Five + Years of Ecosystem Monitoring in the Northern GOA

M. Lindeberg, K. Hoffman, R. Suryan, D. Aderhold, R. Hopcroft, M. Arimitsu, H. Coletti

The Long-term Monitoring Program of the *Exxon Valdez* Oil Spill Trustee Council

EVOSTC: A Legacy of Significant Science and Ecosystem Approach

History of Funded Science:

1989
- Injury assessment studies

Early 1990s
- Recovery studies

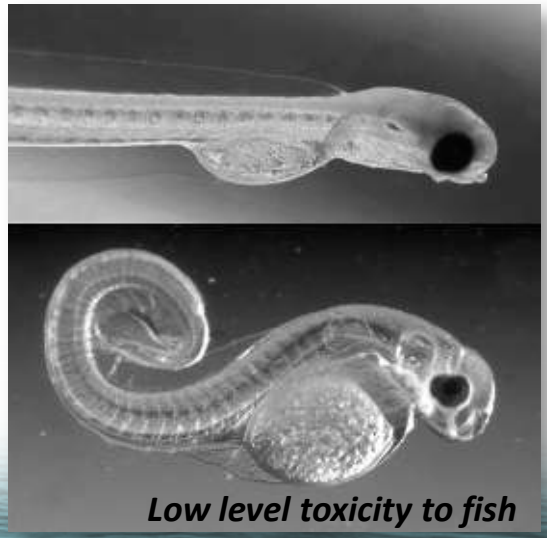
Mid 1990s
- Ecosystem programs (SEA, APEX, NVP)

2012
- Herring Research & Monitoring
- GOA Long-term Monitoring Gulf Watch Alaska

2032?

Current Programs

March 1989: tanker & Orcas


Low level toxicity to fish

Gulf Watch Alaska Program (20 years)

Goals:

- Sustain and build upon existing time series data in EVOS-affected region
- Monitor multiple ecosystem factors and their potential impacts to injured resources
- Make current and historical ecosystem data readily available to a wide variety of users
- Develop science synthesis products for management agencies and the public
- Collaborate with regional partners






GWA Collaborative Projects and PIs

Gulf Watch Alaska Ecosystem Components

Environmental Drivers

- **GAK-1–** Danielson, Weingartner
- **Seward Line–**Hopcroft
- **Prince William Sound–**Campbell
- **Lower Cook Inlet–**Holderied, Shepherd
- **Cont. Plankton Recorder—**Batten

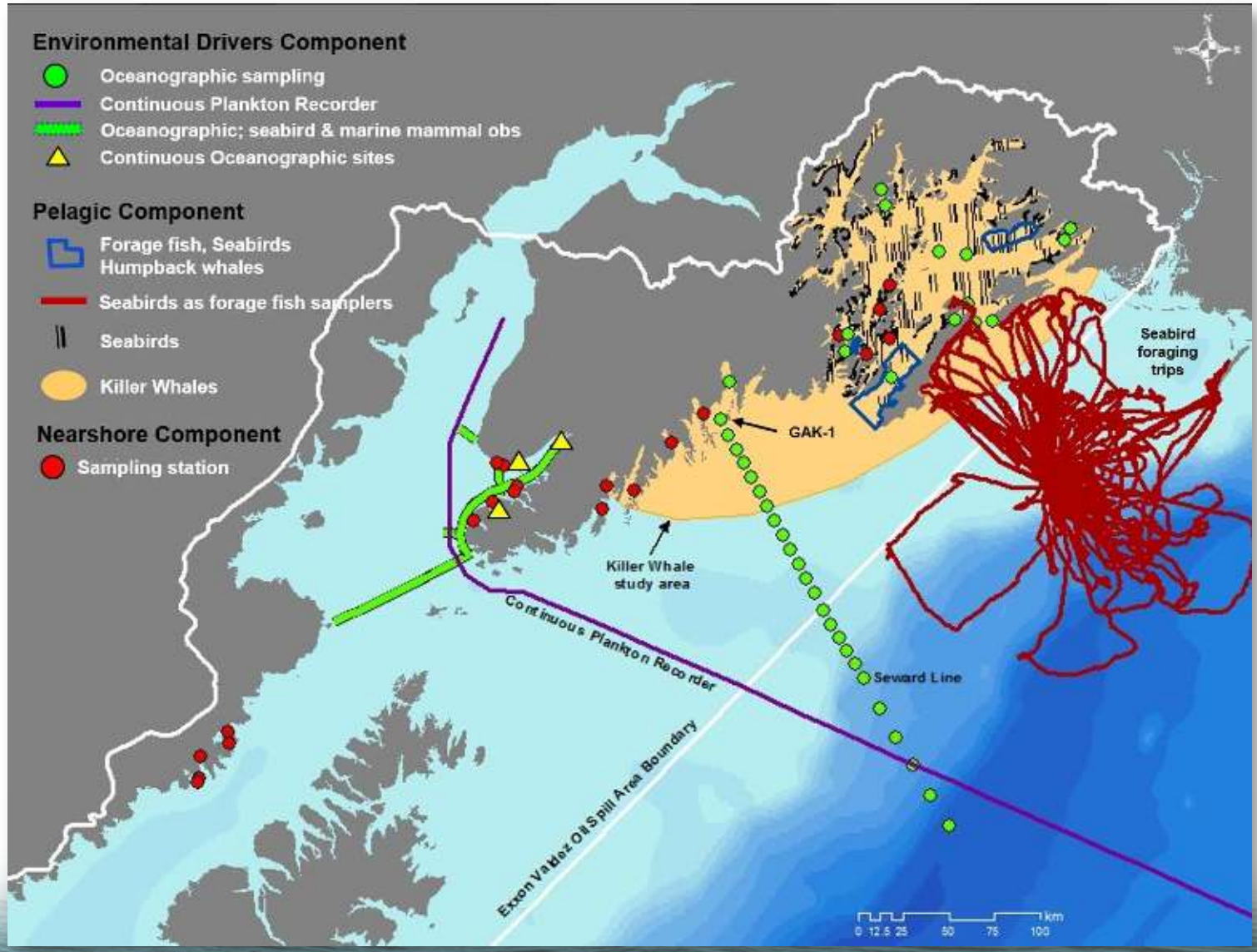
Pelagic Ecosystem

- **Killer Whales–**Matkin
- **Summer Marine Birds–**Kuletz, Kaler
- **Forage Fish–**Arimitsu, Piatt
- **Humpback Whales–**Moran, Straley
- **Winter/Fall Seabirds—**Bishop

Nearshore Ecosystem

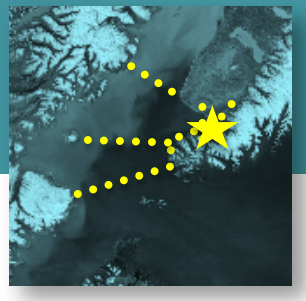
- **PWS, Kenai Fjords, Kachemak Bay, Katmai**
- **Status of >200 species –** e.g. sea otters, nearshore birds, oyster catchers, intertidal organisms
- Coletti**,** Esler, Kloecker, Monson, Weitzman, Konar, Iken

GWA Monitoring Locations



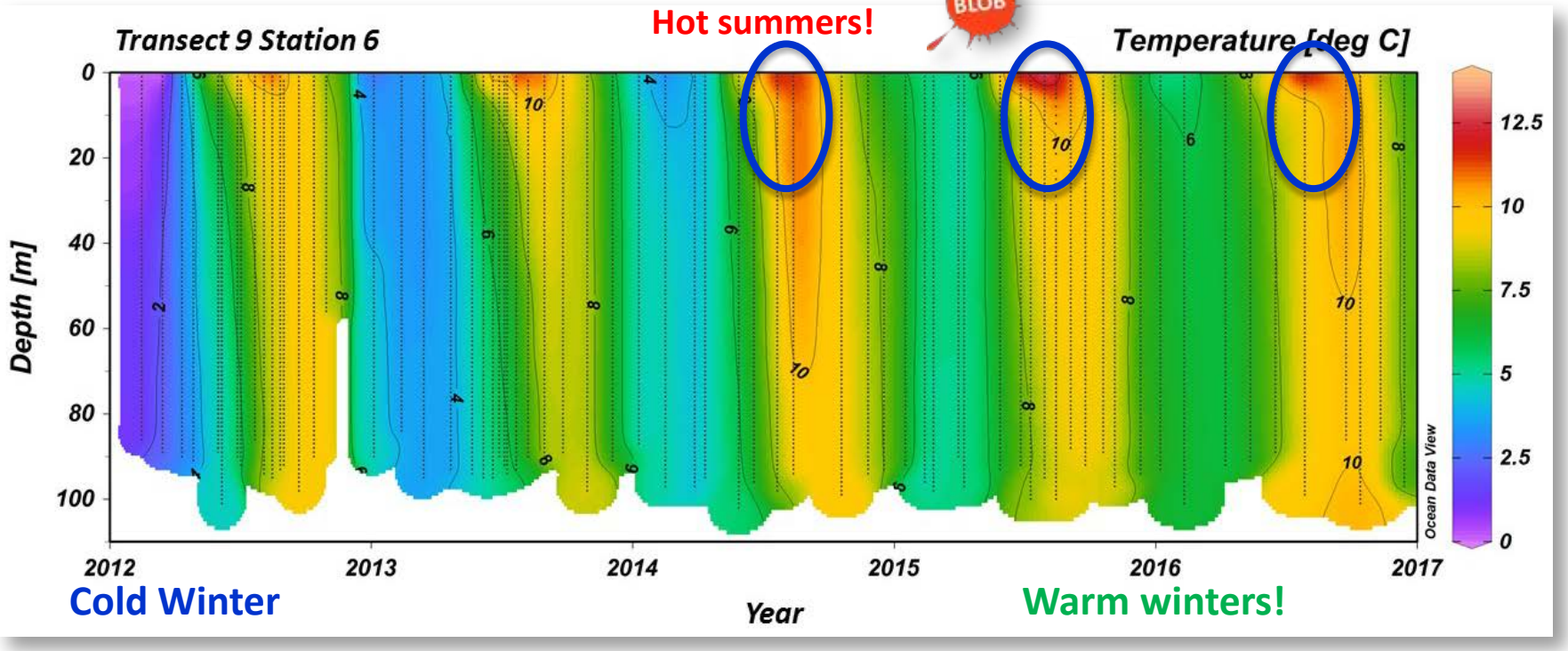
Environmental Drivers:

Lower Cook Inlet & Kachemak Bay - *Doroff, Holderied*

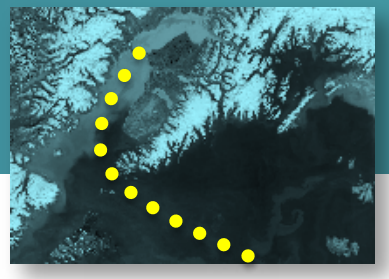


INSIDE WATERS:

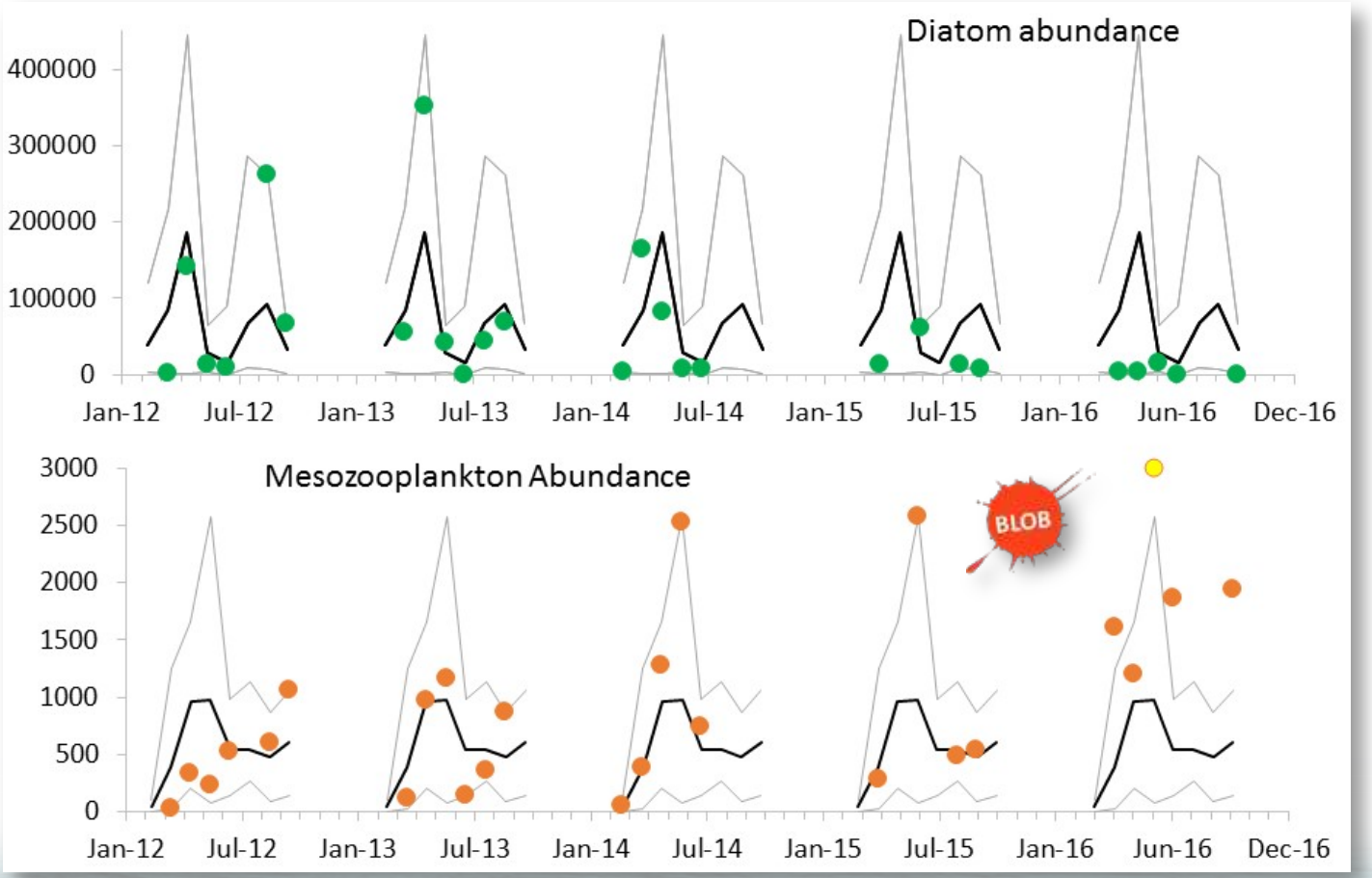
2012-2016 Kachemak Bay Water Temperature Profiles



