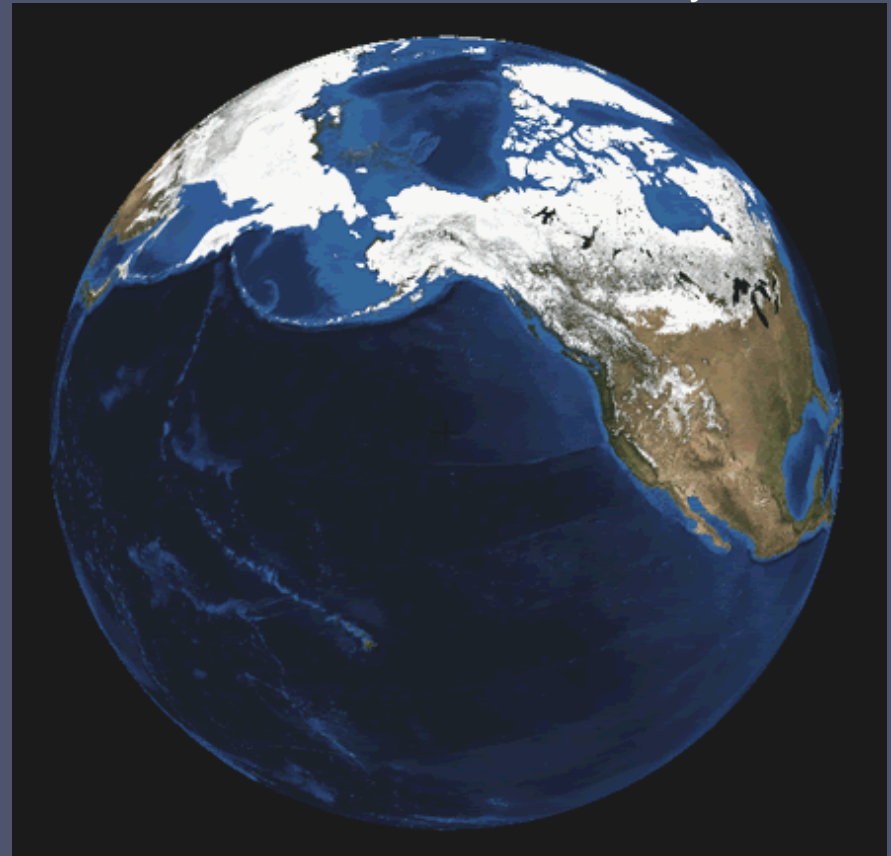


ECOSYSTEM CONSIDERATIONS

Status of Alaska's Marine Ecosystems

Stephani Zador
Elizabeth Siddon
Ellen Yasumiishi
Ivonne Ortiz

NPFMC Dec 8, 2016



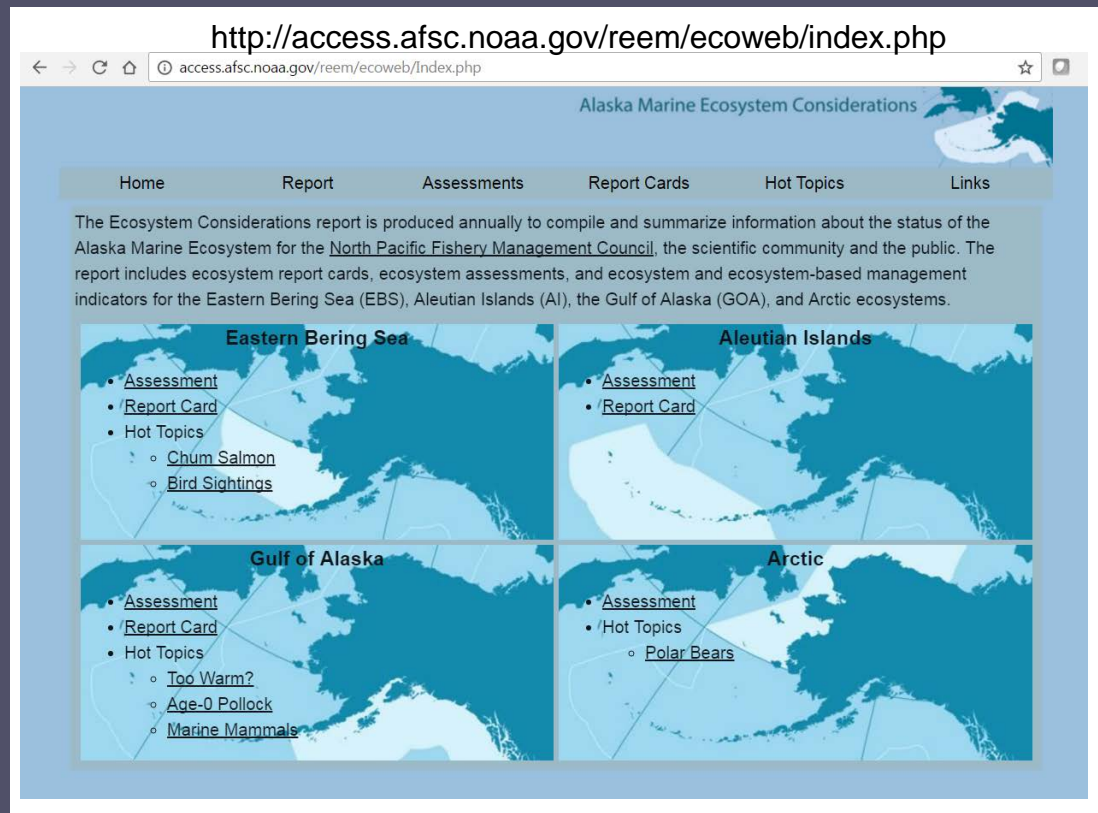
Outline



1. New Report Structure
2. Eastern Bering Sea
 - Past – 2015
 - Present – Report Card
 - Future – Forecasts and predictions
3. Aleutian Islands
4. Gulf of Alaska

Evolution of the Ecosystem Considerations Report

Now separated by ecosystem



Website

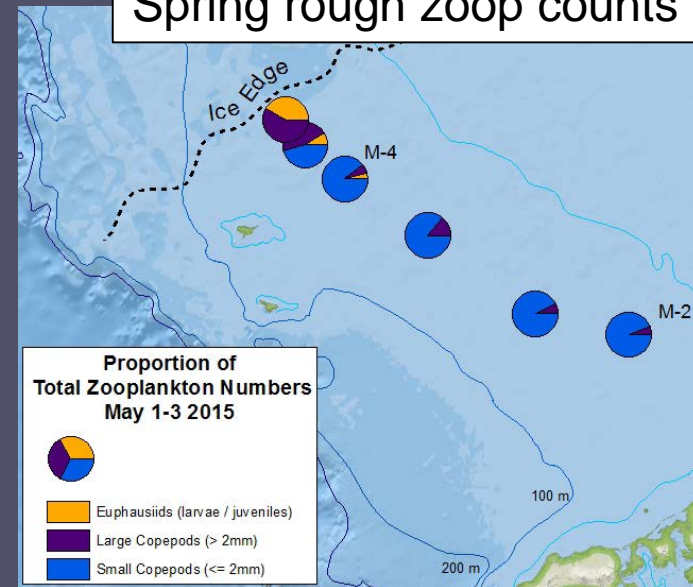
Eastern Bering Sea



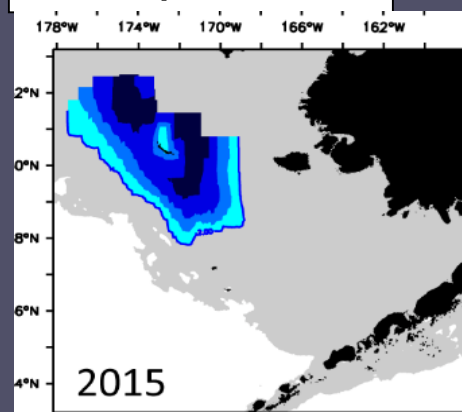
Complete recap of 2015

- WARM
- Mostly low productivity
- Small copepods predominant
- Jellyfish declining from peak
- CPUE in trawl survey remained high
- Groundfish condition average to poor
- Lots of juvenile sockeye
- Poor seabird productivity and die-off
- Uptick in seabird bycatch

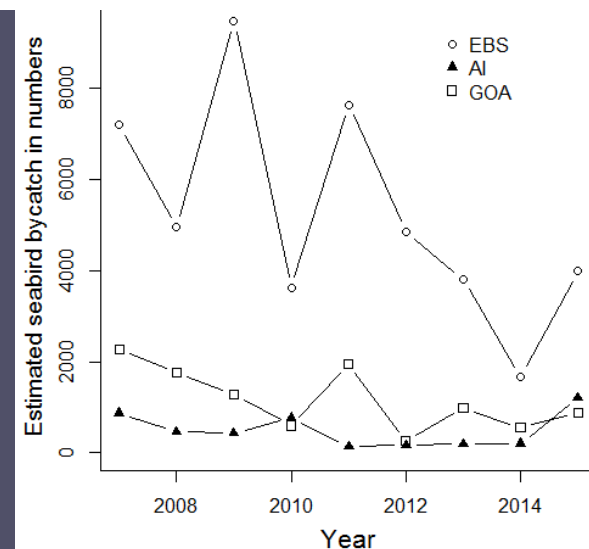
Spring rough zoop counts



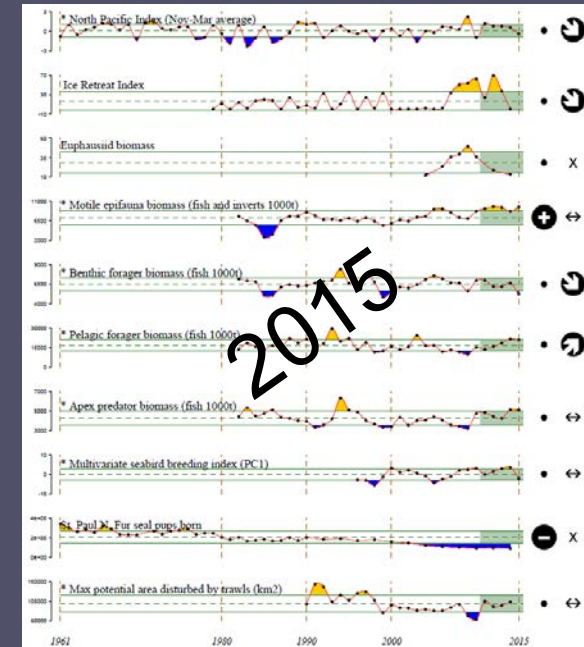
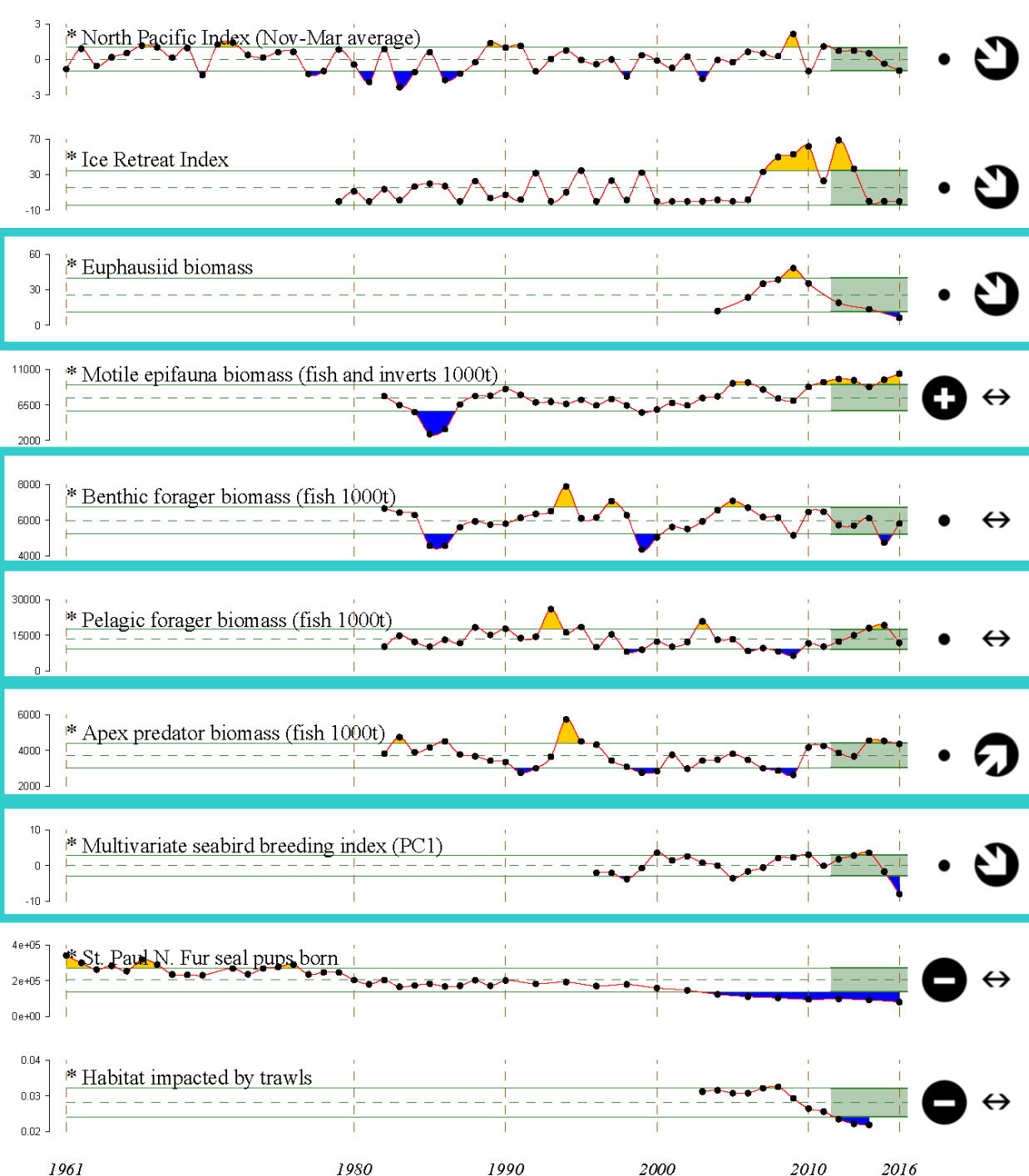
Cold pool



Total estimated seabird bycatch



2016 EBS Report Card



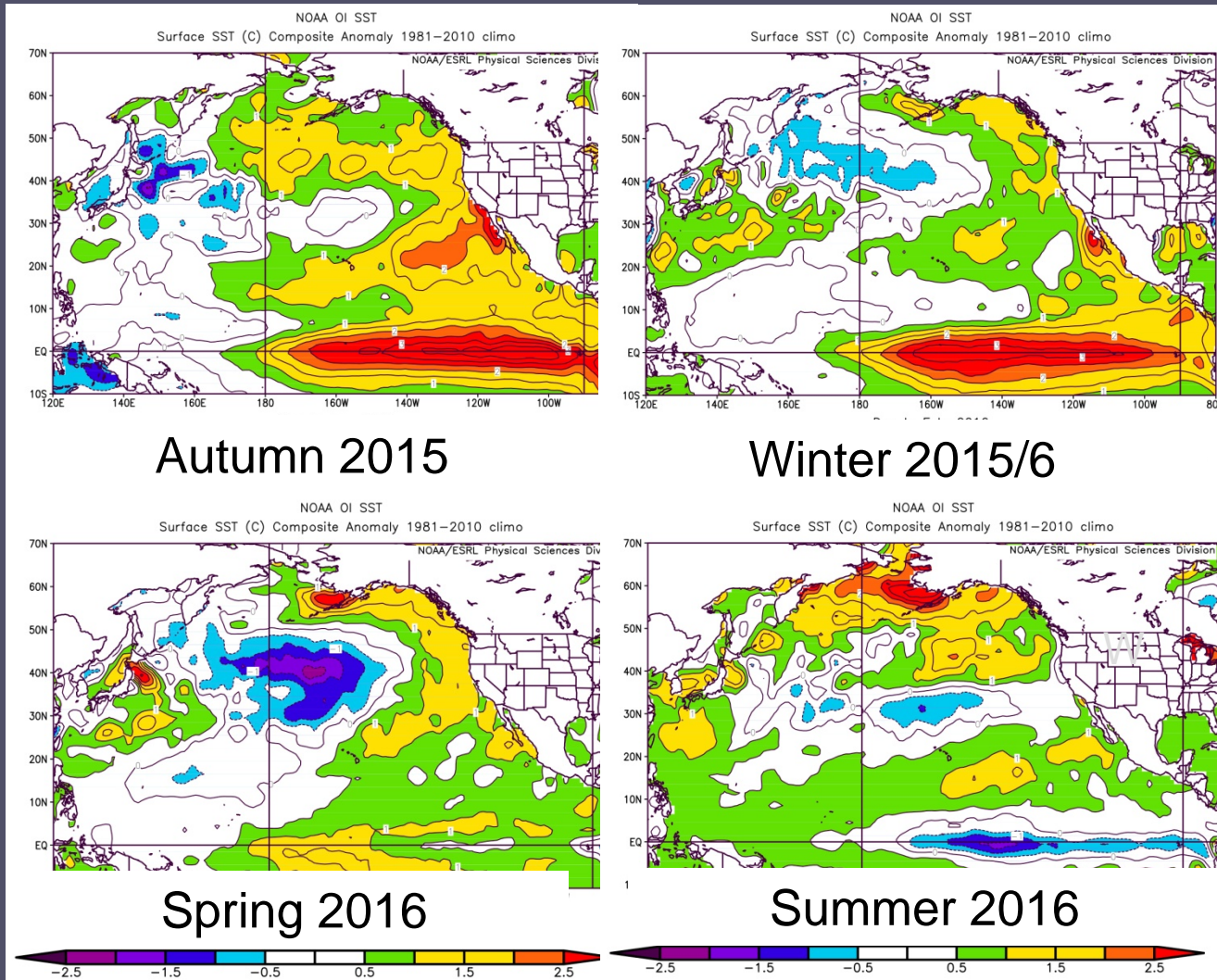
2012-2016 Mean

- +** 1 s.d. above mean
- 1 s.d. below mean
- within 1 s.d. of mean
- X fewer than 2 data points

2012-2016 Trend

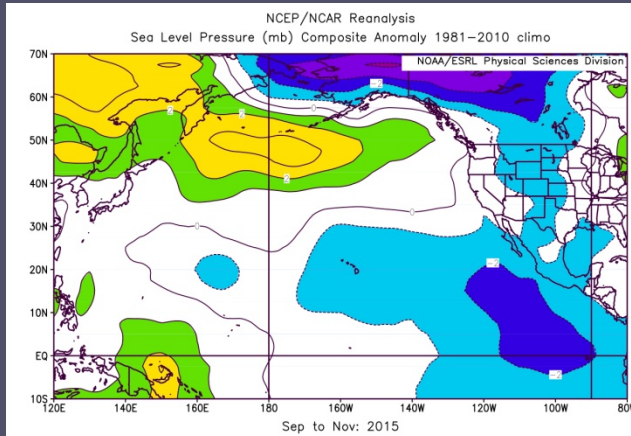
- ↗** increase by 1 s.d. over time window
- ↘** decrease by 1 s.d. over time window
- ↔** change <1 s.d. over window
- X fewer than 3 data points

Sea Surface Temperature Anomalies (Bond)

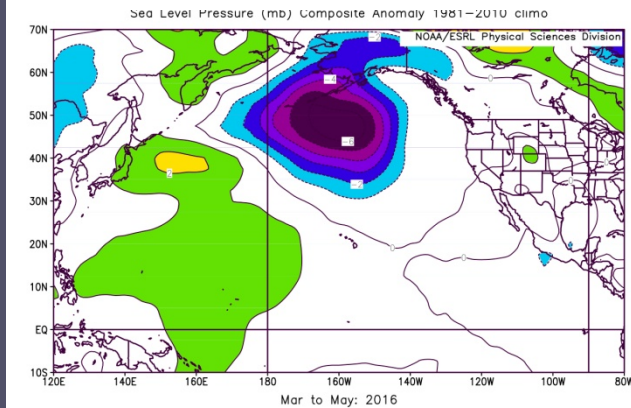


Sea Level Pressure Anomalies (Bond)

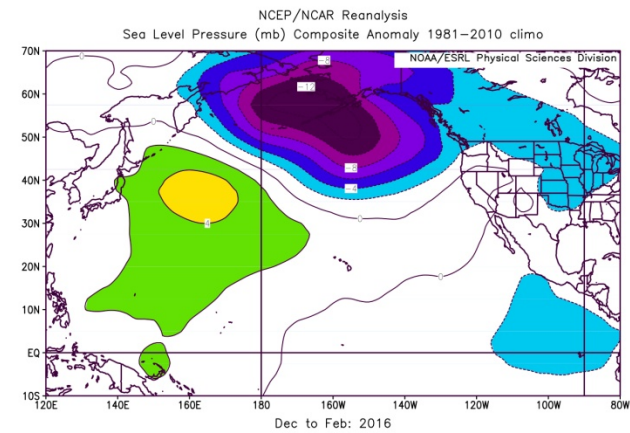
Pattern
implies
anomalous
westerly
winds and
upwelling in
GOA



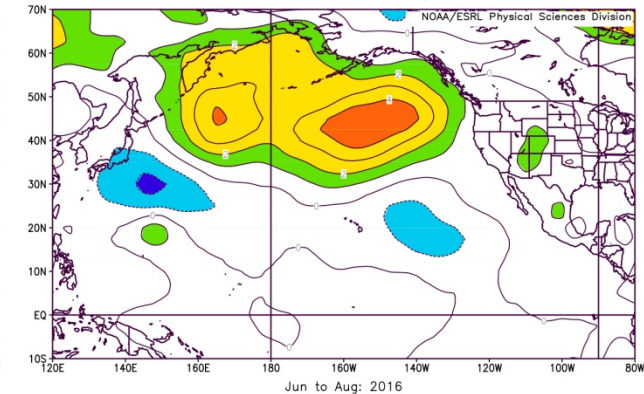
Autumn 2015



Spring 2016



Winter 2015/6



Summer 2016

Lowest low
since 1949

Warm wind
to E GOA

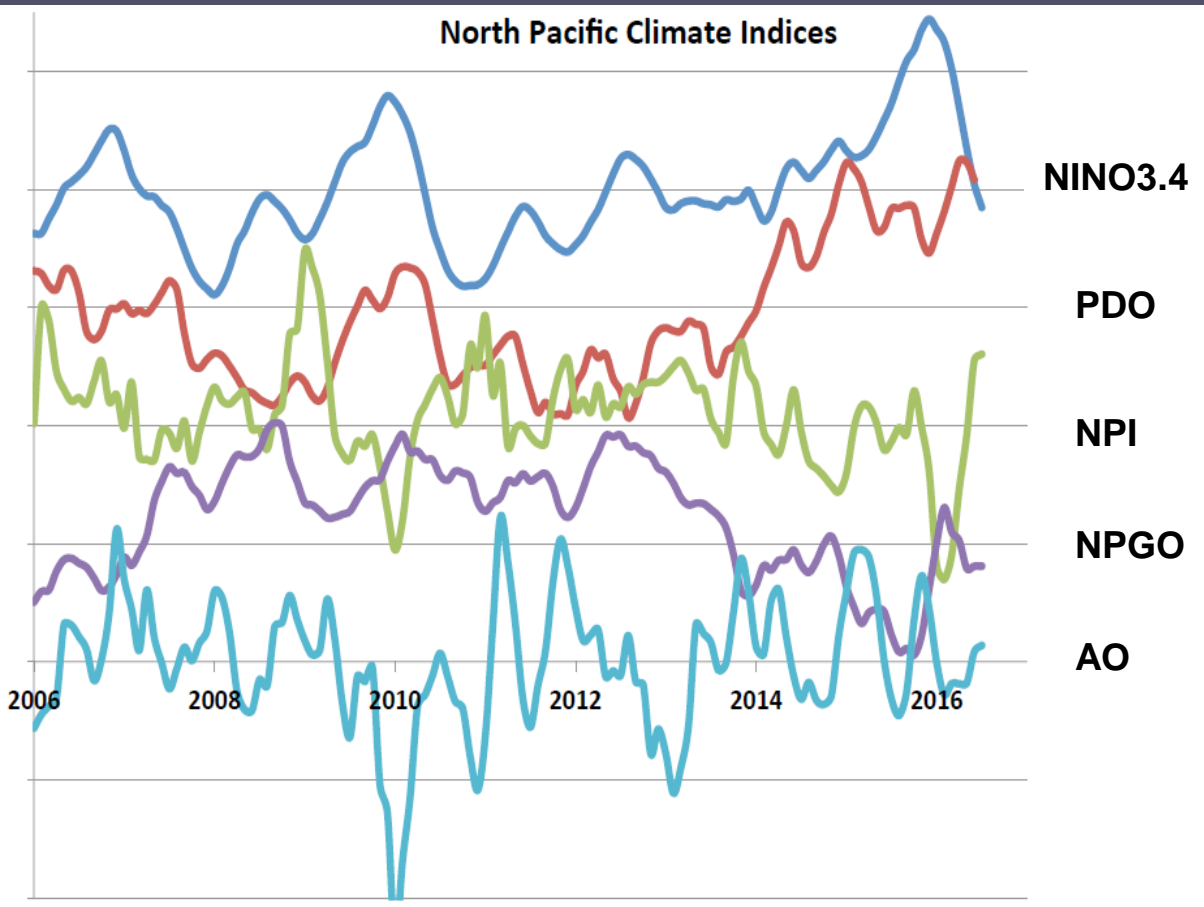
Suppressed
storminess

Little mixing,
hence warm
surface temp

Climate Indices

(Bond)

