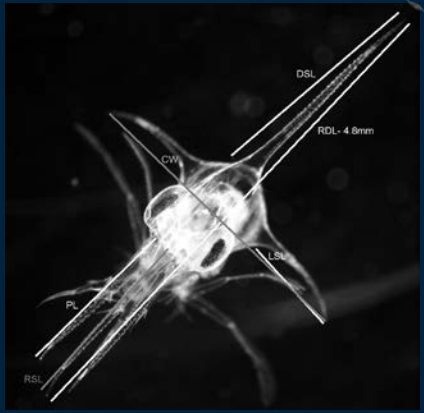
Alaska Ocean Acidification Network

Ocean Acidification and Alaska

Robert Foy, Toby Schwoerer

2019 BOF

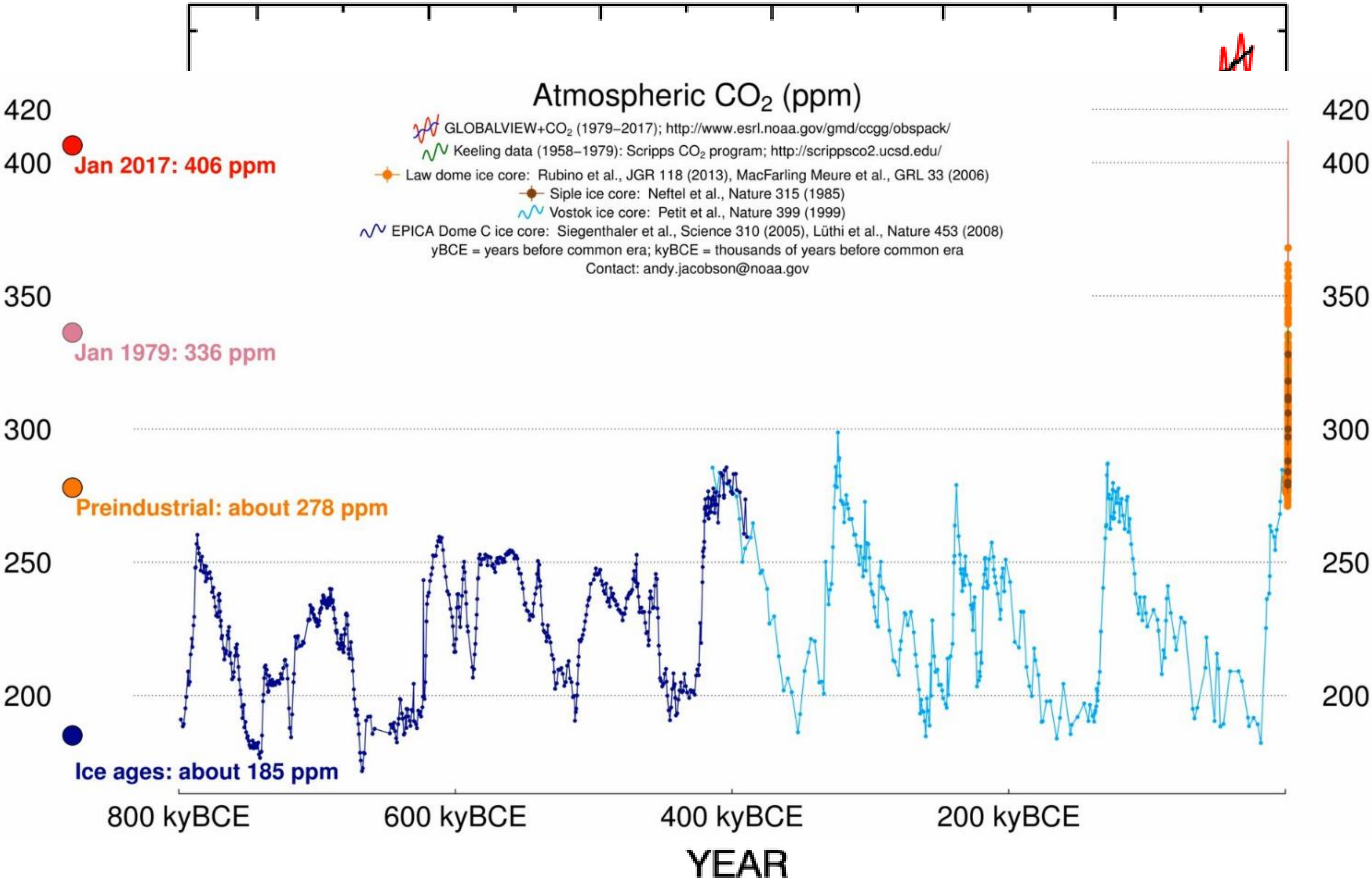


October 23, 2019

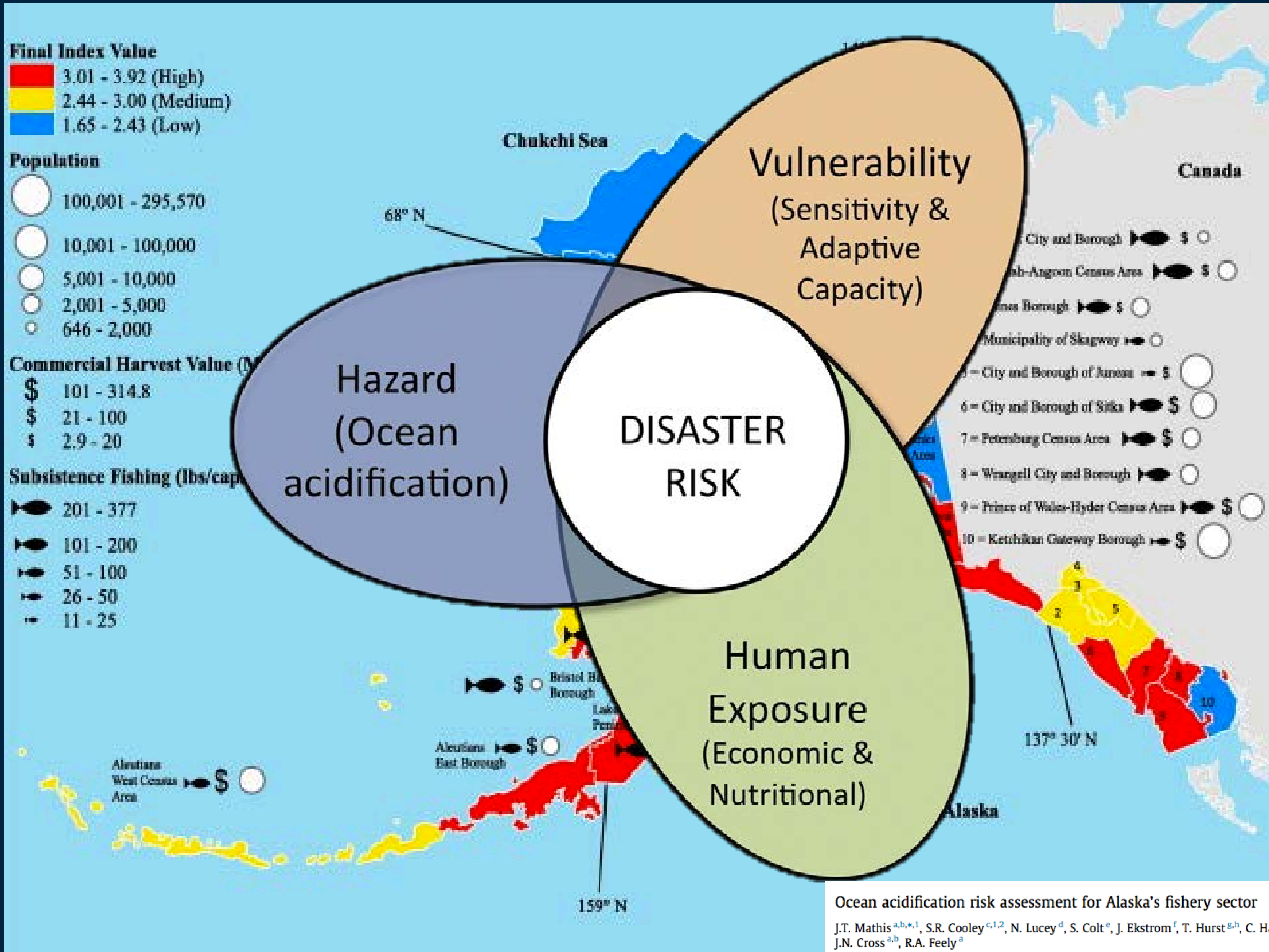
Why are we here?