Environmental Drivers:
Continuous Plankton Rec. – *S. Batton*



SHELF trends for last five years (2012-2016)



Lower

Monthly mean

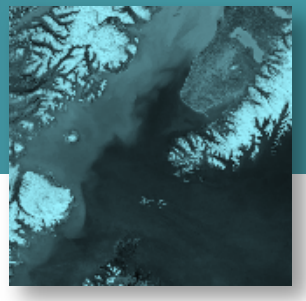
2004-15 mean

2004-15 min/max

Higher

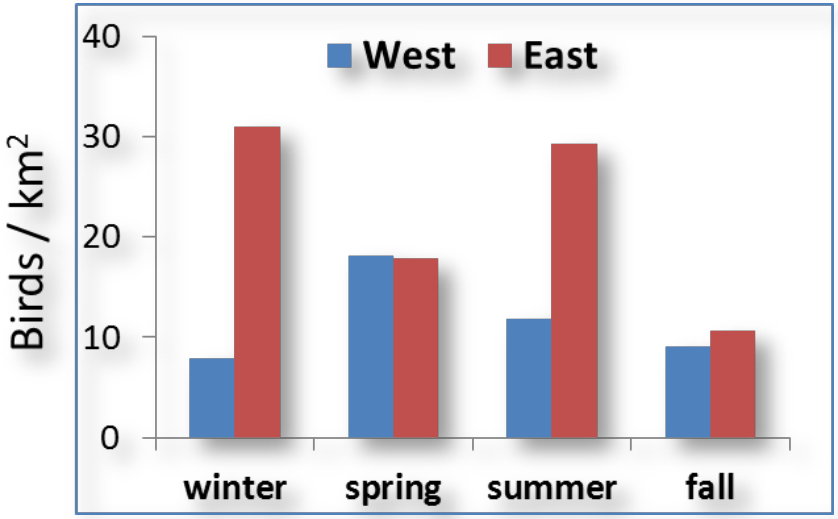
e.g. Warm-water species smaller and less lipid-rich

Pelagic Ecosystem:
Marine Birds – *Kuletz & Kaler*



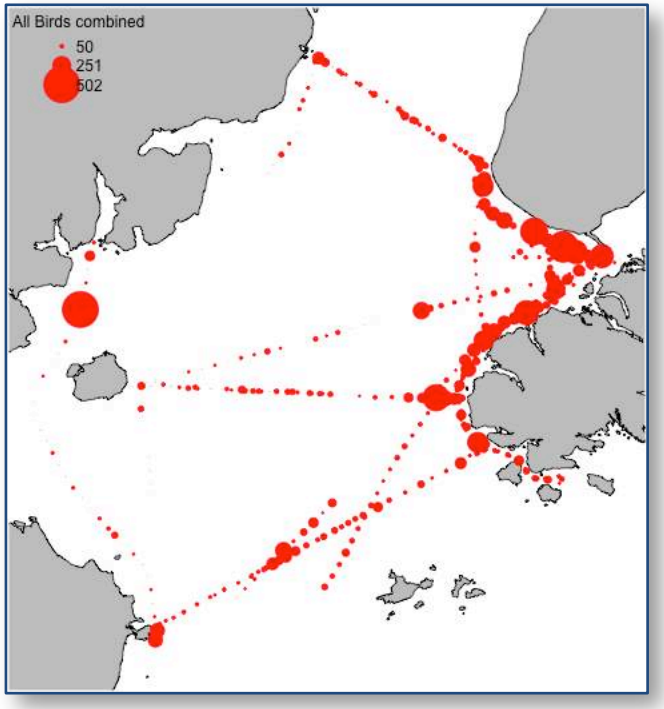
INSIDE WATERS: Lower Cook Inlet: 2012-16 Seabird Surveys

Outer Kachemak attracts lots of foragers!



Of most abundant species, 2* nest commonly in LCI:

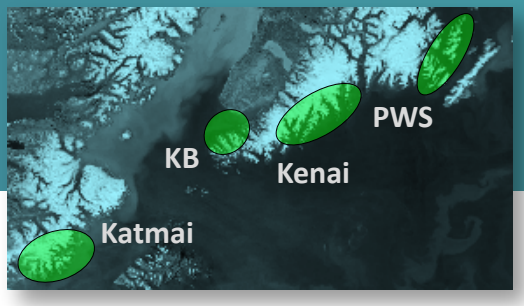
- Black-legged kittiwake*
- Common murre*
- White-wing scoter
- Sooty shearwater
- Northern fulmar
- Red-necked phalaropes



Highest densities on east side - Influence of oceanic water from ACC (*consistent with S. Speckman et al. 2005)*

Nearshore Ecosystem:

Coletti, Esler, Iken, Kloecker, Konar, Monson, Weitzman, Bodkin, and Ballachey



Patterns in the Nearshore

General findings: Patterns of variability differed across metrics, with some fluctuating synchronously at broad spatial scales and others showing site-specific variation.

Spatially nested design:

To determine if changes are due to local, regional, or broad GOA-wide drivers

Monitoring the Nearshore Food Web

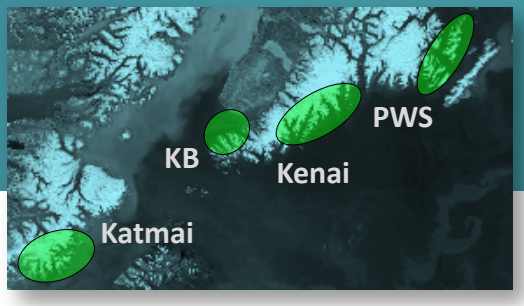
Nearshore Predators

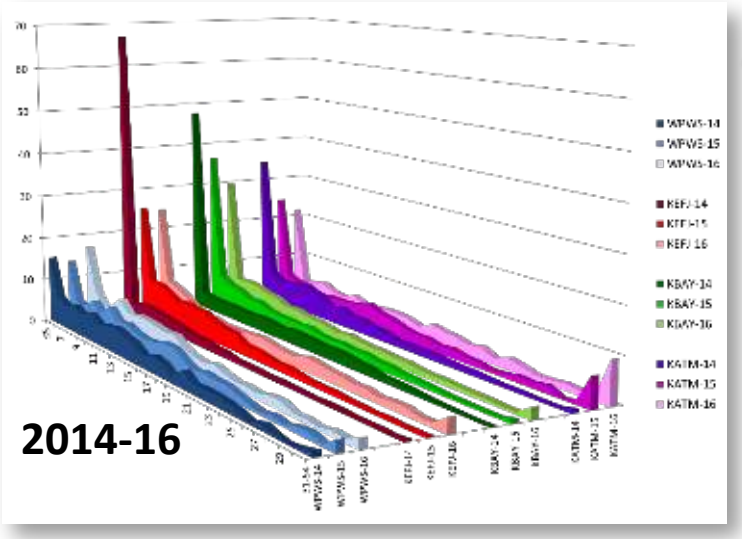
Primary Benthic Consumers

Primary Producers

Environmental Variation

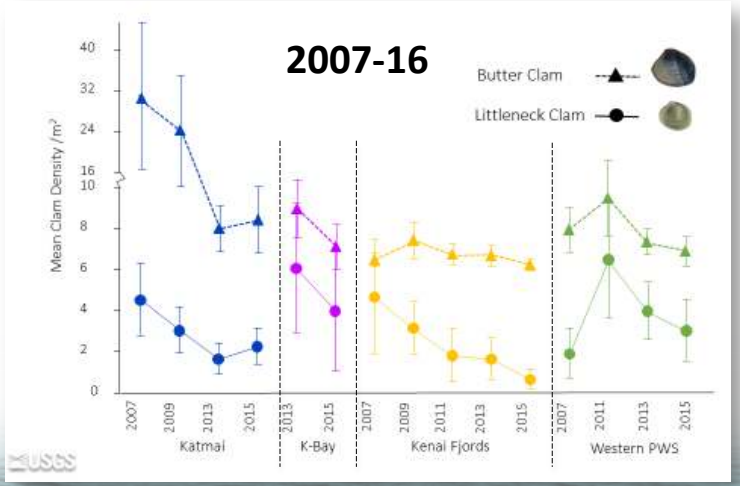
Nearshore Ecosystem:





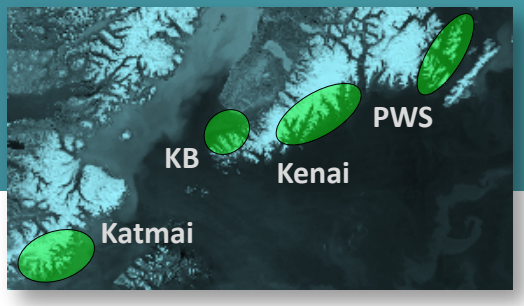
e.g. Patterns of Primary Benthic Consumers

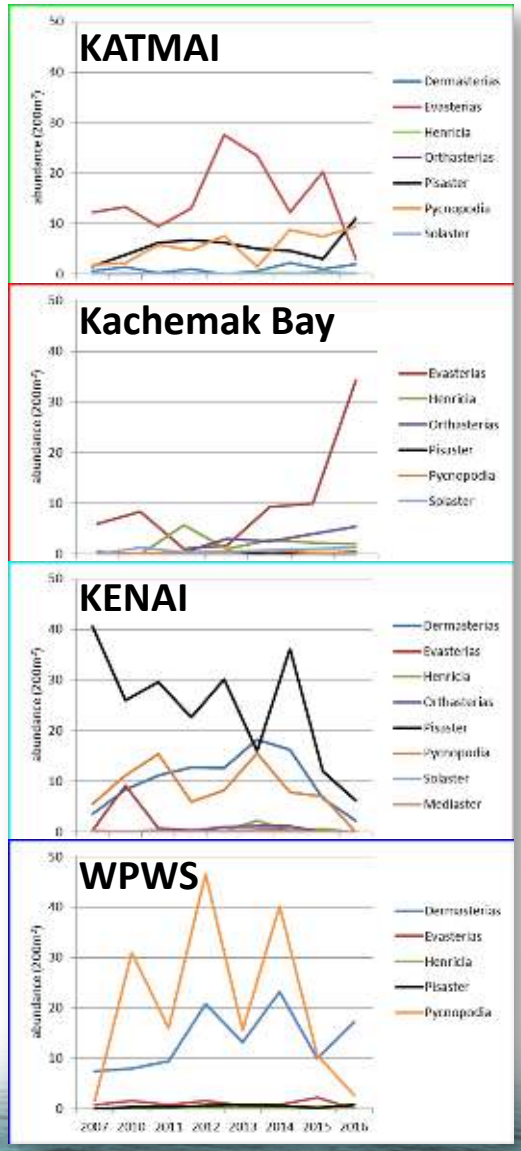
- **Mussels**
  factors operating across the northern GOA and local drivers were affecting mussel survival and subsequently abundance



- **Clams**
  In general densities are declining in all regions but they are known to be highly variable, influenced by both top-down and bottom-up drivers