North Pacific atmosphere-ocean climate system “highly perturbed”



ENSO declining

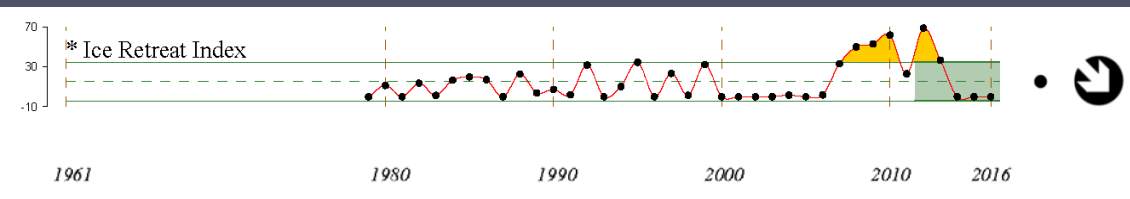
PDO has been positive; did not track with recent El Niño

NPI implies deep Aleutian Low; contributed to EBS warmth

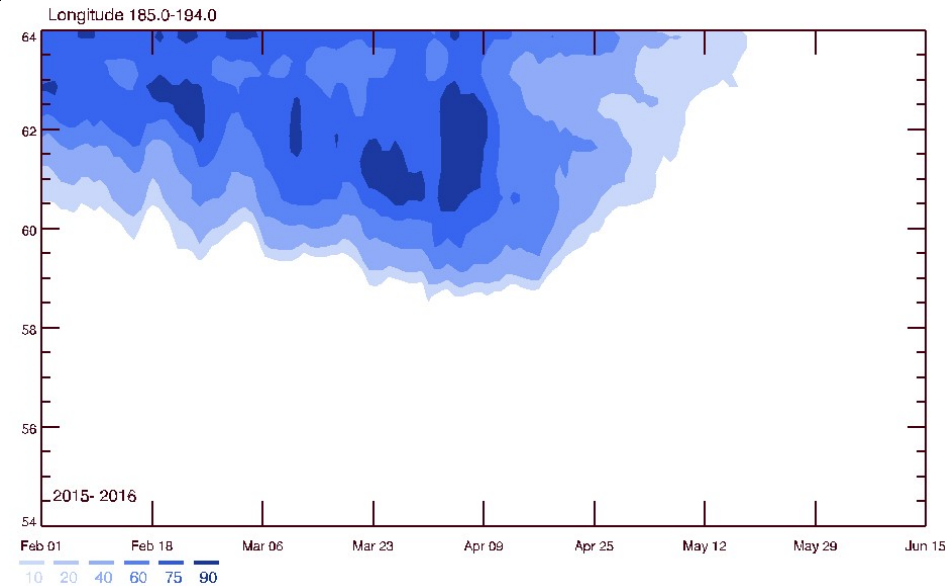
NPGO relates to chemical and biological properties in GOA and CalCOFI area. Negative → reduced flows in Alaska and CA currents

AO measures strength of polar vortex. Positive = low pressure over Arctic, high over Pacific (45°). Variable signal last winter

2016 EBS Physical Conditions

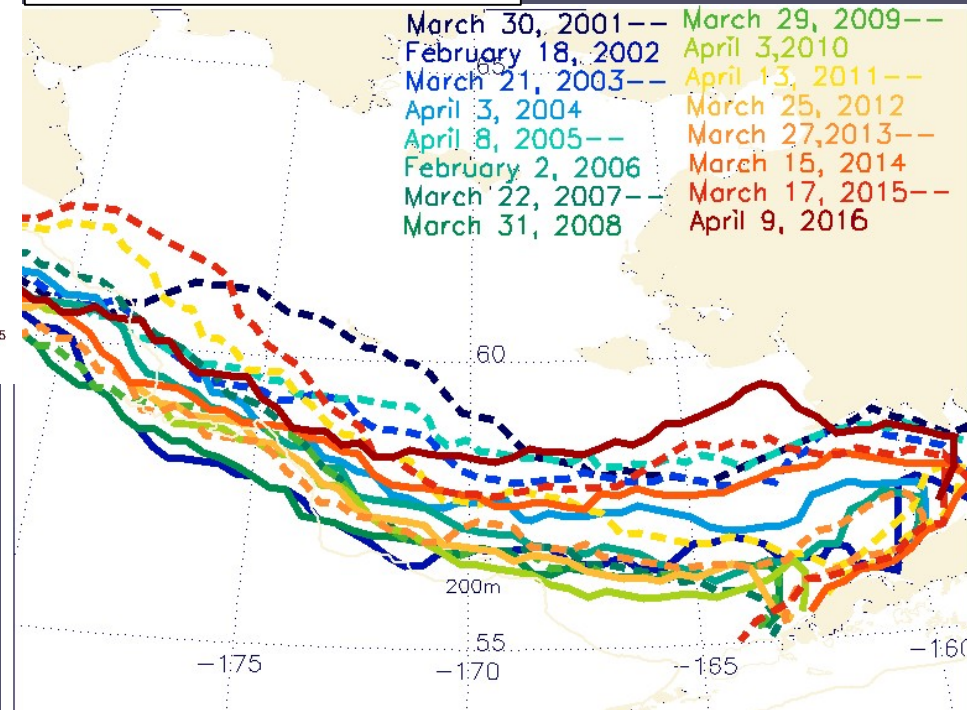


Ice Concentration Over Time



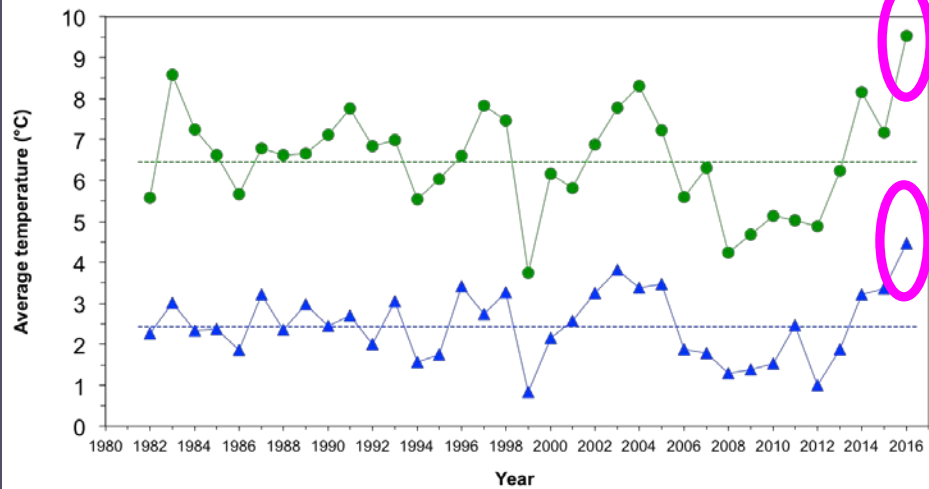
Extraordinarily warm, low ice

Maximum Ice Extent

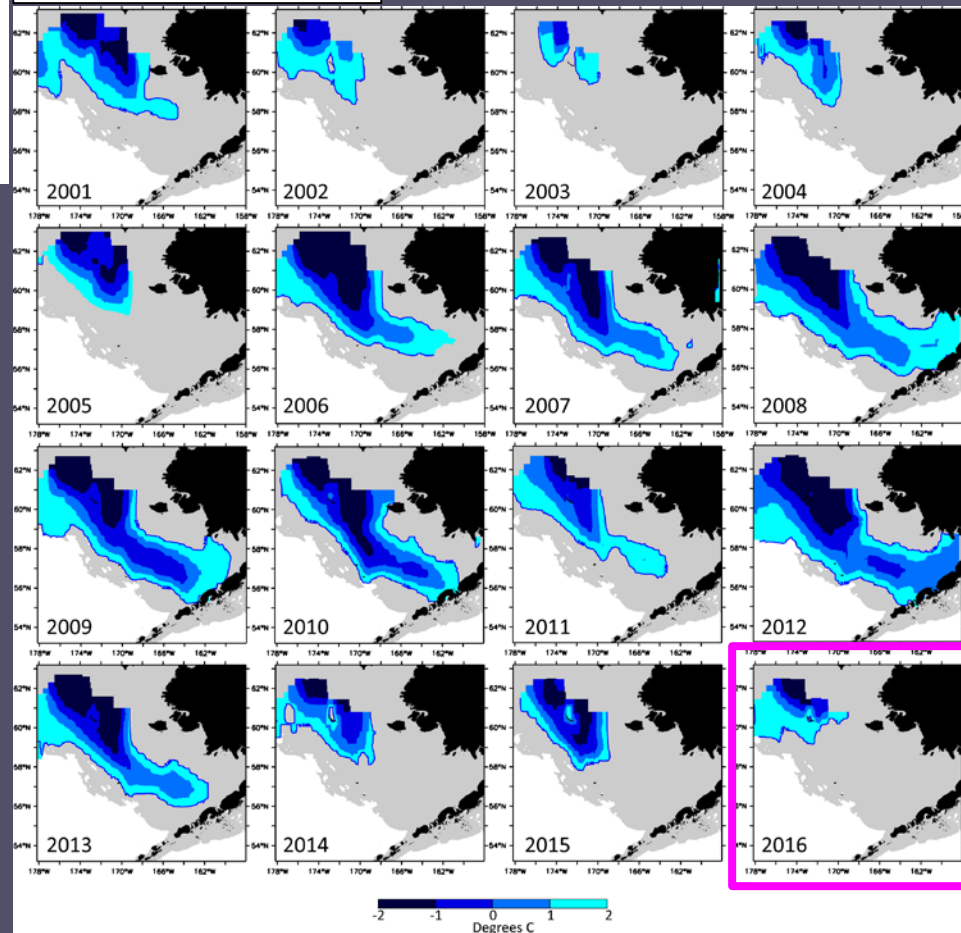


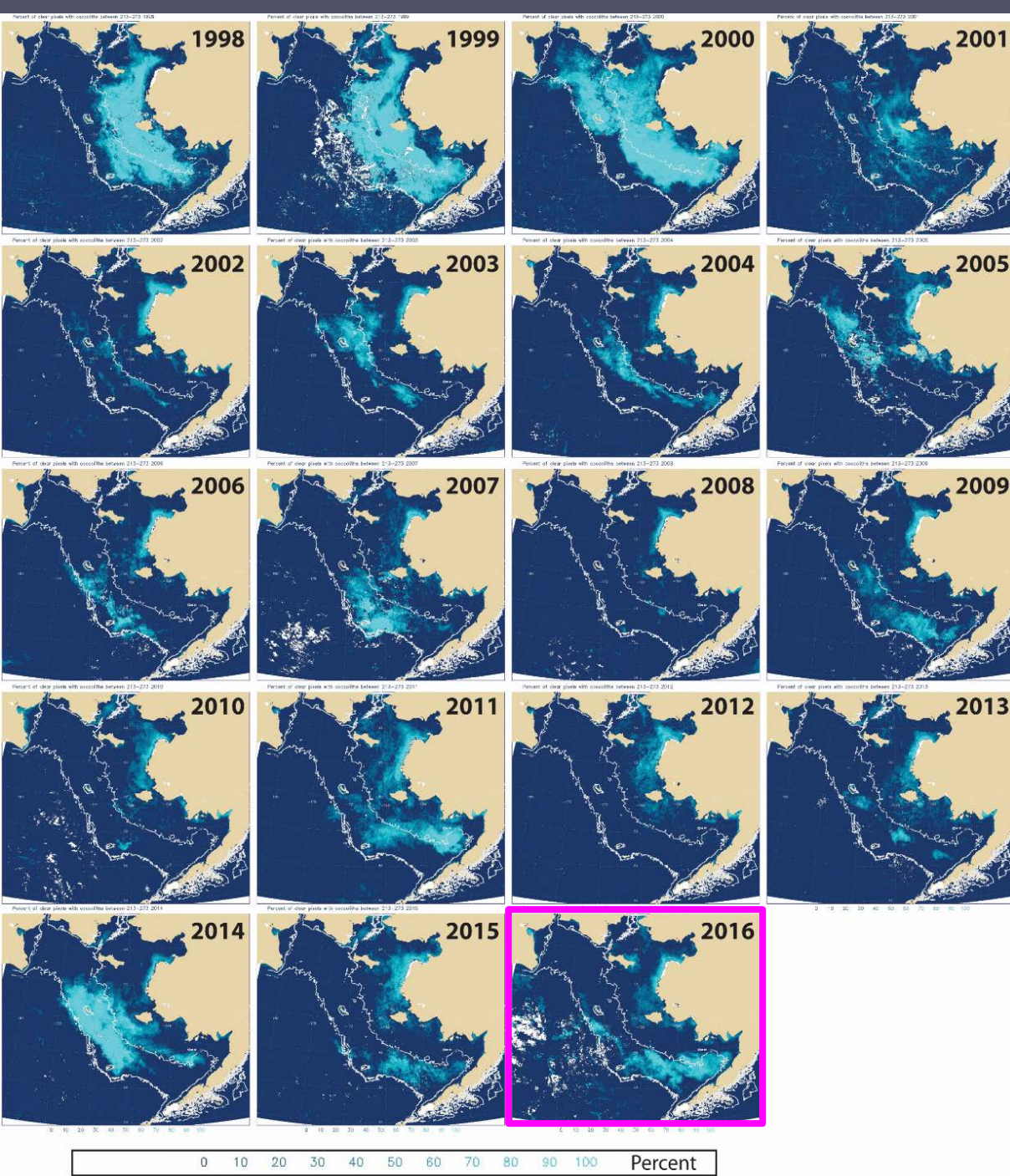
2016 EBS Physical Conditions

Surface and Bottom Temps



Cold Pool Size



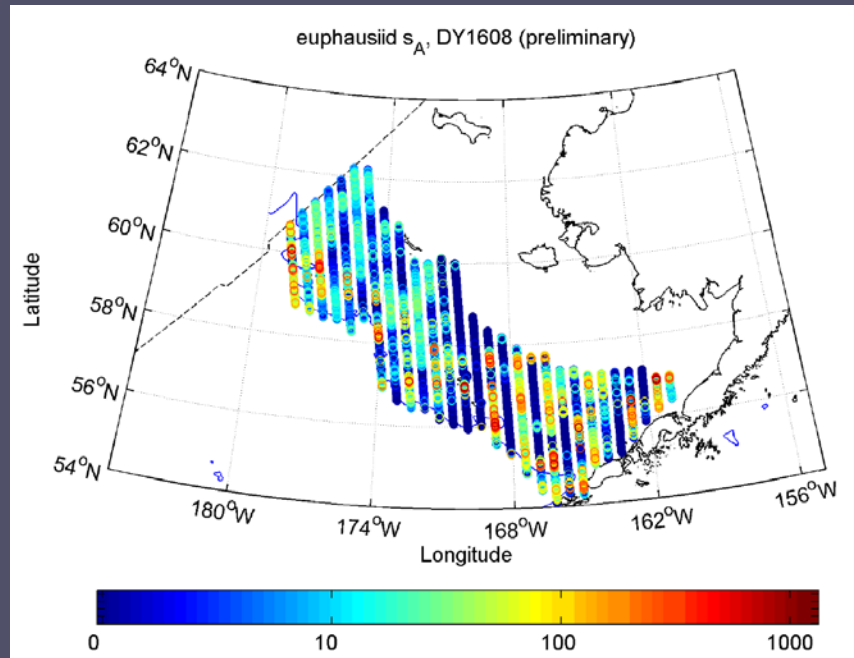
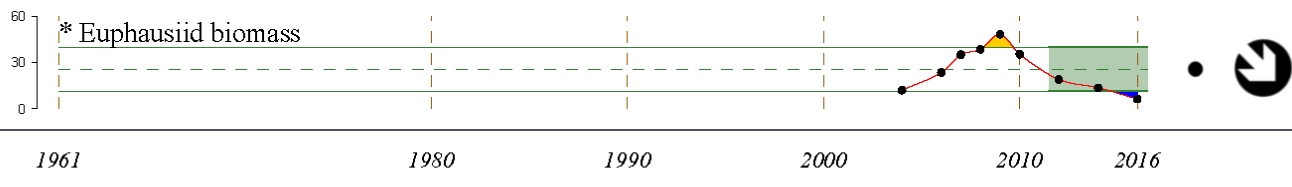


New

Coccolithophores (Ladd and Eisner)

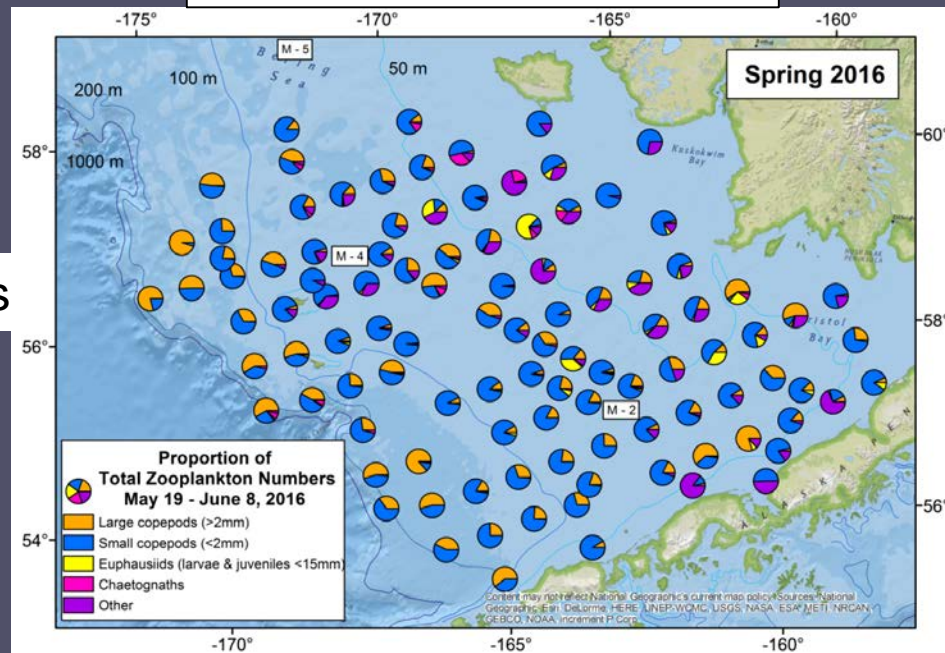
- Average area covered by coccoliths Aug 1- Sept 30
- Influenced by strength of density stratification
- Trophic implications – smaller than diatoms -> longer chains; less desirable for microzooplankton
- Neg impacts on visual foragers

2016 EBS Zooplankton

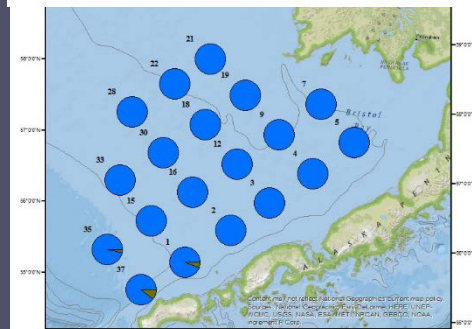


- Acoustic survey of euphausiids – preliminary estimate **LOW**
- Small copepods more prevalent than lipid-rich large copepods or euphausiids spring and fall
- Overall **very low** abundance

Spring rough zoop counts



Fall rough zoop counts



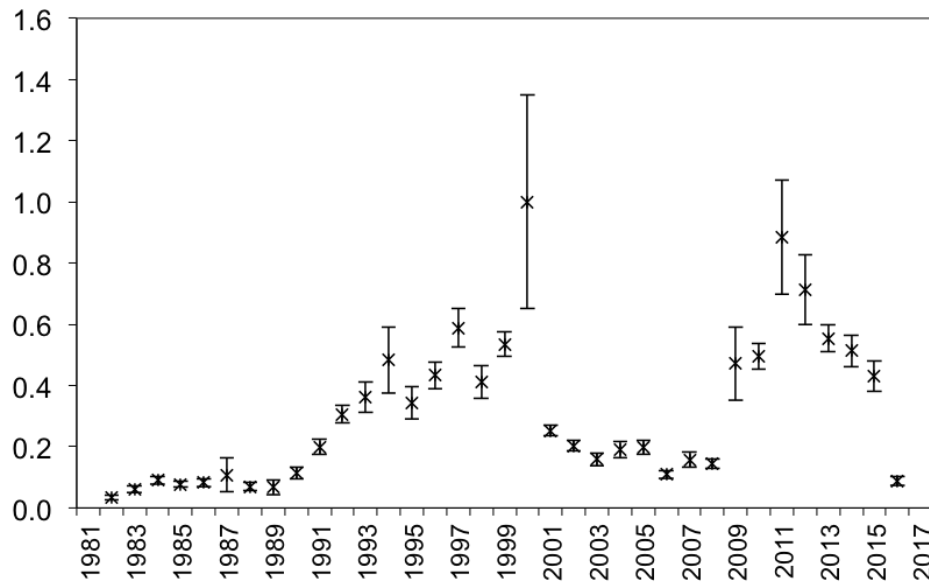
Jellyfish - end of recent boom?

(Lauth and Hoff; Cieciel et al.)

