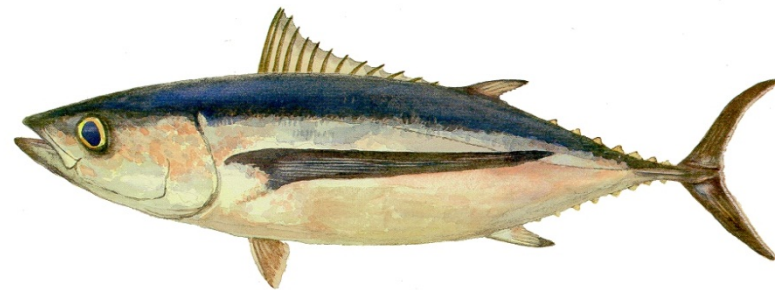
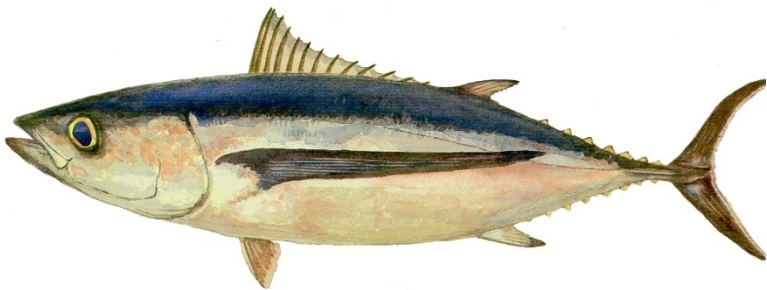


**Expansion of albacore tuna habitat in the
northeast Pacific Ocean under
anthropogenic warming**

**James Christian and John Holmes
Fisheries and Oceans Canada**



"Best Choices are abundant, well-managed and caught or farmed in environmentally friendly ways."

Arctic Char	Arctic Char (US farmed)
Barramundi	Barramundi (US farmed)
Catfish	Catfish (US farmed)
Clams, Eastern	Clams, Eastern (US farmed)
Cod: Pacific	Cod: Pacific (US)
Crab: Dungeness	Crab: Dungeness (US)
Halibut	Halibut (US)
Lobster	Lobster (US)
Rockfish	Rockfish (US)
Sablefish	Sablefish (US)
Salmon: Wild	Salmon: Wild (US)
Sardine	Sardine (US)
Scallop	Scallop (US)
Shrimp	Shrimp (US)
Striped Bass	Striped Bass (US)
Tilapia	Tilapia (US)
Trout: Rainbow	Trout: Rainbow (US)
Tuna: Albacore	Tuna: Albacore (US)
Tuna: Skipjack	Tuna: Skipjack (US)
Whitefish	Whitefish (US)
Abalone	Abalone (US)