Nearshore Ecosystem:





e.g. Patterns of a Benthic Apex Predator - Sea Stars

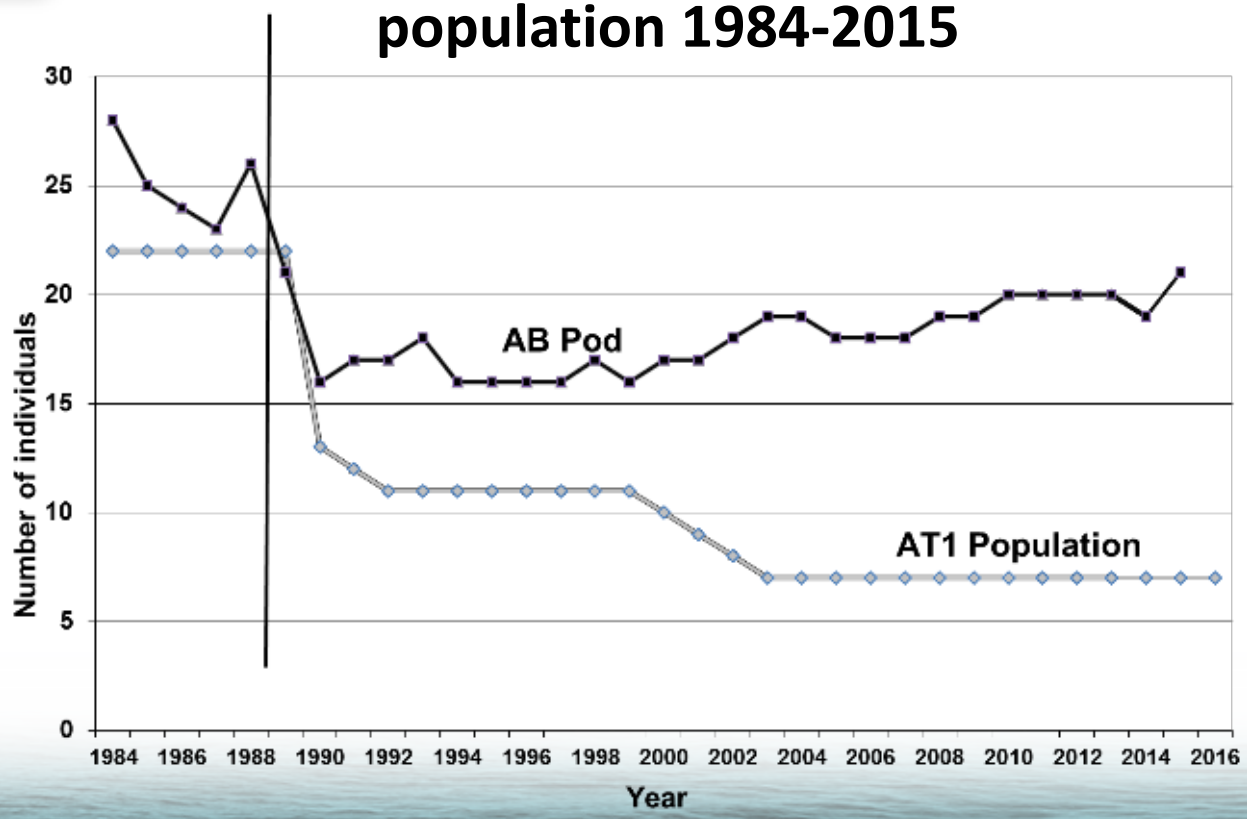
- **KATMAI** dominated by *Evasterias* in all years except for the last sampling year (2016).
- * **KACHEMAK BAY** had overall low densities in the early years but later, *Evasterias* became the dominant genus.
- **KENAI** had the highest diversity of sea stars of all the regions, dominated by *Pisaster* in most years but all were declining over time.
- * **Western PWS** had the lowest diversity of sea stars.

↑↓↑

* **Sea Star Wasting Disease**

Pelagic Ecosystem:
Killer Whales – *Matkin & Olsen*

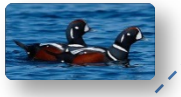
Numbers of whales in AB pod and AT1 population 1984-2015



Lingering Oil:

NMFS: *Carls, Lindeberg;* USGS: *Esler, Ballachey*

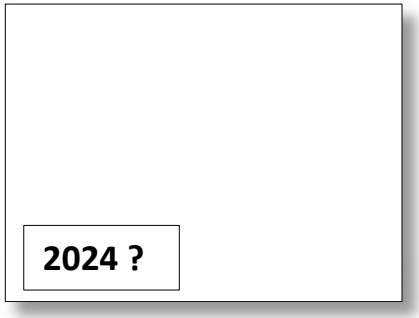
Monitoring Decades of Persistent Oil



Heavy
Surface oil

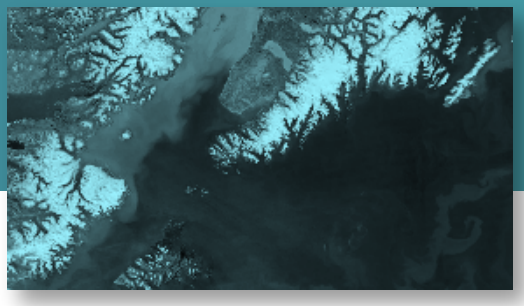
Heavy
Subsurface oil

Heavy
Subsurface oil



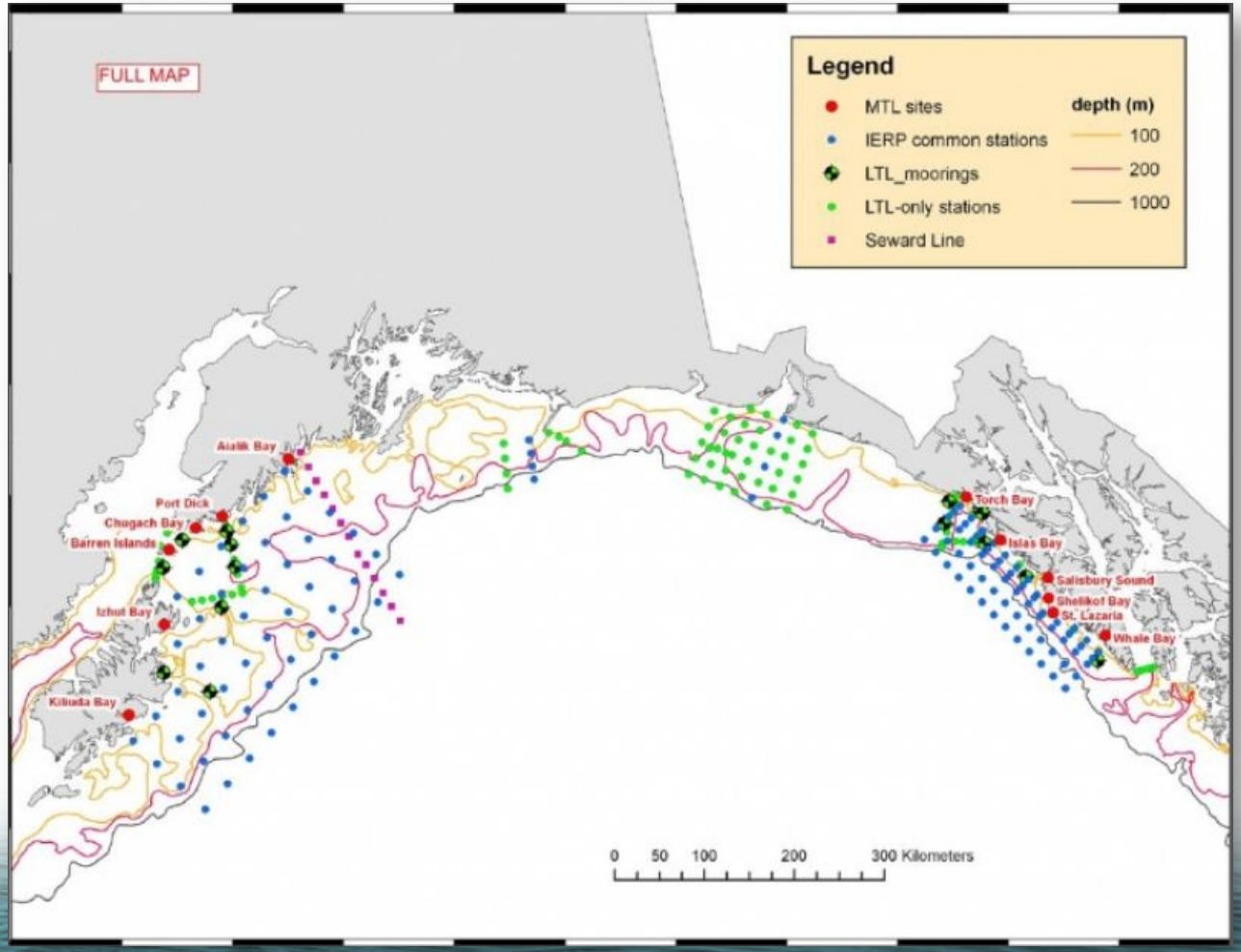
?
Subsurface oil

Related GOA Monitoring

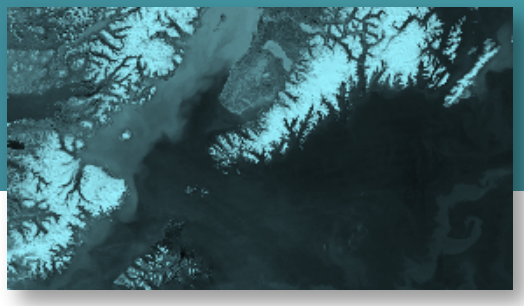


North Pacific Research Board
Gulf of Alaska Integrated Ecosystem Research Project (GOA IERP)

Now called: Gulf Survey

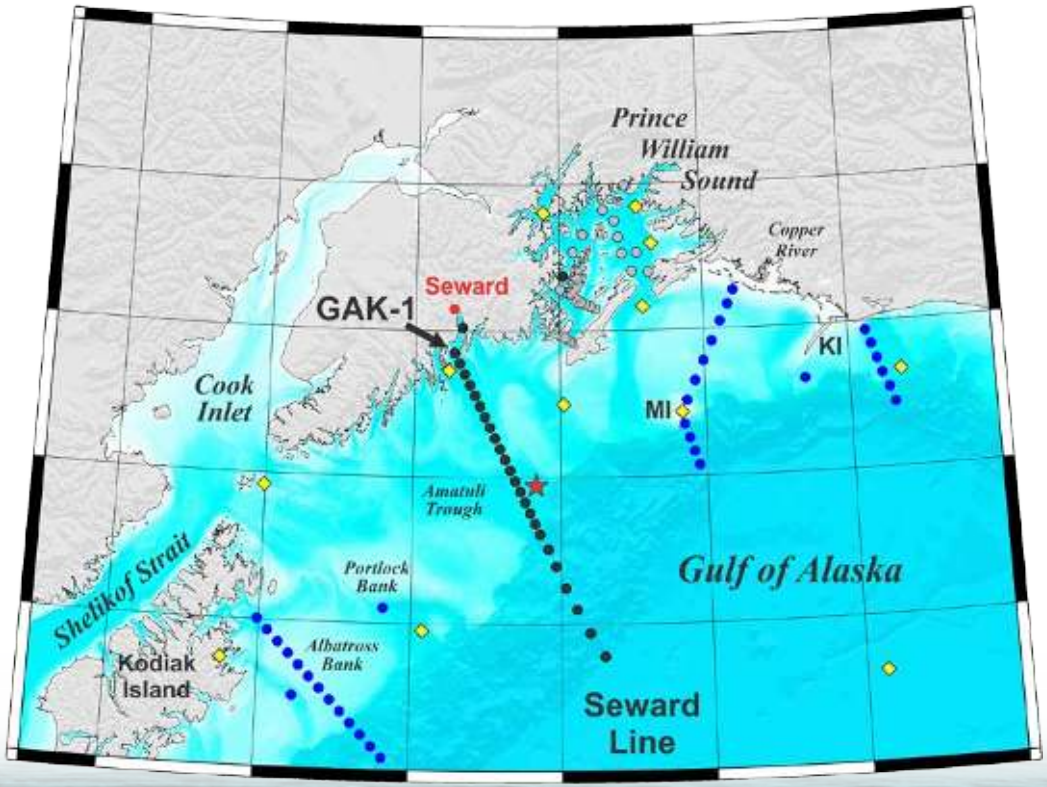


Related GOA Monitoring

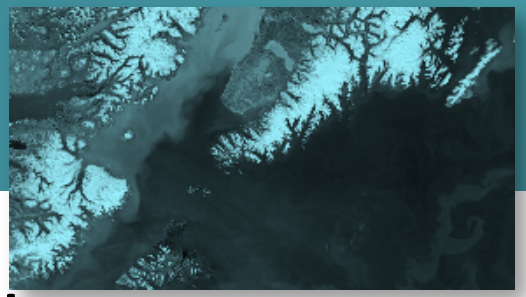


National Science Foundation
Long-term Ecological Research (LTER)

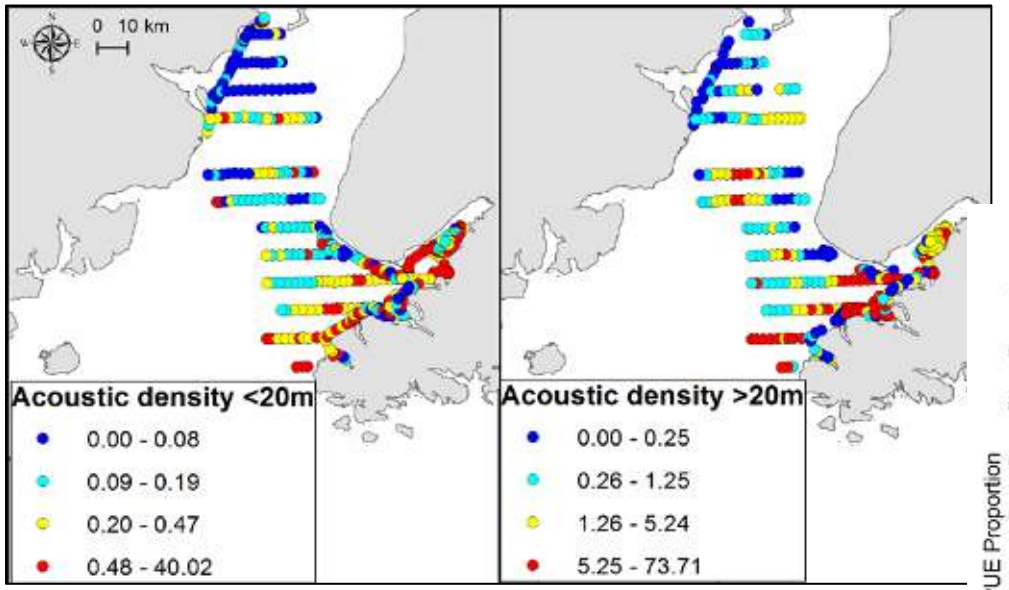
- Physics (T, S, Optical properties)
- Macronutrients (N, P, Si)
- Carbon (Ocean acidification)
- Iron (Gulf of Alaska Project)
- Chlorophyll (+Primary production)
- Phyto/Microzooplankon
- Metazooplankton (3 mesh sizes)
- Seabird/Marine Mammal observer