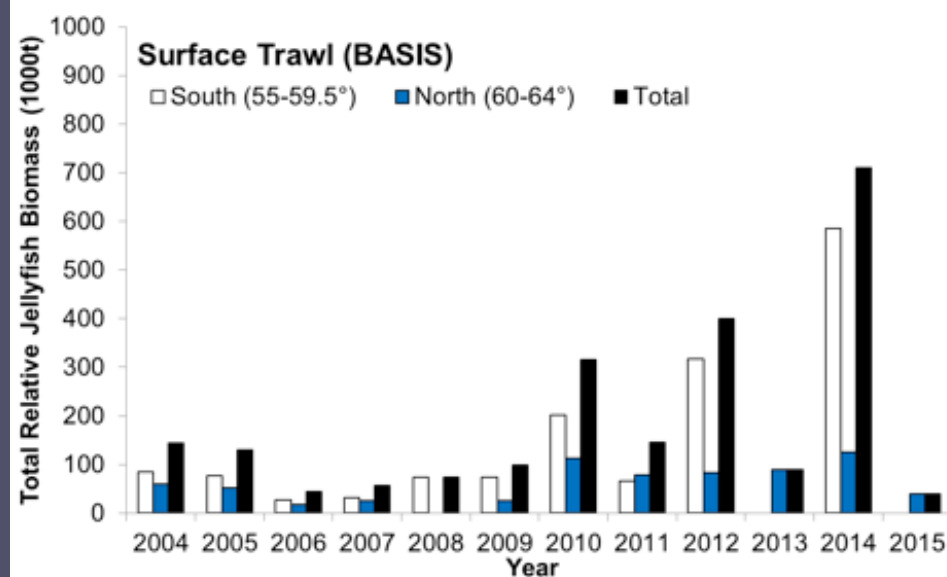
- Fall 2015 and summer 2016 down
- Jellyfish biomass influences: Ice cover, spring/summer SST, wind mixing
- Large blooms can have predatory impact on juvenile and forage fishes



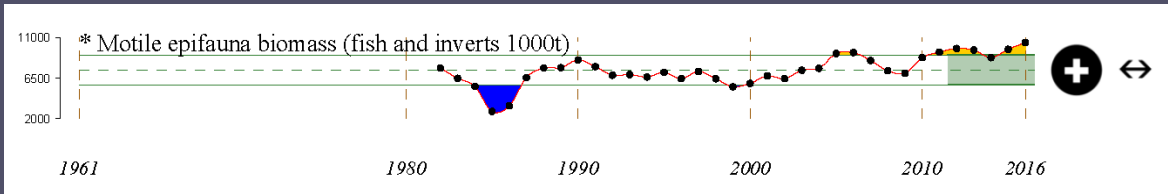
Summer 2016



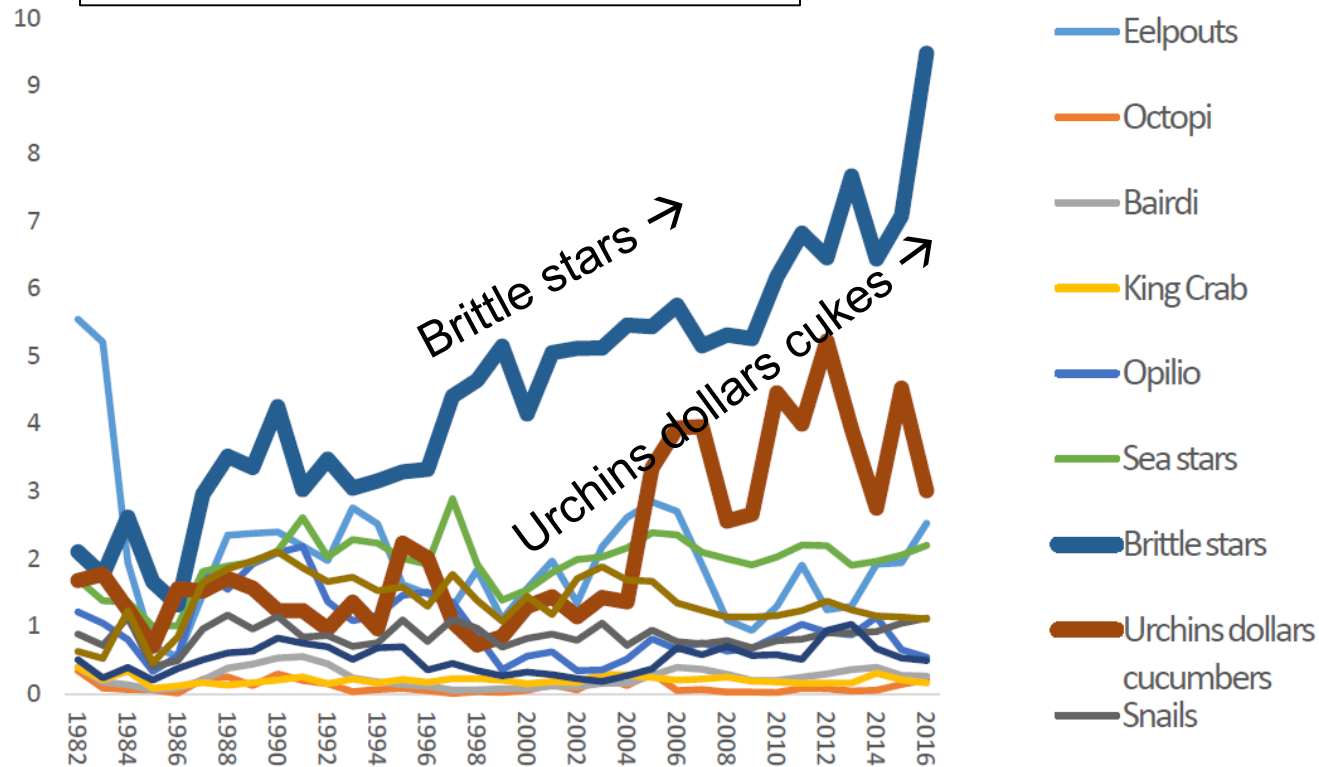
Fall 2015



2016 EBS Motile Epifauna

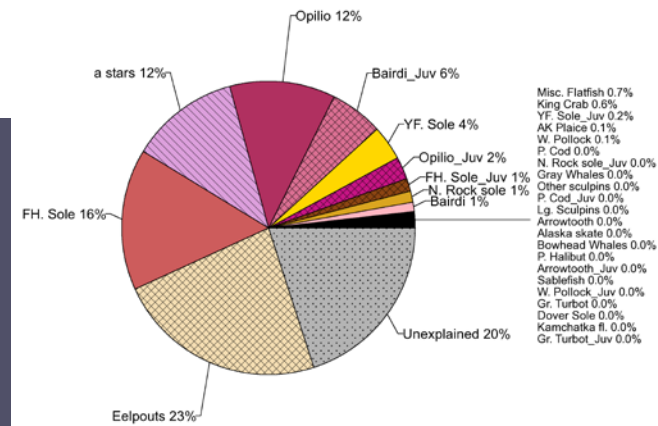


Motile Epifauna survey biomass

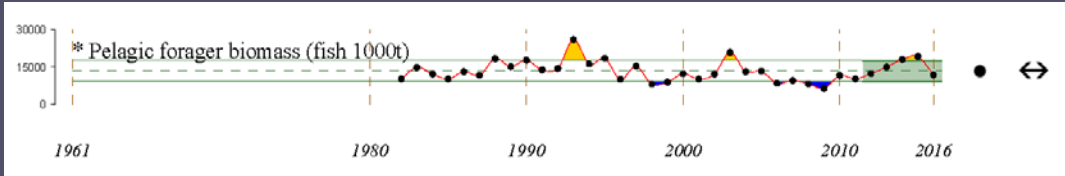


- Brittle star increase due to less predation?
- Major predators have been declining (opilio, FHS, eelpouts)
- Less habitat disturbance?

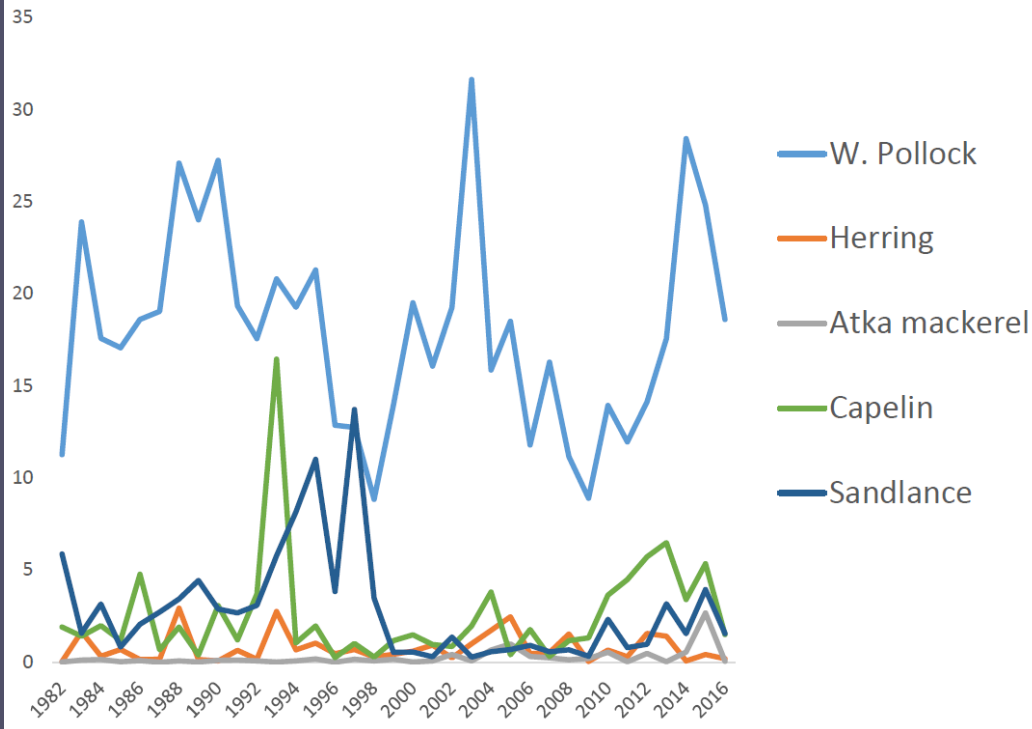
BS Brittle stars mortality



2016 EBS Pelagic foragers

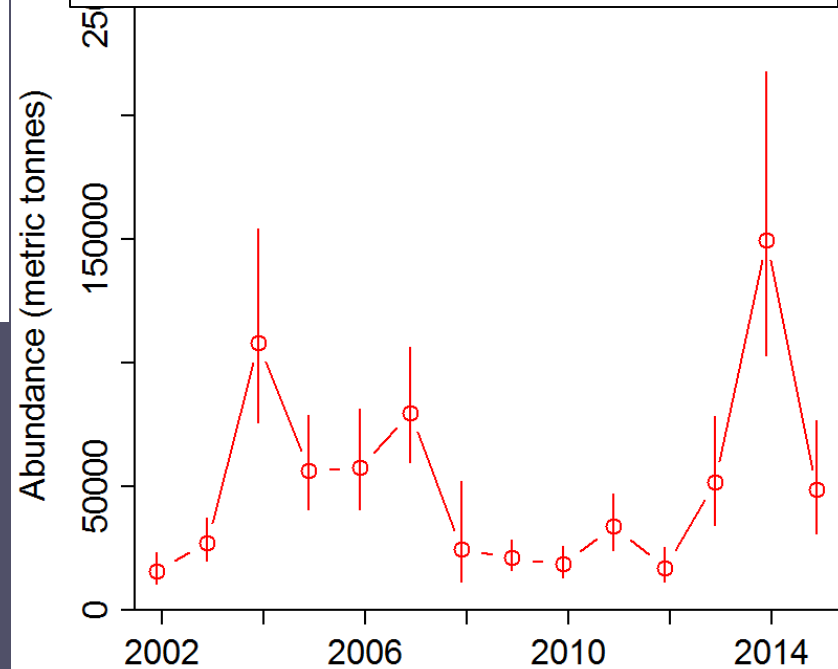


Pelagic forager survey biomass



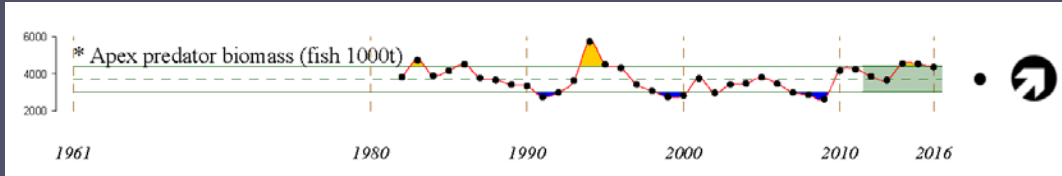
- Declined 2016
- Due to pollock and capelin

Juvenile herring abundance index

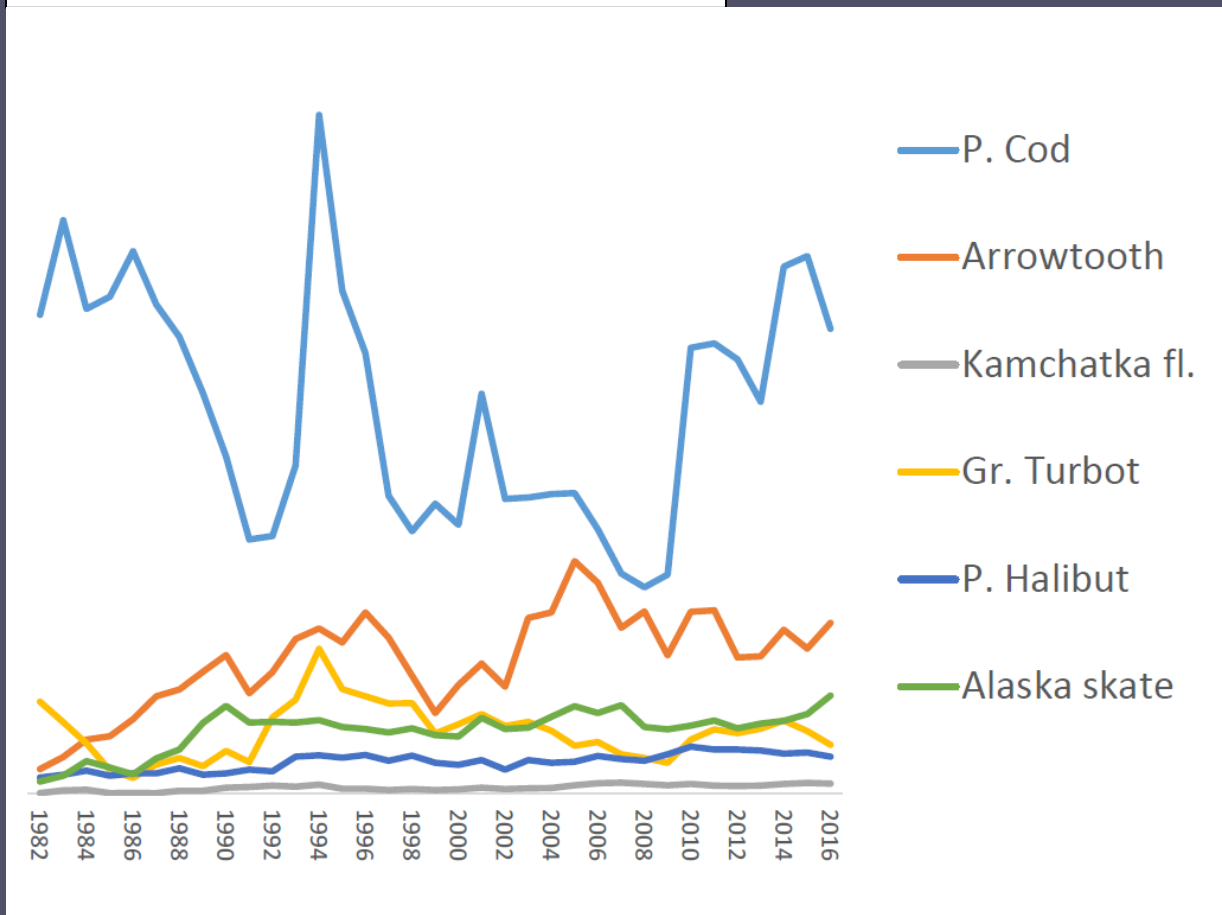


New indicator
Yasumiishi et al
Thorson geostatistical
delta-glm (Thorson et
al 2015)

2016 EBS Apex fish



Apex fish survey biomass



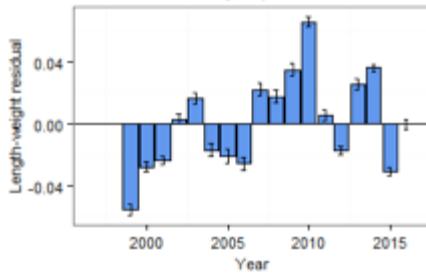
- Above 30 year mean
- Trend changed to increasing
- Increase from 2009 driven by P cod
- No expected large increase in ATF (different from last warm stanza?)

2016 Groundfish Condition

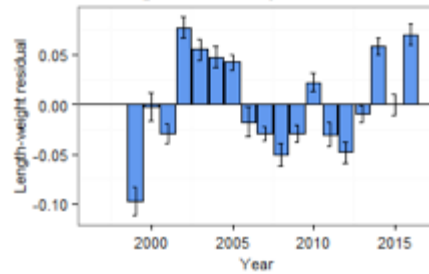
(Boldt, Rooper et al)

Length-weight residuals

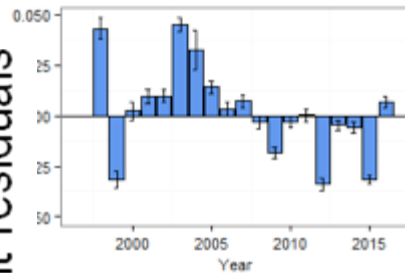
Walleye pollock



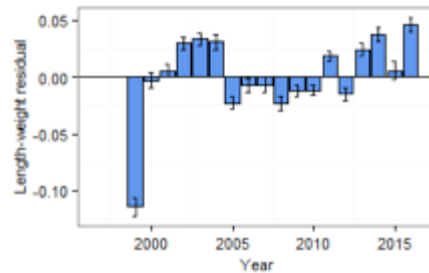
Age 1 Walleye Pollock



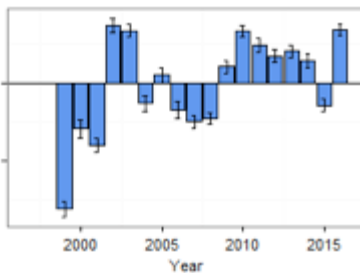
Pacific cod



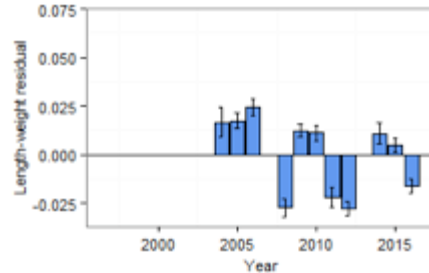
Northern rock sole



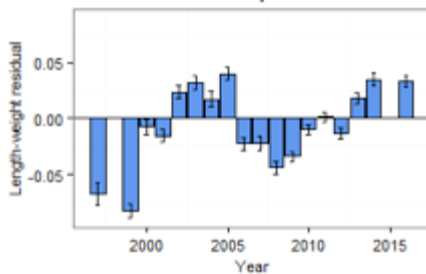
Yellowfin sole



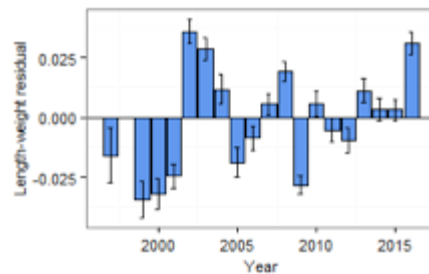
Arrowtooth flounder



Alaska plaice



Flathead sole

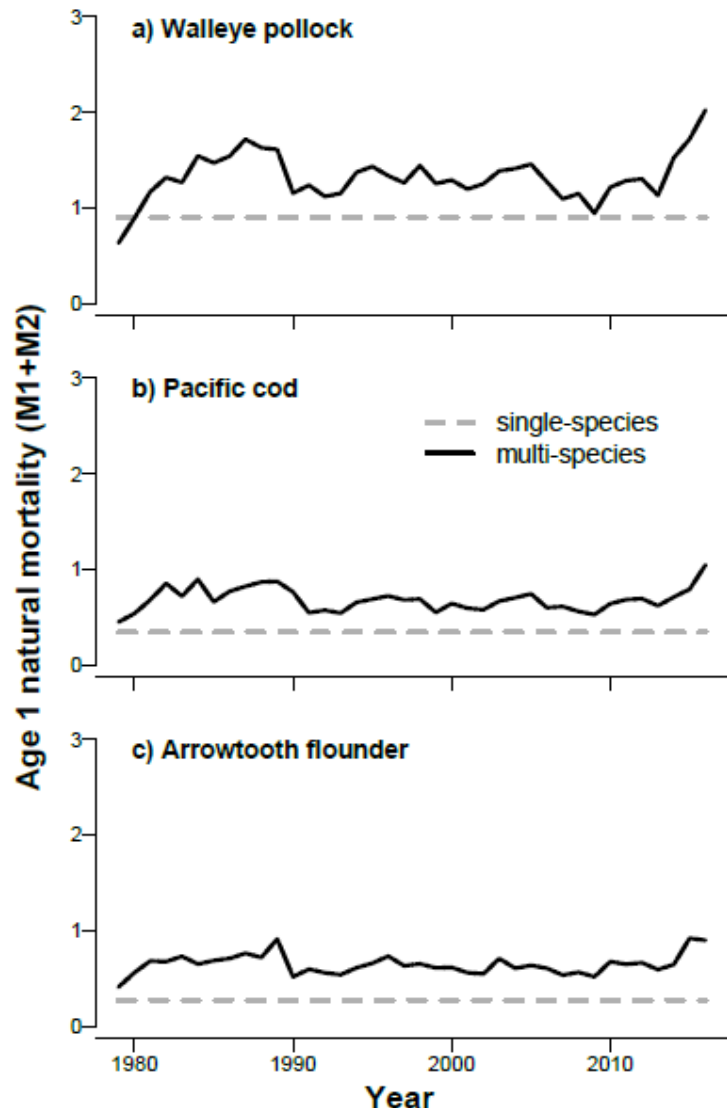


- Length-weight residuals from survey
- Residuals **positive** for all but ATF and pollock (average)
- Negative trend in cod since 2003 slowing?
- Age-1 and age-2+ pollock not well correlated

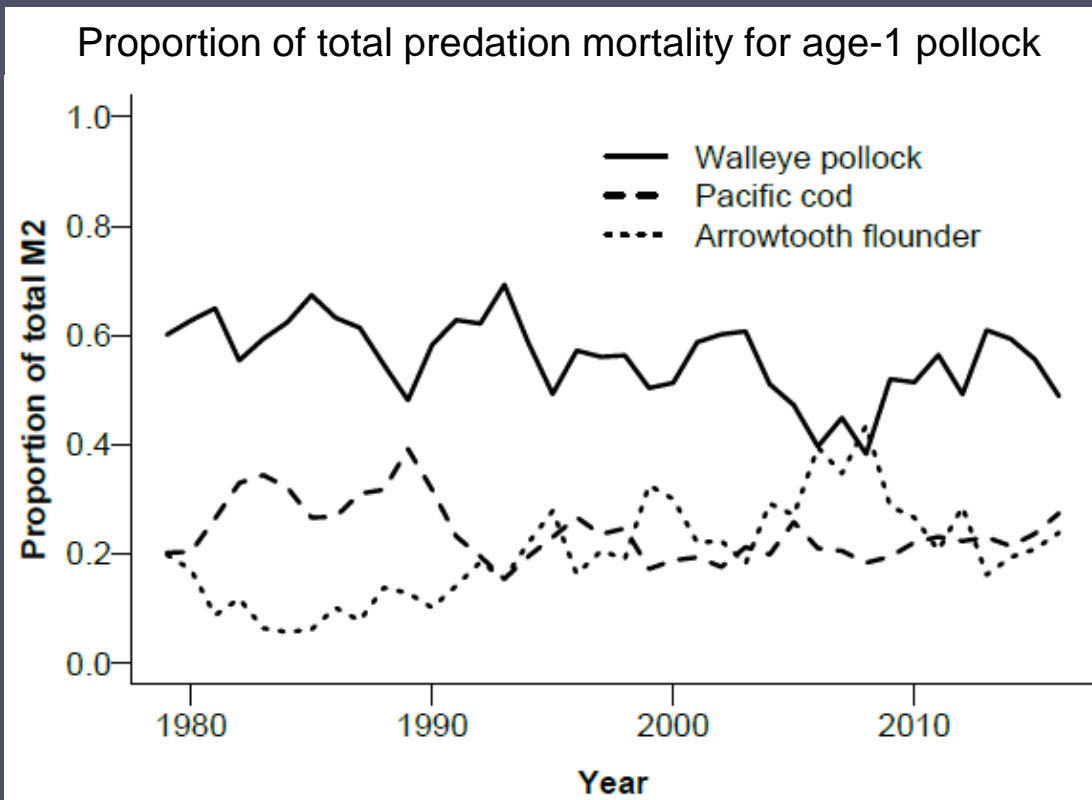
Multispecies model estimates of time-varying natural mortality

(Holsman et al)

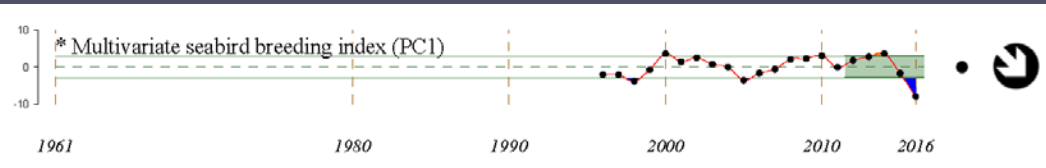
Annual variation in total mortality (M1 + M2) for age 1 groundfish



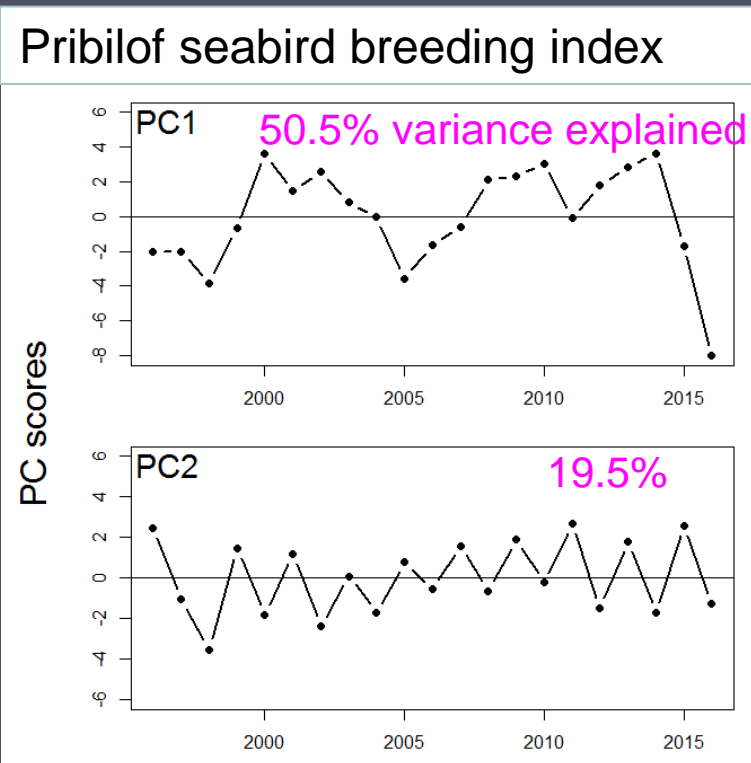
- CEATTLE model
- Age-1 mort highest overall in 2016, but highest for pollock relative to cod and ATF
- ATF predation on age-1 pollock exceeded cannibalism in 2006-2008



2016 EBS Seabirds



- Poor breeding success in EBS
- Dead puffins (250+) at the Pribilofs
 - Not many breeding in the EBS
 - Good reproduction in Unimak area
 - Cause of die-off???