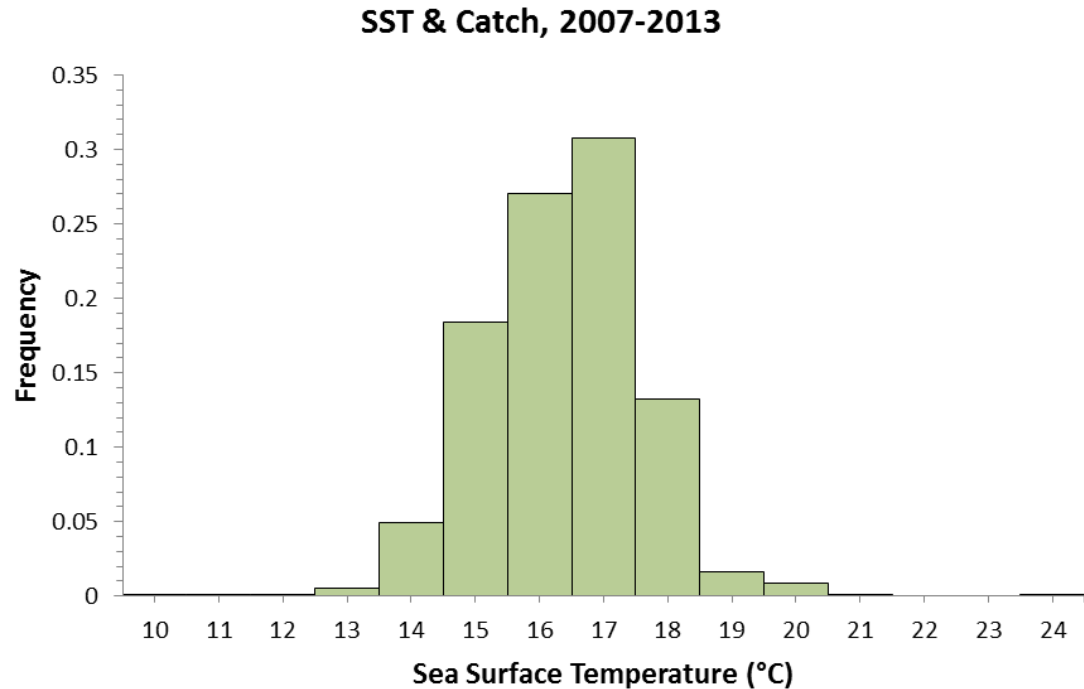
Albacore and SST

**Range of SSTs
searched: 10-24°C**

**Catches recorded at
narrower range, 13-20°C**

Preferred SST: 14-19°C

Optimal range: 16-18°C

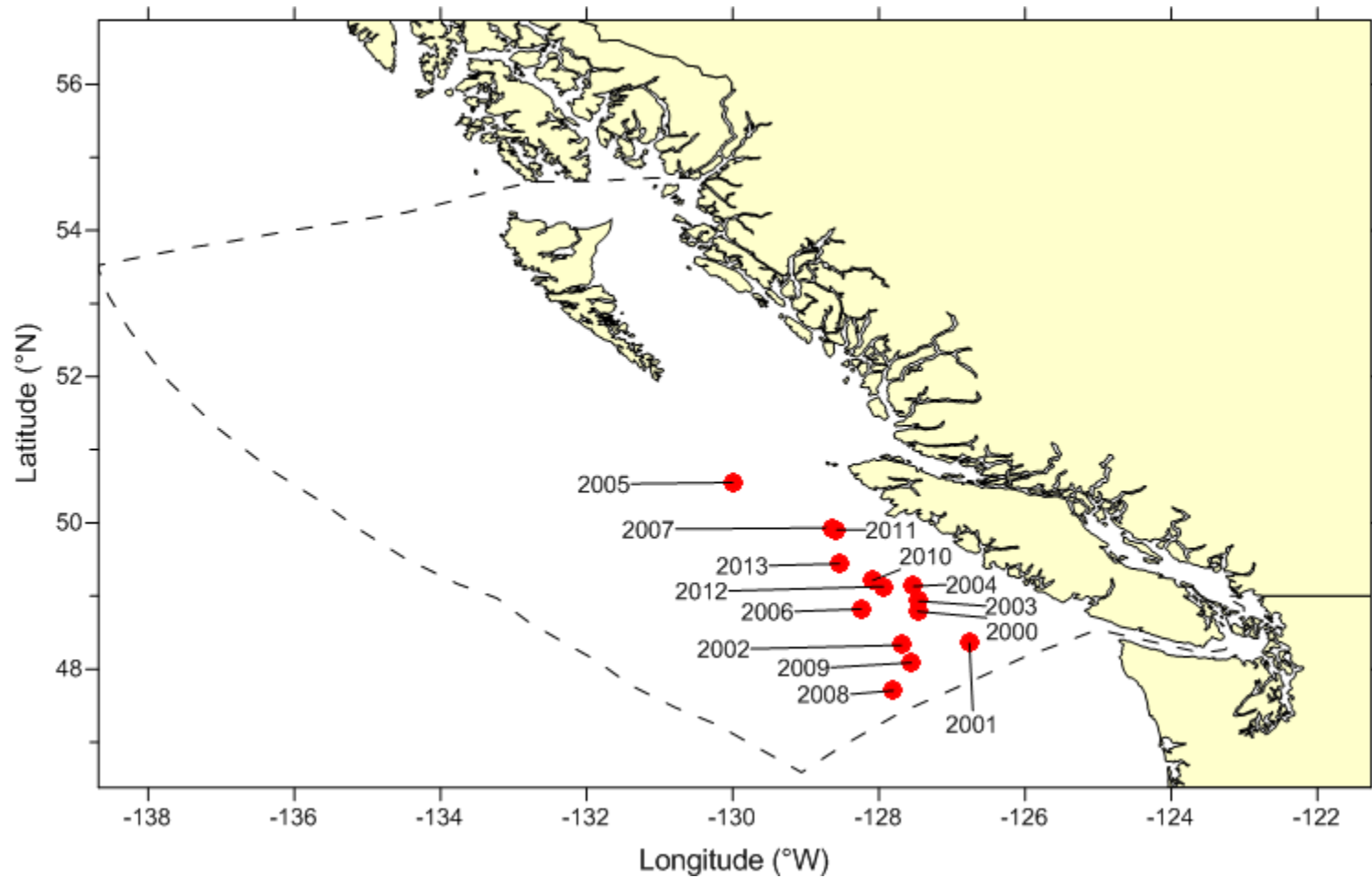