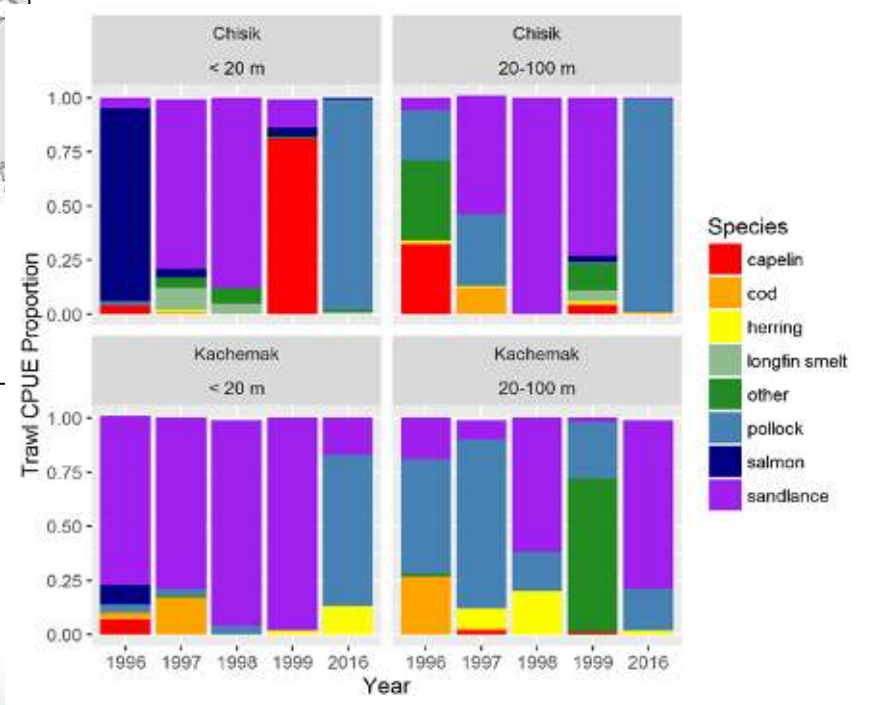


Related GOA Monitoring



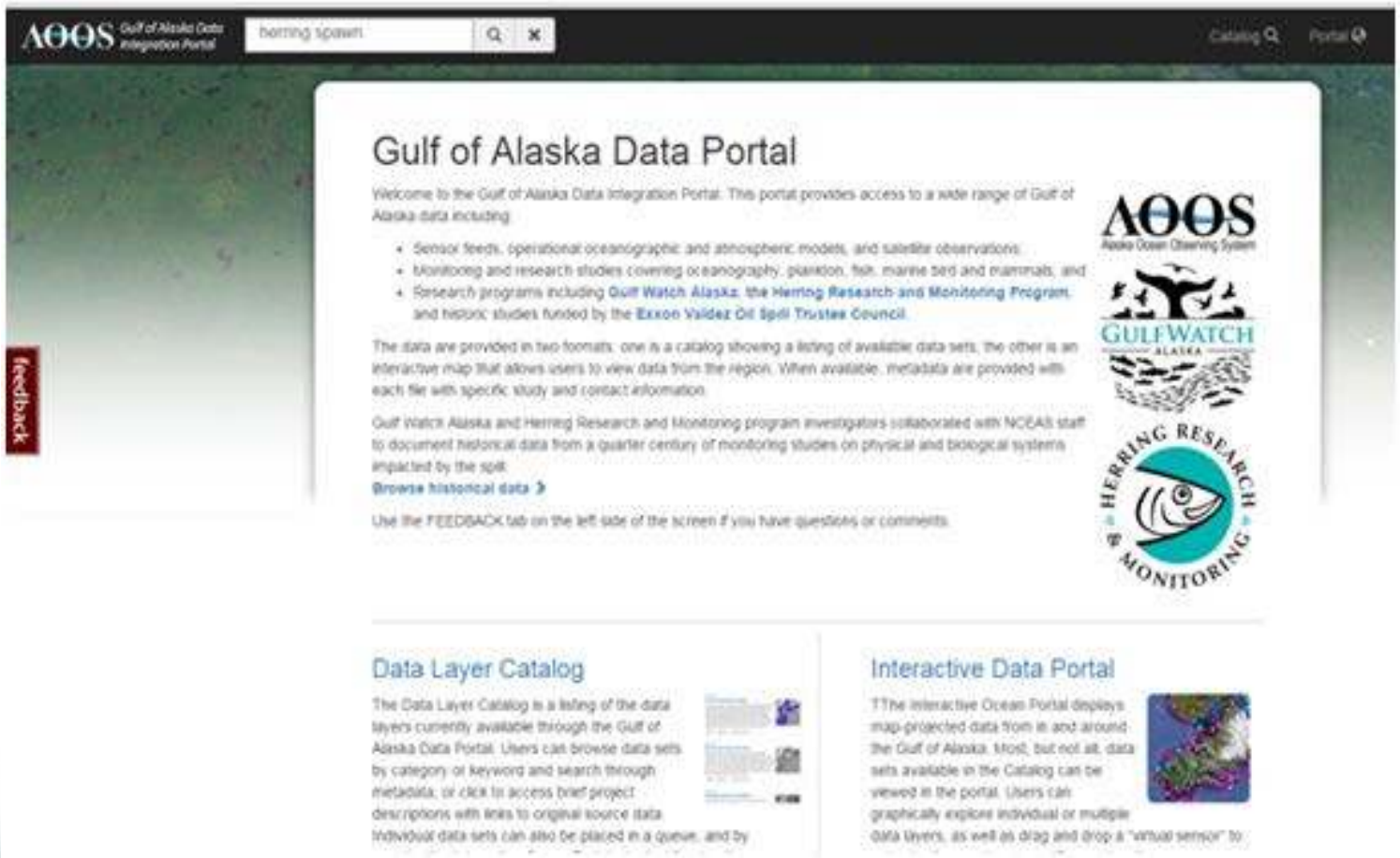
U.S. Geological Survey Alaska Science Center
Status of Forage Fish and Seabirds, Lower Cook Inlet





GWA Data and Publications

First 5 years of data publically available on the Gulf of Alaska Data Portal: http://portal.aoos.org/gulf-of-alaska.php



GWA Data and Publications

- Science Synthesis Report available on EVOSTC Website: http://www.evostc.state.ak.us/index.cfm?FA=projects.gulfWatch
- More than 50 publications in peer-reviewed journals and books, most available as open access: http://www.gulfwatchalaska.org/resources/publications/
- Special Issue Forthcoming – *Spatial and Temporal Ecological Variability in the Northern Gulf of Alaska: What Have We Learned Since the Exxon Valdez Oil Spill?*

Thank You - Questions?

Contact me!
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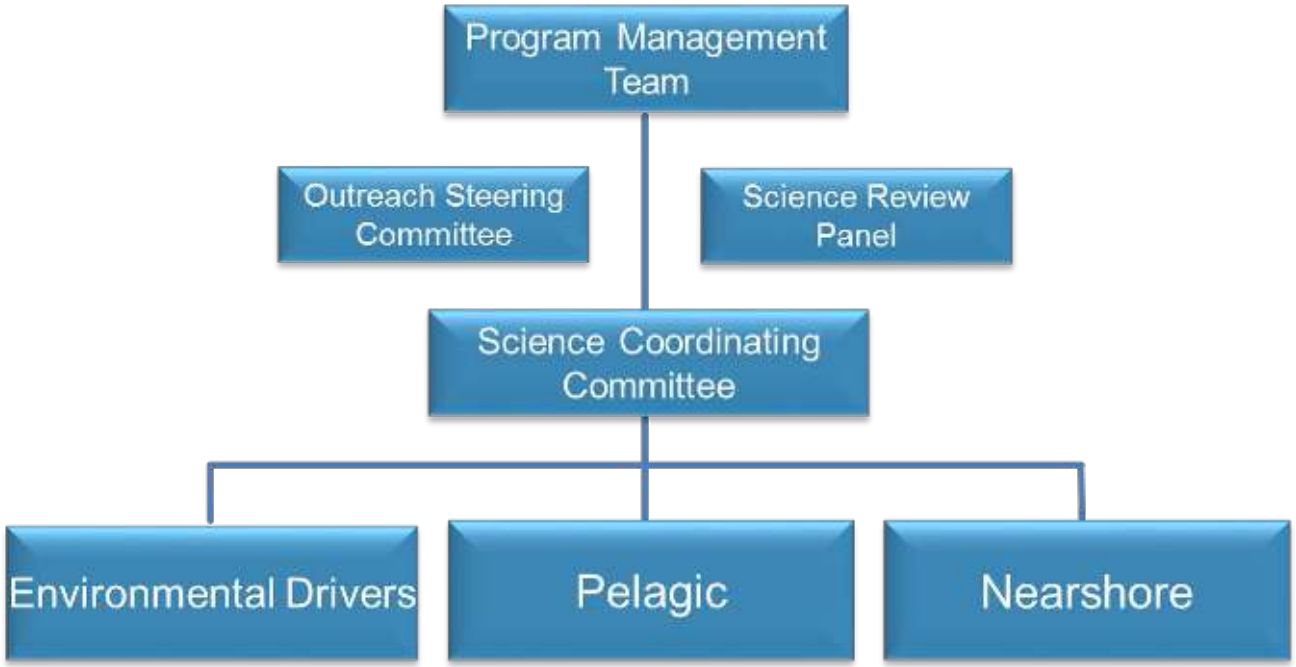
Donna.Aderhold@noaa.gov
907-226-4617

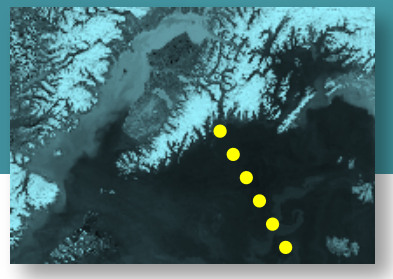
GWA Program Organization

An Integrated Ecosystem Approach



Environmental Drivers:

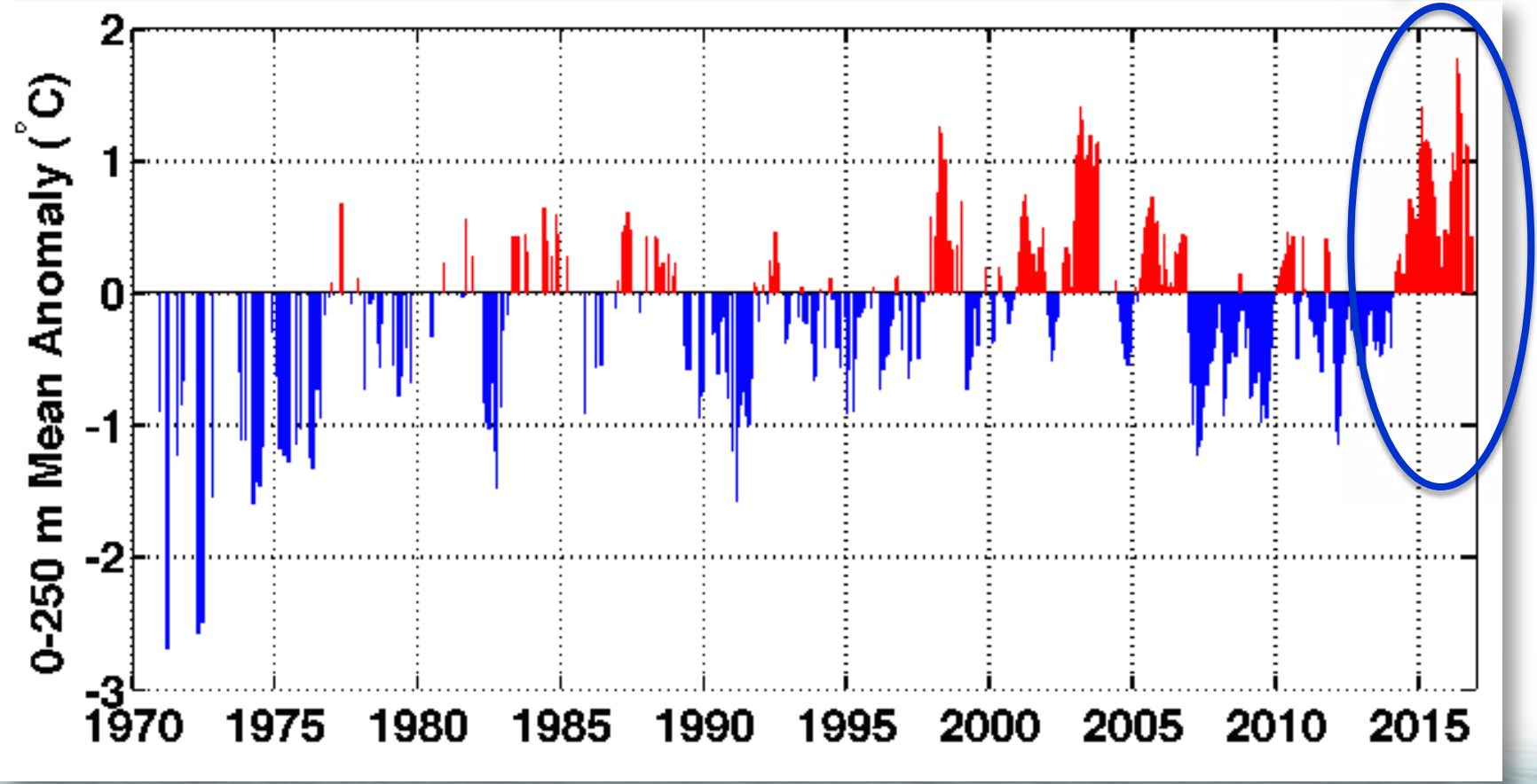
GAK 1 – *S. Danielson, T. Weingartner*



SHELF:

Water Colum Temperature Anomaly 1970-2016

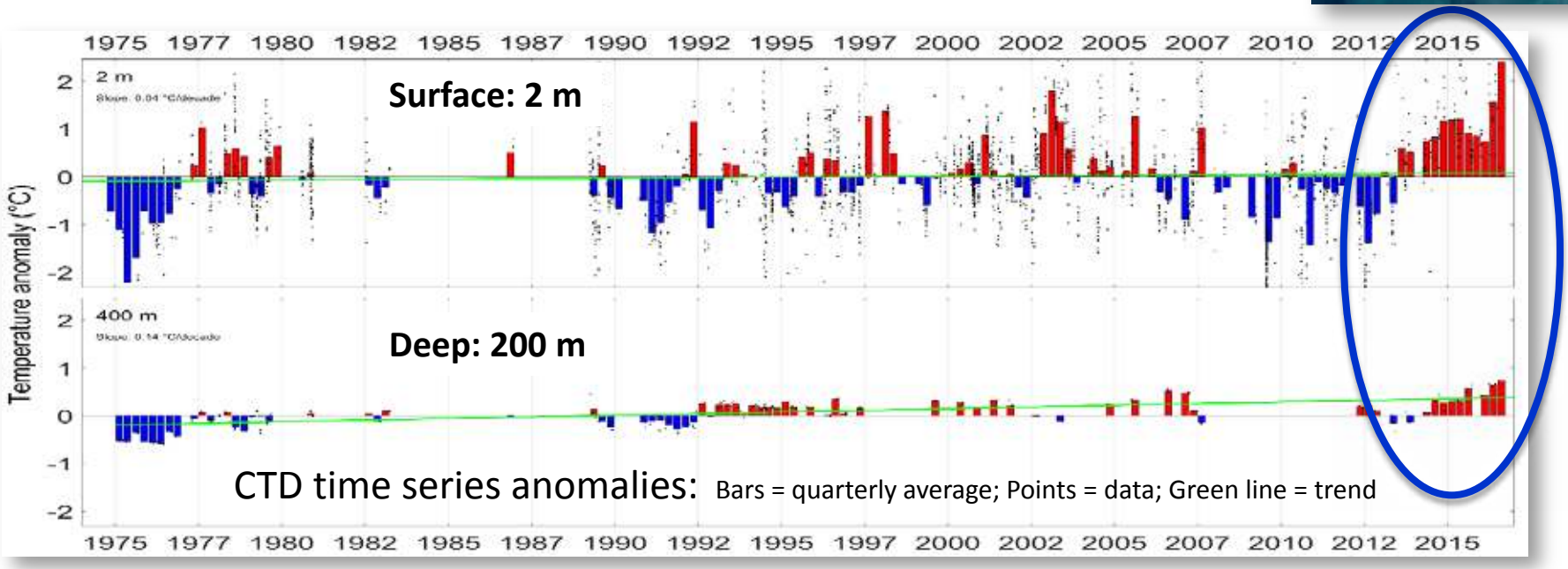
BLOB



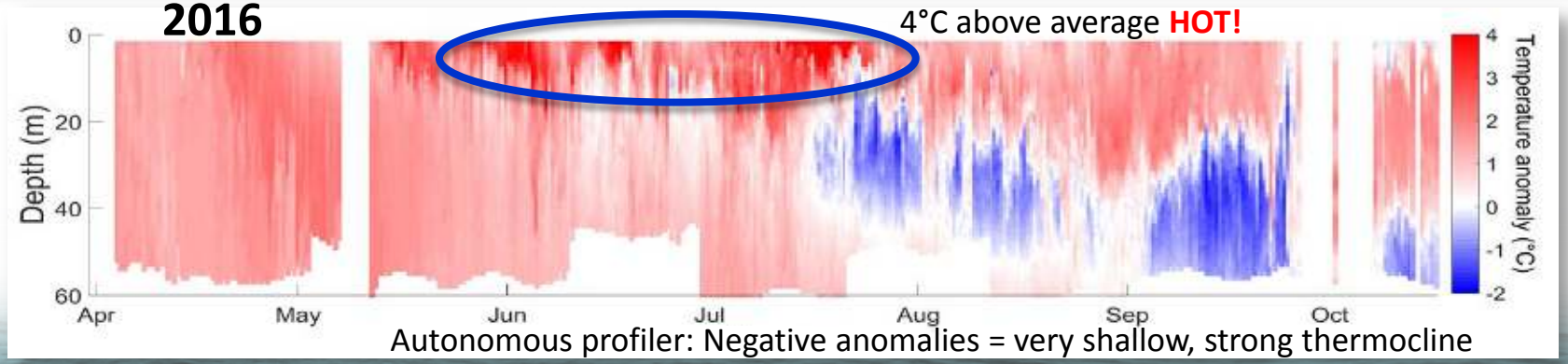
Environmental Drivers:
PWS oceanography – *R. Campbell*

Pstr

INSIDE WATERS: Temperature Anomalies



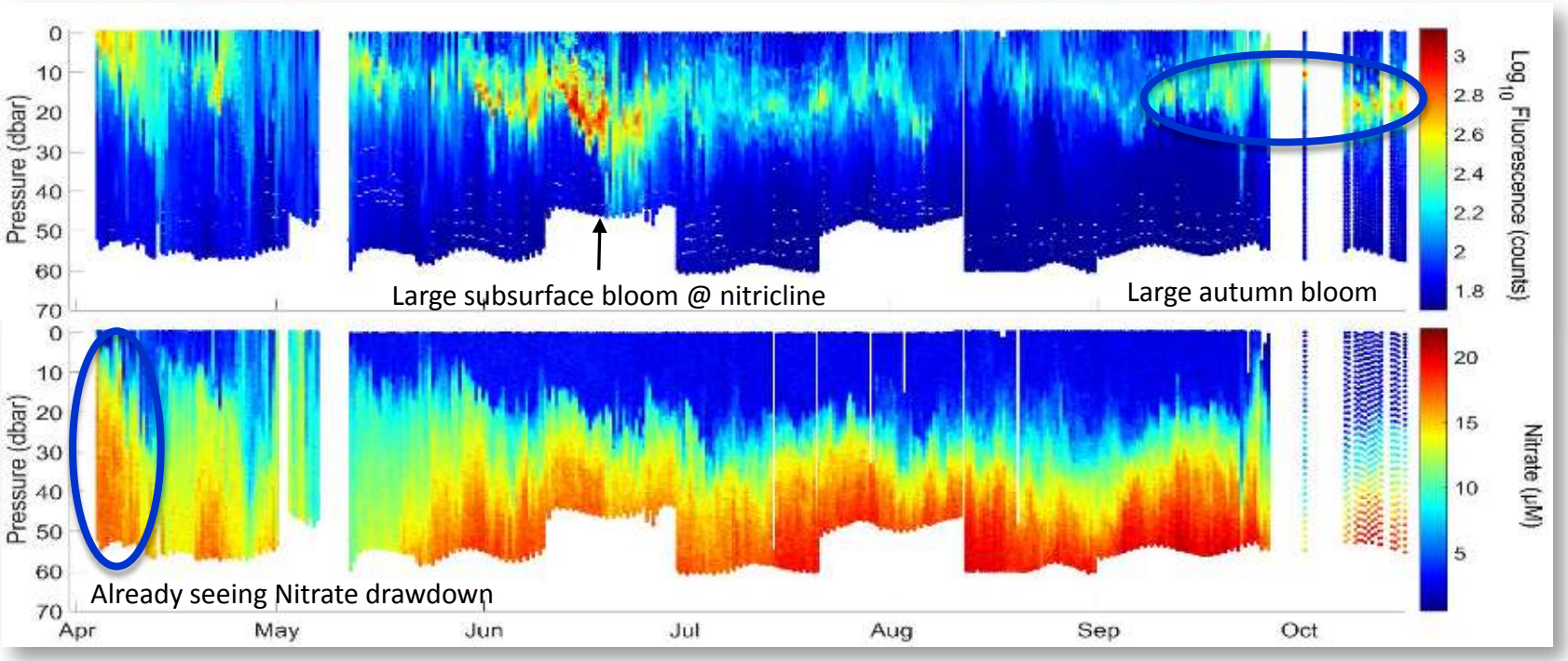
CTD time series anomalies: Bars = quarterly average; Points = data; Green line = trend



Autonomous profiler: Negative anomalies = very shallow, strong thermocline

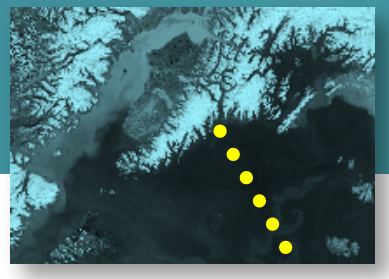
Environmental Drivers:
PWS oceanography – *R. Campbell*

INSIDE WATERS: 2016 Spring Bloom Anomalies

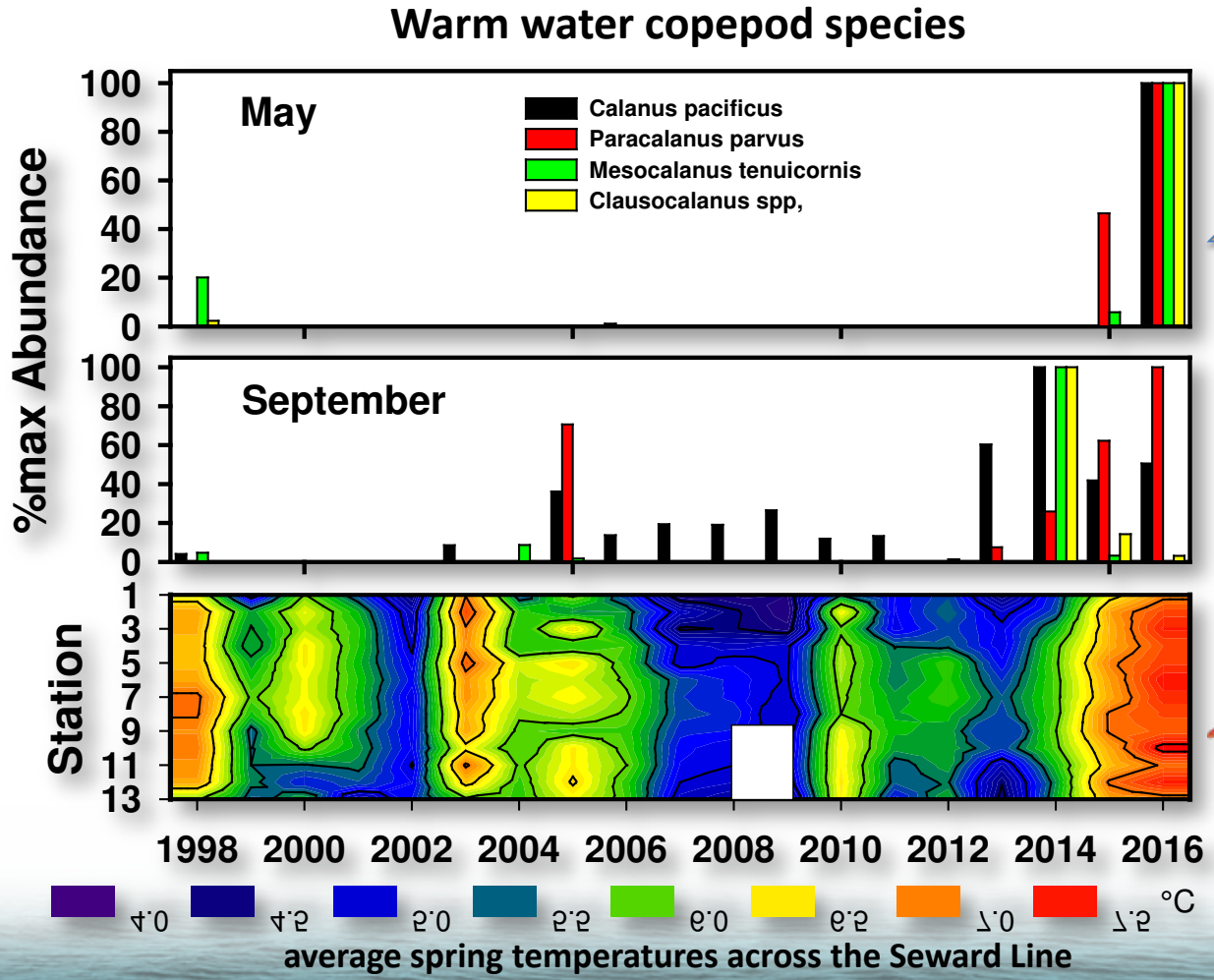


Environmental Drivers:

Seward Line – *R. Hopcroft*



SHELF Plankton: 1998-2016

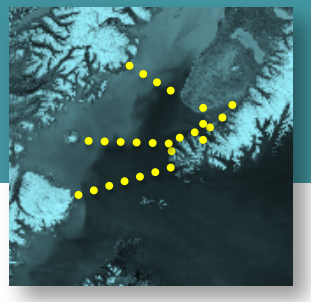


Latest Observations:

- Warm water persistence over winter (15/16) allowed survival of many warm-water species of copepods
- 4 species monitored had their highest observed spring abundances
- High fall abundances correspond to Blob/El Nino period