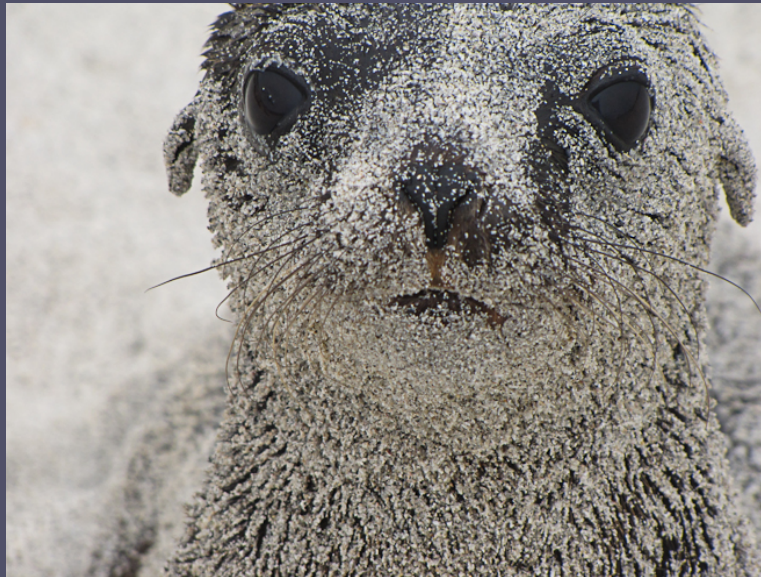
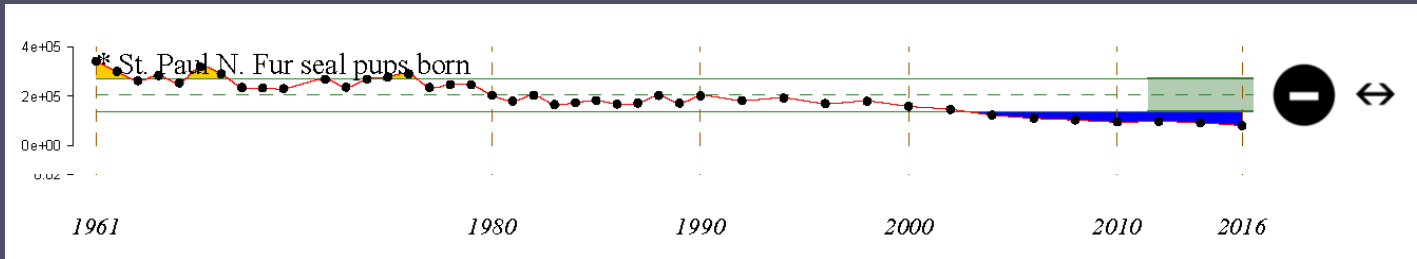
Lower murre
and cormorant
productivity.
Later seabird
hatch dates

Lower
kittiwake
productivity



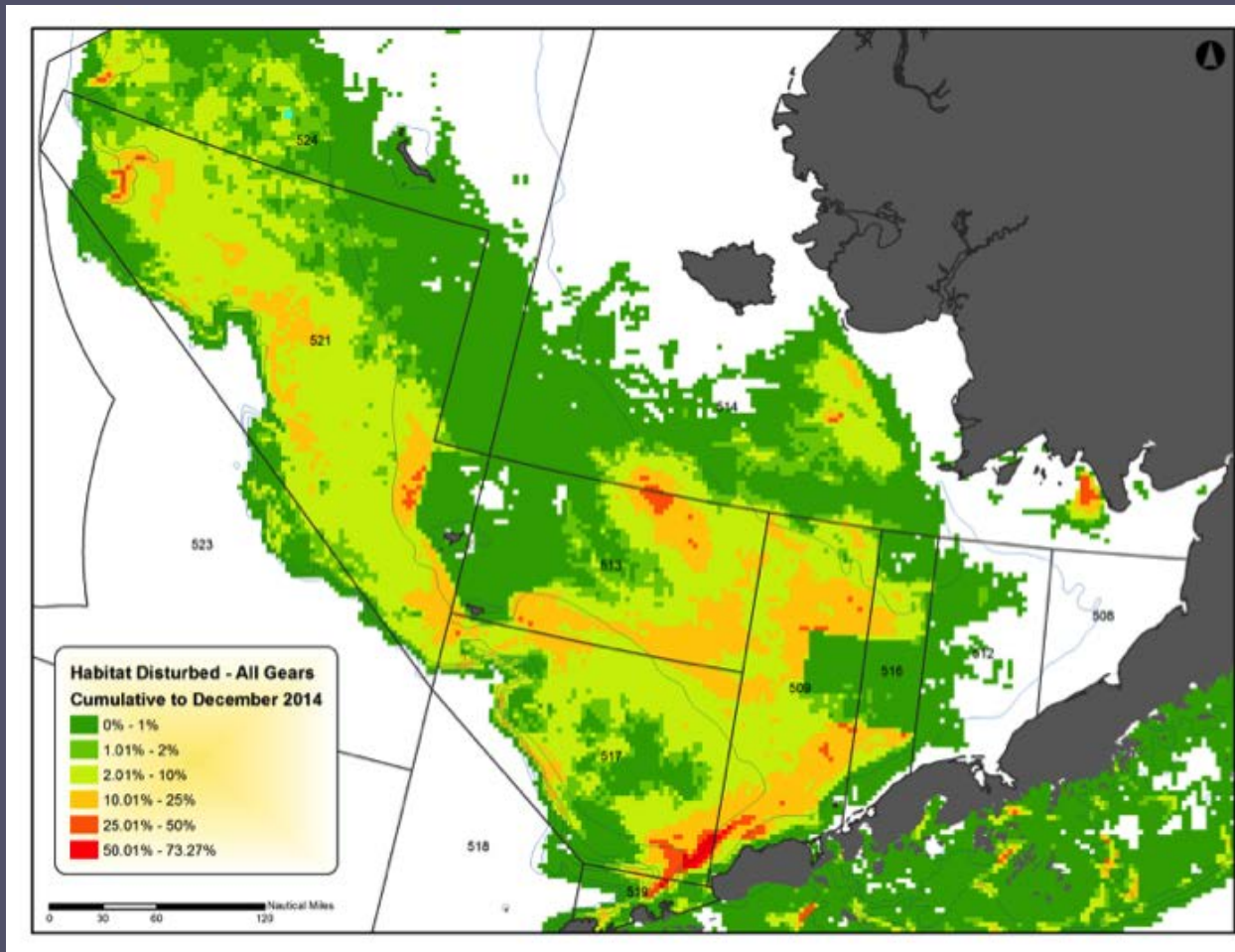
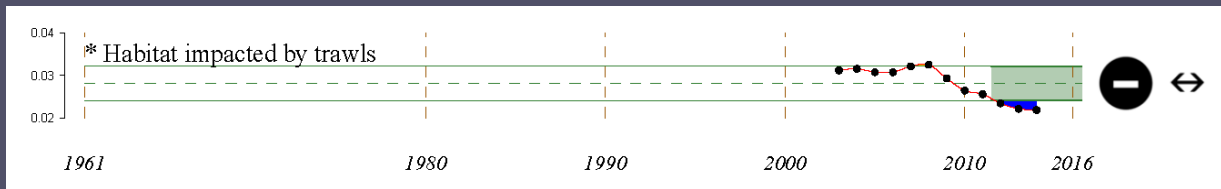
Paul Melovidov

2016 EBS Fur seals



- Pup production remained low in 2016
- Fewer pups produced than during previous survey in 2014

(2014) EBS Fishing impacts

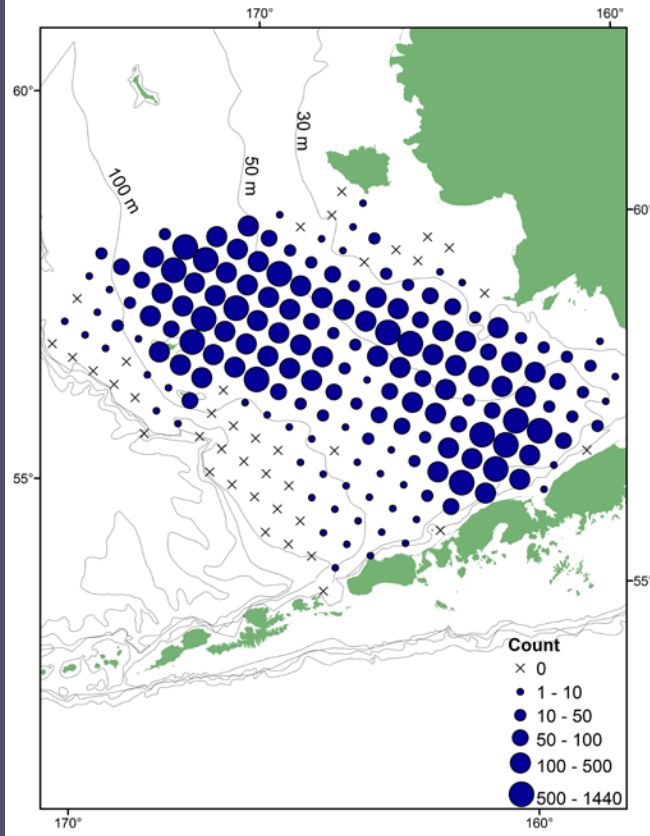


- New indicator
- Based on Fishing Effects model
- Effects are cumulative
- All gear types
- Considers impacts and recovery

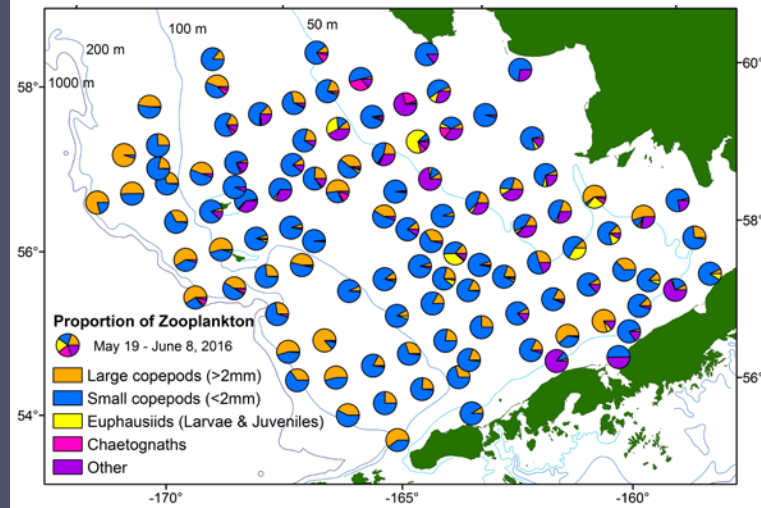
Mismatch between pollock larvae and lipid-rich prey?

(Steve Porter)

Age-0 pollock larvae



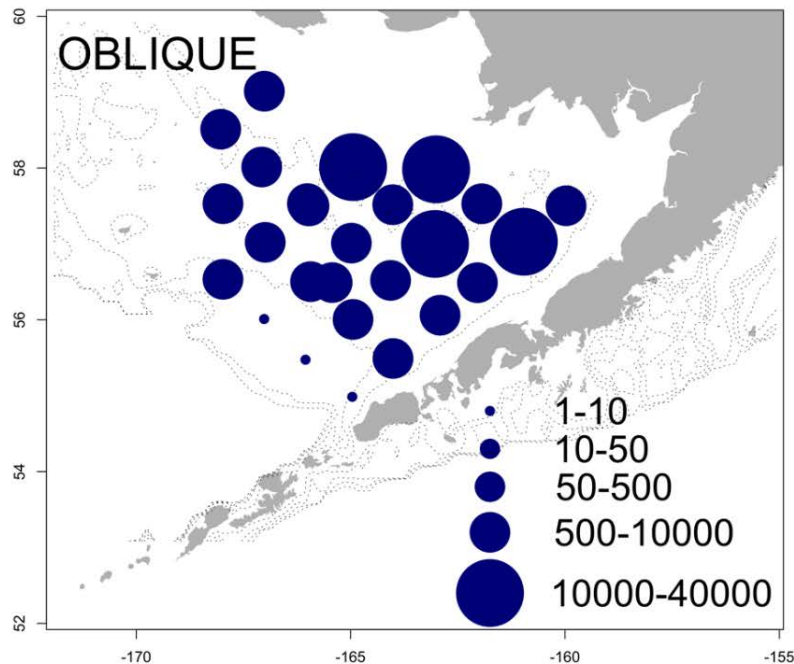
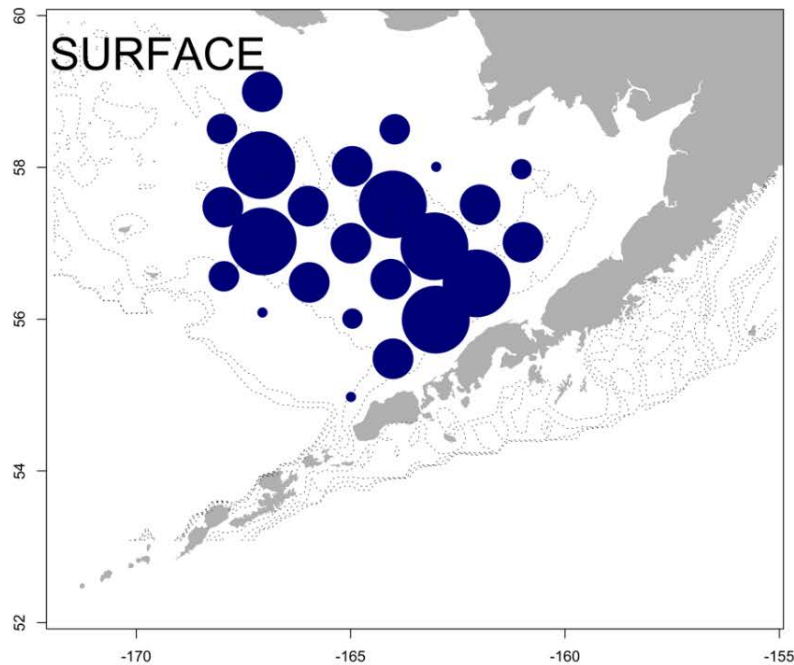
Spring zooplankton rapid assessment



- Eco-FOCI/EMA ichthyoplankton survey
- Abundant larvae, but likely feeding on early stages of less nutritious copepods
- Negative implications for survival?
- But lots of age-0 still present in fall

Fall age-0 pollock

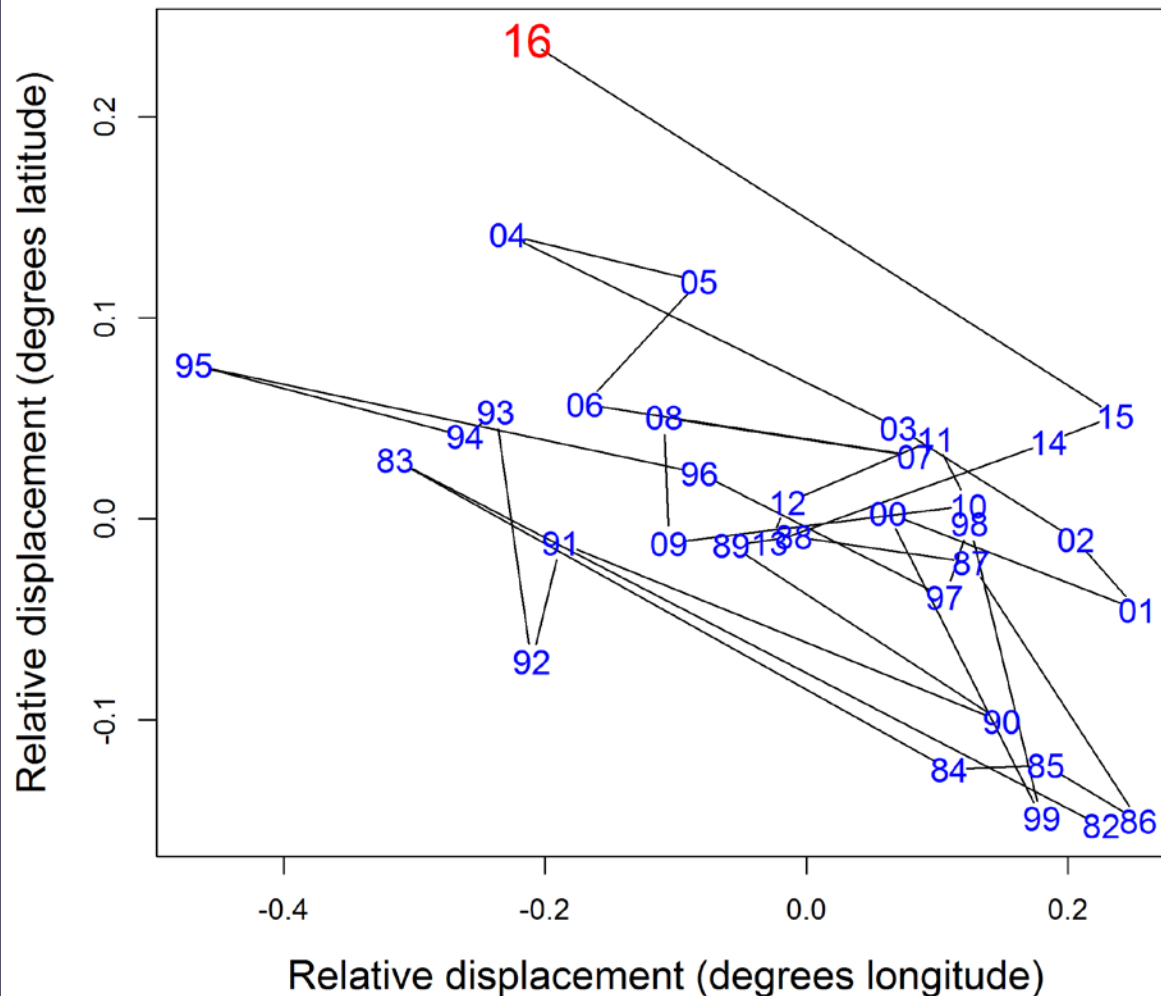
(Andrews, Siddon, Cooper (RPA))



- High catches of age-0 pollock in surface and oblique (midwater)
- Age-0 pollock were the dominant prey of salmon, sandfish, rainbow smelt, age-1 & adult pollock

Spatial distribution of groundfish stocks in the EBS (Mueter)

Average north-south and east-west displacement

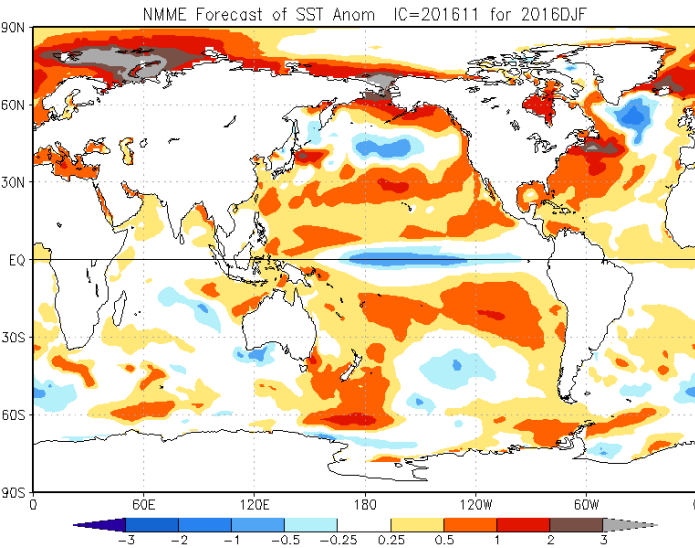


- Early 2000's: shifter to NE
- 2006: southward shift
- Currently further NW and shallower (not shown)

2016 Forecasts and Predictions

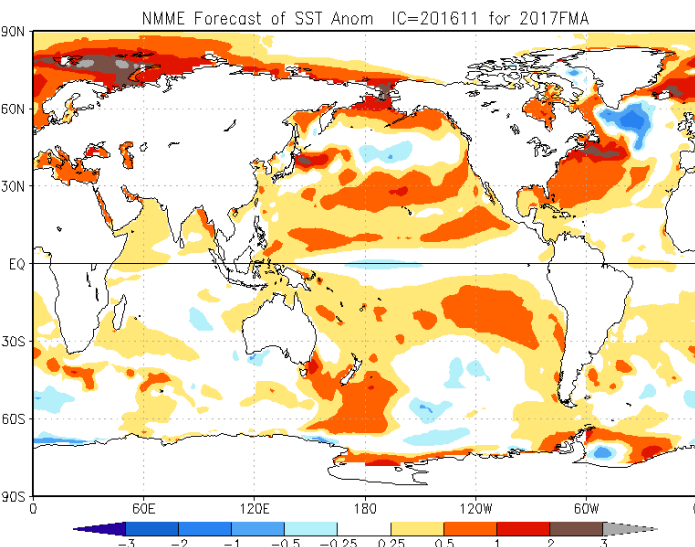
Seasonal Projections from the National Multi-Model Ensemble (NMME) (Bond)

2016 Dec-Jan-Feb

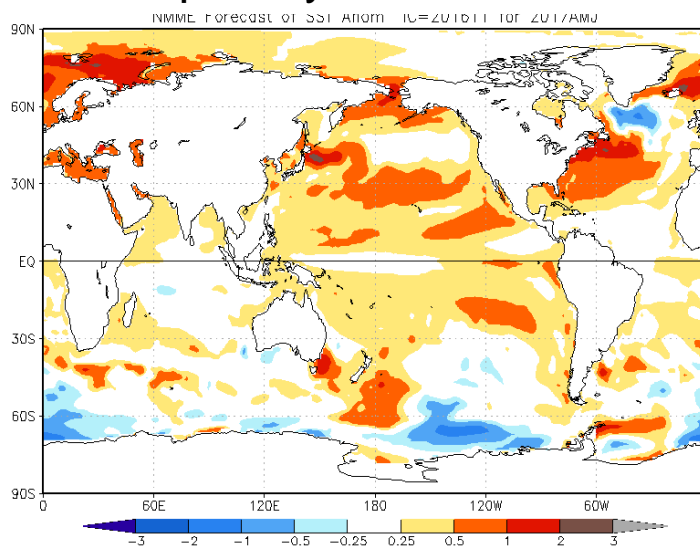


- SST projections
- NMME is average of 6 models
- Continuation of warm
- Strongest positive anomalies in EBS and GOA
- Maintenance of positive PDO conditions with La Niña could reflect extra heat in system