Historical catch data explained mainly by SST

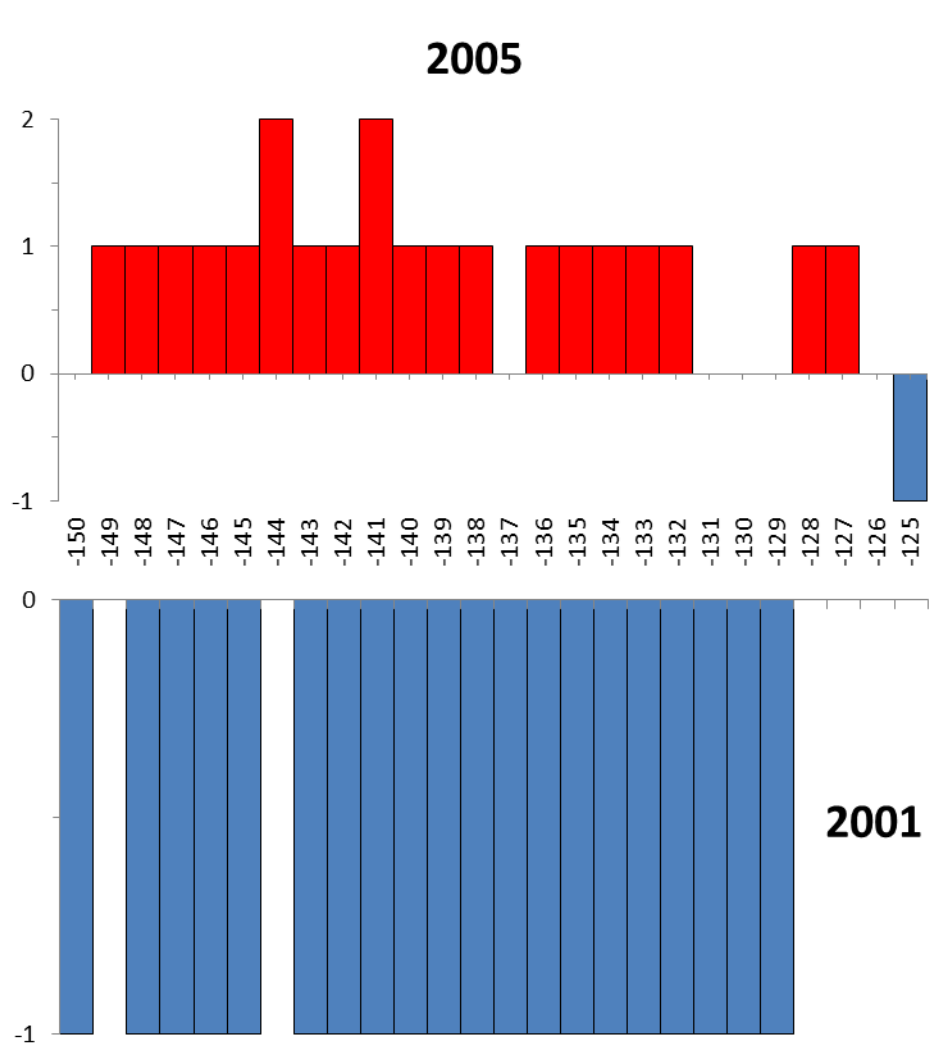
Thermal niche is narrow

Only summer SST matters

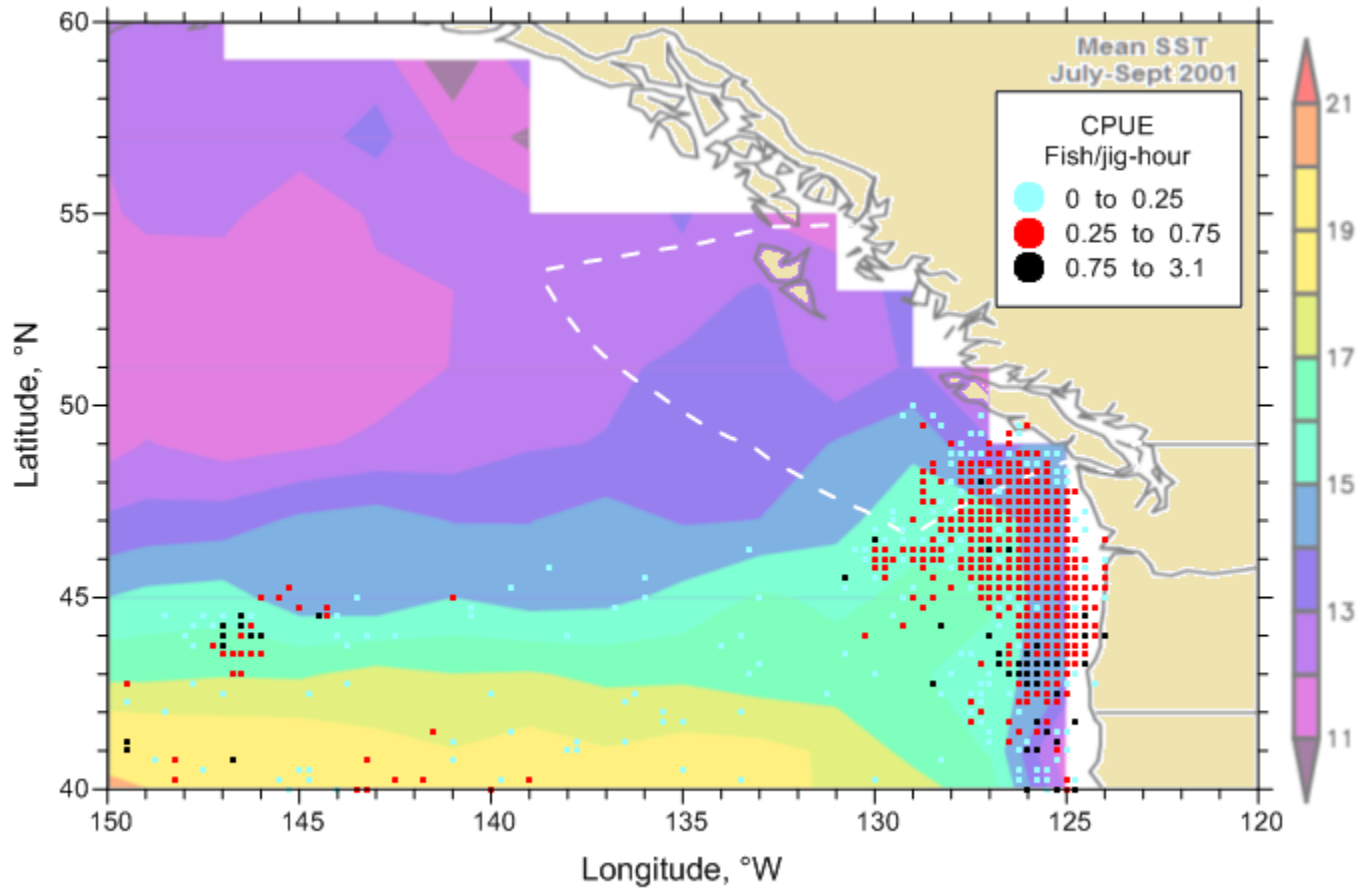
Centroids of Catch & Effort in Canadian Waters, 2000-2013