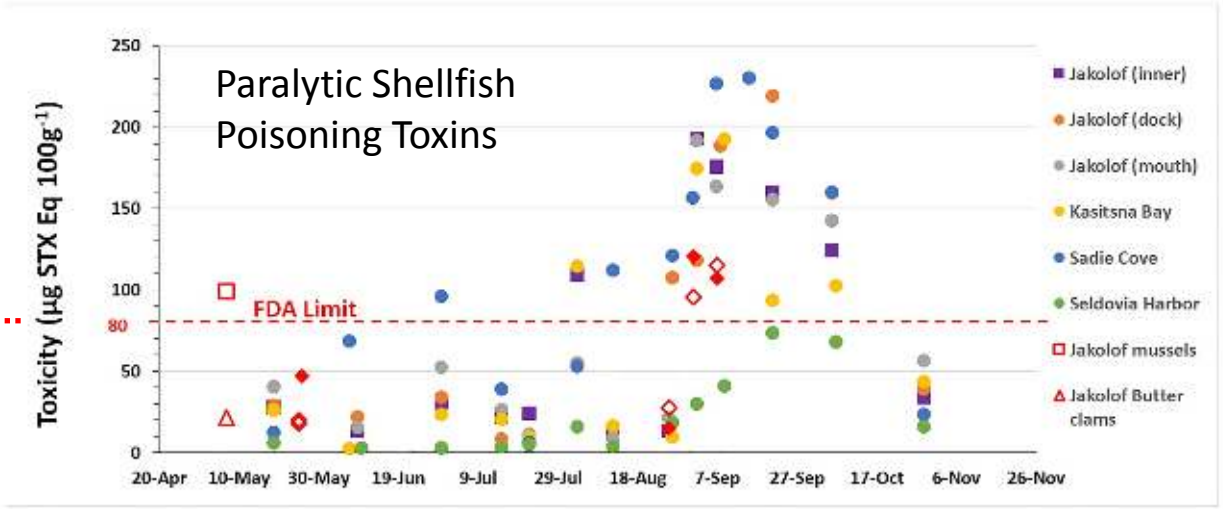
Environmental Drivers:

Lower Cook Inlet & Kachemak Bay - *Doroff, Holderied*

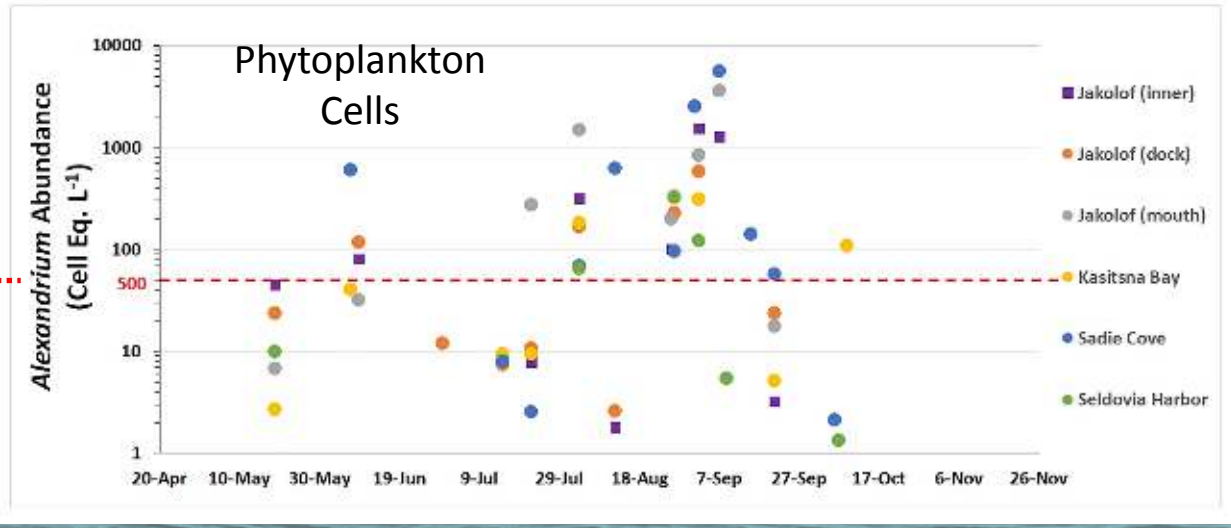


INSIDE WATERS: Warm water = more PSP events

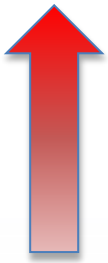
Regulatory limit for eating shellfish



Plankton "bloom"threshold

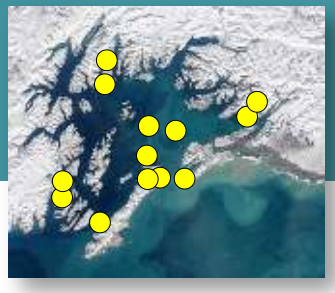


Summer 2016



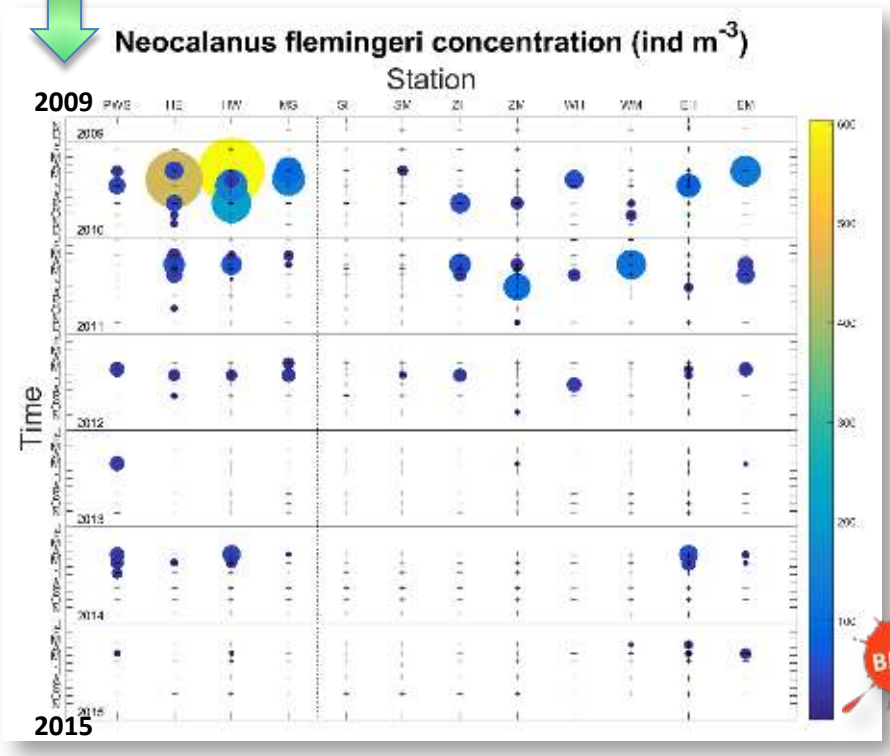
Environmental Drivers:
PWS oceanography – *C. McKinstry, Campbell*

Pstr

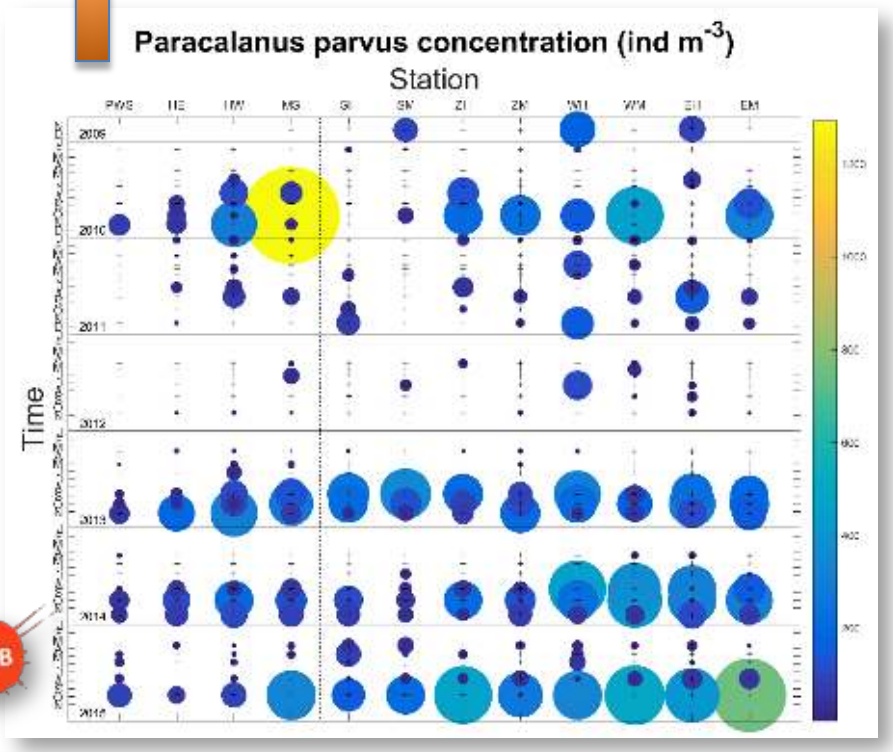


INSIDE WATERS: Change in Plankton Assemblages (2009-15)

Cold water species



Warm water species



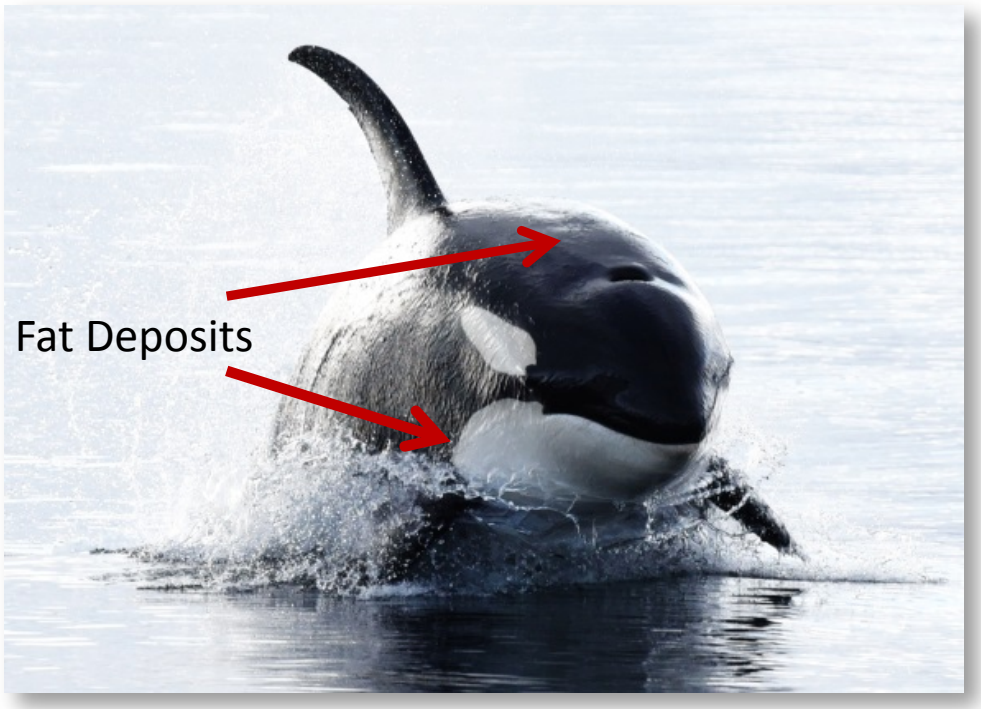
Note: a few examples, but many changes in many species

Pelagic Ecosystem:
Killer Whales – *Matkin & Olsen*

Recent Observations

Feeding conditions:

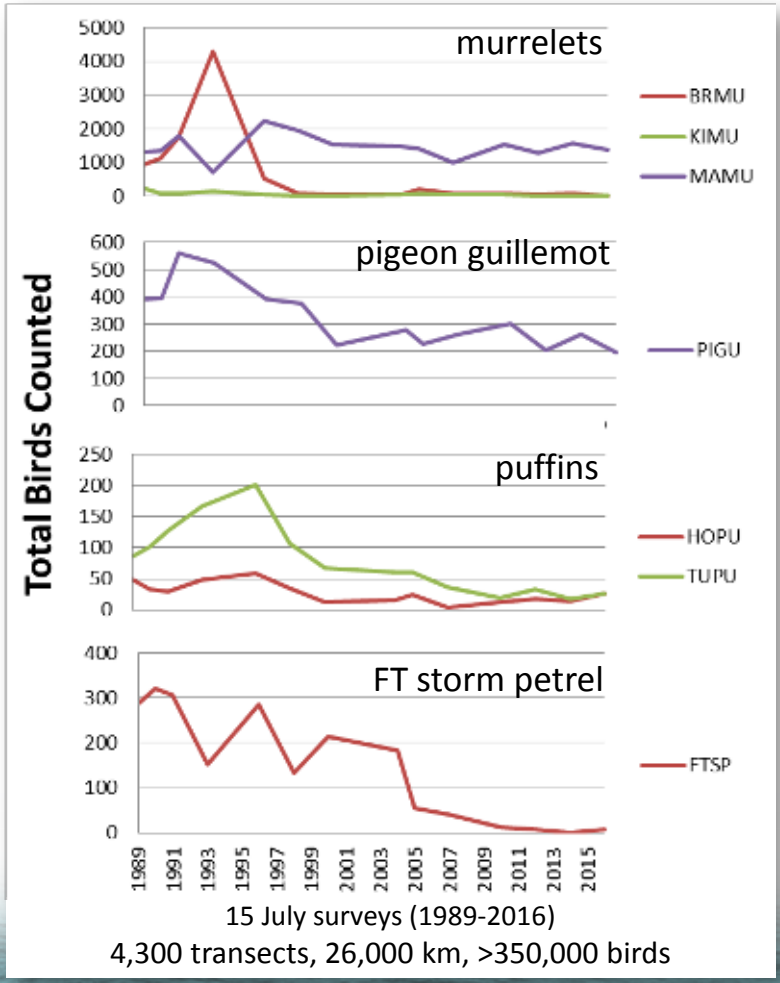
- **2015 Coho up – whales with "doughnut" heads (fat), socializing**
- **2016 Coho down – whales not so fat, no fall social groups, likely feeding out of PWS/KF, over at Copper River**