- Ocean Acidification: what is it and what have we learned?
- Why should the Board of Fish know about ocean acidification?
- Introduction to pink salmon study.

Atmospheric CO_2 at Mauna Loa Observatory

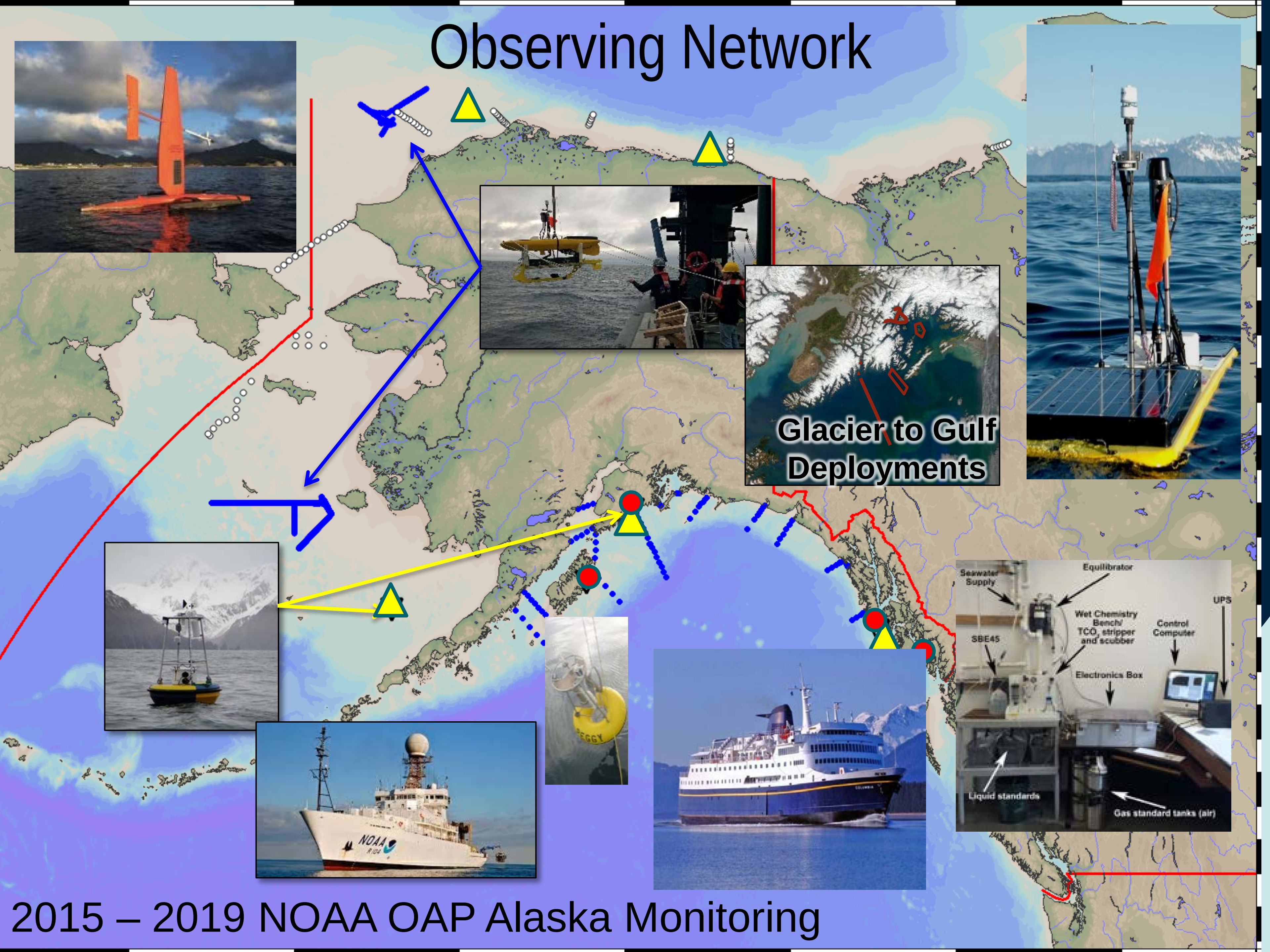


OA Risk Assessment: AK Fishery Sector

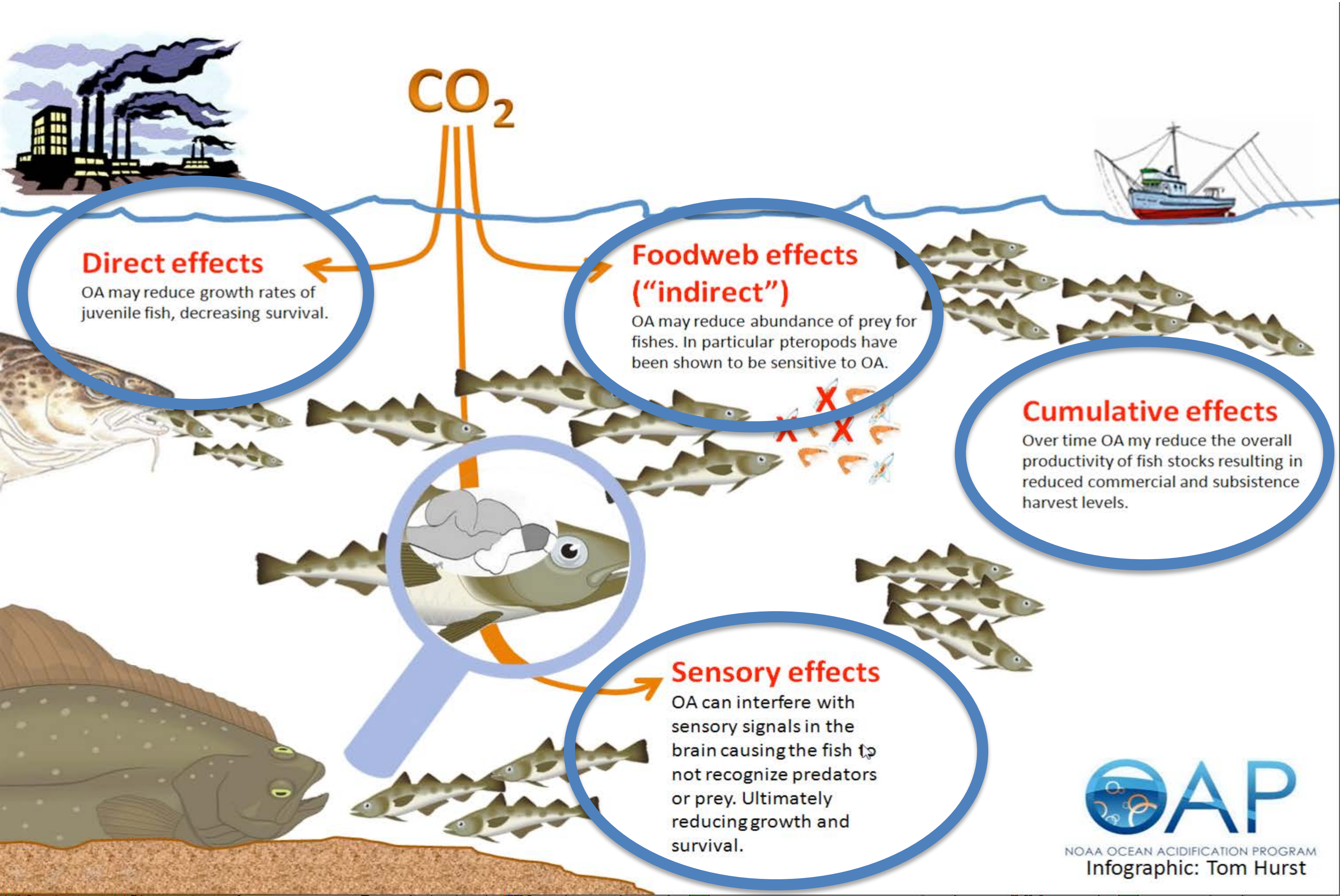


Ocean acidification risk assessment for Alaska's fishery sector

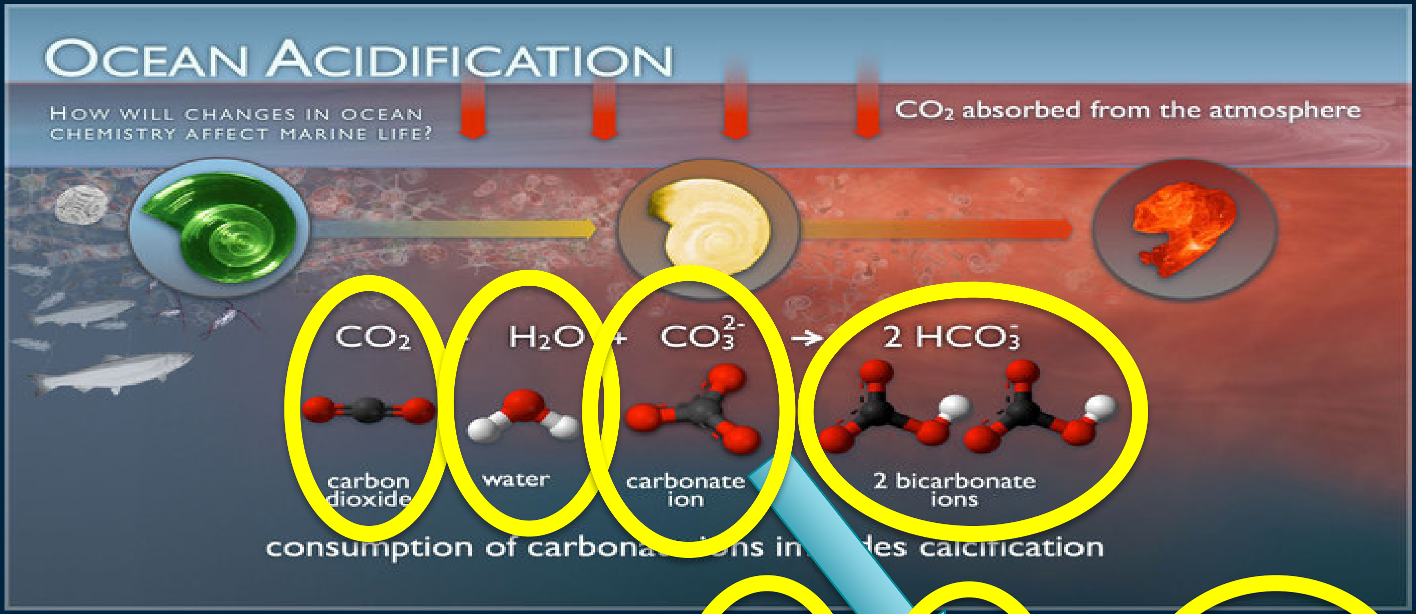
J.T. Mathis [a,b,*,1], S.R. Cooley [c,1,2], N. Lucey [d], S. Colt [e], J. Ekstrom [f], T. Hurst [g,h], C. Hauri [i], W. Evans [a,b], J.N. Cross [a,b], R.A. Feely [a]


Observing Network
Glacier to Gulf Deployments
Seawater Supply
Equilibrator
UPS
Wet Chemistry Bench/ TCO$_2$ stripper and scrubber
Control Computer
SBE45
Electronics Box
Liquid standards
Gas standard tanks (air)
2015 – 2019 NOAA OAP Alaska Monitoring

OA: individual and ecosystem response



Ocean Acidification: effects on crab?



Shellfish and corals *need* carbonate (inorganic carbonate)

$$Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3$$

Calcium + Carbonate = Calcium Carbonate shell

Changes found in many calcifying organisms

- Changes in respiration rate
- Changes in aerobic metabolism
- Greater energy in shell maintenance
- Less energy in reproduction and growth
- Changes in stress tolerance

Framework to assess climate change and OA

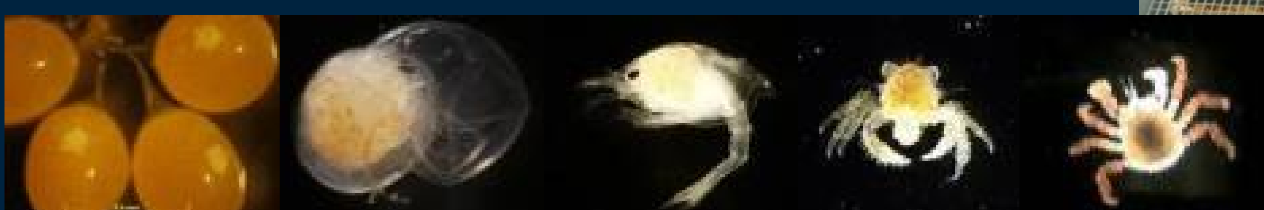
<u>Organismal (individual tolerance)</u>, population, and ecosystem level response

Experiments: (2010-2019)

- Red king crab
- SouthernTanner crab
- Golden king crab
- Snow crab

Life Stages: oocyte, embryo, larvae, juvenile

Response variables: Survival, fecundity, morphometrics, growth, calcification, hemocyte function, genetics (protein expression), and mechanics.