SST Jul-Sept Anomalies along 49°N

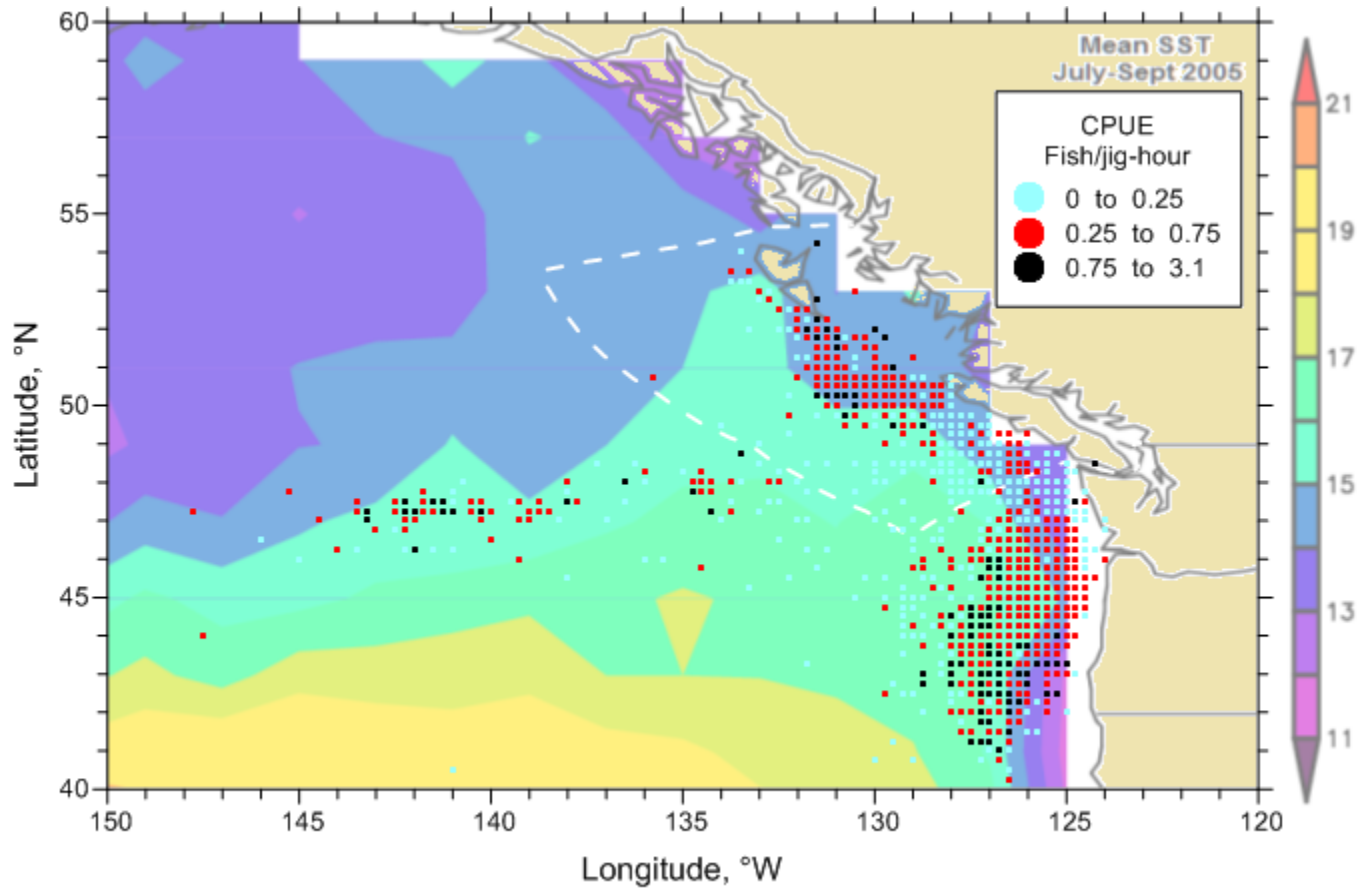


CPUE Distribution - 2001



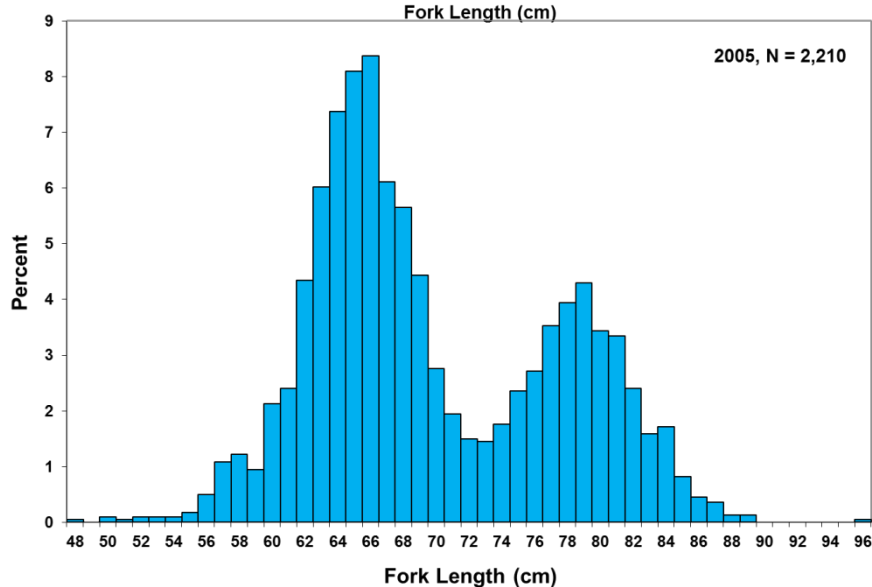
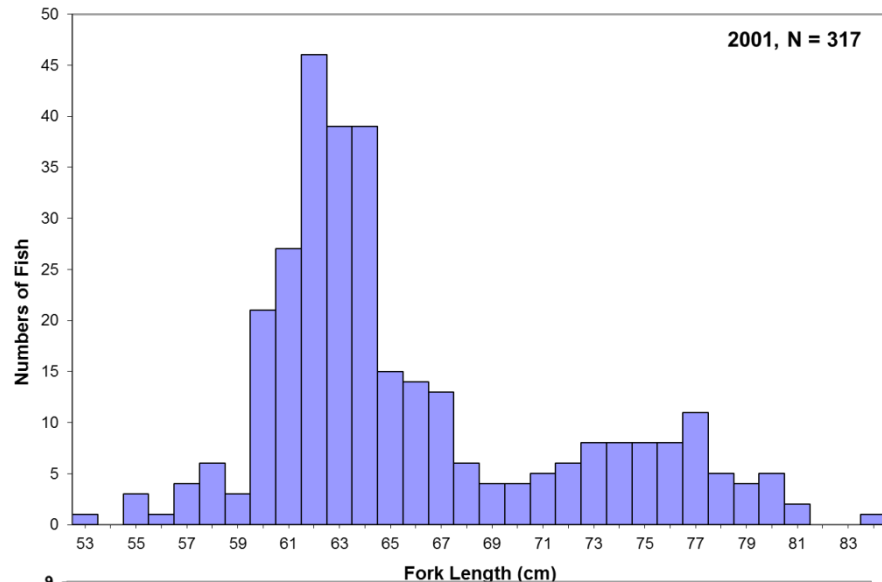
COADS SST Image provided by the NOAA/ESRL