Pelagic Ecosystem:
PWS Marine Birds – *Kaler, Kuletz, Cushing, Labunski*

INSIDE WATERS: Summer Marine Bird Surveys

Pelagic foragers declining



15 July surveys (1989-2016)

4,300 transects, 26,000 km, >350,000 birds

Recent Observations:

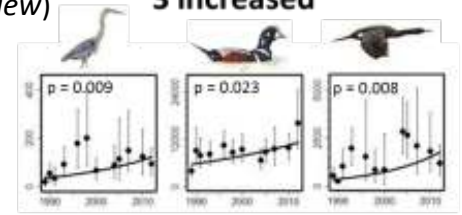
- **2014, 2016 marine bird survey data followed trends, pelagic species numbers remained low since at least 2005**
- **Largest murre wreck ever reported in AK, 2015-2016**
- **Complete reproductive failure of PWS Black-legged Kittiwake in 2016, not seen in 32 yrs (D. Irons, unpubl data)**

BLOB

Cushing et al. (*in review*)

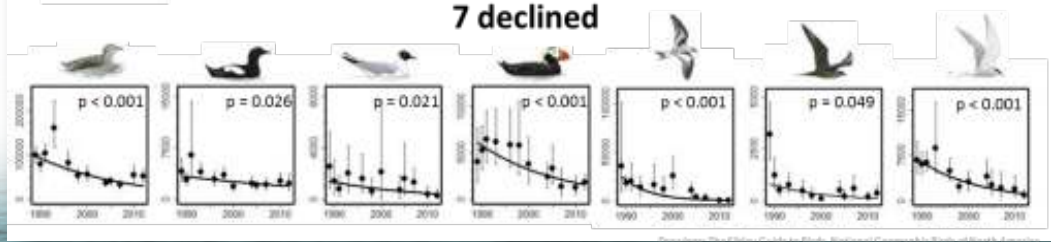
1989-2012

3 increased



- consistent with changes in pelagic (offshore) food webs
- Species feeding on plankton and forage fish most negatively affected

7 declined

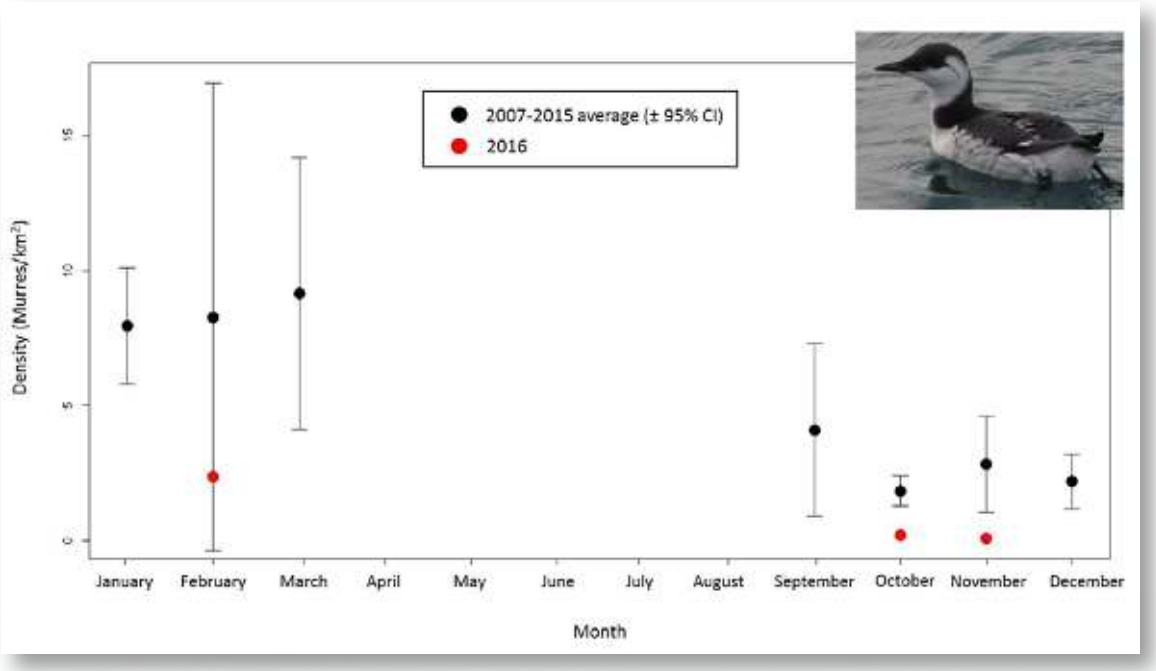


Pelagic Ecosystem:
PWS Fall/Winter Seabirds – *M. Bishop*

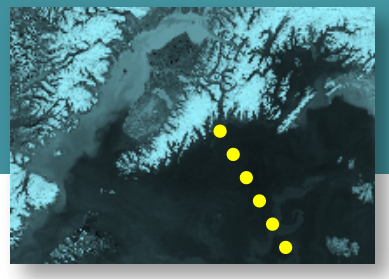
INSIDE WATERS: Unusually low numbers of common murres observed compared to previous years

- October and November 2016 densities were significantly below average
- We suspect the lower densities in 2016 may be a result of the massive murre die-off observed during late 2015

Average monthly densities observed over 36 surveys from 2007-2015 (black)



Pelagic Ecosystem:
Marine Birds – *Kuletz & Kaler*



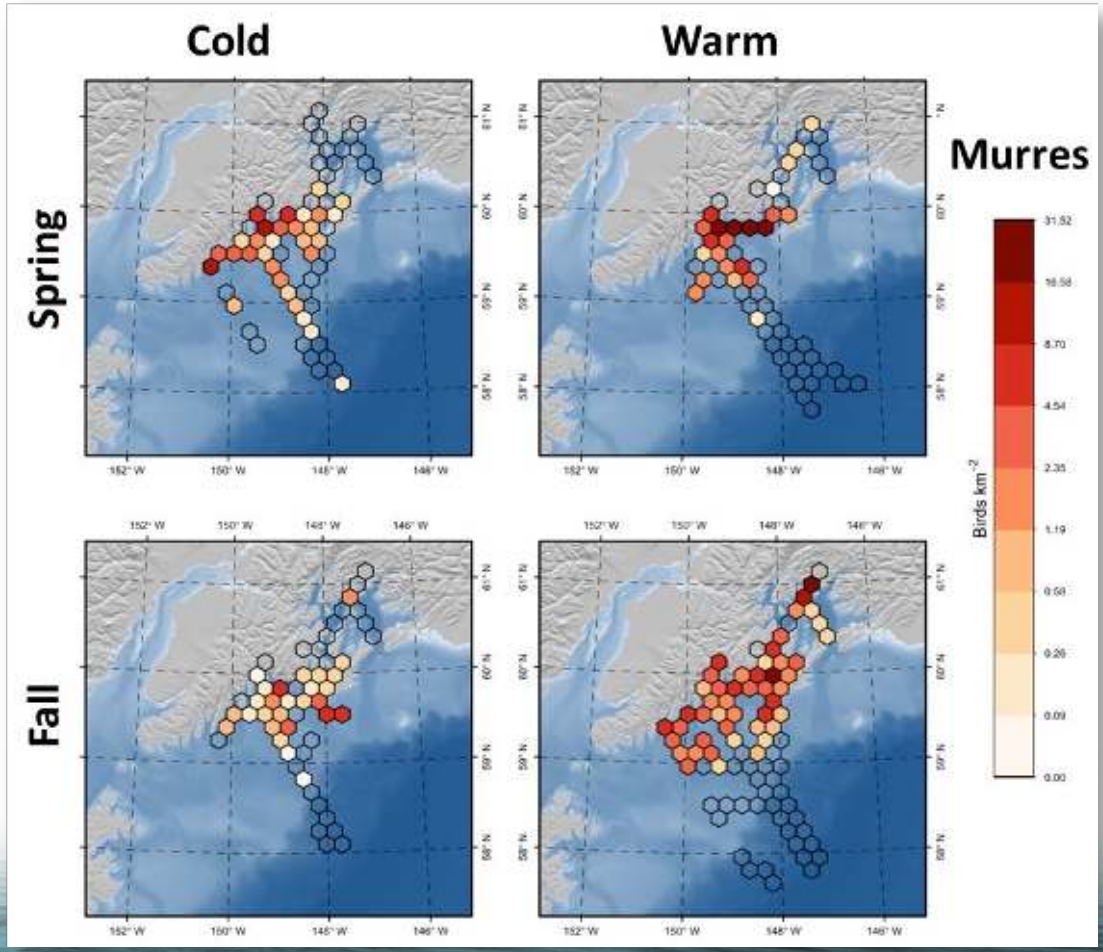
SHELF: Seward Line & PWS 2007-2015

Shifts in seabird distribution under different temperature regimes

All species

- **Warm** = Higher densities; fall
- '**Inshore**' seabirds most influenced by GOA conditions
- '**Offshore**' species always in Outer/Off-shelf (fulmars, storm-petrels, albatrosses)

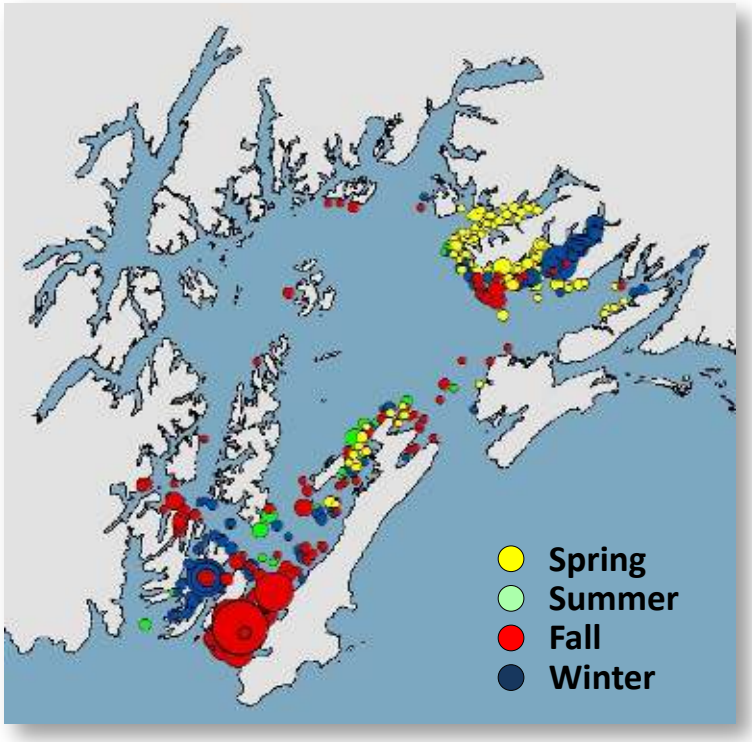
T. Zeller, USFWS

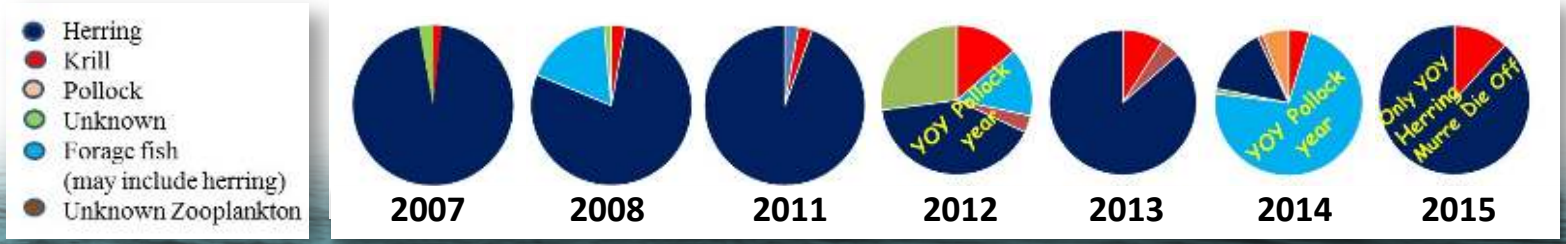


Pelagic Ecosystem:
PWS Humpback whales – *Moran & Straley*

Abundance, Distribution, and Diet

- Preliminary population estimate of 465 (95% CI; 405-552)
- Movements follow herring, primary prey
- Herring failing, whale diet changing
- May be reaching carrying capacity



