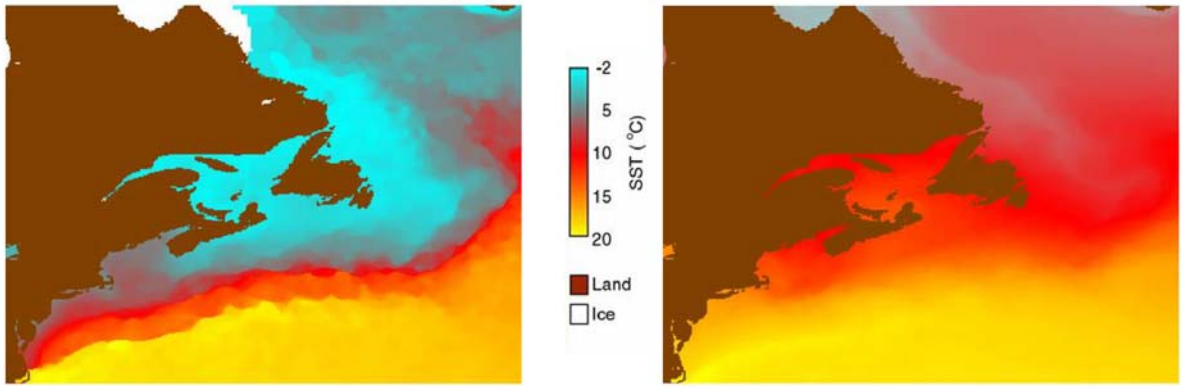
CLIMATE CHANGE AND THERMAL SENSITIVITY OF COMMERCIAL MARINE SPECIES



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Sea surface temperature in the Northwest Atlantic during February (left) and August (right). Temperature estimates correspond to monthly averaged data between 1985 and 1999. These data were obtained from the NASA Physical Oceanography Distributed Active Archive Center at the Jet Propulsion Laboratory, California Institute of Technology.

The Research Team is comprised of scientists from the Huntsman Marine Science Centre[1], the Atlantic Reference Centre[2], Fisheries and Oceans Canada[3] and McGill University[4]:

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Our research program considers thermal sensitivities for various life stages and pathogens characteristic of a selection of economically important marine species. We are identifying critical thresholds in their life stages and survival, thus their vulnerability and sensitivity to climate change and barriers to adaptation. Our focus is on nearshore waters of eastern Canada, including species with their southern or northern limit in our near Canadian waters. The 33 species we are studying include invertebrate and vertebrate fauna, as well as seaweeds which are harvested. Each species meets at least one of the following five criteria. Many have economic importance as part of both capture fisheries (see below) and aquaculture.

1) Aquaculture
- Present – These species, such as the eastern oyster are cultured and grown in commercial aquaculture operations in Canadian waters.
- Storage- Some species, such as lobster and cod are harvested from natural populations, but stored live in tidal pens (called lobster pounds) or ponds until ready for the retail market.
- Experimental – Many species have the potential to be produced through aquaculture operations and are the subject of pilot scale or experimental culture (e.g., sea urchin and halibut).
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2) Bioinvader – The species is an introduction to western Atlantic waters. Introduced species can be very successful at competing with native species and displacing natural populations. Their

population expansion and range is often enabled by environmental disturbances, such as temperature changes expected with greenhouse warming.

3) Capture fishery - These are species that exist on the Atlantic coast as natural populations that are conventionally harvested or harvested under experimental permits In table 1 below, we include these under the category capture fishery. An example of the former is menhaden and the latter, the seaweed (macroalga) called rockweed.

4) Prey – Changes in distributions of prey and predators species will have a major impact on commercial fisheries, thus economic impacts. However, development of such a list is a major research project in itself. We have compromised by selecting the most widely consumed prey in Canadian waters, the planktonic copepod *Calanus finmarchicus*.

Each target species is of economic importance, or has the potential to become commercially important if sea temperatures increase. Our inclusion of cultured species will enable us to identify the vulnerability of aquaculture operations to climate change and changes in practices that would be required in order to adapt to climate change. We expect this exercise will help the business community to identify opportunities for expansion or introduction of new capture and aquaculture fisheries.