AFSC/Kodiak Laboratory

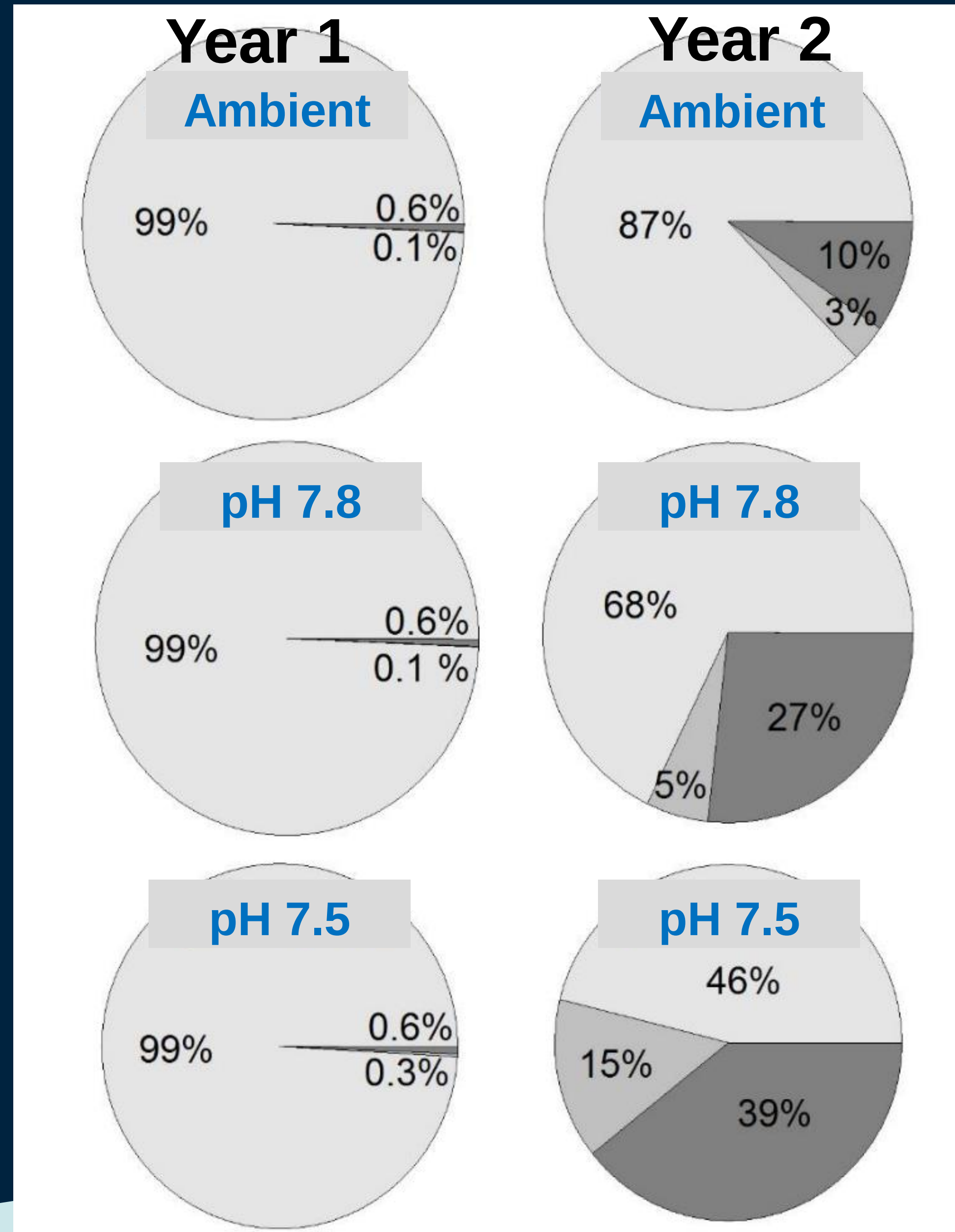
Tanner crab larvae hatching success

- Hatching success lower in year 2 than year 1-carryover effect
- Larvae 10% smaller in pH7.5
- Larvae that survived lived longer in year 2 (acclimation?)
  - Decreased metabolism OR higher energy reserves
- Adaptation due to variable environment?