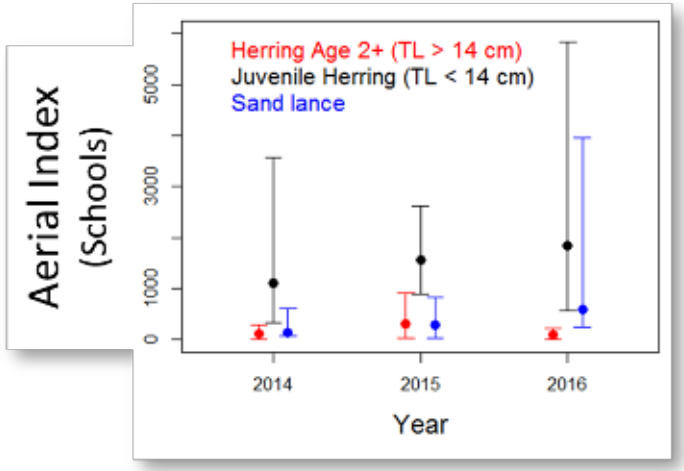


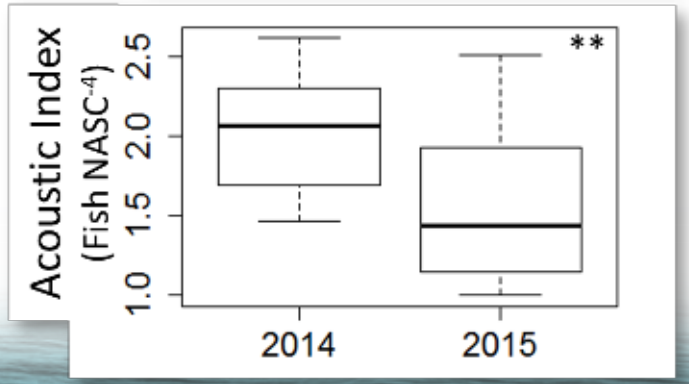
Whale photo credit: Steve W. Lewis. NOAA MMPA Permit #14122

Pelagic Ecosystem:
PWS Forage Fish – *Arimitsu & Piatt*

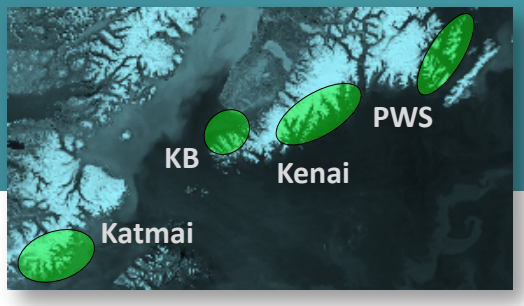
- Aerial schools indices were **dominated by juvenile herring**
- Acoustic index showed a **significant decrease** of fish biomass between 2014 and 2015; due to low abundance YOY pollock in 2015
- 2014-16 **low occurrence of cold-water capelin** in PWS trawls and Middleton Island seabird diets
- 2015 **Unusual "Jelly" Bloom**; low fish biomass
- 2016 was **favorable for age 0 forage fish** in both PWS and inshore areas of Cook Inlet (sand lance, herring and walleye pollock)

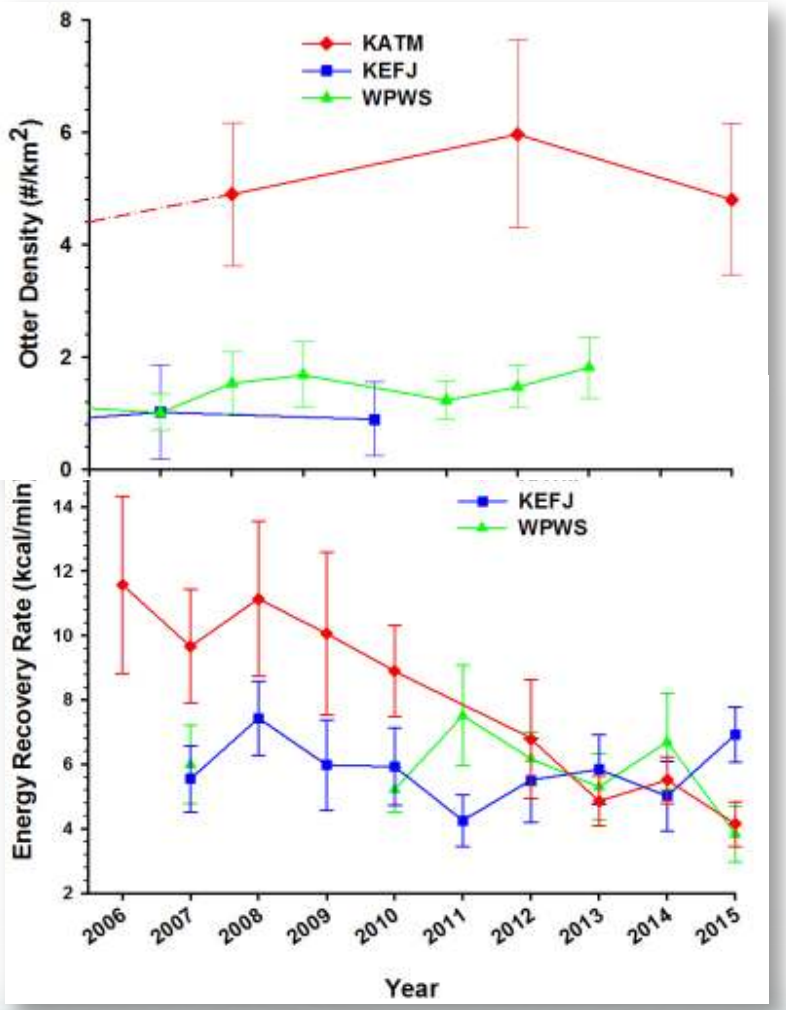
Combined Aerial-Hydroacoustic Trawl Survey





Nearshore Ecosystem:

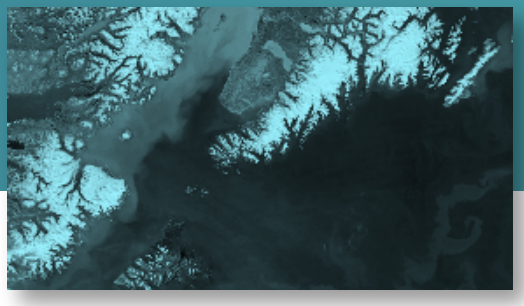




e.g. Patterns of a Major Predator: Sea Otters (2006-2015)

- **KATMAI** densities have increased with declining energy recovery rates, suggesting a food-limited state.
- **KENAI** densities and energy recovery rates have been stable, indicating population at carrying capacity
- **PWS** pre-spill; may be reaching carrying capacity

Recap of Recent Trends



2014-2016:

- **ENVIRONMENTAL DRIVERS:**
  - Temperature – warm water anomaly present throughout all GWA regions
  - Primary productivity – decline of cold water species, warm water species persist

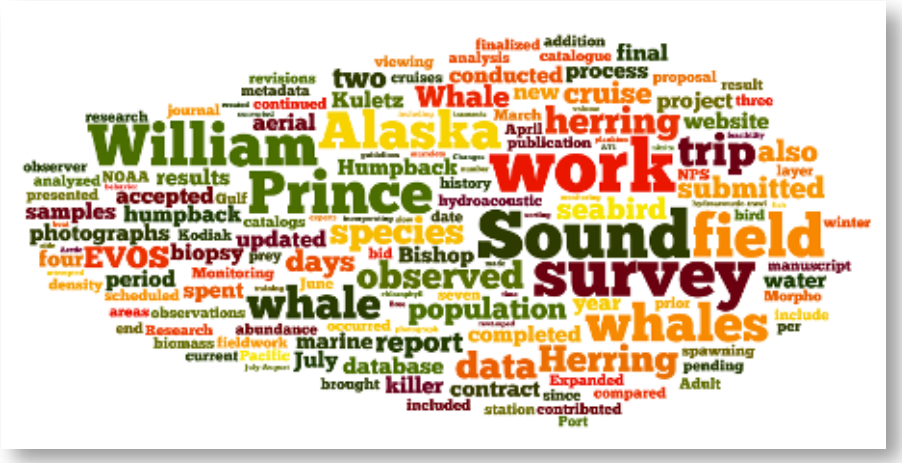
- **PELAGIC ECOSYSTEM:**
  - Declining populations – seabirds, forage fish
  - Change in behavior, distribution, diets
  - Die offs and Unusual Mortality Events
- **NEARSHORE ECOSYSTEM:**
  - Highly variable patterns among key trophic species driven by local and Gulf-wide influences
  - Disease – sea stars coincides with warm anomaly

GWA's First 5-Year Report Card

Goals Achieved!

Program Management

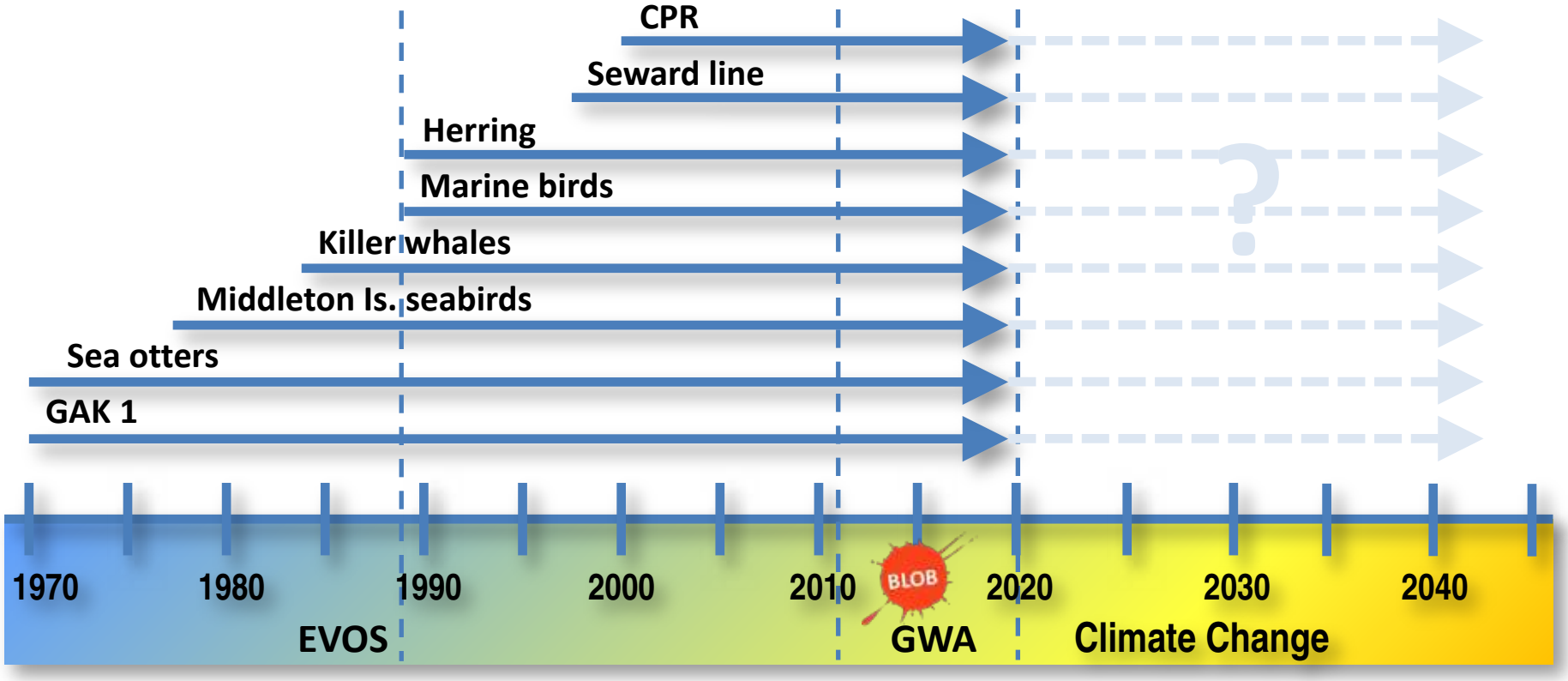
- **Y1 (2012)** Launching program
  Data recovery time series
- **Y2 (2013)** Dev. fully automated data/metadata publishing (AOOS)
- **Y3 (2014)** Trend analyses;
  Science synthesis rpt
- **Y4 (2015)** 2 NCEAS working groups;
  Planning for 5-yr close-out;
  next 5-yr proposal pkg
- **Y5 (2016)** Public Datasets (50)
  Journal publications (20+)
  Deep Sea Research II (25)
  Outreach (lots!)



Program Wordle

GWA and Future Monitoring

Legacy Datasets in the Northern GOA



Uniquely situated to capture change at multiple ecosystem levels

"We are now monitoring the unusual"

GWA Data and Publications

More than 50 publications in peer-reviewed journals and books, most available as open access:
http://www.gulfwatchalaska.org/resources/publications/

Publications from Gulf Watch Alaska principal investigators

Ballachey, B.E. and J.L. Bodkin. 2015. Challenges to sea otter recovery and conservation. Chapter 4 in J. Bodkin, S. Larson, and G. R. VanBlaricom, Eds. *Sea Otter Conservation.* Academic Press, Boston. Pp 63-96.

Ballachey, B.E., J.L. Bodkin, D. Esler, and S.D. Rice. 2014. Lessons from the 1989 *Exxon Valdez* oil spill: A biological perspective. In: J.B. Alford, M.S. Peterson and C.C. Green, Eds. *Impacts of Oil Spill Disasters on Marine Habitats and Fisheries in North America.* CRC Marine Biology Series. Pp. 181-198.

Ballachey, B. E., J.L. Bodkin, and D.H. Monson. 2013. Quantifying long-term risks to sea otters from the 1989 *Exxon Valdez* oil spill: Reply to Harwell & Gentile. *Marine Ecology Progress Series* 488:297-301. doi:10.3354/meps10498.

Batten, S. 2013. Large ships, little critters. *Delta Sound Connections* newspaper.

Bishop, M.A. 2014. At-sea seabird surveys. *Delta Sound Connections* newspaper.

Bishop, M.A. 2016. Seabird die-off in Prince William Sound. *The Cordova Times* newspaper, January 8, Page 1.

Bishop, M.A., J. Watson, K. Kuletz, and T. Morgan. 2015. Pacific herring consumption by marine birds during winter in Prince William Sound, Alaska.

GWA Data and Publications

Special Issue Forthcoming –
Spatial and Temporal Ecological Variability in the Northern Gulf of Alaska: What Have We Learned Since the Exxon Valdez Oil Spill?