Physical Sciences Division: <http://www.esrl.noaa.gov/psd/>

CPUE Distribution - 2005



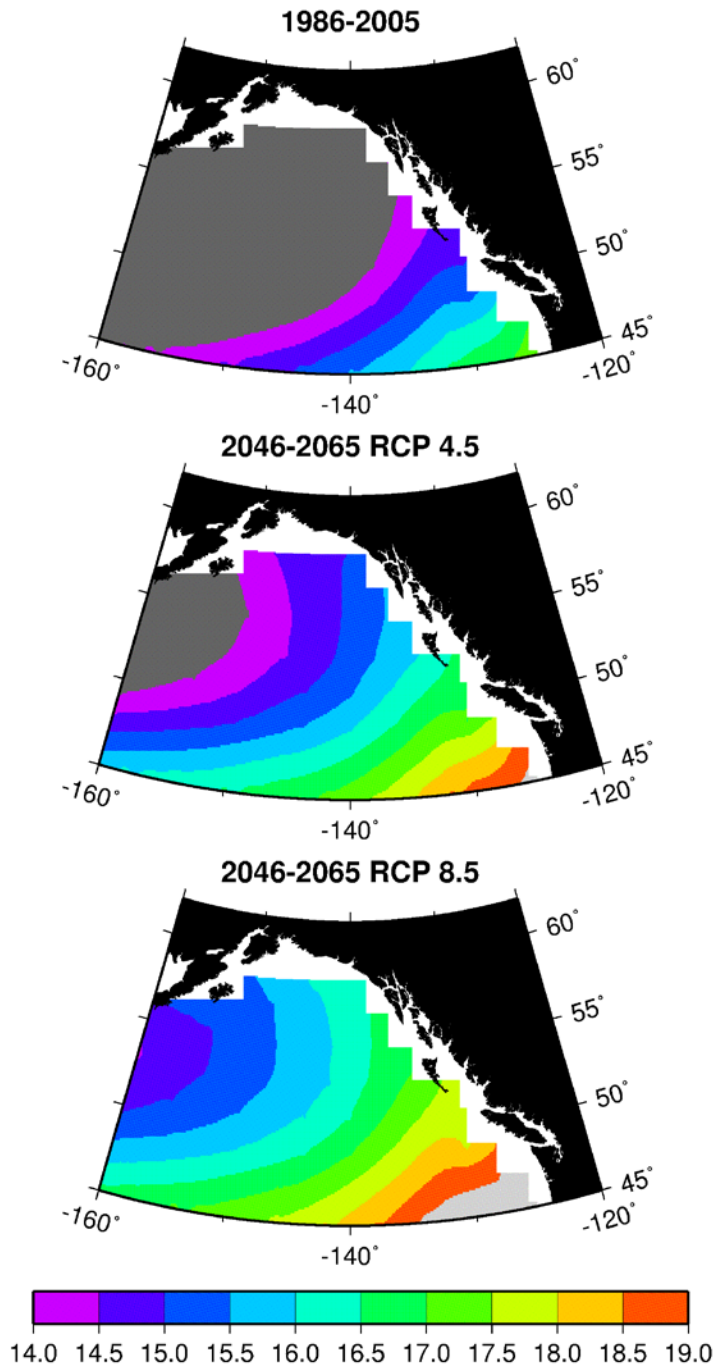
COADS SST Image provided by the NOAA/ESRL Physical Sciences Division: <http://www.esrl.noaa.gov/psd/>

