Other Projects

1) Ocean Acidification

2) Loss of Sea Ice
   o Arctic – winners and losers
   o Will fish move norths?
North Pacific fisheries are at risk because calcium carbonate saturation horizons are relatively shallow there

Ocean Acidification Effects on Crabs

Red king crab distribution

Golden king crab distribution
Alaska King Crab

Kodiak Fisheries
Research Center
Seawater Facility

Bob Foy
Red King Crab Embryos

- Adult females collected from Bristol Bay fishery
- pHs: Ambient and 7.7 (~2100)
- Decreased pH associated with smaller eggs and embryos and larger yolks.
Red King Crab Juveniles

- Crabs held in individual containers
- Control, pH 7.8, pH 7.5
- 30 crabs/treatment
- **Survival decreased with decreasing pH**
King Crab Population Effects: Red King Crab

stock dynamics without OA

- At a pH of 7.8, stocks and catches decline
- Under current catch levels fishery would be closed in about 2100

stock dynamics with OA

Alaska Groundfish

Newport Seawater Facility

Tom Hurst
Alaska groundfish comparison

Based on laboratory experiments exposing eggs and larvae to elevated CO$_2$ in laboratory experiments.

Northern rock sole

**More sensitive**
- To 1600 μatm CO$_2$; to 60 days post hatch
- No effect on hatch success or size at hatch
- Reduced growth and condition in post-flexion fish
- Trend toward higher mortality at high CO$_2$ levels
Hurst et al. 2015

Walleye pollock

**Resilient**
- To 2100 μatm CO$_2$; to 28 days
- No effect on survival to hatch
- Slight growth improvement at intermediate CO$_2$
- No CO$_2$ effect on survival
Hurst et al. 2012 & 2013

The direct effects of OA on growth energetics of walleye pollock and northern rock sole appear to be minor, but are not equal.
Coldwater Corals

Depth distribution of Aleutian corals.

Undersaturated (aragonite)


Projects:
Coral mineralogy catalog
Experiment *Primnoa* spp. (red tree coral)

Bob Stone (holding red tree coral)
Issue: Loss of Sea Ice

Declining Sea Ice Extent (Sept)

Sea Ice Extent/Duration (Spring)
Strategies to obtain data

August to October

September
2002 to 2015 (2008)

August to October

Fish
On board Fish Diet
Physical Oceanography
Zooplankton
Acoustics

F/V SEA STORM
R/V OSCAR DYSON

Relative Percent of Total Lipid
Structural Lipids
Metabolic Intermediates
Storage Lipids
In the Arctic, It’s Survival of the Fattest

Food Web

Polar Bear

Ice seals

Arctic cod

Zooplankton
Summer Distribution and Abundance of Young Arctic and Saffron Cod

Arctic cod
(2.6 × 10^{11} fish)

Saffron cod
(6.5 × 10^{9} fish)

Prefer colder water

Prefer warmer water

Fat Content of Cods

Heintz & Vollenweider Unpublished data

Predators must consume 2.7x the Saffron Cod to get the same lipid as 1 Arctic Cod
Summer Sea Surface Temperature Model Projections 2081 to 2100

Water will be too warm for Arctic Cod?

Courtesy of Muyin Wang, Pacific Marine Environmental Laboratory, Seattle, WA
North-South Shifts in Species Distributions in the Southeastern Bering Sea, 1982-2006

Fish distribution and movement on the eastern Bering Sea shelf are influenced by bottom temperatures specifically the “cold pool” (<2°C), a remnant of sea ice extent during spring.

Will Fish Move North?
Future Ocean Conditions: The North Will Remain Cold and Dark

What is the Potential for Other Fish Species to Move North?

Juvenile Salmon Move North (Sept. 2007)

Arctic Fishery Management Plan (2009)
- Baseline data for: Arctic cod; Saffron cod; Snow crab
- Baseline data for oil and gas development, fishing, and anthropogenic influences.
- NOAA’s Arctic Action Plan
- Strengthen foundational science – understand impacts of climate change on ecosystem
- Improve management and stewardship of ocean and coastal resources
Extends surveys for fish and crab north.

Addresses goals within the NOAA Arctic Action Plan (NOAA 2014) and NOAA’s Arctic Vision and Strategy (NOAA 2011) by providing information on how species distribution and marine food webs are altered by climate and seasonal ice in the northern Bering Sea and Chukchi Sea.
Communication to the Public