Viable larvae hatched

Non-viable hatched larvae

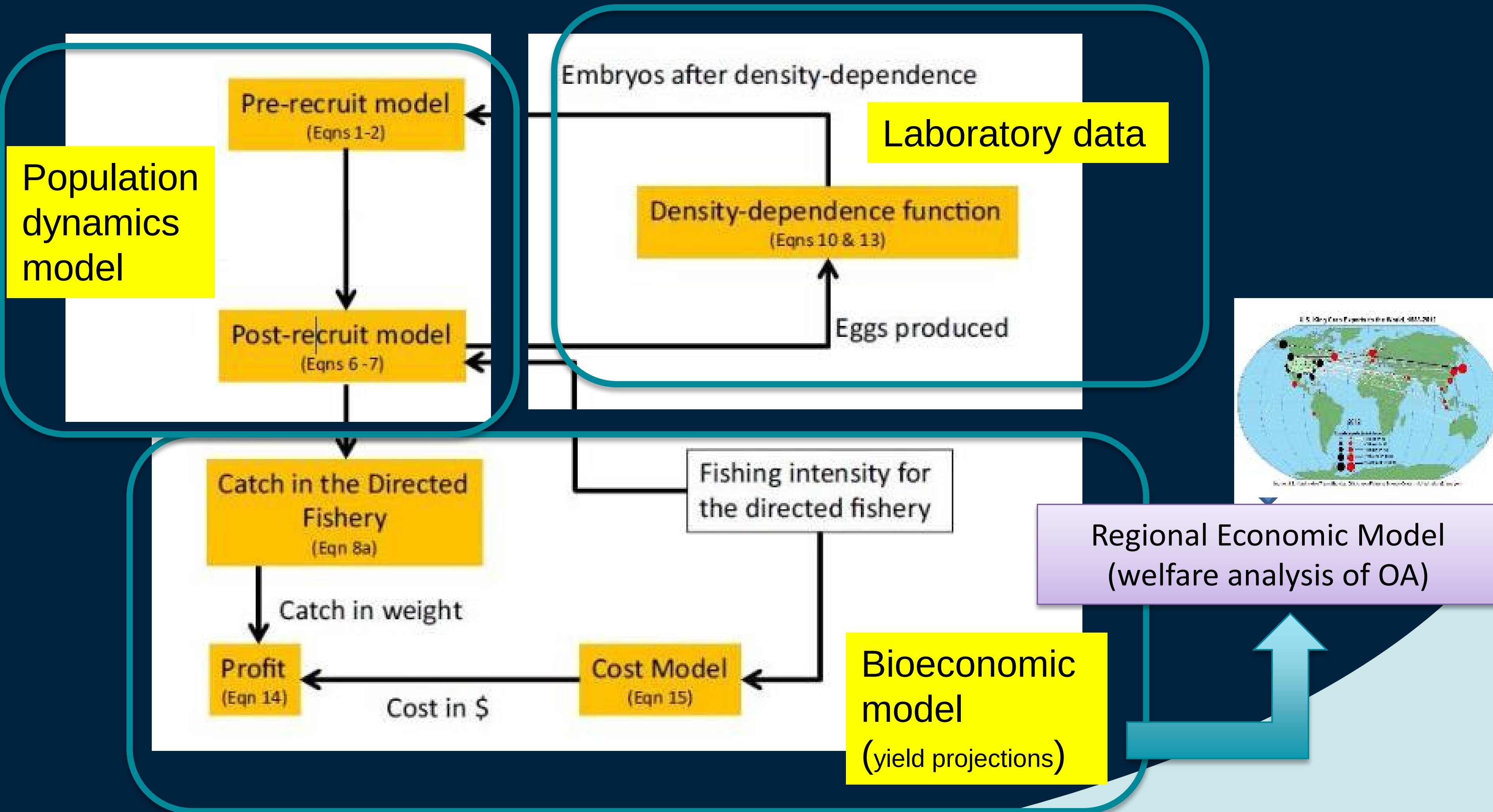
Eggs that did not hatch



Swiney et al. 2016 *Long et al. 2016*

Forecasting fisheries population effects

Experimental results were used to inform population and economics models

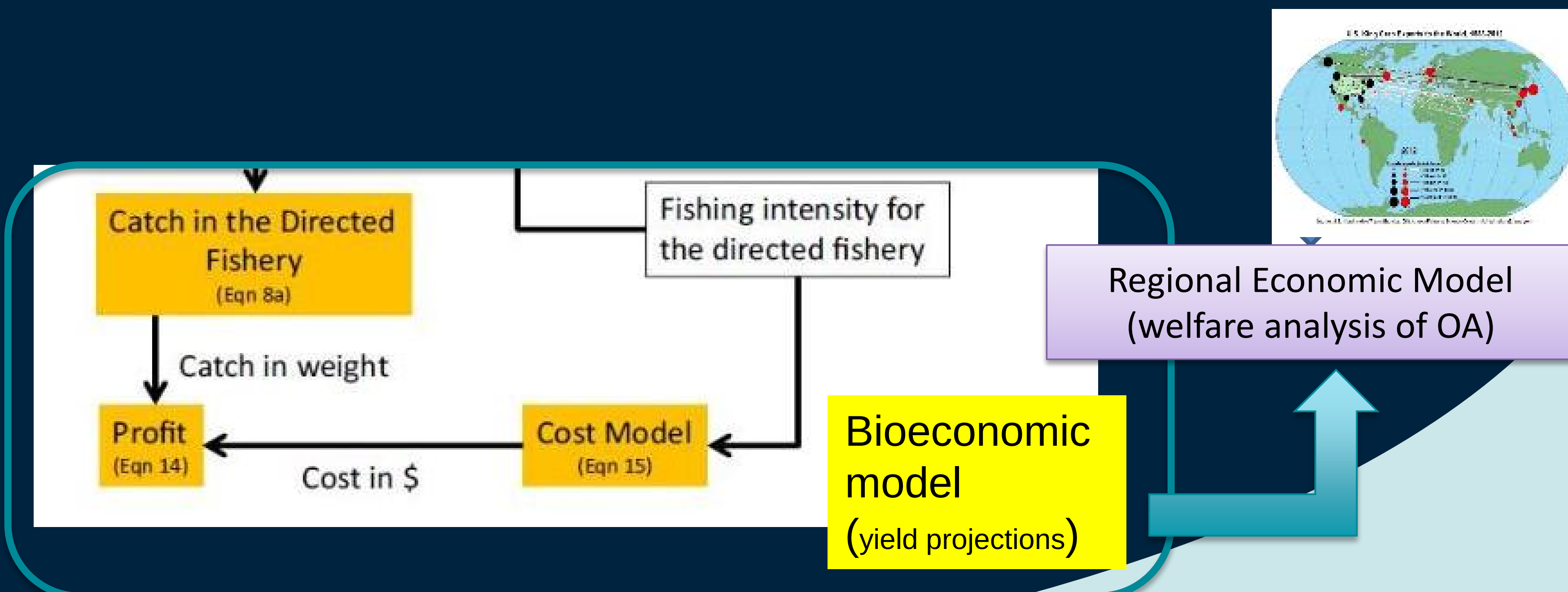


Seung et al. 2015; Punt et al. 2014 & 2016

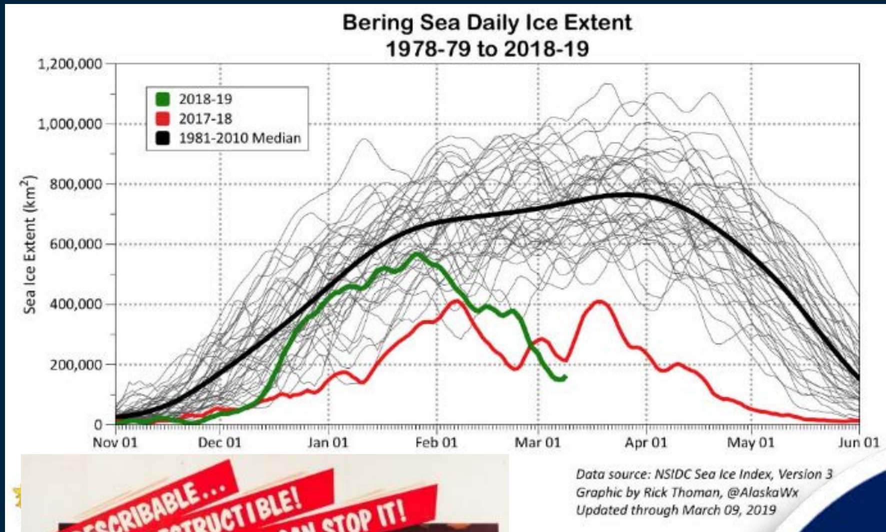
Forecasting fisheries population effects

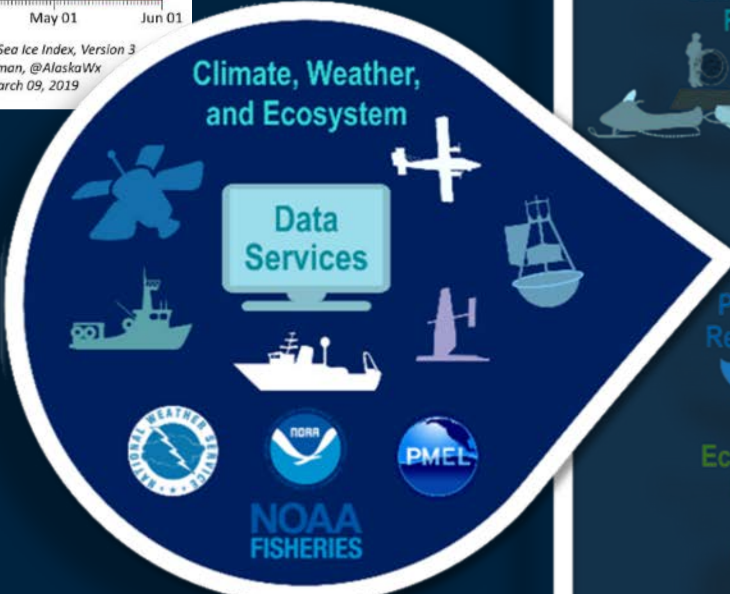
Experimental results were used to inform population and economics models

- Proportion larvae hatching that survive to juvenile stage C8 could decline by 25% over 100 y.
- >50% decrease in catch and profits within 20 years
- Only significant when oocyte development is included in survival estimates
- $500 million - $1 billion welfare loss to Alaska households



Seung et al. 2015; Punt et al. 2014 & 2016





Commercial Fisheries

- Northward migration due to loss of cold pool: pollock abundance up 5,640%, Pacific cod up 2,060% in northeastern Bering Sea (since 2010)
- $1.7B first-wholesale value on pollock and cod stocks
- Changes in sea-ice affect operational costs in Bering Sea crab fisheries

Subsistence Fisheries

- Crab fisheries conducted on the ice largely failed in 2019 due to poor sea ice condition
