grouping by deriving the distribution, movements, and behavior of population components from 1920s data and surveys of retired fishermen. These derivations are consistent with current cod populations and with the existence of localized spawning components. Nearly half the coastal spawning grounds of 50 to 70 years ago are abandoned today and their spawning components have disappeared, suggesting depletion, undetected by system-wide assessments, may have been well advanced by the 1980s.

Edward P. Ames

Ames is a commercial fisherman with the Stonington Fisheries Alliance and Penobscot East Resource Center in Stonington, Maine. This study is supported by the Gulf of Maine Research Institute. He can be reached at 207/367-2473 or ames@hypernet.com.

The Gulf of Maine (GOM) fishery for Atlantic cod (*Gadus morhua*), a mainstay for New England and Canadian fishermen (Rich 1929; O'Leary 1981), has remained relatively productive and resilient to fishing pressure until recently, even though the stock biomass has been declining for a number of years. In 1998, National Marine Fisheries Service (NMFS) reported Atlantic cod stocks in the Gulf of Maine were overexploited and at extremely low biomass levels (Mayo et al. 1998). Historical studies describe the decline of some Atlantic cod stocks as long-term processes that vary greatly in the short term and are related to human interactio
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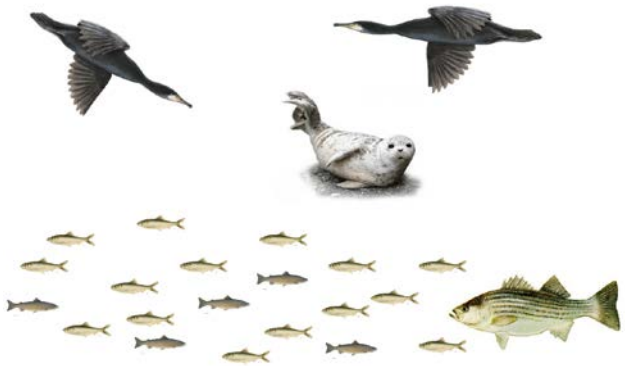
a line from northern Massachusetts Bay (42 30'N) to Wrights Swell (42 30'N, 68W), thence northeast to Yarmouth, N. S. (43 50'N, 66 7'W) (Figure 1).

A Review of Atlantic Cod Population Structure and Dynamics in the Gulf of Maine. To clarify the terms used to describe population structure, the following definitions were used: a population is a self-reproducing group of conspecific individuals that inhabit the same range at the same time, are affected by similar environmental factors, and are reproductively isolated from other populations. A

Penobscot EAST RESOURCE CENTER

Prey buffering

- Estuarine survey
  - Timing, location, size range, and abundance and distribution of diadromous species
- Telemetry
  - Salmon smolt migration timing, dynamics, ecology and survival
- Combining data to investigate the prey buffering hypothesis



Marine-derived nutrients

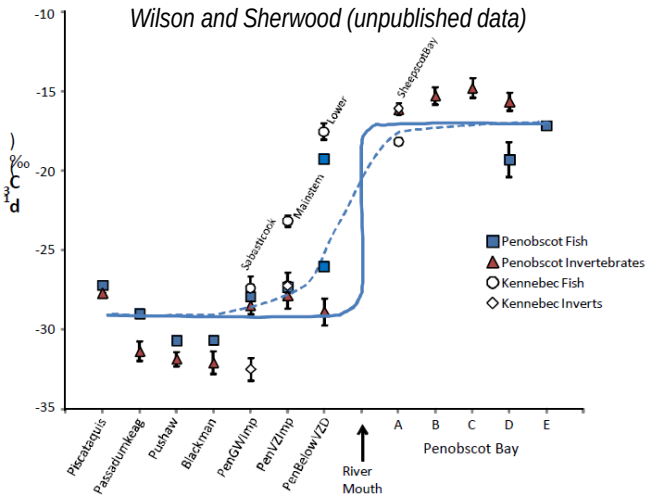
- Evaluation of impacts of salmon carcass analogs on productivity
  - Increased composition and abundance of the macroinvertebrates and ichthyofauna
  - Increased Atlantic salmon growth

- Baselines collected to study food-web structure and function post dam removals
  - Marked differences for fresh and saltwater consumers
  - Abrupt freshwater to marine transition
  - Not as strong in adjacent systems

860
NRC Research Press
ARTICLE

Carcass analog addition enhances juvenile Atlantic salmon (*Salmo salar*) growth and condition

Margaret Q. Guyette, Cynthia S. Loftin, and Joseph Zydlewski



Major Successes

- Marine Survival
  - Have partitioned marine mortality in time and space
  - Offered plausible hypotheses on the causal mechanisms
- Dam Impacts
  - Quantified impacts to salmon restoration
  - Quantitative support for management
- Ecosystem Approach to Recovery Science
  - Testing diadromous species connection to salmon restoration hypotheses
  - Facilitating diadromous species restoration efforts

Questions - Discussion