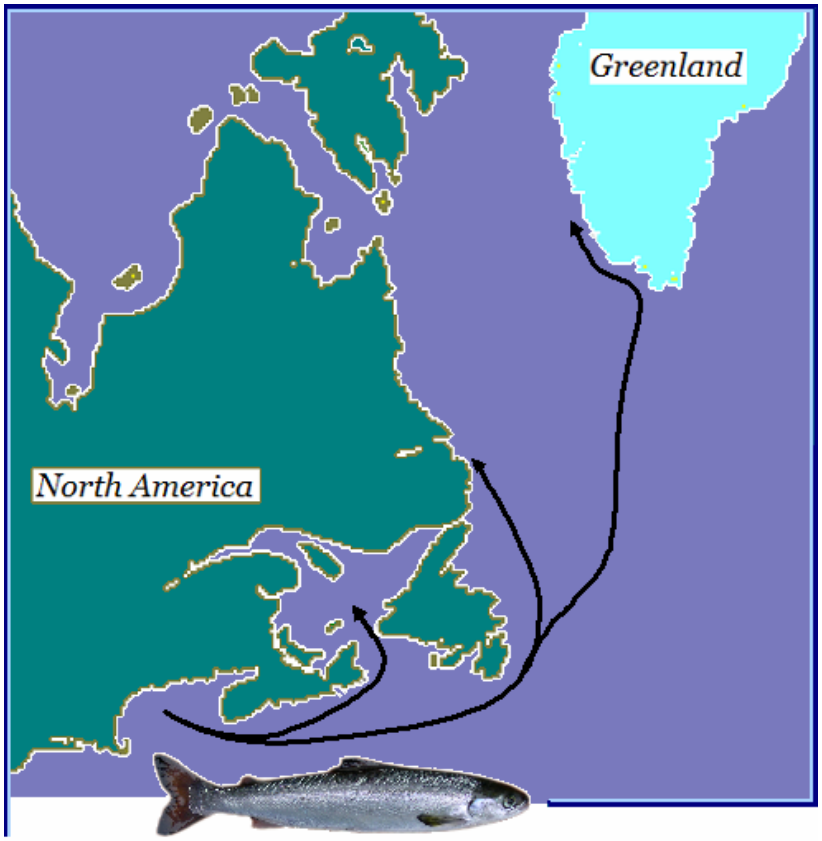
Northeast Salmon Team (NEST) Fact Sheet Collection

Survey of North Atlantic Fishes for Salmonid Pathogens

All fish, including Atlantic salmon, can host and transmit a variety of parasites, bacteria and viruses. Under certain circumstances, these pathogens can impair a fish's health and result in the expression of disease. Although the hosting and transmission of pathogens is a both natural and common, disease-causing pathogens pose a significant threat to remnant, already-compromised populations. Imperiled species such as Atlantic salmon are particularly vulnerable to disease outbreaks for several reasons.

First, a population's *resiliency* (in this case, its ability to absorb a disease outbreak and persist through time) is largely related to abundance. Threatened and endangered species lack the capacity in numbers necessary to buffer against the potentially devastating population-level effects of disease outbreaks. Not only does any source of mortality threaten the continued persistence of imperiled species, but a reduced gene pool also decreases the likelihood that some individuals will possess and pass disease-resistant genetic traits to their offspring.



The migration route of U.S. Atlantic salmon. *Throughout their life cycle, Atlantic salmon are exposed to and interact with a variety of different fish species in freshwater, estuary and marine environments that may host pathogens.*

Second, disease is more apt to occur under stressful conditions. Juvenile Atlantic salmon undergo *smoltification*, a natural (albeit taxing) physiological transformation that prepares them for the marine environment. Coupled with human-caused environmental stressors, such as degraded water quality and obstacles hindering migration (e.g. dams and drawn-down river water), a wild salmon's natural ability to fight disease could decrease.

Third, Atlantic salmon intermingle with a variety of different fish species that can host and transmit a number of pathogens. At any point during their residency in freshwater, estuary or marine environments, Atlantic salmon can be exposed to pathogens through ecological interactions with other fishes. Recent outbreaks of Infectious Salmon Anemia (ISA), a lethal viral disease, in marine aquaculture sites also pose a disease threat to migrating Atlantic salmon passing in close proximity.