Size Composition



Mode at 60-66 cm fork length (2-yr old fish) is always observed in albacore caught in Canadian waters

Prominence of second mode (76-82 cm FL – 3 yr olds) in 2005 is consistent with northward shift in albacore population, not simply a range expansion in 2005

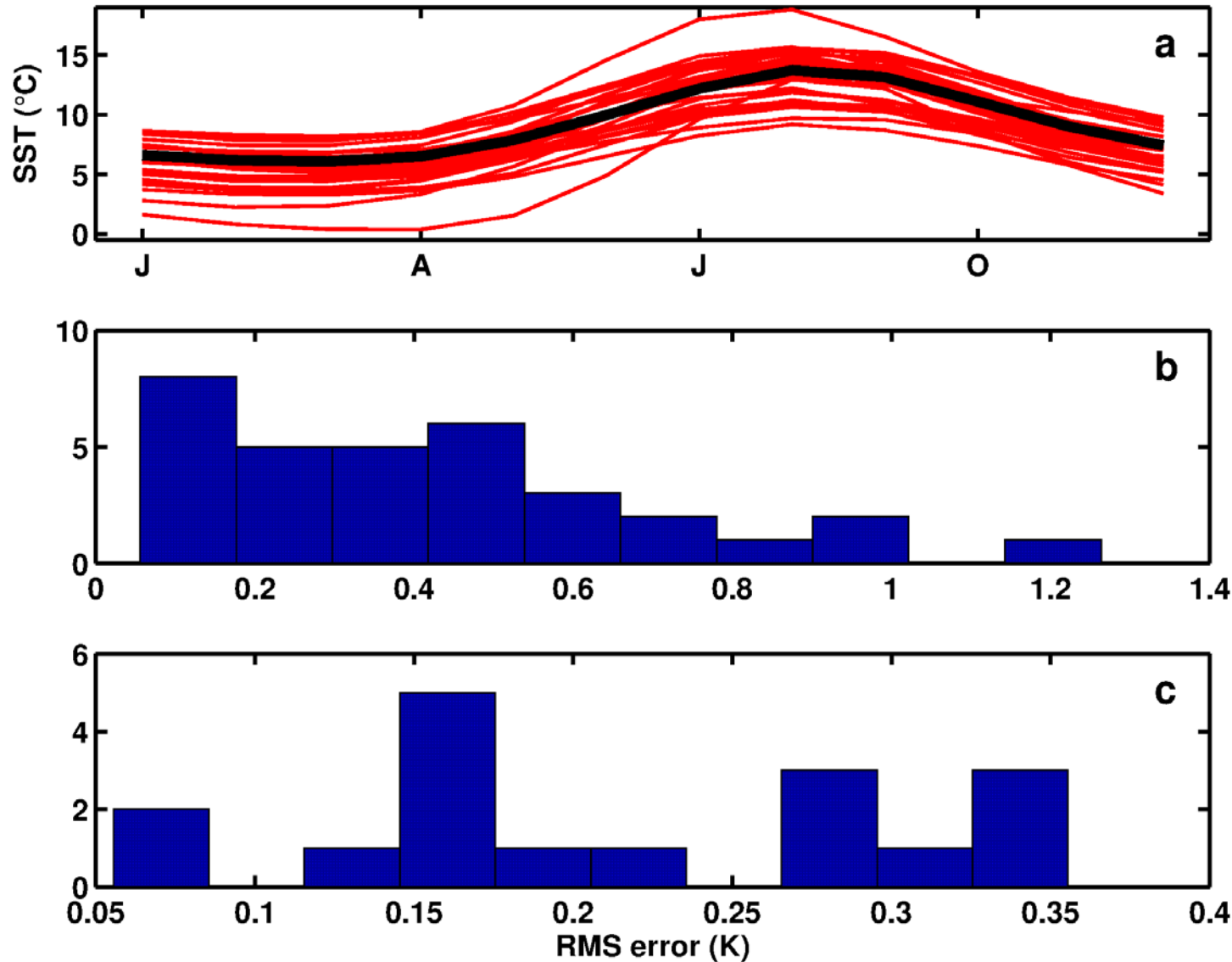


Projected future climates show substantial expansion of potential habitat in NE subarctic Pacific.