- Sea ice quality (not just extent) important factor in the future
- Local communities are having to adapt to reduced access to resources due to changes in sea ice conditions

Protected Resources

- Migration: Humpback, fin, killer, and minke whales and harbor porpoise numbers increasing in Chukchi Sea

Ecosystem Services

- Arctic cod larval biomass changing: high during anomalous warming of spring and summer sea surface temperatures
- Changes in the base of the food chain: large copepod and capelin biomass decrease in northeastern and southeastern Bering Sea as temperature increases

Fisheries Management

- Management of cod and pollock stocks must now consider migration
- Arctic fisheries management plan limits commercial fishing

The Washington Post
Democracy Dies in Darkness

Capital Weather Gang

Another extreme heat wave strikes the North Pole

By Jason Samenow Email the author
May 7 at 3:19 PM

Anchorage Daily News 2 KTUU

The Washington Post
Democracy Dies in Darkness

Capital Weather Gang

'Fallen off a cliff': Scientists have never observed so little ice in Bering Sea in spring

By Jason Samenow Email the author
May 3

The Washington Post

Energy and Environment

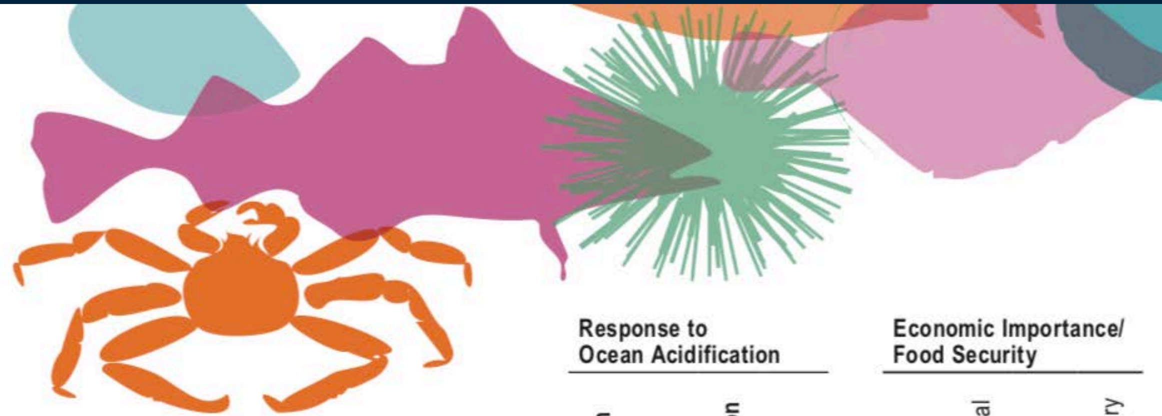
Temperatures in the Arctic are skyrocketing — for the third time this winter