Of particular concern are pathogens that commonly affect *salmonids* (salmon and trout species) as these are most likely to be transmitted to and affect wild Atlantic salmon. Due to their potential to be spread, cause disease or even result in death, the salmonid pathogens with the greatest potential to threaten remnant populations of Atlantic salmon are parasitic sea lice, Renibacterium salmoninarum (the causative agent of bacterial kidney disease, or BKD), infectious salmon anemia virus (ISAV), salmon swimbladder sarcoma virus (SSSV) and viral hemorrhagic septicemia virus (VHSV).

Although there is little information on the potential for non-salmonids to be carriers of salmonid pathogens, there is scientific evidence demonstrating that certain marine species can be carriers of ISAV. As such, NEST is conducting a survey of fishes in Maine's rivers, coastal New England areas and the North Atlantic Ocean to determine which species could host and transmit these pathogens.

Species Surveyed for Pathogens

Alewife (*Alosa pseudoharengus*)

American eel (*Anguilla rostrata*)

American plaice
(Hippoglossoides platessoides)

Roman Slaboch

American shad (*Alosa sapidissima*)

Atlantic cod (*Gadus morhua*)

Atlantic halibut
(*Hippoglossus hippoglossus*)

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Atlantic herring
(*Clupea harengus harengus*)

Uwe Kils

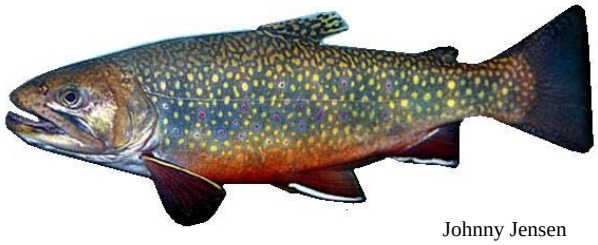
Atlantic salmon (*Salmo salar*)

Robert M. McDowall

Atlantic mackerel
(*Scomber scombrus*)

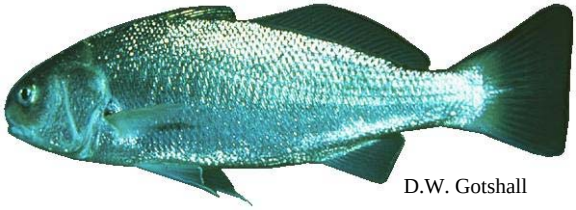
Bernd Ueberschaer

Sea-run brook trout (*Salvelinus fontinalis*)



Johnny Jensen

Atlantic tomcod (Microgadus tomcod)



D.W. Gotshall

Blueback herring (*Alosa aestivalis*)

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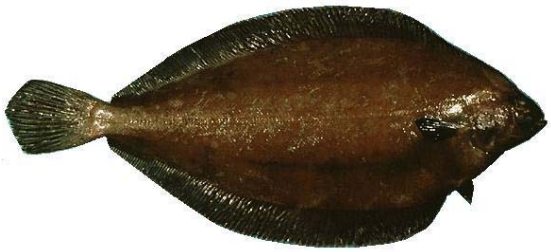
Haddock (*Melanogrammus aeglefinus*)

Gray sole
(Glyptocephalus cynoglossus)



Longhorn sculpin
(*Myoxocephalus octodecemspinosus*)

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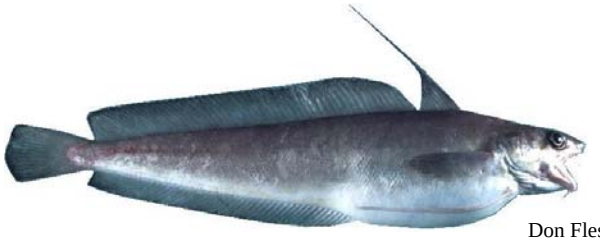
Lumpfish (*Cyclopterus lumpus*)

Pollock (*Pollachius virens*)

Rainbow smelt (*Osmerus mordax mordax*)

Red hake (Urophycis chuss)



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Sea lamprey (*Petromyzon marinus*)

Silver hake (*Merluccius bilinearis)*

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White hake (*Urophycis tenuis*)