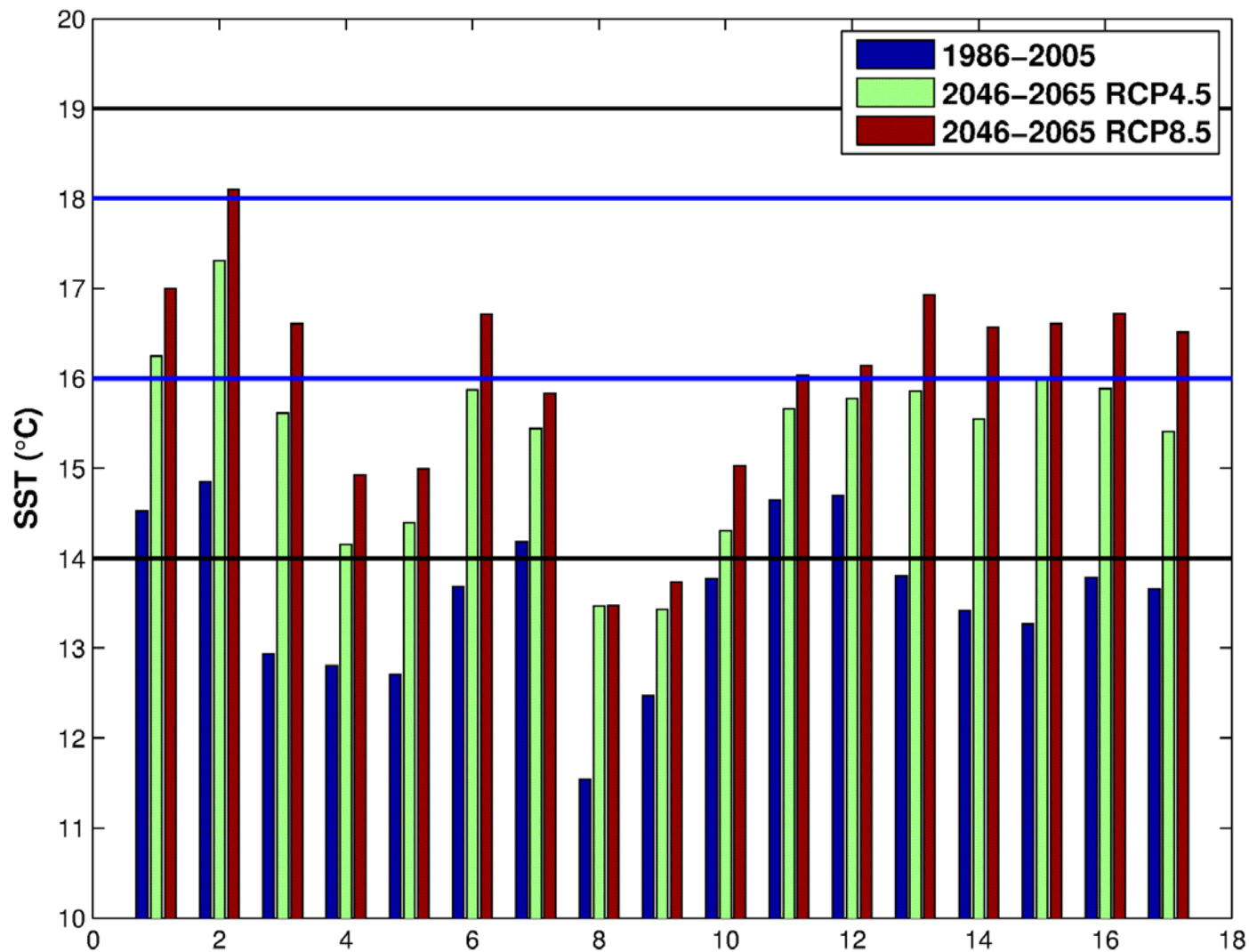
There is some potential loss of habitat within the existing range.

Present day climate already shows range expansion relative to preindustrial.