2017 Feb-Mar-Apr



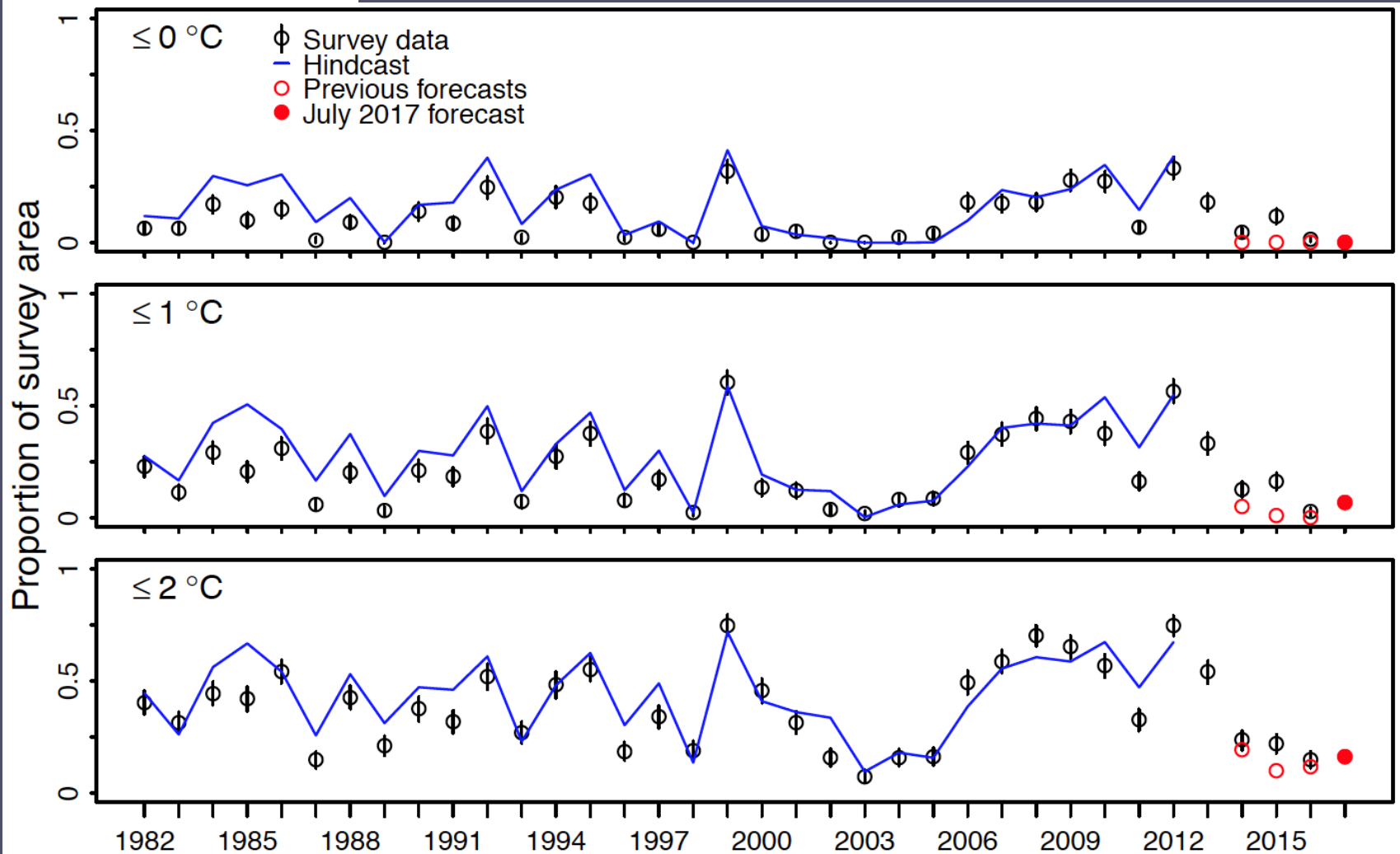
2017 Apr-May-June



EBS 9 month forecast

(Aydin and Hermann)

Cold Pool



A collection of pollock recruitment predictions

2016

- Age-1 pollock to have above average recruitment and age-3 above average recruitment based on current temperature change index (Yasumiishi)
- Age-1 pollock predicted to have below average recruitment (Indicator: chum salmon, SST; Yasumiishi)
- Age-1 pollock predicted to be intermediate based on low energy content and small size (Heintz et al)

2018

- Age-3 pollock predicted to have intermediate recruitment (Heintz et al)
- Age-3 pollock predicted to have above average abundance (TCI, Yasumiishi)

2019

- Poor 2016 year class?? Based on small size of zooplankton this year (Eisner, Yasumiishi)

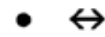
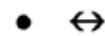
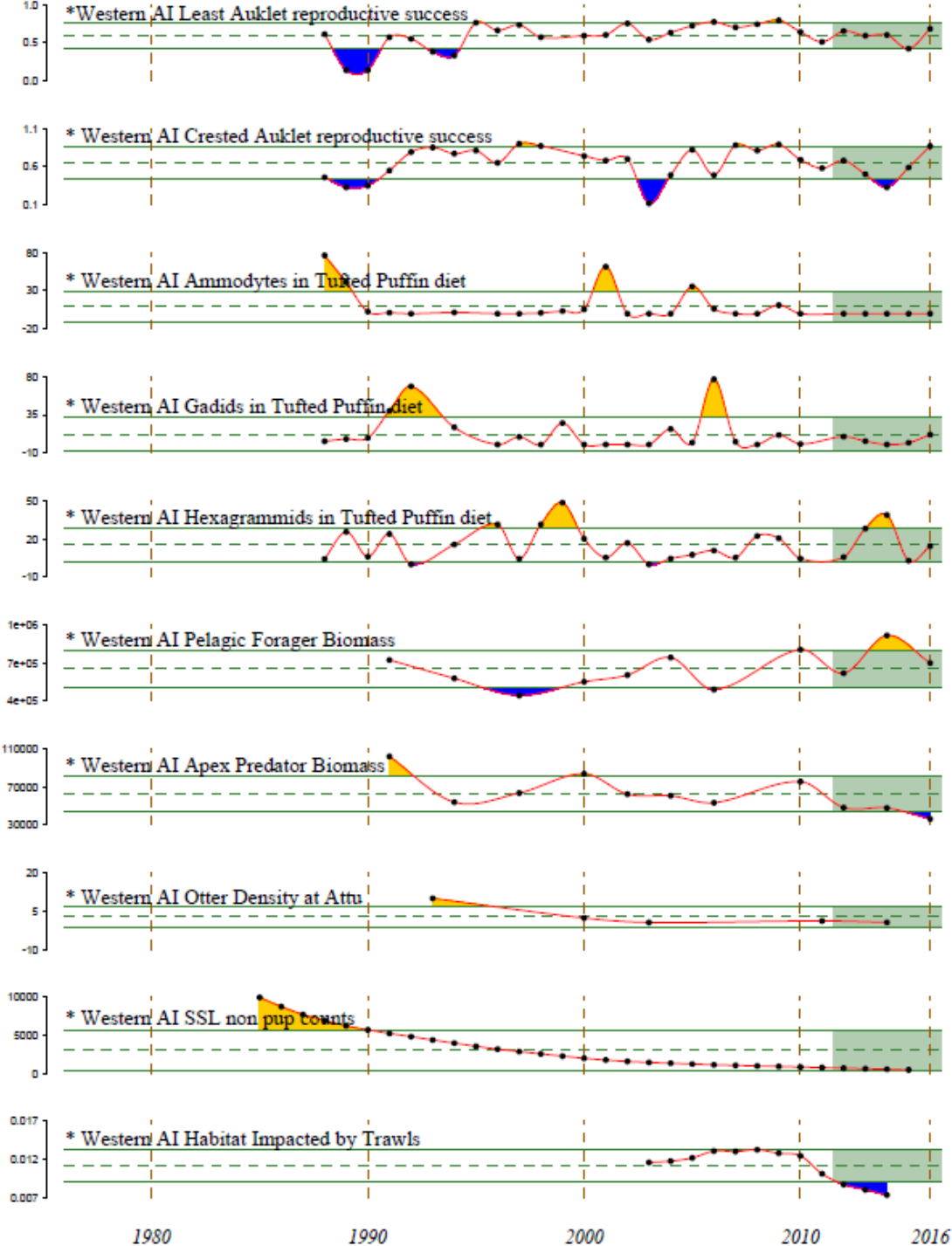


Aleutian Islands



2016 Aleutian Islands Report Card

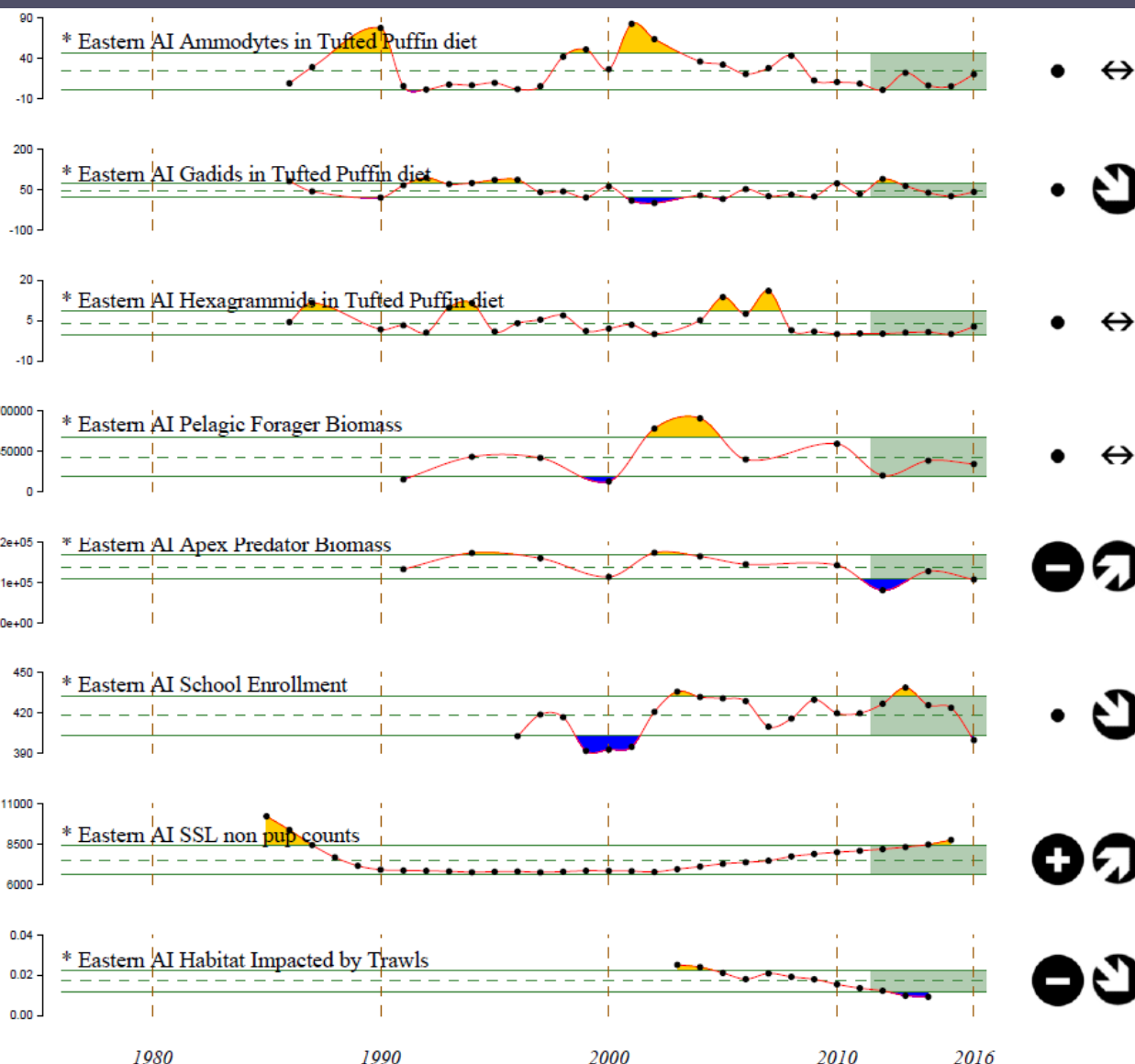
Western Ecoregion



- Planktivorous auklets had above average breeding success
- Age-0 gadids and hexagrammids average
- Pelagic foragers declined due to Northern rock sole
- Low sea lion estimates (2015)

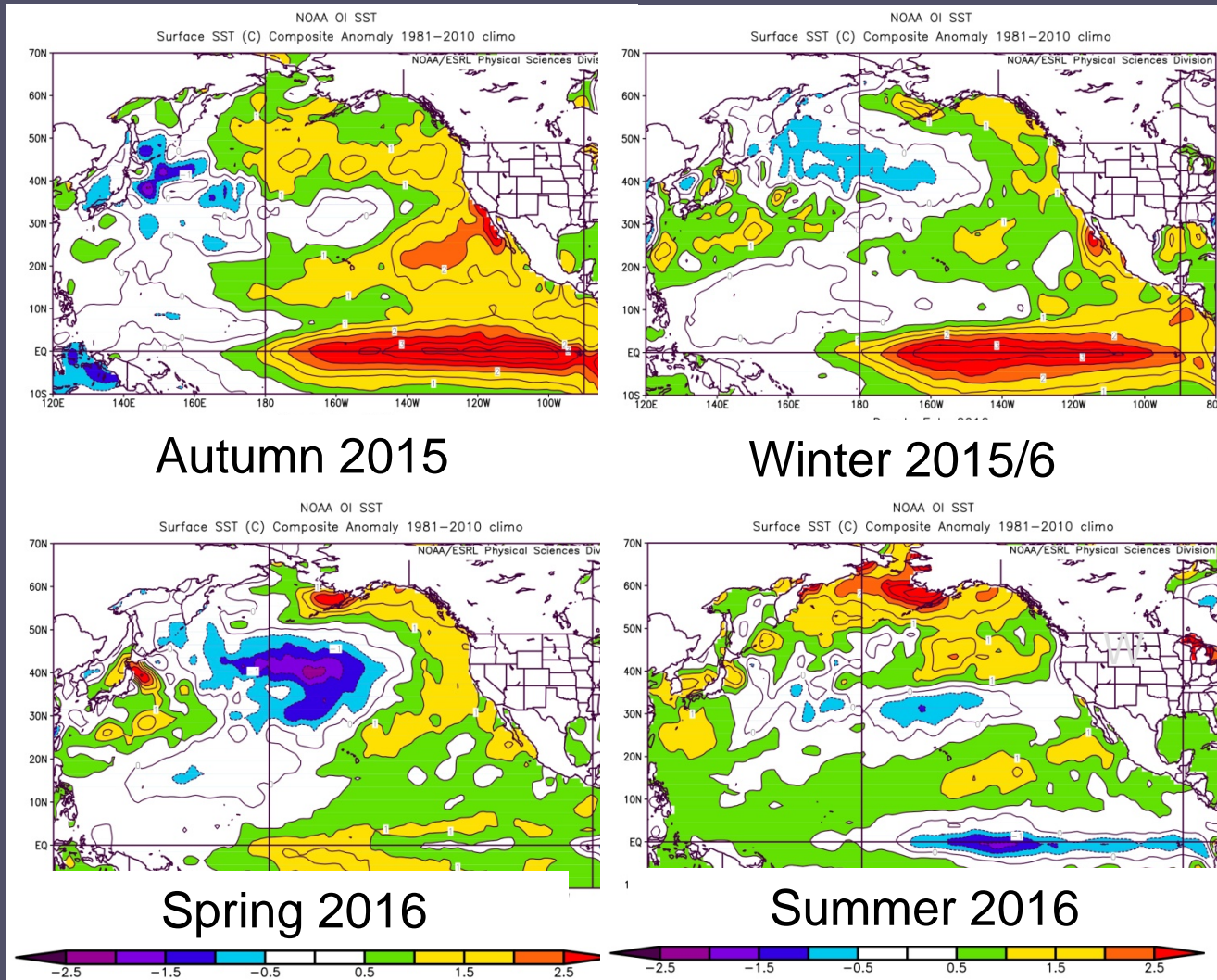
2016 Aleutian Islands Report Card

Eastern Ecoregion



- All forage fish increased in puffin diets, but gadids still declining from 2012 peak
- Pelagic and apex predators declined slightly from 2014
- School enrollment dropped sharply
- Sea lions continue to increase.

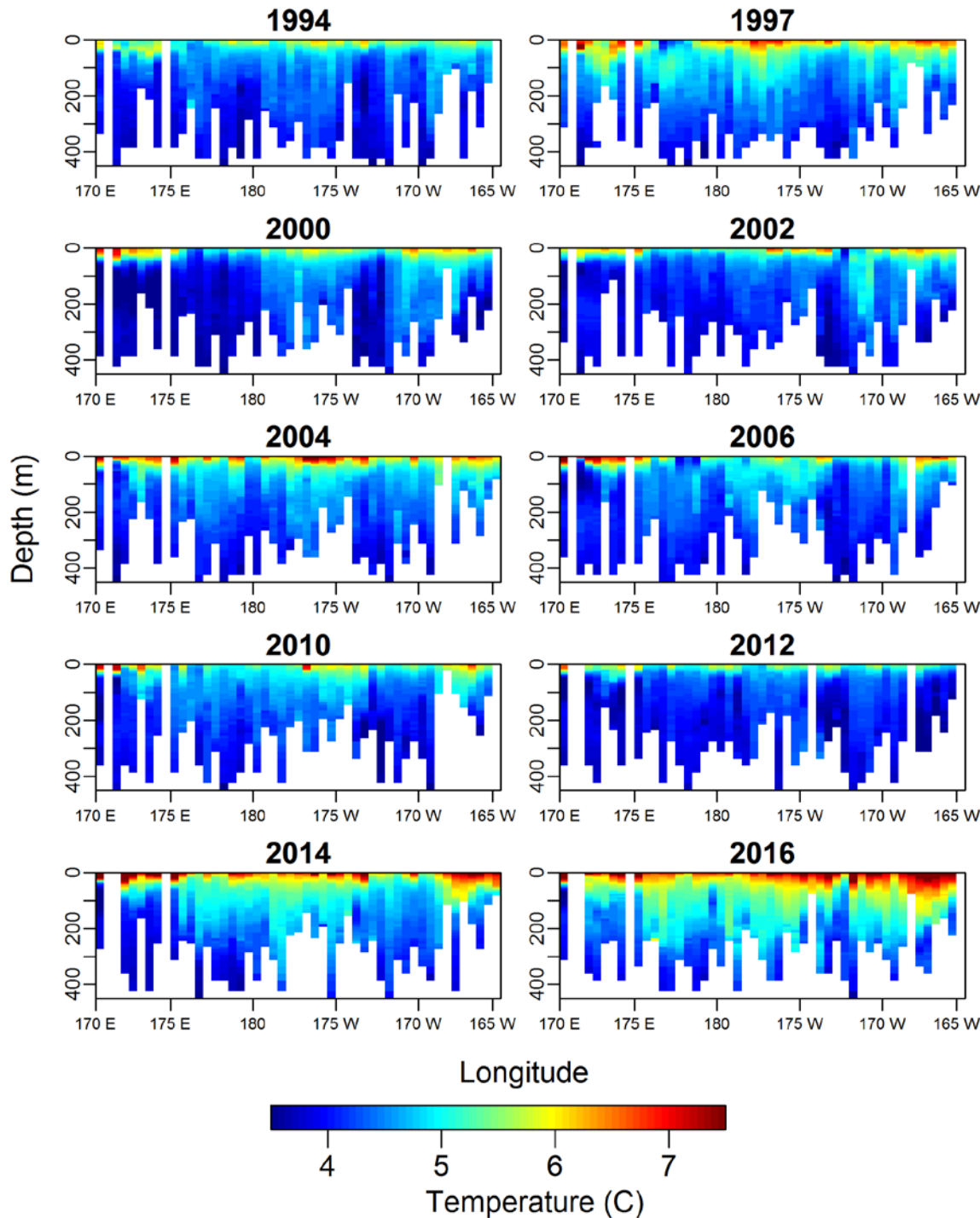
Despite that the Aleutians cooled to normal during winter...



...2016 survey
temperatures were
very warm

(Laman)

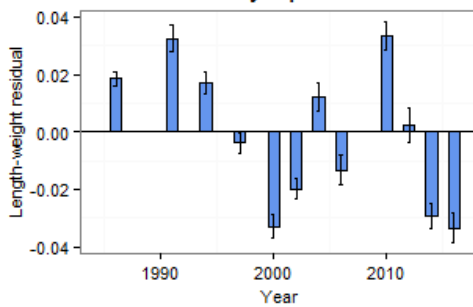
- Warmest and most pervasive (vertical and horizontal) in time series
- Similar to 2014, but warm water deeper



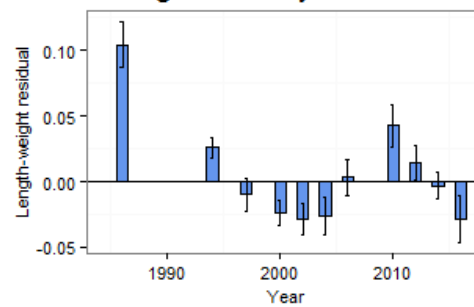
2016 Groundfish Condition (Boldt, Rooper et al)

Length-weight residuals

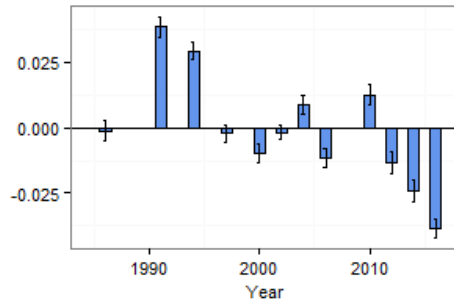
Walleye pollock



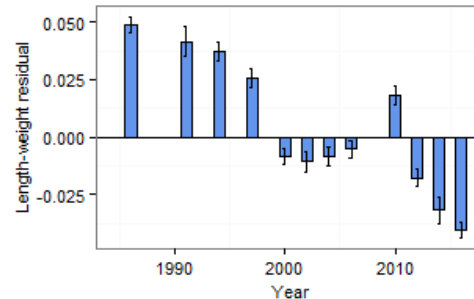
Age 1 Walleye Pollock



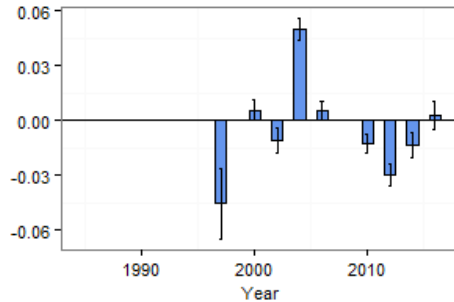
Pacific cod



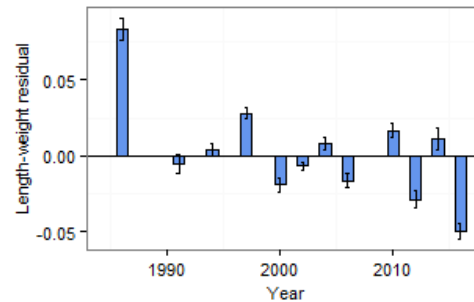
Northern rockfish



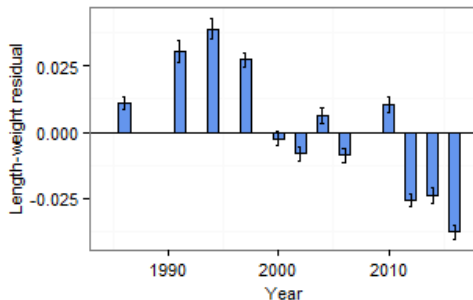
Southern rock sole



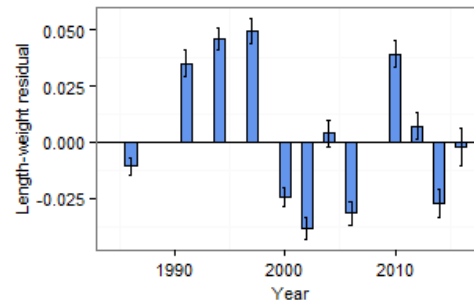
Arrowtooth flounder



Pacific Ocean perch



Atka mackerel

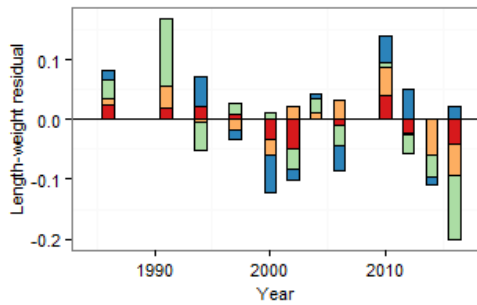


- Length-weight residuals **negative** for all in 2014 and 2016
- Positive for all but southern rock sole in 2010
- Northern rockfish, cod, POP generally declining over the survey

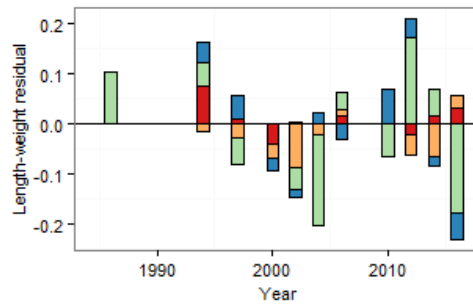
2016 Groundfish Condition (Boldt et al)