By Chelsea Harvey
February 10

Take Home

- OA is already impacting Alaskan coastal areas!
- Southeast and Southwest Alaska face the highest risk from OA
- As human CO_2 emissions rise, Ocean Acidification will get worse.
- Can We Adapt?
  - Manage to allow species specific adaptation
  - Diversify economies in high and moderate risk regions
  - Communicate with coastal communities
  - Increase access to alternative sources of protein
  - Reduce other environmental stressors

What we know so far about species response



Resident marine species	Response to Ocean Acidification: Calcification	Growth	Reproduction	Survival	Economic Importance/ Food Security: Commercial	Sport/personal	Subsistence	Closed Fishery
Southern Tanner crab	↓	↓	↓	↓	●	●	●	◒
Red king crab	↓	↑	↓	↓	●	●	●	◒
Pink salmon*	N/A	↓	↓		●	●	●	
Dungeness crab*	U	↓	—	↓	●	●	●	
Blue king crab		↓	U	↓	●		●	◒
Northern rock sole*	N/A	↓	U	↓	●		●	
Walleye pollock*	N/A	—	U	—	●		●	
Northern shrimp*	U	↓	U	↓	●		●	
Pteropod*	↓	↓	U	U				
Baltic clam*	↓	↓	↓	↓		●	●	
Pinto abalone* (endangered)	U	U	U	↓				●
Common cockle*	↓	↓	U	U		●	●	
Red sea urchin*	U	U	↓	U			●	

*Non-Alaska populations studied

KEY: ↑ Increase ↓ Decrease — Equilibrium N/A Not applicable U Unknown ◒ Only certain populations

Resident Alaska species whose responses to OA have not been studied

<u>Top Commercial Value</u>

Pacific Cod
Sockeye Salmon
Snow crab
Pink salmon
Pacific halibut
Sablefish
Chum salmon
Atka mackerel
Yellowfin sole
Pacific rockfish
Chinook salmon
Coho salmon
Rock sole
Rockfishes
Pacific herring

<u>Highest biomass in bottom trawl surveys</u>

Pacific ocean perch
Giant grenadier
Atka mackerel
Pacific sleeper shark
Salmon shark
Yellowfin sole
Redstripe rockfish
Canary rockfish
White sea urchin
Arrowtooth flounder
Pacific hake
Shortaker rockfish
Clonal plumose anemone
Sharpshin rockfish
Silvergray rockfish

<u>Other important species</u>

Broad whitefish
Capelin
Crescent gunnel
Dolly varden
Longfin smelt
Ninespine stickleback
Pacific sand lance
Rainbow smelt
Threespine stickleback
Sidestriped shrimp

Tipping points in a changing ocean:

bio-economics, adaptation, and Alaska's salmon fisheries

ALASKA DEPARTMENT OF FISH AND GAME

UNIVERSITY of WASHINGTON

UAA Institute of Social and Economic Research
UNIVERSITY of ALASKA ANCHORAGE

NOAA Northwest Fisheries Science Center

UAF COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks

UNIVERSITY OF WYOMING

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NOAA OCEAN ACIDIFICATION PROGRAM

Existing salmon research

Pink – seawater entry (Ou et al. 2015)

Growth ⬇

Yolk-to-tissue conversion ⬇

Oxygen uptake ⬇

Reduced sense of smell ⬇

Behavior and anxiety ⬇

Coho – ocean phase (Williams et al. 2018)