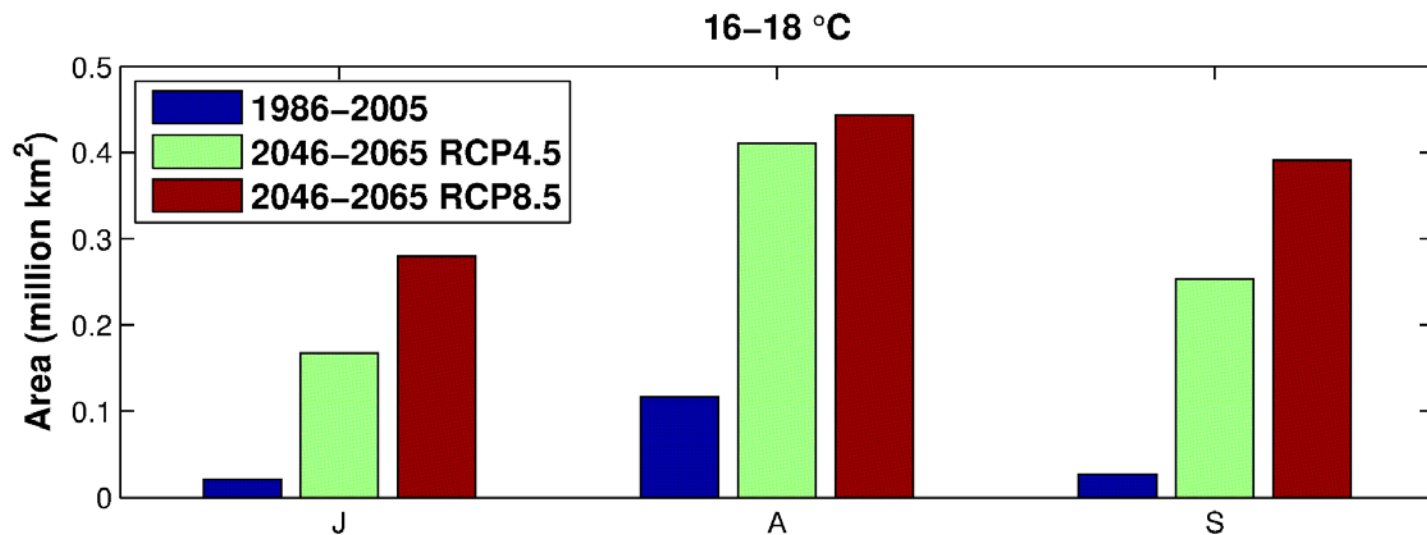
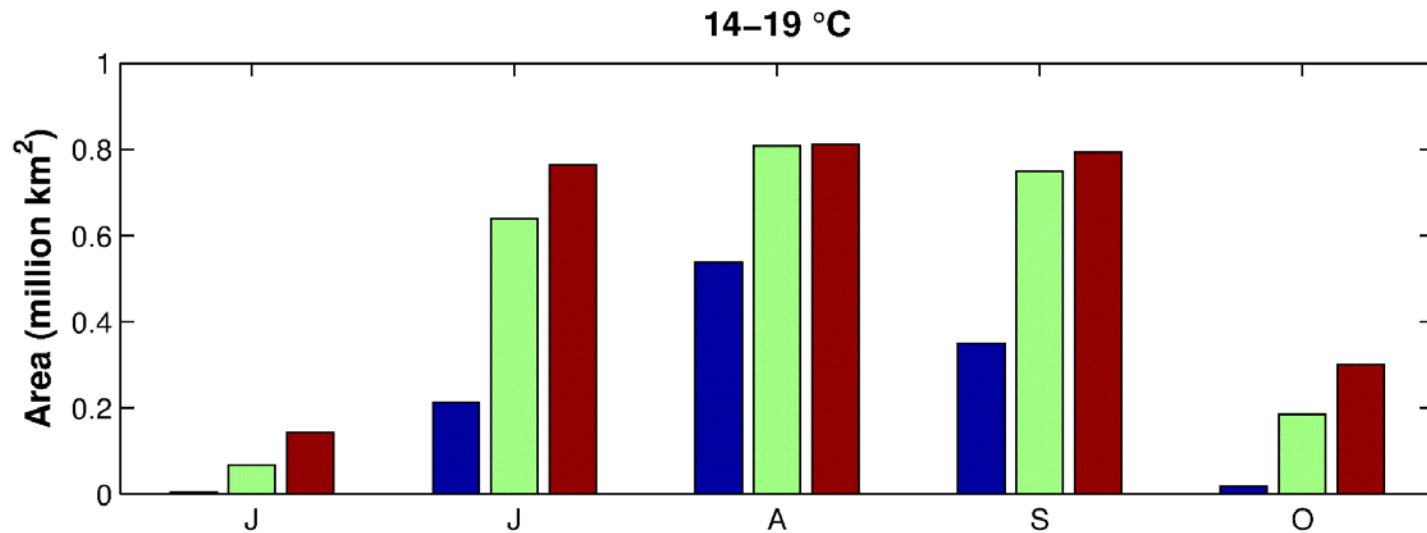
About half of models have RMS error below 0.4 K for regional mean annual cycle.



Most models project mean summer temperatures within the fish's thermal range for 49-56°N.



Net habitat expansion projected as 0.5 million to 1 million km² by 2055.



The Present

Signals in the distribution (and abundance) of albacore in the Canadian EEZ in response to SST changes of 1-2°C are detectable; size composition is consistent with a northward shift.

Habitat for albacore based on SST should more than double by 2045-2065.

Other things being equal (e.g., food, oxygen, etc.) or not limiting, then we might expect albacore distribution and abundance to increase proportionately.

The Future

Other things are not equal: juvenile albacore migrate into the Canadian EEZ to feed along the shelf-break (200 m isobath), where upwelling supports productivity and small pelagic forage fishes (sardine, saury, anchovy, herring, hake) that are main component of albacore diet.

Area north of Vancouver Island is usually a downwelling zone, even in summer. However, in 2005 and 2006, weak upwelling occurred in the summer at 51°N, 131°W.

While habitat may expand in space and time with climate warming, response of albacore will likely be driven by changes in productivity centers as well as SST.