Length-weight residuals

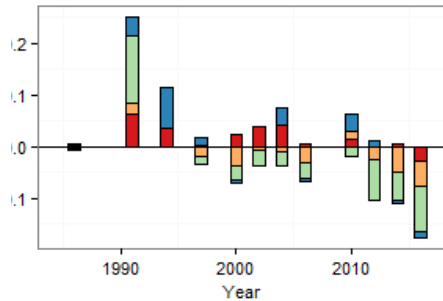
Walleye pollock



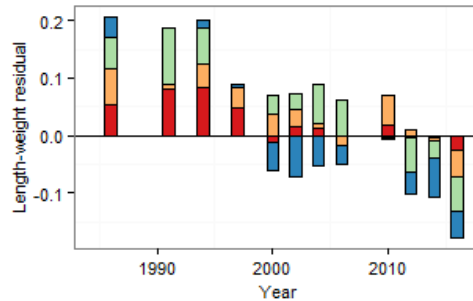
Age 1 Walleye Pollock



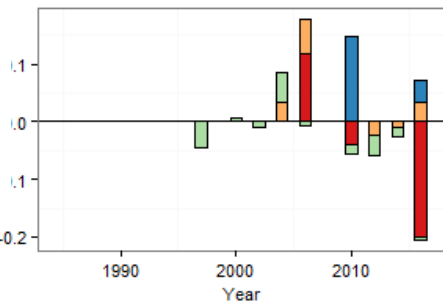
Pacific cod



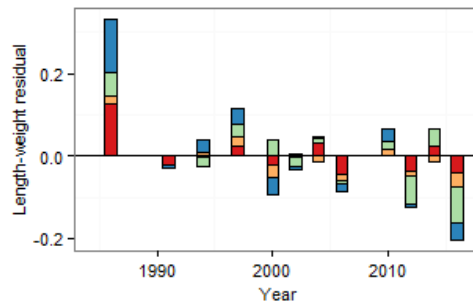
Northern rockfish



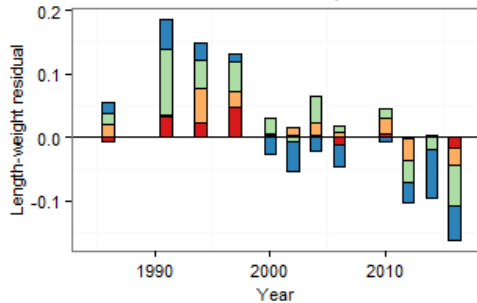
Southern rock sole



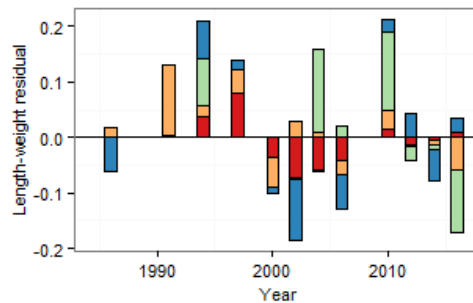
Arrowtooth flounder



Pacific Ocean perch



Atka mackerel



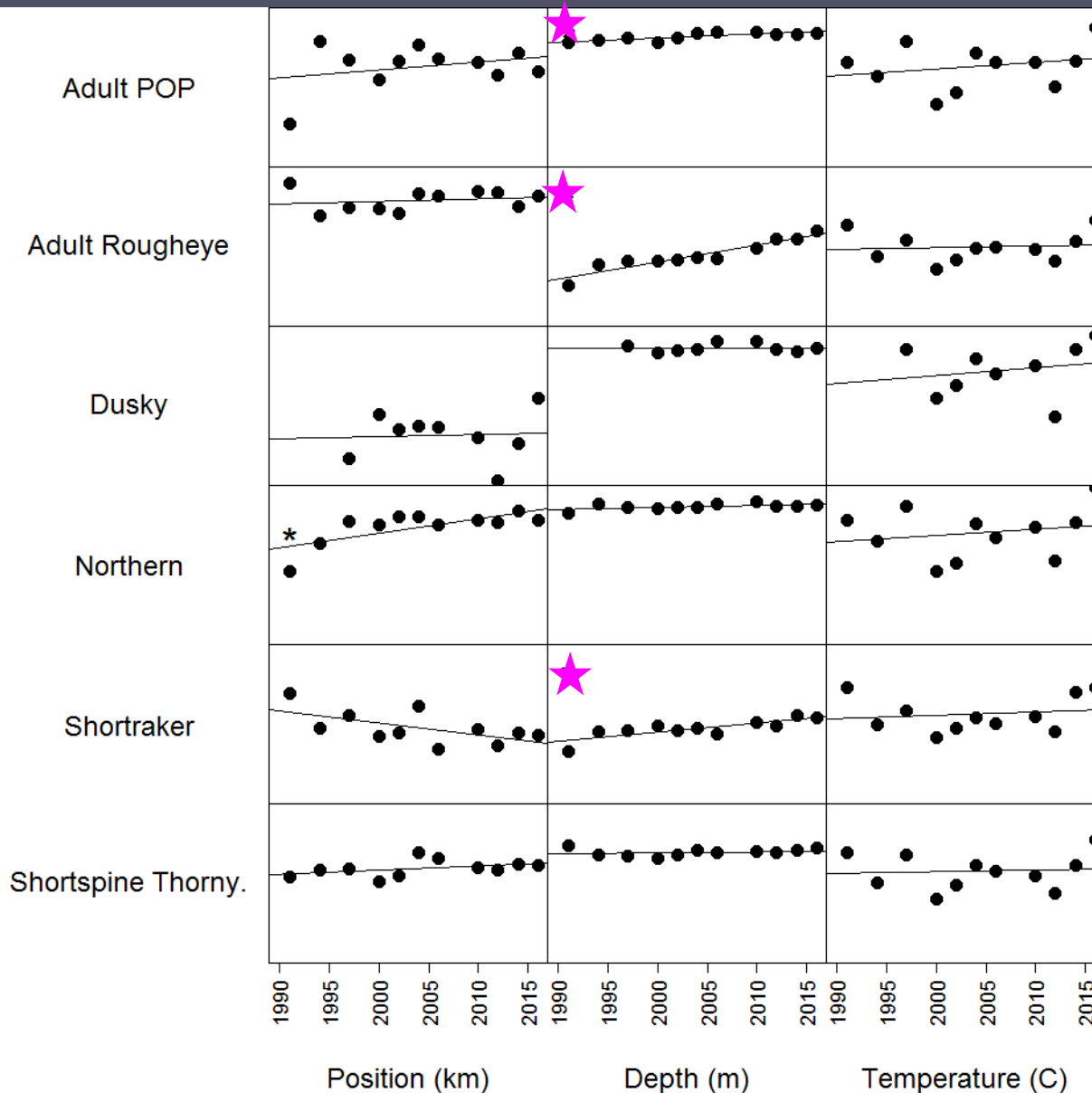
- Negative in the southern Bering Sea
- Mixed in the western AI

Stratum



Distribution of rockfish

(Rooper)



POP, Rougheye and Shortraker have moved shallower statistically, but temperature range has not changed

Increases in mean-weighted temperature likely due to warm overall temps, but no statistical trend



Summary - BSAI

2015

- 2nd year of warm conditions.
- Average to poor productivity.

2016

- Continuation of warm conditions.
- **Mixed** productivity and all-around assessment for the AI.
- **Poor** productivity and die-offs in the EBS.

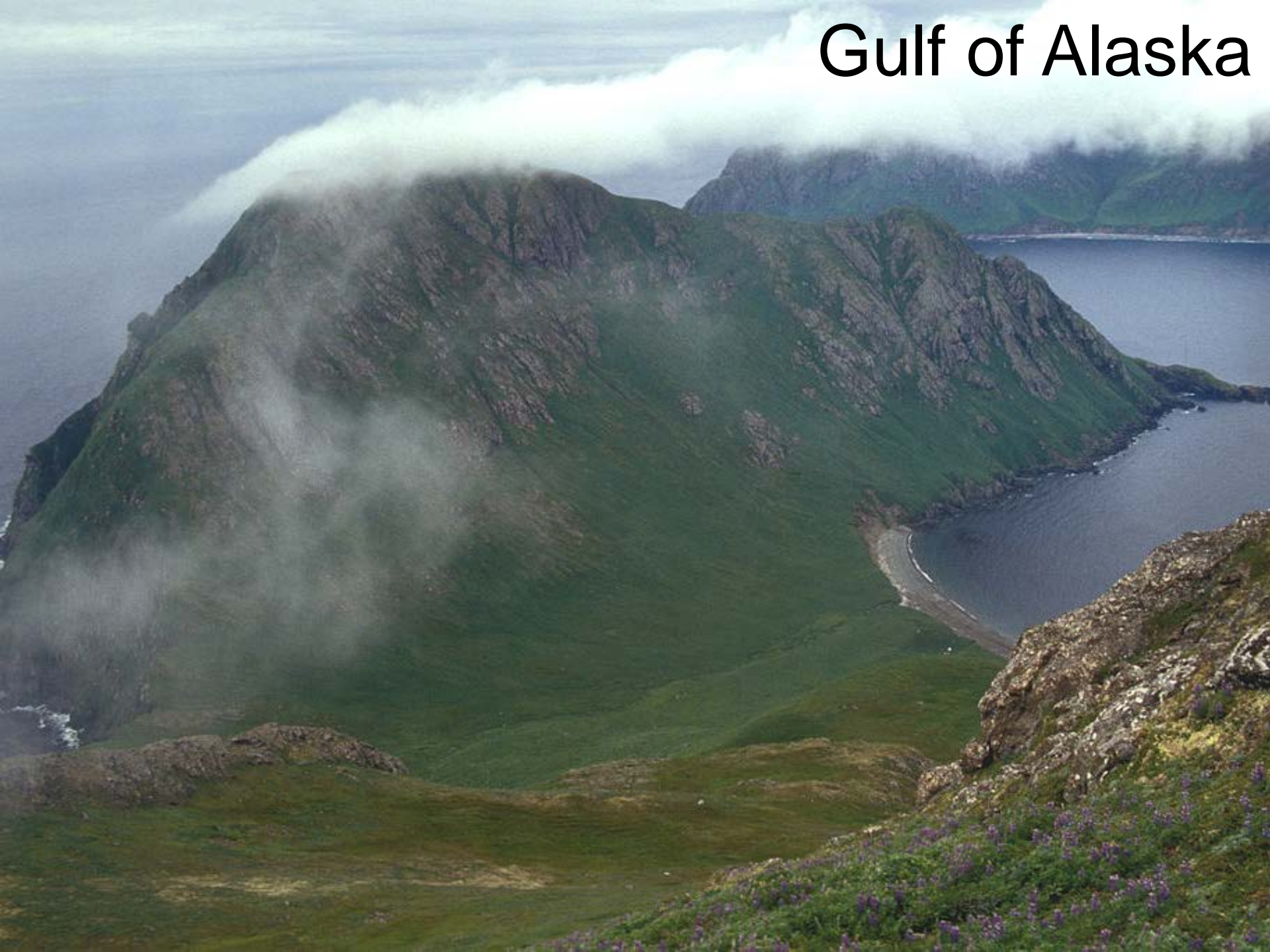
Contributors

Alex Andrews, Claire Armistead, Mary Auburn-Cook, Kerim Aydin, Jennifer Boldt, Nick Bond, Kristin Cieciel, Ben Daly, Lisa Elsner, Ed Farley, Nissa Fern, Shannon Fitzgerald, Robert Foy, Madisyn Frandsen, Lowell Fritz, Sarah Gaichas, Jeanette Gann, Pam Goddard, Colleen Harpold, Ron Heintz, Jerry Hoff, Kirstin Holsman, Katharine Howard, Jim Ianelli, David Kimmel, Chris Kondzela, Carol Ladd, Jesse F. Lamb, Robert Lauth, Jean Lee, Michael Litzow, Jennifer Mondragon, Franz Mueter, Jim Murphy, John Olson, Jim Overland, Steve Porter, Rolf Ream, Patrick Ressler, Chris Rooper, Sigrid Salo, Anna Santos, Elizabeth Siddon, Phyllis Stabeno, Rod Towell, Muyin Wang, Andy Whitehouse, Tom Wilderbuer, Ellen Yasumiishi, and Stephani Zador.

Sonia Batten, Jennifer Boldt, Nick Bond, Shannon Fitzgerald, Pamela Goddard, Sarah Gaichas, Jerry Hoff, Carol Ladd, Ned Laman, Jean Lee, Jennifer Mondragon, John Olson, Ivonne Ortiz, Chris Rooper, Anna Santos, Tim Tinker, Andy Whitehouse, Stephani Zador

Thank you!

Gulf of Alaska





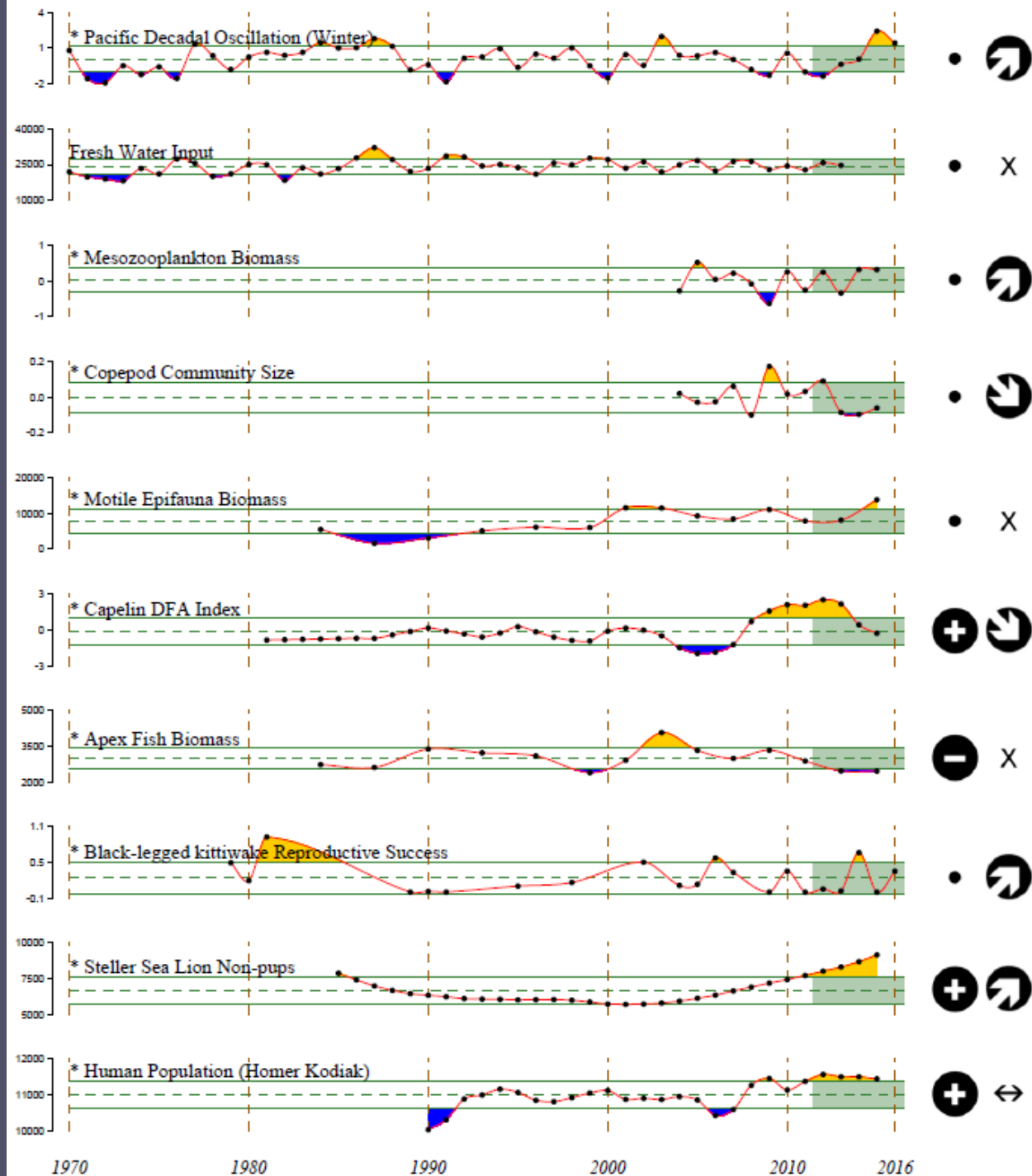
Gulf of Alaska Report Card



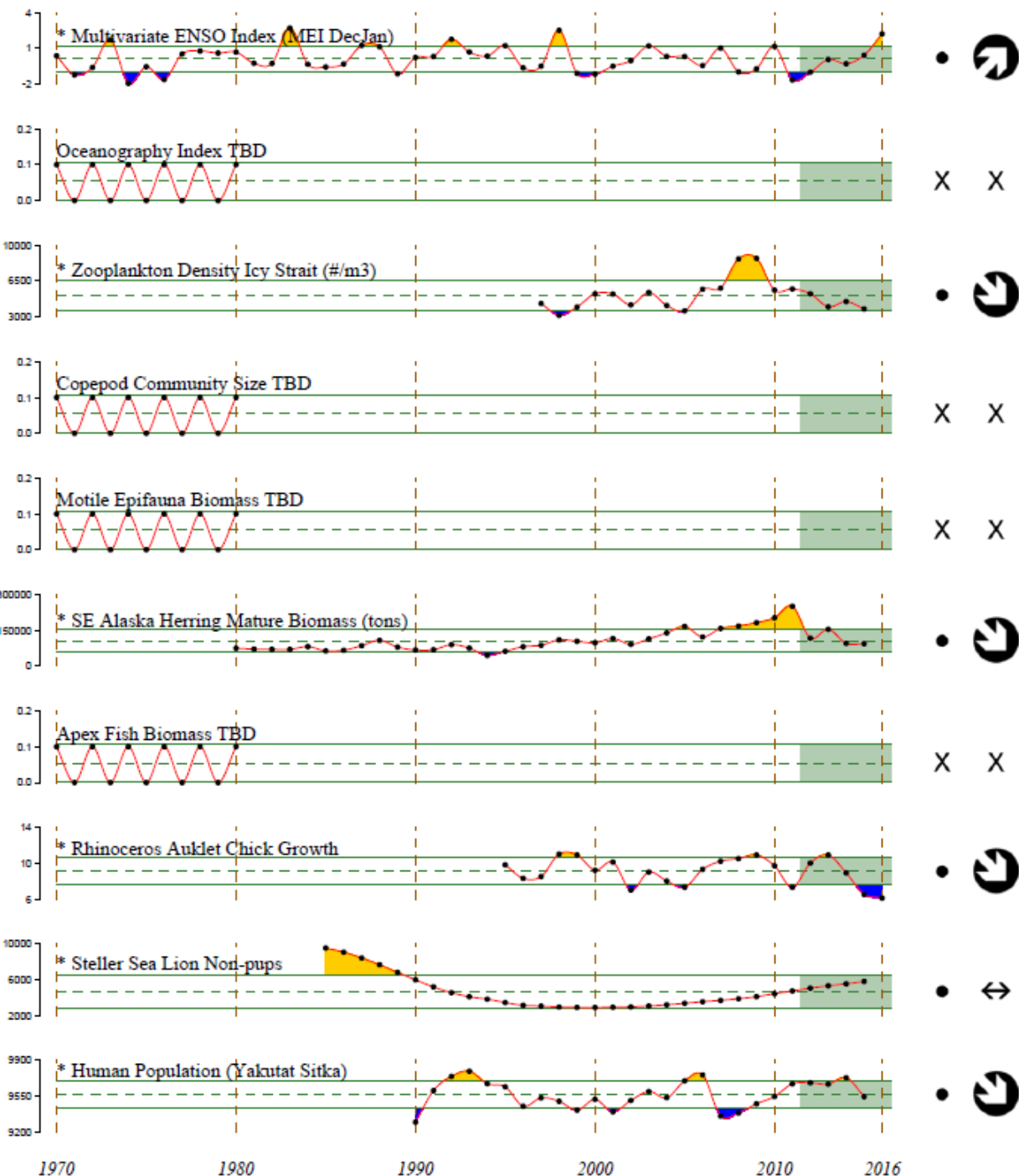
Now West and East

2016 Western Gulf of Alaska Report Card

1. PDO
2. Fresh Water Input
3. Mesozooplankton
4. Copepod Size
5. Motile Epifauna Biomass
6. Capelin
7. Apex Fish Biomass
8. Kittiwake Reproductive Success
9. Steller Sea Lions
10. Human Population

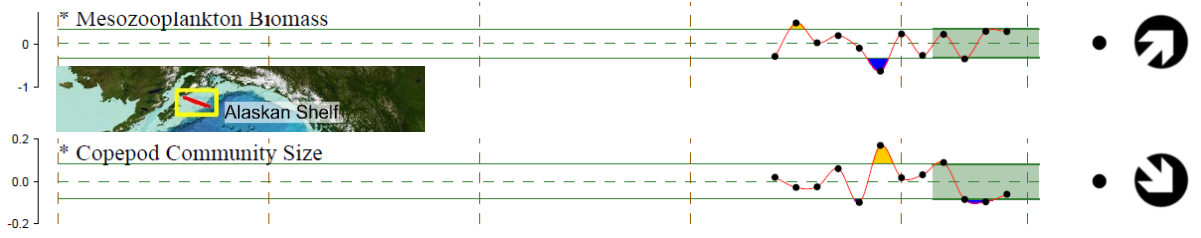


2016 Eastern Gulf of Alaska Report Card

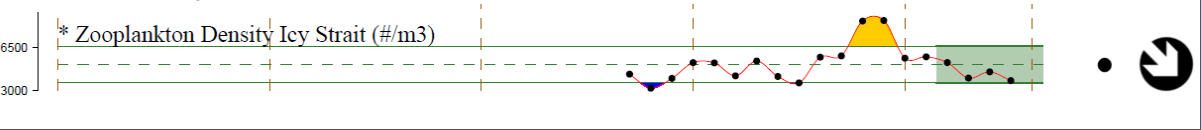


1. MEI
2. (Oceanography)
3. Zooplankton density
4. (Copepod Size)
5. (Motile Epifauna Biomass)
6. SE AK Herring
7. (Apex Fish Biomass)
8. Rhinoceros auklet chick growth
9. Steller Sea Lions
10. Human Population

West - CPR



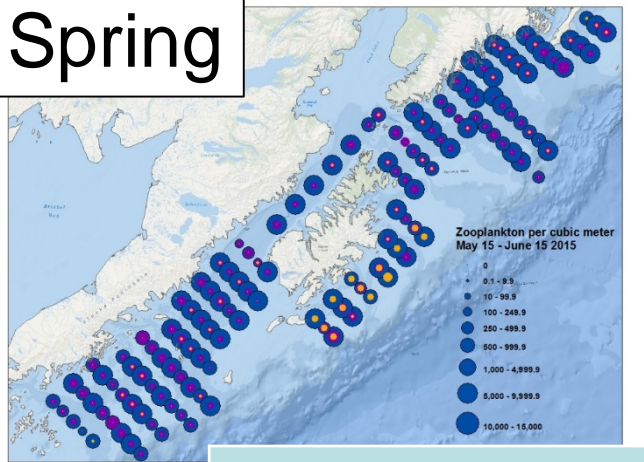
East – Icy Strait



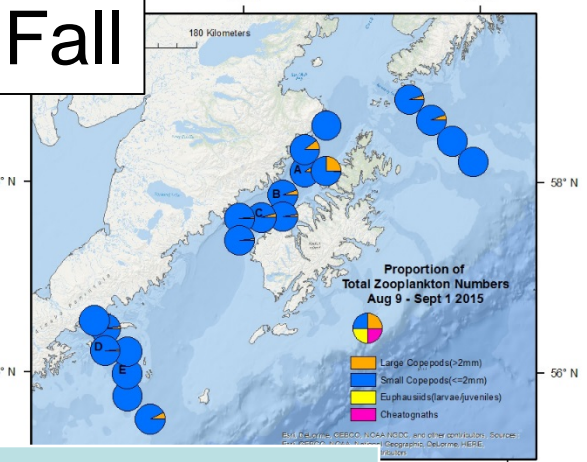
2015
Zooplankton
(Batten, Kimmel, Ressler et al.)