We realize that shifts in temperature will not follow a linear, latitudinal gradient. Of utmost importance to marine species are changes in circulation and stratification of coastal waters. At this stage, output of global climate models (GCMs) cannot be used to predict such changes. We believe our work will help to demonstrate what detail of information is necessary as modelers begin to focus on regional models and improve resolution.

For each target species we are first trying to identify the thermal parameters for a number of characteristics such as adult range limits and geographical limits of commercial harvest of the species, as well as its larval and juvenile stage. We are also considering thermal parameters critical to reproduction (such as egg production or shedding) and pathogen exploitation or distribution. Thermal parameters include the maximum and minimum temperatures controlling an organism's distribution limits and optimum temperature. The entire list of characteristics will not be appropriate to all species (e.g., juvenile stage will not be considered for seaweeds). For some species, such as the American lobster, documentation of many parameters for each species characteristics is fairly complete but information has not been compiled. Based upon our experience with the scientific literature we expect that information on thermal parameters for characteristics of a number of species is incomplete. Our analyses will identify these knowledge gaps.

We will attempt to fill some knowledge gaps through a GIS analysis of remotely sensed sea surface temperature data. (We are using Advanced High Resolution Radiometer, AVHRR, data supplied by the US National Oceanic and Atmospheric Administration, NOAA.) For those species for which thermal parameters have not been reported, we will compare mapped distributions to distributions of sea surface temperatures. Various temperature indices, such as maximum summer and winter minimum will be studied for their relative information value in explaining distributions. These indices will be calculated from the remotely sensed sea surface temperature data. Our base maps already have been completed and are displayed above.

The information we collect will be synthesized and summarized to demonstrate the most vulnerable characteristic of each species in terms of thermal parameters. We will then rank our target species with respect to vulnerabilities to temperature change.

In 2005 we will hold a workshop to present and discuss results of our project. If you have comments on the project now, or wish to be on our contact list email Dr. Gail Chmura (chmura@felix.geog.mcgill.ca). Advertisements of the workshop will be placed on regional listservers and the Huntsman web site.

Table 1. List of target species to be investigated in the CCAF project “Climate Change and Thermal Sensitivity of Commercial Marine Species”. Capture fishery refers to conventional harvest. Aquaculture terms refer to those species part of commercial operations (present), those used in pilot or experimental operations (experimental), or those species harvested, but stored in the “natural” environment until sold (storage). Bioinvaders refers to non-native species.

Scientific name	Common name	Aquaculture				
		present	storage	experimental	bioinvader	capture
Mytilus edulis	blue mussel	x				
Crassostrea virginica	eastern oyster	x				
Salmo salar	Atlantic salmon	x				x
Homarus americanus	American lobster		x			x
Gadus morhua	cod		x	x		x
Hippoglossus hippoglossus	halibut			x		x
Stongylocentrotus droebachiensis	green sea urchin			x		x
Melanogrammus aeglefinus	haddock			x		x
Anarhichas lupus	Atlantic wolffish			x		
Littorina littorea	common (edible) periwinkle				x	x
Fucus serratus	serrated wrack				x	x
Carcinus maenas	green crab				x	
Hemigrapsus sanguineus	Japanese shore crab				x	
Ascophyllum nodosum	knotted wrack					x
Fucus vesiculosus	rock weed					x
Laminaria longicruris	kelp					x
Laminaria digitata	kelp					x
Laminaria saccharina	kelp					x
Laminaria nigripes	kelp					x
Mya arenaria	soft-shelled clam					x
Placopecten magellanicus	Atlantic deep-sea scallop					x
Mercenaria mercenaria	quahog					x
Loligo pealei	Atlantic long-fin squid					x
Cancer irroratus	Atlantic rock crab					x
Callinectes sapidus	blue crab					x
Merluccius bilinearis	silver hake					x
Hippoglossoides platessoides	American plaice					x
Brevoortia tyrannus	Atlantic menhaden					x
Clupea harengus	herring					x
Arctica islandica	black clam					x
Pandalus borealis	northern (Maine) shrimp					x
Mallotus villosus	capelin					x
Calanus finmarchicus						