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Winter flounder
(*Pseudopleuronectes americanus*)

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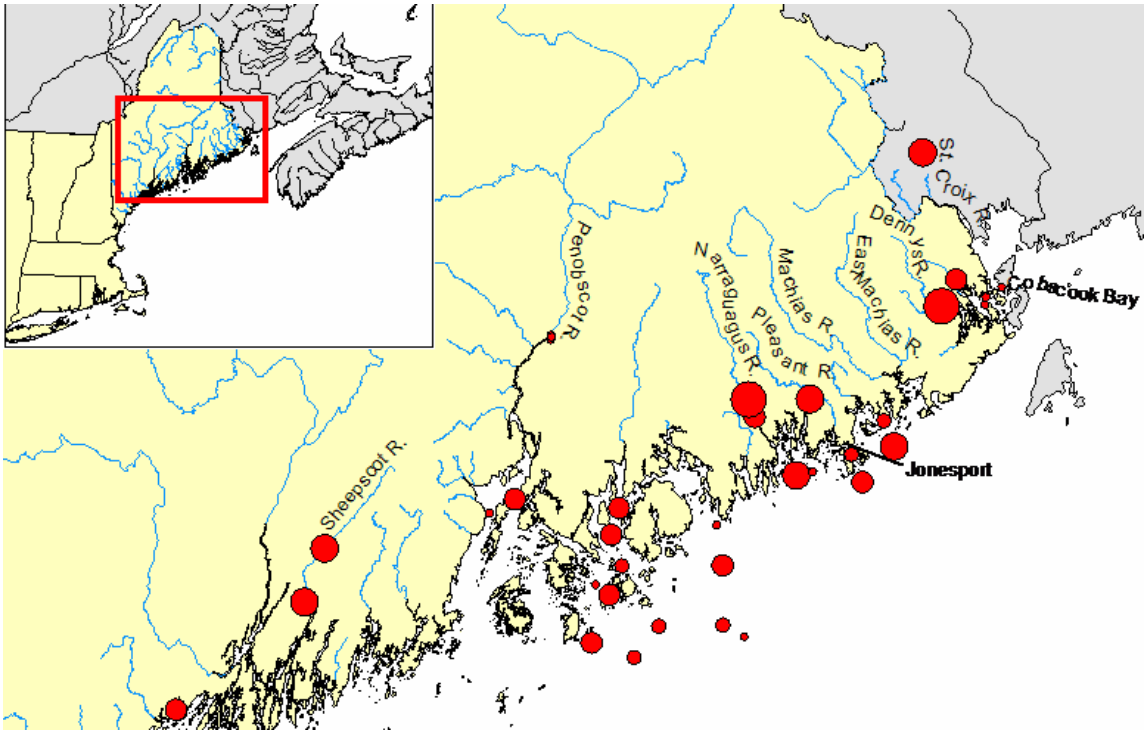
Since 2000, a multitude of individuals from NEST, Maine's Atlantic Salmon Commission and Departments of Marine Resources and Inland Fisheries and Wildlife, the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service, the University of Maine Sea Grant, and Atlantic salmon aquaculture industry have cooperated to sample more than 5,000 individual fish representing these 23 species. Fish were collected in NEST's rotary screw traps and state-run weirs, during coastal and offshore bottom trawl surveys, from fishermen's catches of Atlantic salmon from the coast of West Greenland, near and inside ISAV-positive marine net pens, experimental river enclosures and more.

A cooperator form the USDA collects alewives from the Dennys River for pathogen/disease screening. Like Atlantic salmon, the alewife is anadromous and occupies the same space as Atlantic salmon during certain portions of its life history.

All of the species sampled to date spend at least a portion of their life in the marine environment. Like Atlantic salmon, species such as the alewife, American shad, rainbow smelt, sea lamprey and tomcod, are *anadromous*—they spend their juvenile life in freshwater, migrate to sea as adults, and return to the river in which they were born to spawn. The catadromous American eel spends its juvenile life at sea and in riverine environments as an adult. Still others, like the Atlantic cod, lumpfish and flatfish species (sole, plaice, halibut, flounder) spend their entire life in estuarine and marine environments.