- Small copepods dominated and increased from spring to fall

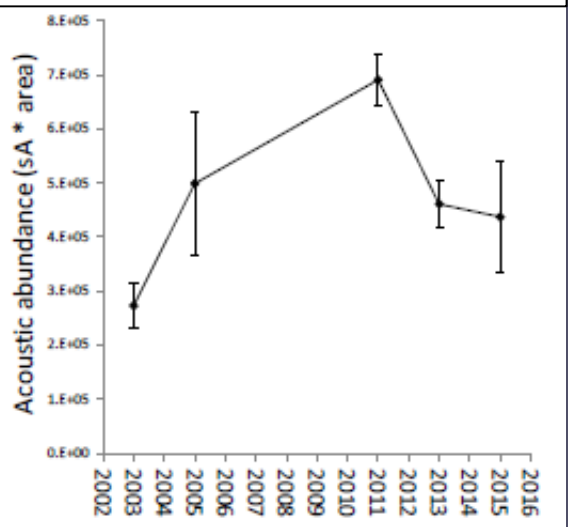
Spring



Fall



Euphausiid acoustic survey



Zoop Rapid Assessment	Δ proportion
Large copepods	-4.1
Small copepods	+8.9
Euphausiids	+0.1
Chaetognaths	-7.8

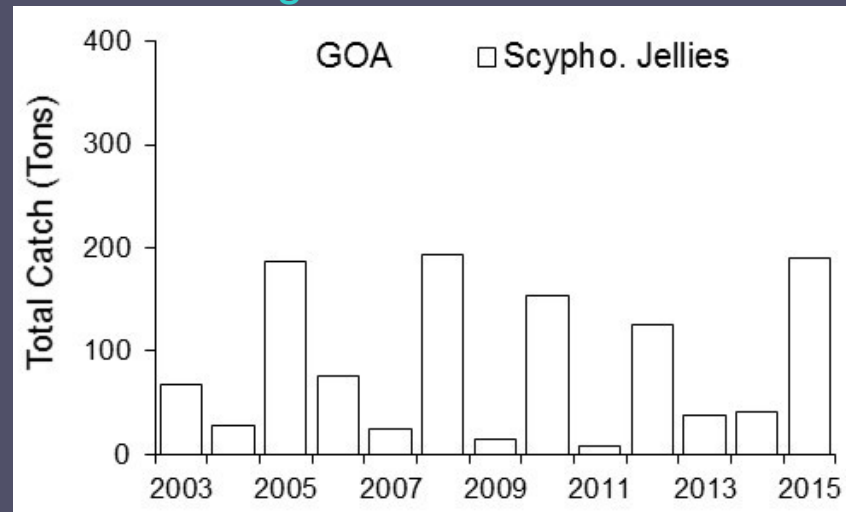
2015

Plentiful jellyfish in fisheries and survey

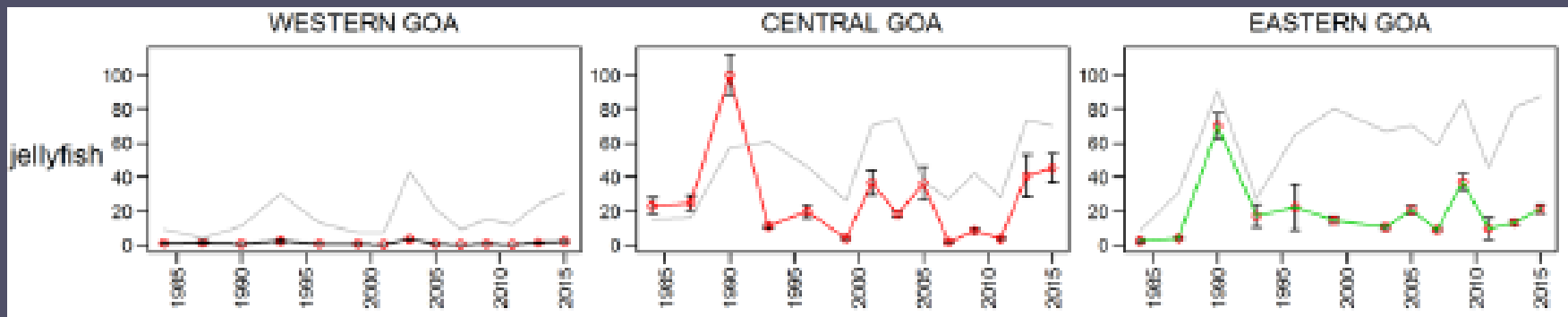
Whitehouse, Rooper



Non-target catch

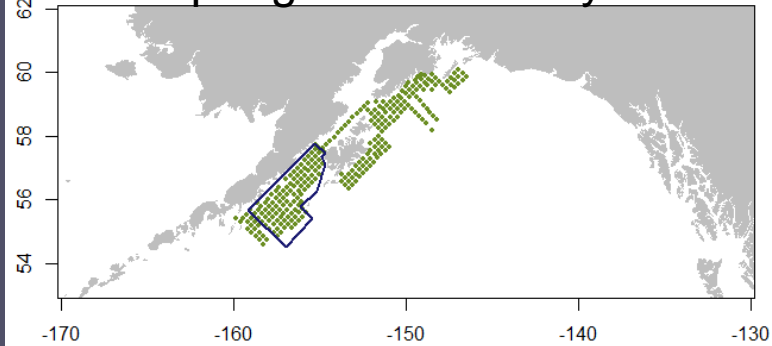


Bottom Trawl Survey



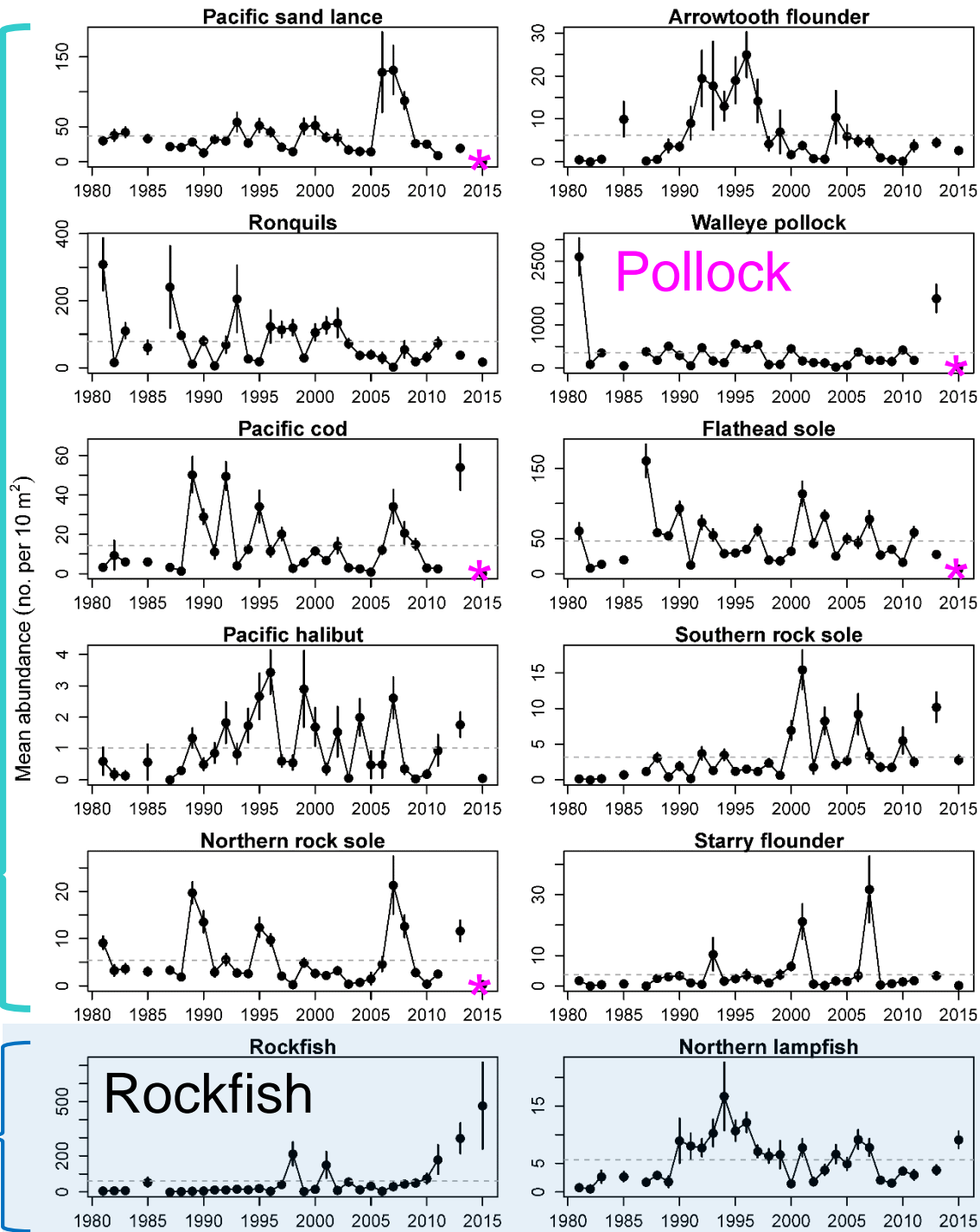
Mostly low
ichthyoplankton
abundance
(Duffy-Anderson, Rogers)

2015 Spring Larval Survey



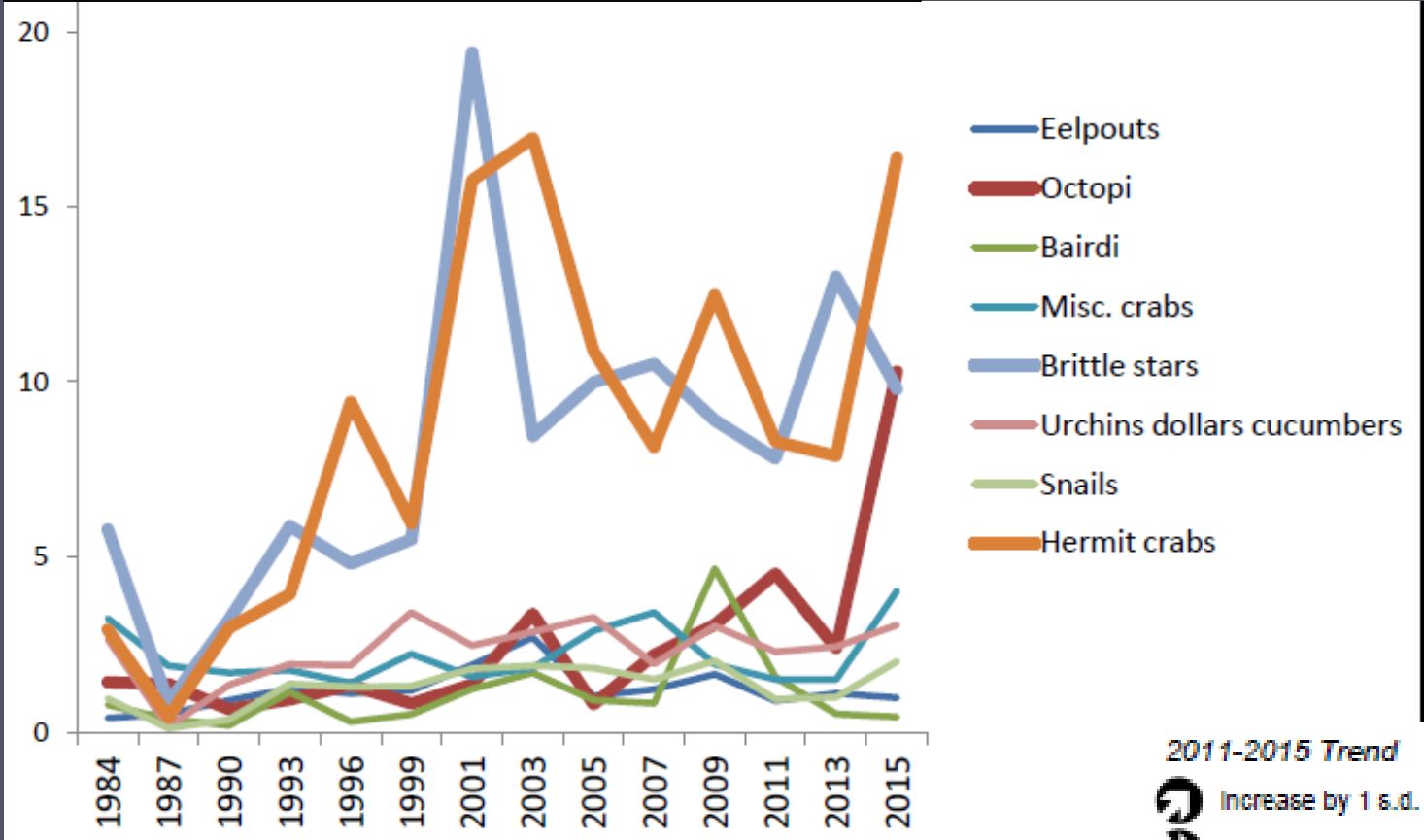
Negative anomalies
(* lowest in time series)

Positive anomalies

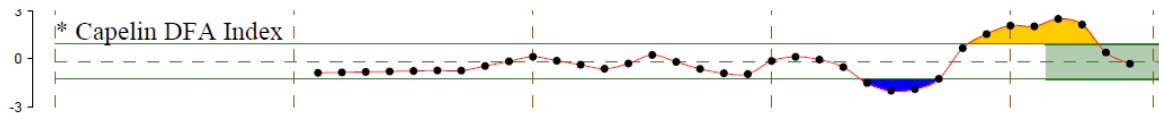




Aggregated biomass from the BT survey

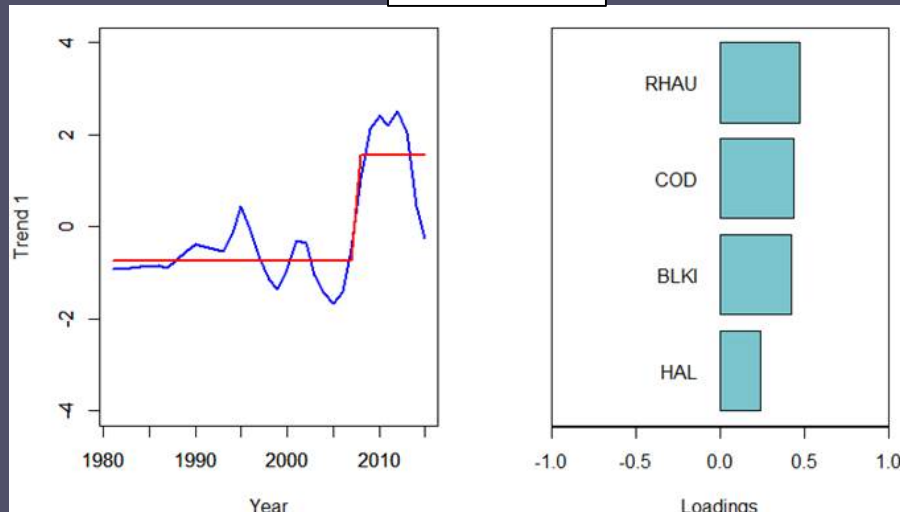


- 2011-2015 Trend
- ↗ Increase by 1 s.d. over time window
 - ↘ decrease by 1 s.d. over time window
 - ↔ change <1 s.d. over window
 - fewer than 3 data points

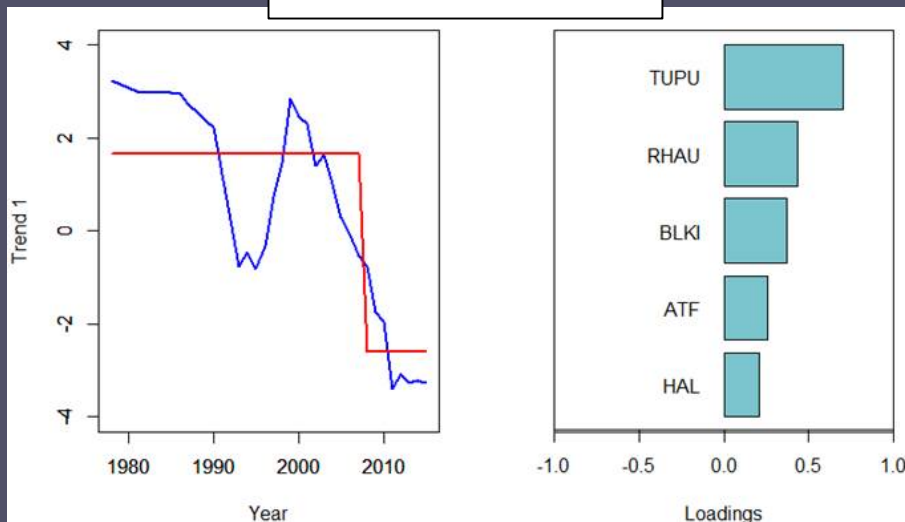


New indicator

Capelin



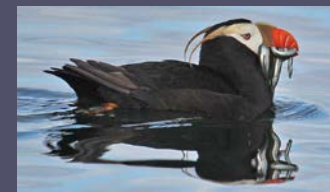
Sand lance

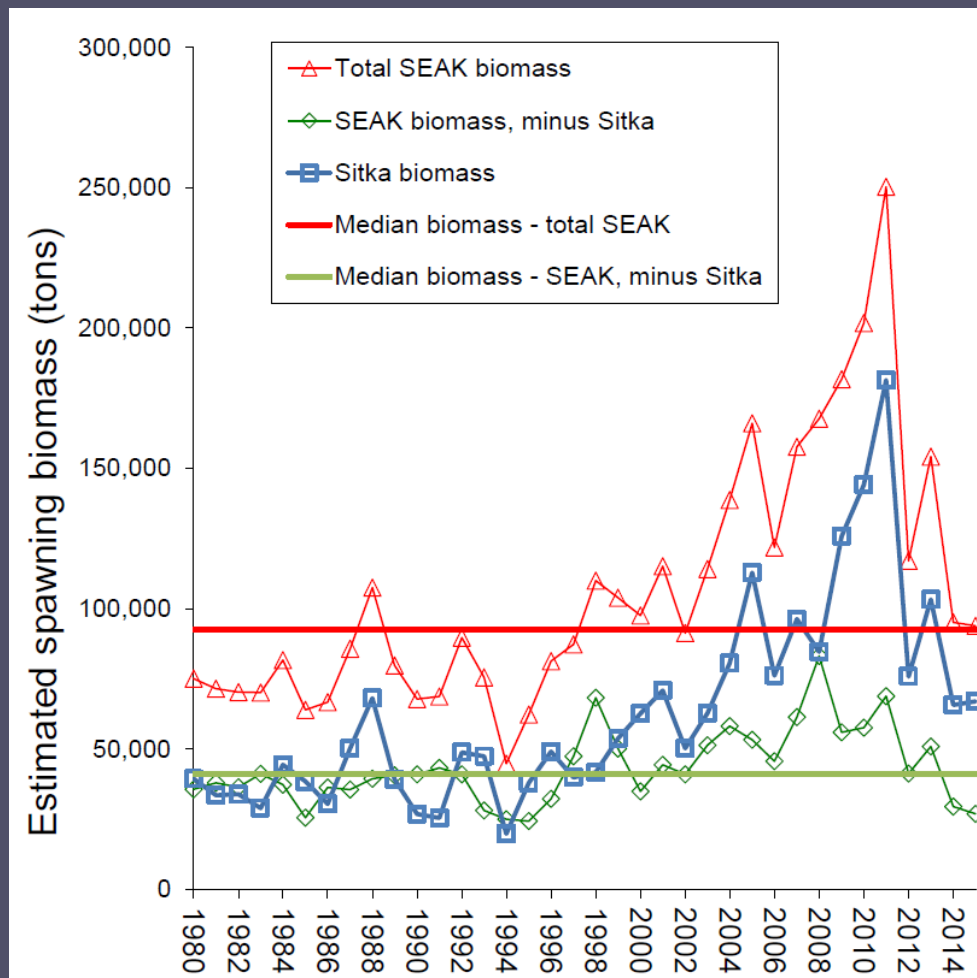
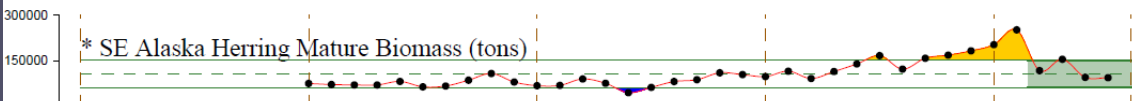


Capelin and Sand Lance Trends

Zador

- Groundfish and seabird used as “samplers” with diverse foraging strategies.
- ~1980-2015
- Dynamic Factor Analysis with SRSD (sequential regime shift detection, Rodionov)
- Single trend best fit model for both
- Regime shifts detected in 2008

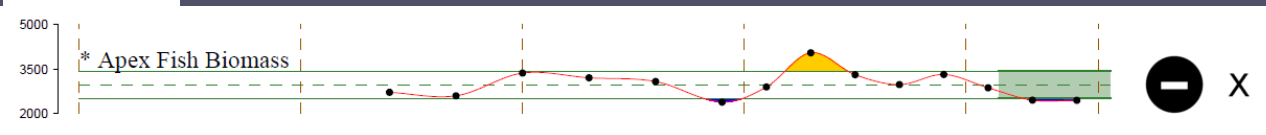




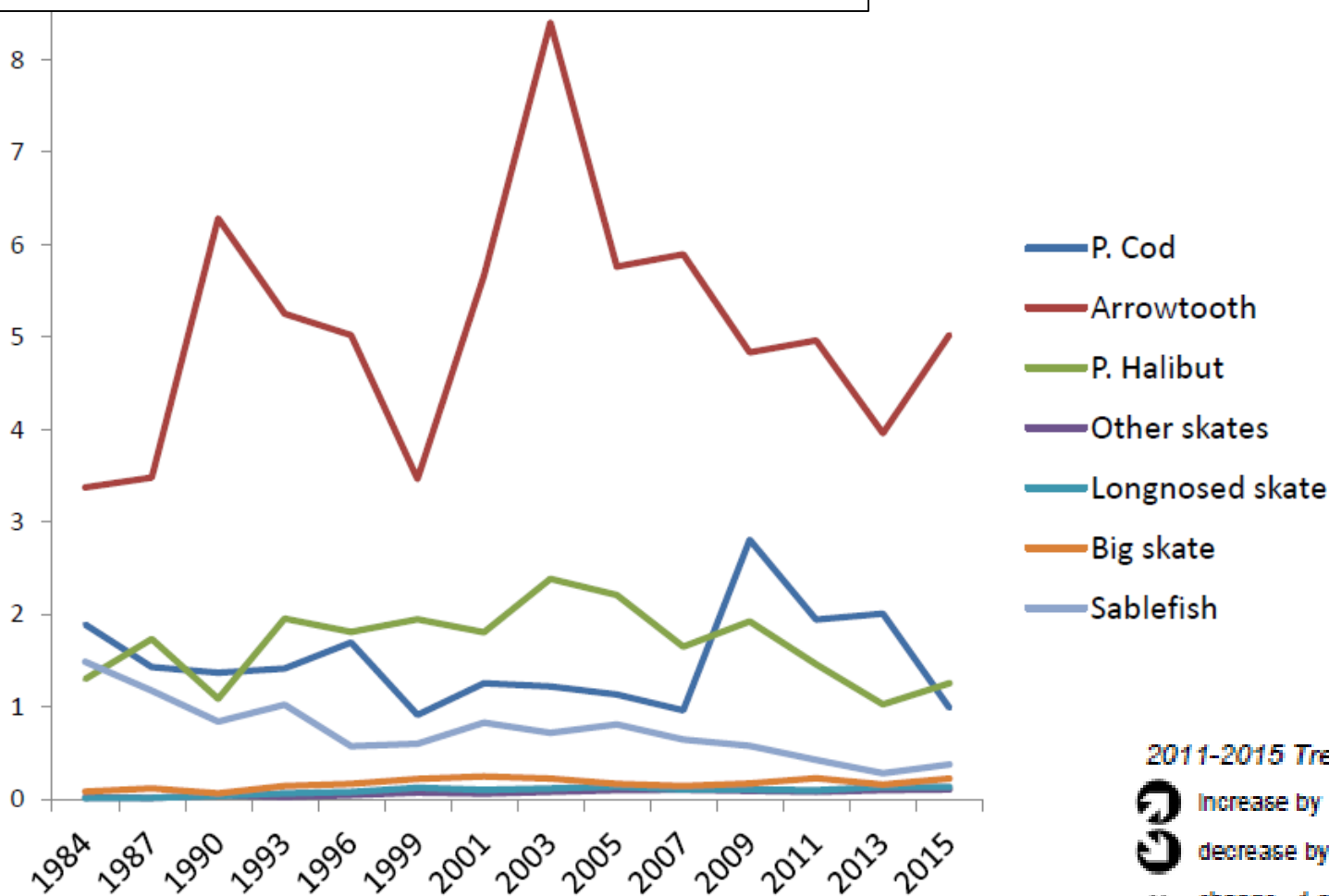
Southeast Alaska Herring

(Hebert and Dressel)