Growth ⬇

Neural function ⬇

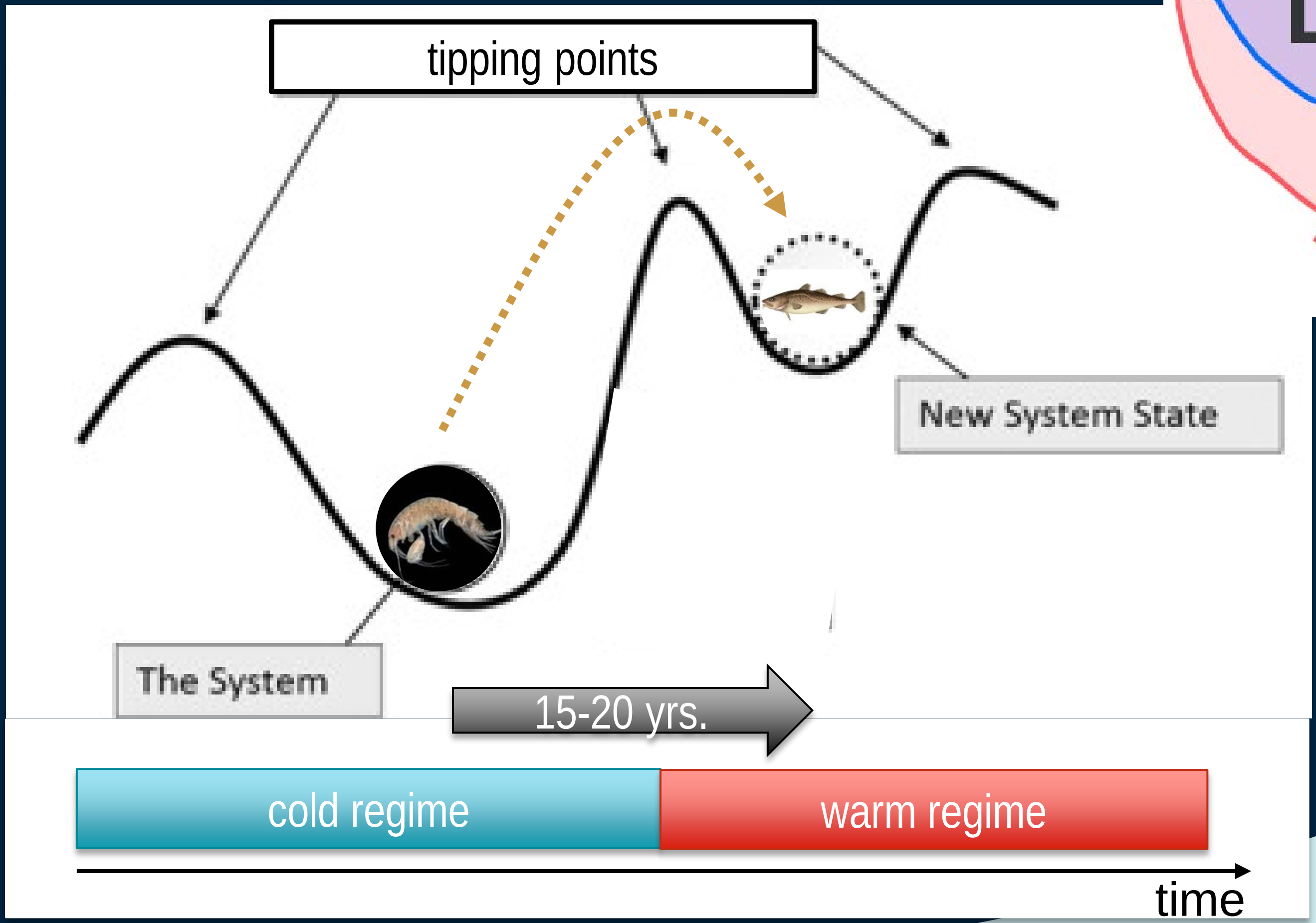
Navigation ⬇

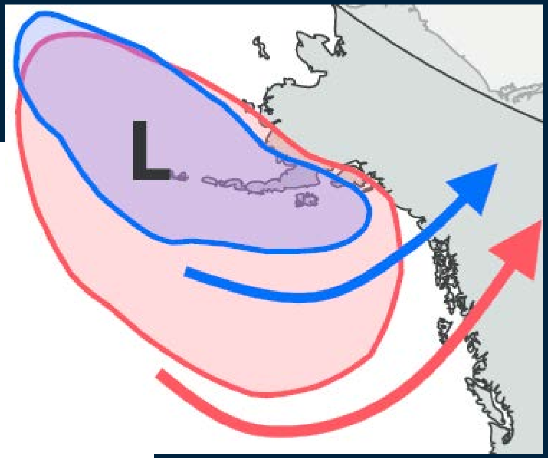
Predator avoidance ⬇

Research objectives

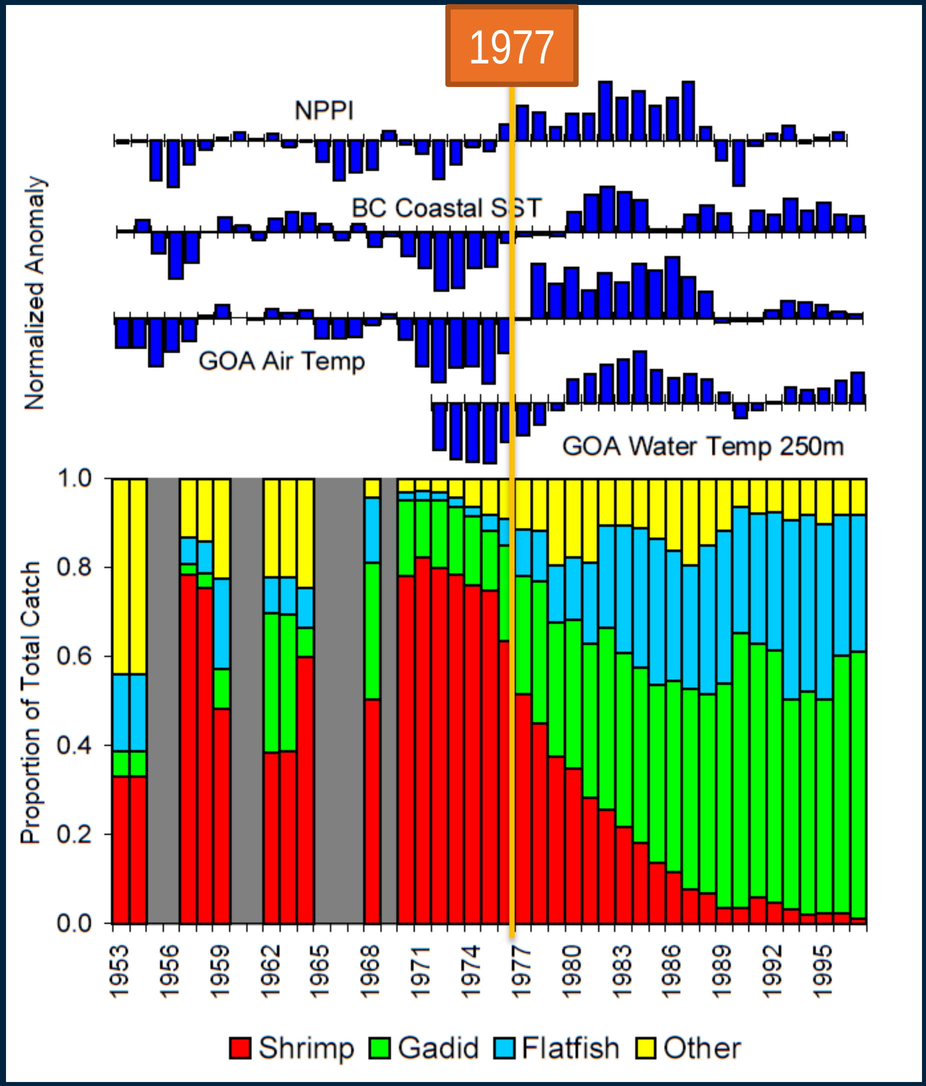
- Identify and synthesize Gulf of Alaska tipping points
- Learn about salmon growth under future ocean conditions
- Develop model to inform response
- Engage salmon stakeholders and decision makers
- Communicate results

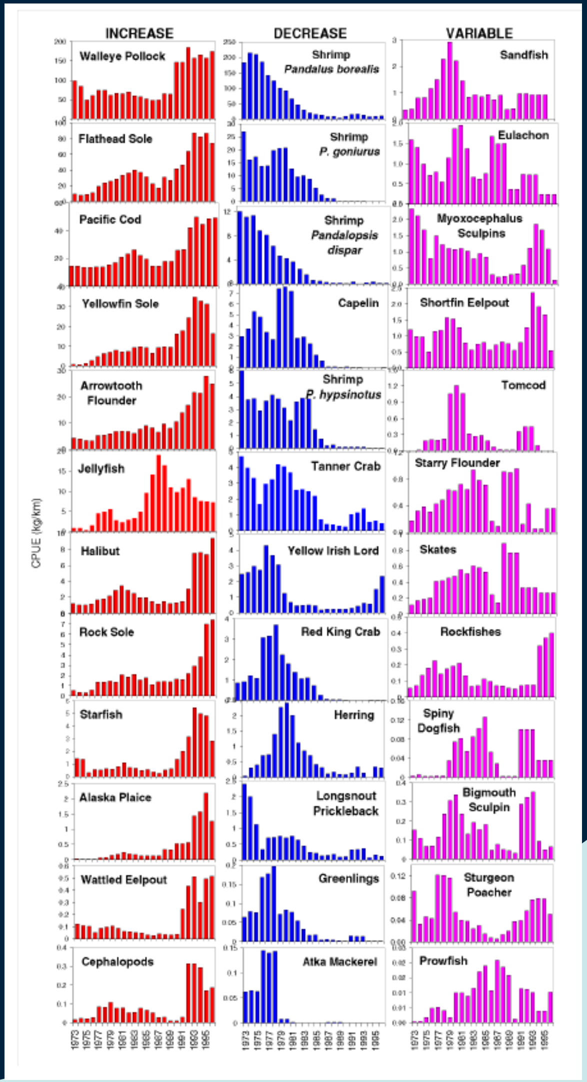
Crossing environmental tipping points:
Gulf of Alaska example