These species can inhabit the same space during various stages of an Atlantic salmon's life history and interact ecologically. For example, adult alewives overlap in time and space with Atlantic salmon smolts. As adult alewives are migrating upstream in Maine's rivers to spawn, Atlantic salmon smolts are migrating downriver to sea. Non-target species caught during NESTs postsmolt trawl (PST) survey confirm that a number of different species occupy the same space as juvenile Atlantic salmon emigrating from Maine's rivers. PST data revealed that Atlantic herring and lumpfish are the dominant fish species in different areas of Penobscot Bay. Other species caught included American shad, striped bass, sea lamprey, rainbow smelt, Atlantic tomcod, capelin, Atlantic silversides, threespined stickleback, hake species, and butterfish. Furthermore, several marine species (e.g., cod and lumpfish) are commonly found in Atlantic salmon aquaculture net pens, thus allowing for interactions including pathogen transfer.



Locations and relative number of fishes sampled in Maine from 2003-2005. In addition, fishes were collected offshore from New Jersey, Georges Bank, Massachusetts, New Hampshire and Maine and also from the west coast of Greenland.

Results of Pathogen Testing

Parasites. "Sea lice", including the salmon louse (*Lepeophtheirus salmonis*) and other copepods (*Caligus* species, for example), feed on fish blood, mucous and skin. Their feeding activities can cause skin ulcers that put the host fish as risk for secondary infection by bacteria and fungi, affect the host's ability to *osmoregulate* (control the balance of water and electrolytes in its body), and even reduce its swimming performance. While we know the most about the salmon louse (which is primarily a parasite of salmonids), we know less about *Caligus* species. We do know that they primarily parasitize non-salmonid marine fishes, as well as salmonids. The hosts of one particular species, *C. elongates*, include about 80 different marine species.

A salmon louse. Pictured here up-close on an adult salmon.

In addition to compromising a fish's health through parasitism, recent laboratory tests and published articles suggest that these copepods may also transmit the ISA virus. A sample of 44 *L. salmonis* from Atlantic salmon adults harvested from an ISA-diseased marine aquaculture site had 43 of the 44 copepods test positive for ISAV. Ninety-three percent of the ISAV-positive copepods had ISAV-positive host fish, indicating that ISAV can be transmitted by copepods, since infected copepods (especially *Caligus* species) can move from one fish to another.

Necropsy of fish for viral pathogen testing by cooperators from USDA.

Bacteria and Viruses. Tissues samples from fishes were tested for *R. salmoninarum*, ISAV, SSSV and VHSV. The diagnostic procedures followed those presented in the American Fisheries Society's Fish Health Section Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens (commonly referred to as The Blue Book).

Necropsy set-up for juvenile Atlantic cod taken from a harvested salmon net pen by cooperators from USDA.

BKD was not detected in any of the 3,580 fishes tested. Results from the viral testing indicated that salmonid viruses are present in wild non-salmonid fish populations, but not at significant levels. ISAV was detected in one individual from the West Greenland Atlantic salmon fishery. However, the detection of ISAV in samples from non-salmonids, such as Atlantic cod trapped as juveniles in aquaculture net pens and in river-caught alewife, and isolation of VHSV from coastal herring indicate that salmonid pathogens can be transferred between not only cultured and wild fishes, but also between salmonids and non-salmonids.

From a disease management perspective, future concerns lie with the exposure of additional host species to ISAV and other salmonid viruses, the introduction of exotic pathogens into the range of Atlantic salmon, and the potential for native, naturally-occurring pathogens to increase virulence and cause epidemics. Collaborative efforts are now underway to identify and sample sea-run brook trout and rainbow smelt populations in Maine and continue to improve not only our understanding of disease dynamics but also our ability to prevent and manage disease outbreaks and transmission.

The Northeast Salmon Team (NEST) operates within the Northeast Region of NOAA Fisheries Service to promote the recovery and future sustainability of Atlantic salmon.

We are composed of fisheries managers and scientists jointly based out of the Orono, Maine Field Station; scientists based out of the Woods Hole, Massachusetts Northeast Fisheries Science Center (NEFSC) and Narragansett, Rhode Island Laboratory; and managers based out of the Gloucester, Massachussets Northeast Regional Office (NERO).

Please visit our website at **http://www.nefsc.noaa.gov/salmon/**