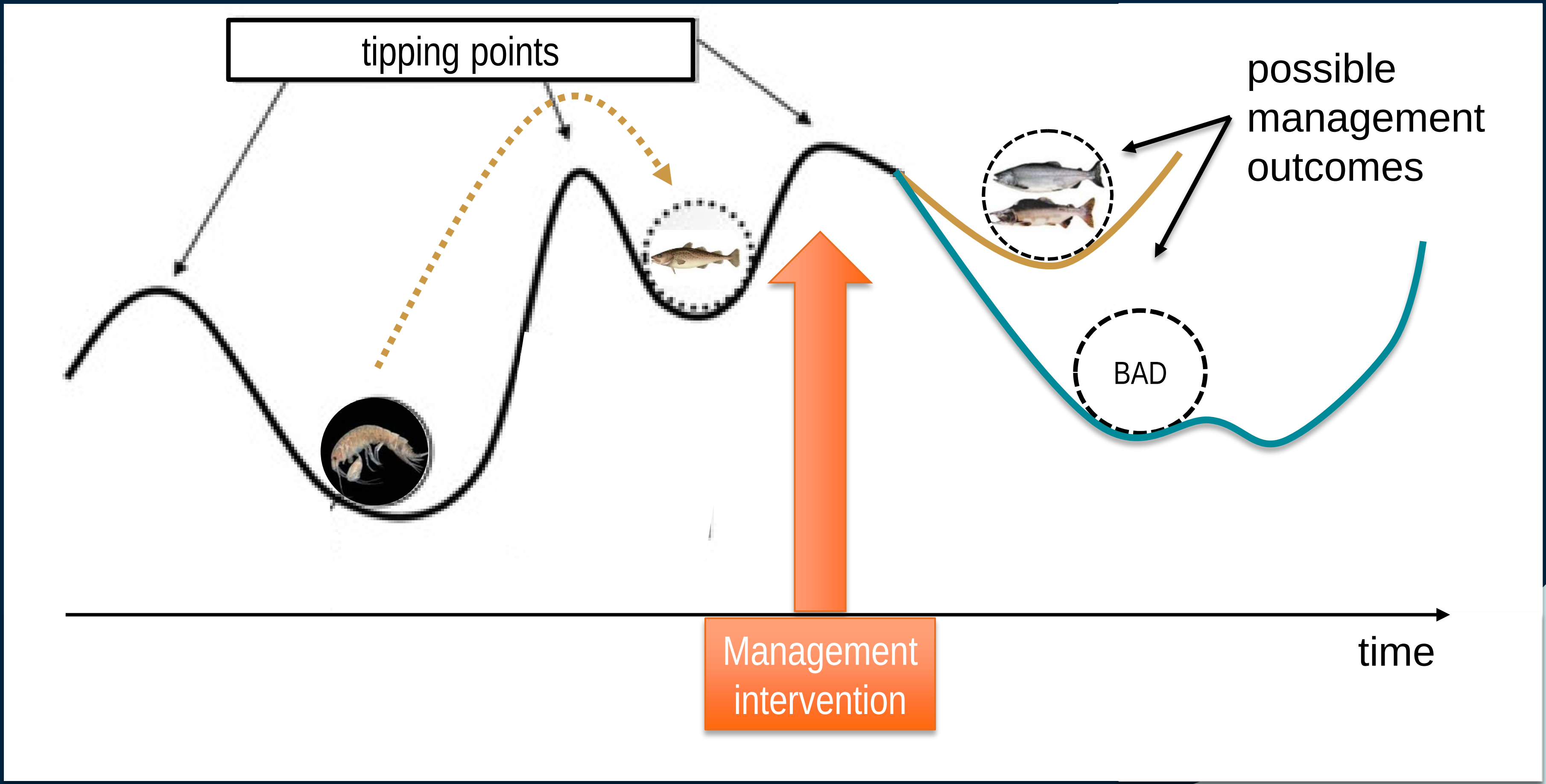
Crossing environmental tipping points





Source: Anderson and Piatt, 1999

Adapting to environmental tipping points



Adapting to environmental tipping points

Possibility for

- Abrupt and irreversible shift
- Social and economic cost

Research questions

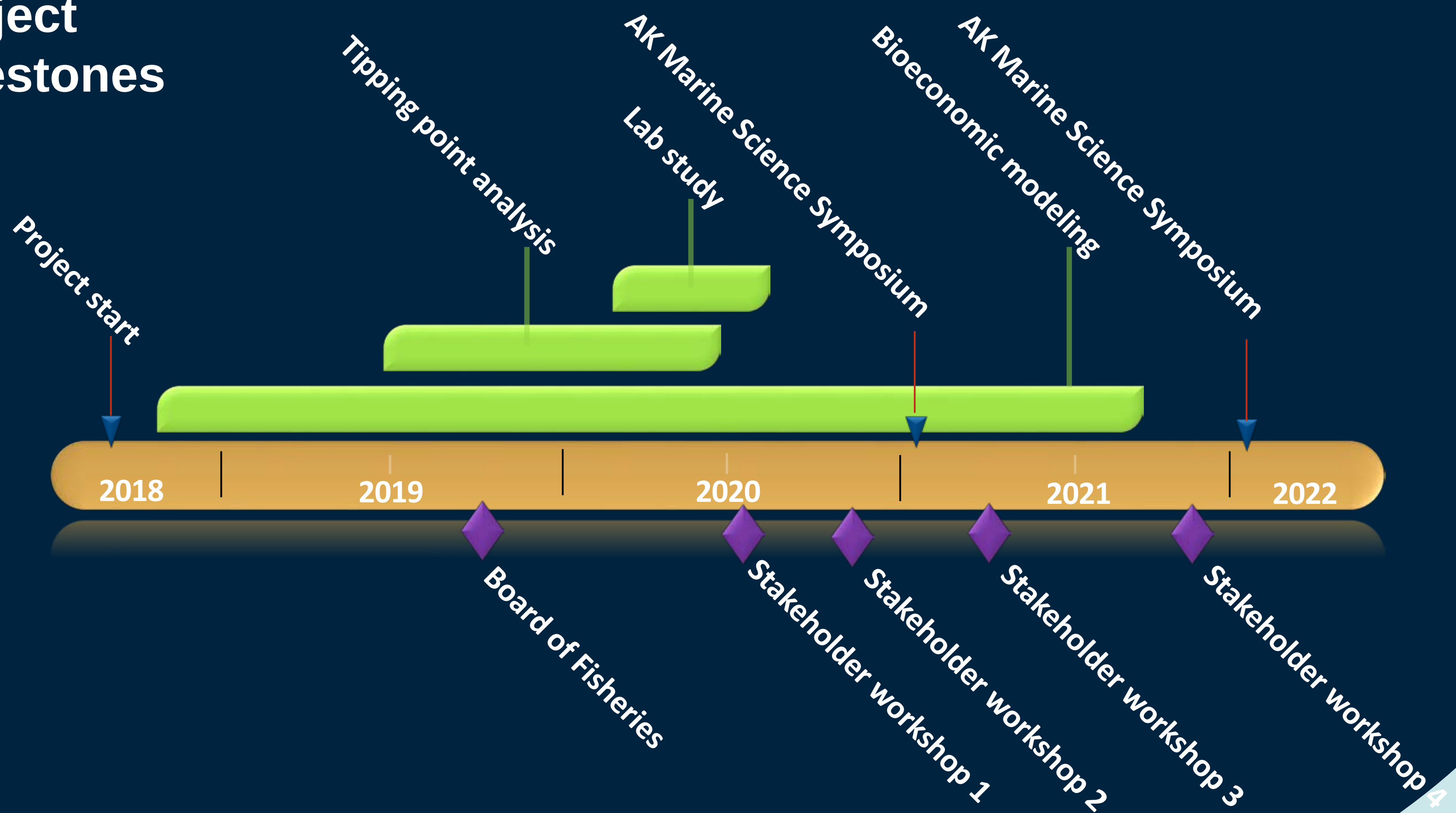
- Can we detect tipping points before they happen?
- How should we respond to avoid a bad outcome?

Goals

- Collaborate with and inform salmon management
- With stakeholders, identify adaptation alternatives

Source: Anderson and Piatt 1999

Project Milestones



Stakeholder engagement

Beyond Research and Modeling

Enable adaptation

- Within existing governance structure
- Identify barriers, gaps, and options for adaptation

Engage affected fisheries stakeholders

- Steering committee (3 members)
    - Help design stakeholder engagement
    - Ensure research remains relevant
- Fisheries participatory group (9 members)
    - Diverse in interest, perspectives, fishery

Communicate results

- Synthesize existing and new research on project website
- Share research results through local radio shows and other channels
- Present research at conferences (Alaska Marine Science Symposium)
- Design OA exhibit at AK SeaLife Center