- Peak biomass in 2011
- 2012, 2014, large declines
- Little change in 2015



Aggregated biomass from the BT survey



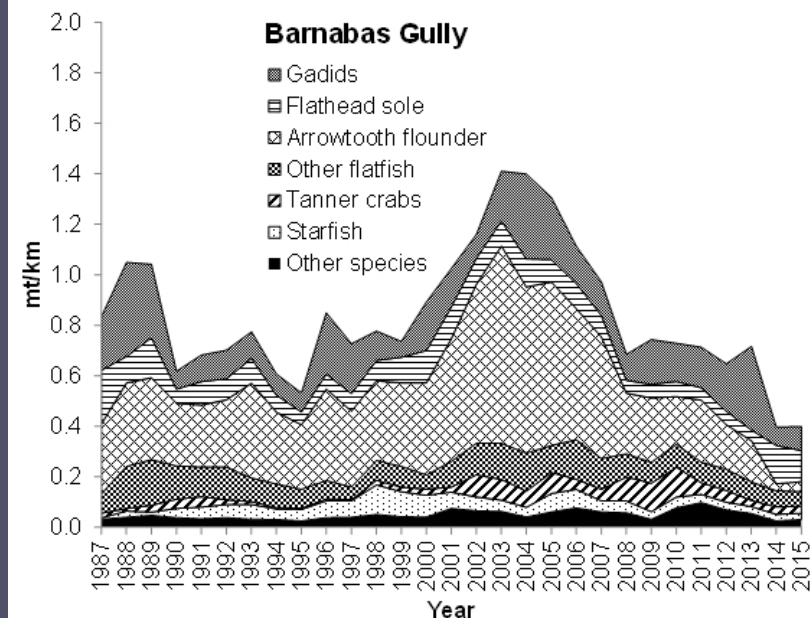
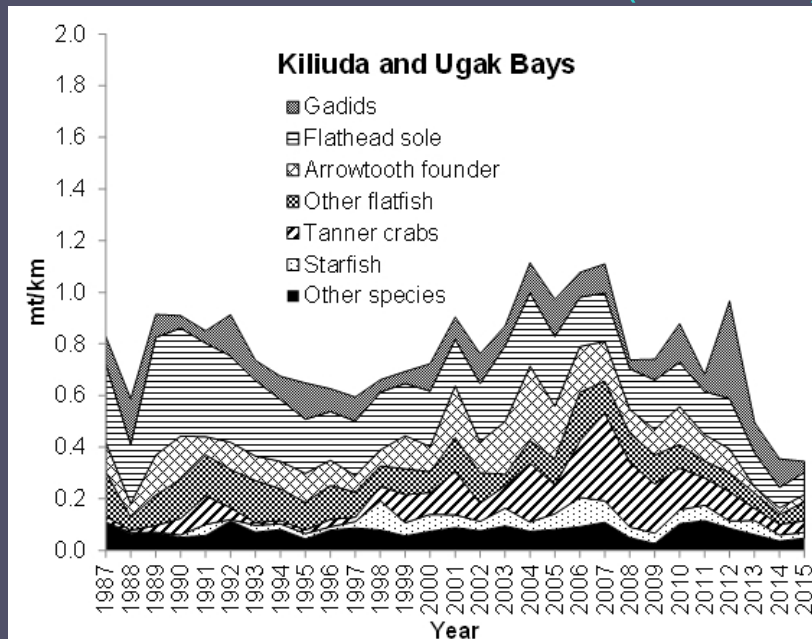
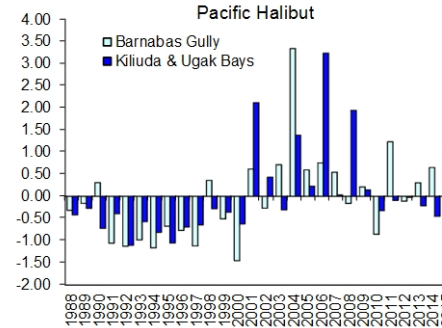
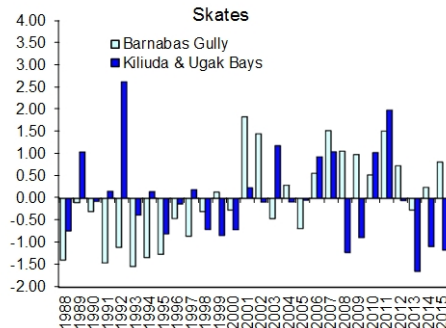
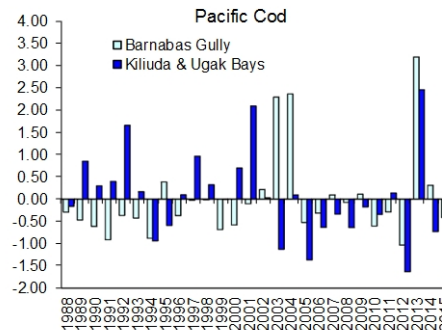
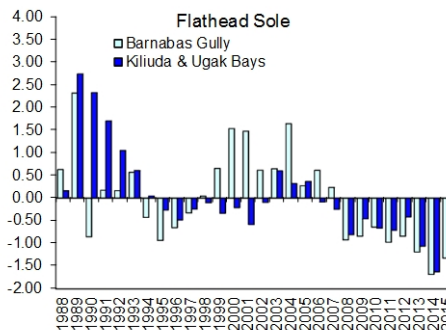
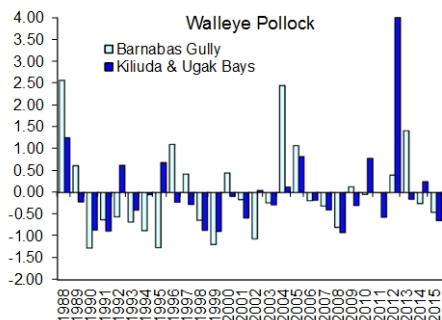
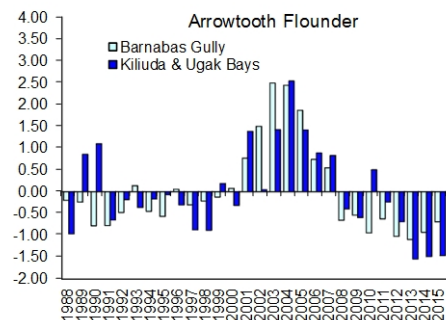
2011-2015 Trend

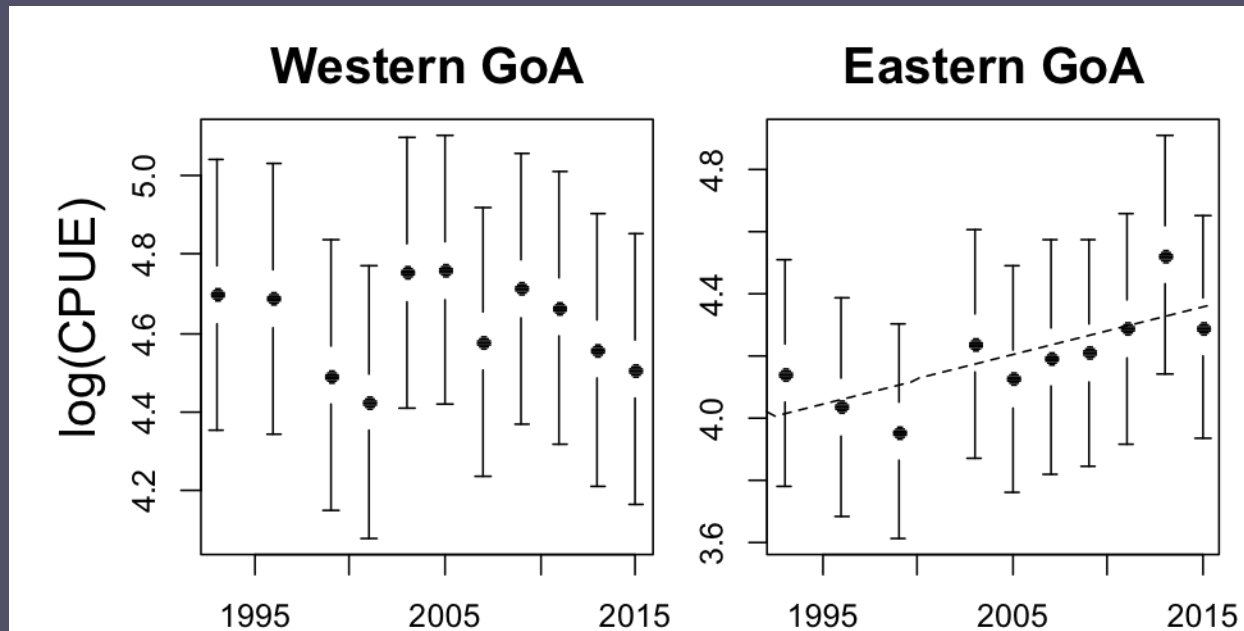
- Increase by 1 s.d. over time window
- decrease by 1 s.d. over time window
- change <1 s.d. over window
- fewer than 3 data points

2015

ADF&G Gulf of Alaska Trawl Survey (Worton)

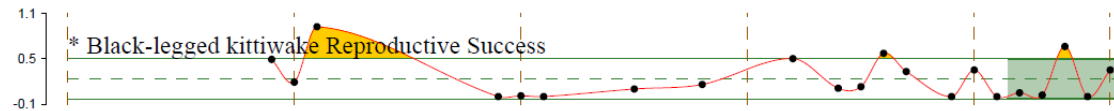
- Decrease in overall biomass since 2007; flatfish continue to dominate catch
- In 2015, halibut increased; flathead sole, ATF, cod, pollock all below; lower skates inshore.



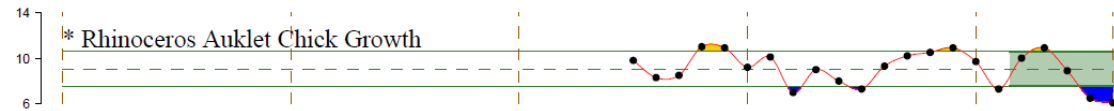


- Aggregated CPUE of fish and invertebrates in bottom trawl survey
- No overall trend in W GOA, though appears to decline in recent past
- Significant increasing trend in E GOA ($t = 3.102$, $p = 0.0146$)
- Suggests prey base has remained stable or increasing

West



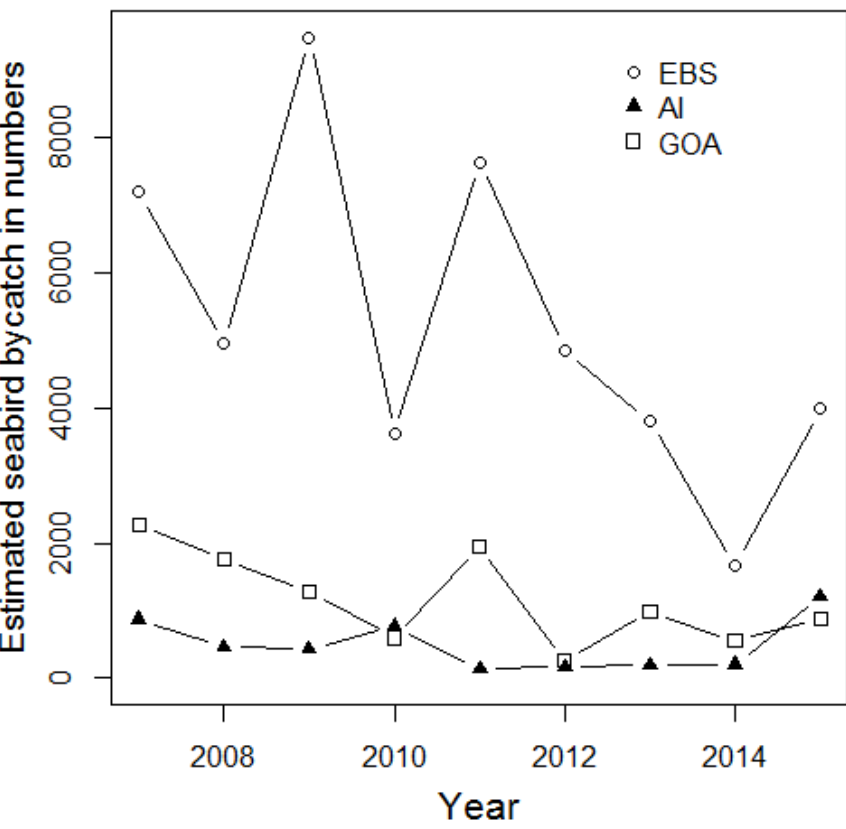
East



- Common surface-foraging, piscivorous seabirds
- Black-legged kittiwakes: proportion of nest sites with chicks that fledged
- Rhinoceros auklets: chick growth rates
- Replace with multivariate seabird indicators in the future?



Total estimated bycatch, all gear types



- Increase in birds bycaught in the GOA in 2015
- Increase in most commonly-caught species
- Indicative of poor “natural” food supply?

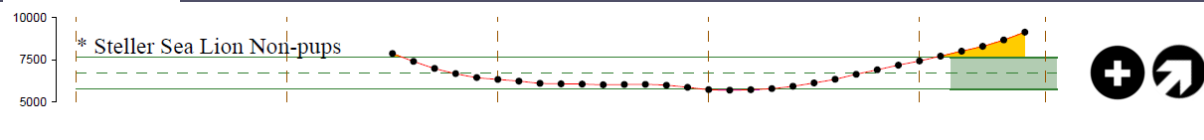
Estimated numbers of birds caught in GOA

Species Group	2007	2008	2009	2010	2011	2012	2013	2014	2015
Unidentified Albatross	17	0	0	0	10	0	28	0	0
Black-footed Albatross	180	273	49	62	215	141	432	269	350
Laysan Albatross	0	168	89	84	163	17	69	32	41
Northern Fulmar	1439	870	602	174	874	19	260	51	88
Shearwaters	31	0	0	0	61	0	56	0	5
Cormorant	0	0	0	0	0	0	0	0	28
Gull	560	182	366	279	615	50	136	157	287
Auklets	0	0	0	0	0	0	0	6	49
Other Alcids	0	0	0	0	0	0	0	39	0
Unidentified	48	266	187	0	9	33	7	0	34
Grand Total	2275	1759	1292	600	1946	260	988	553	883

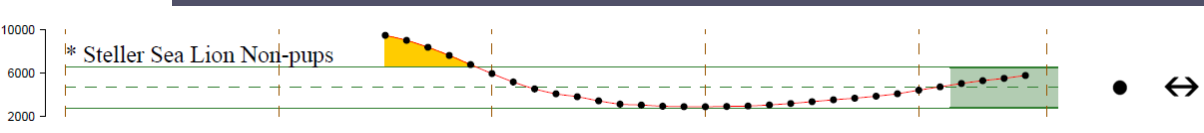


Steller sea lions

West



East



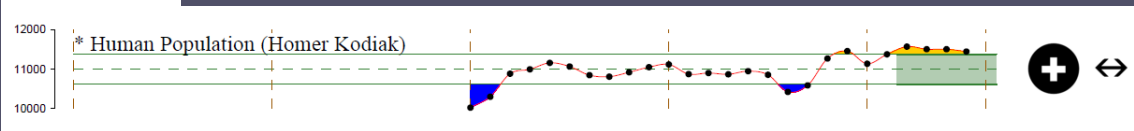
- Marine Mammal indicator
- AgTrend model
- Abundance estimates of non-pups



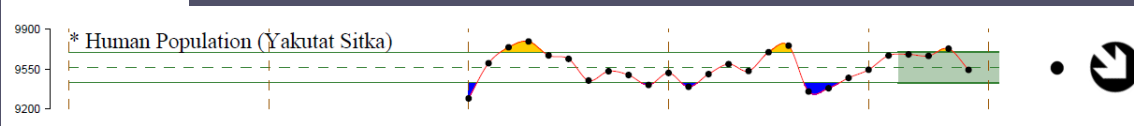
2011-2015 Trend

- ↗ Increase by 1 s.d. over time window
- ↘ decrease by 1 s.d. over time window
- ↔ change <1 s.d. over window
- ✕ fewer than 3 data points

West



East



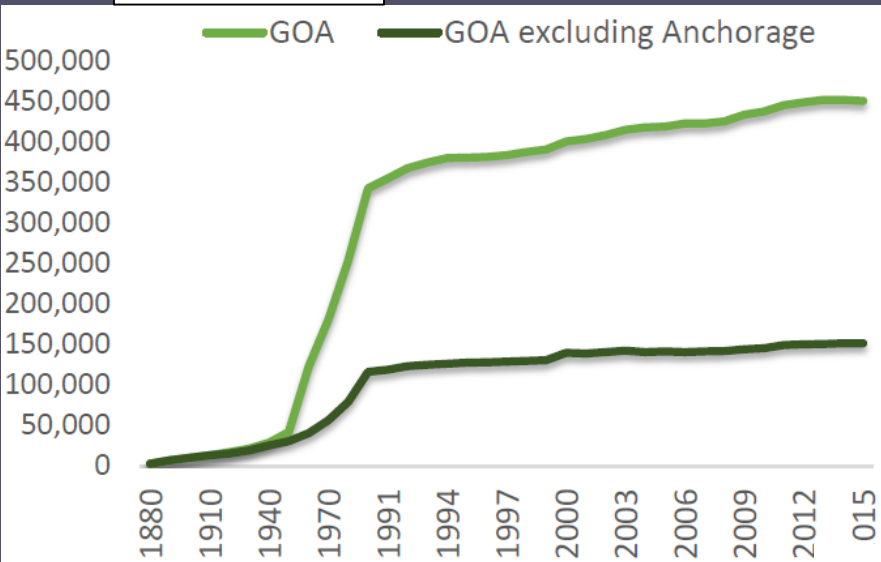
Human populations

- Human Impact Indicator
- Combined populations of Homer and Kodiak (West); Sitka and Yakutat (East)
- Closely associated with the marine ecosystem
- Data from the Alaska State Labor Statistics
- Refine to better represent human population directly influenced by fishing and/or ecosystem state?

2011-2015 Mean

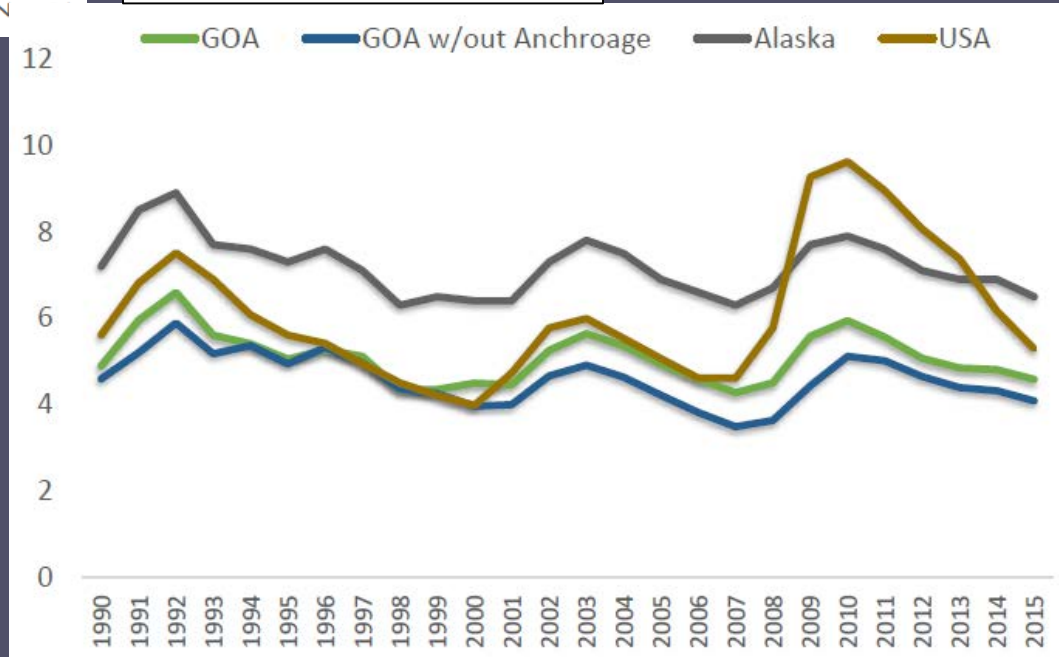
- ⊕ 1 s.d. above mean
- ⊖ 1 s.d. below mean
- within 1 s.d. of mean
- x fewer than 2 data points

Population



- Potential to replace current human indicators?
- Communities within 25 miles of coast or historical fishing involvement
- Unemployment data aggregated and weighted across boroughs

Unemployment rate

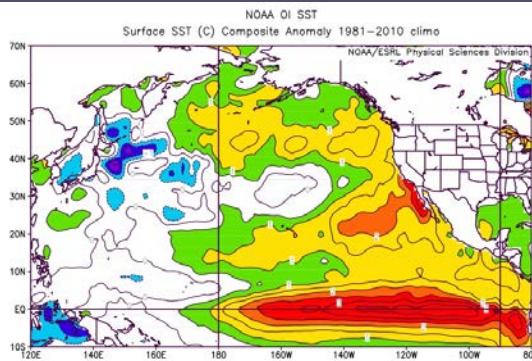




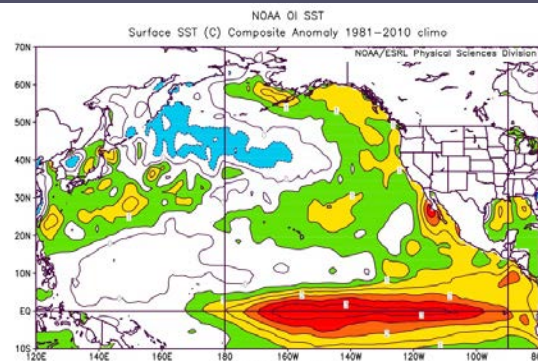
2016 Data and Observations

Physical Conditions

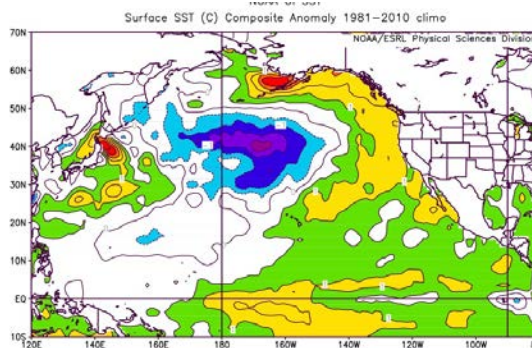
Warm, and forecasted to remain that way



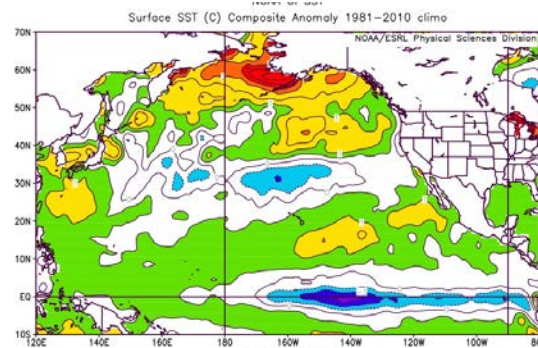
Autumn 2015



Winter 2015/6

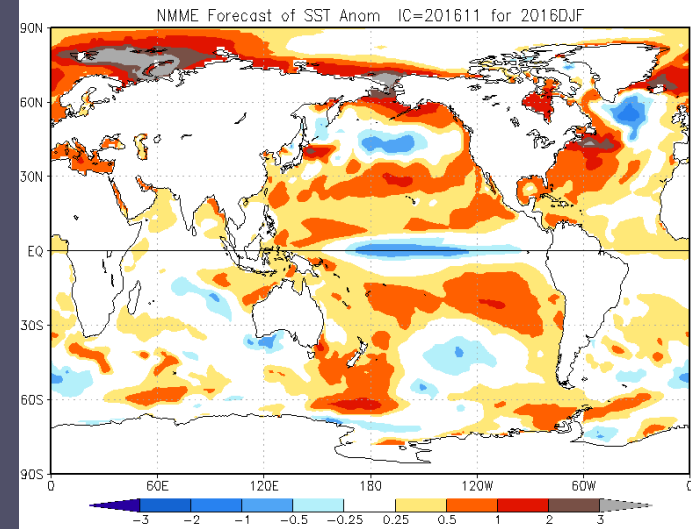


Spring 2016

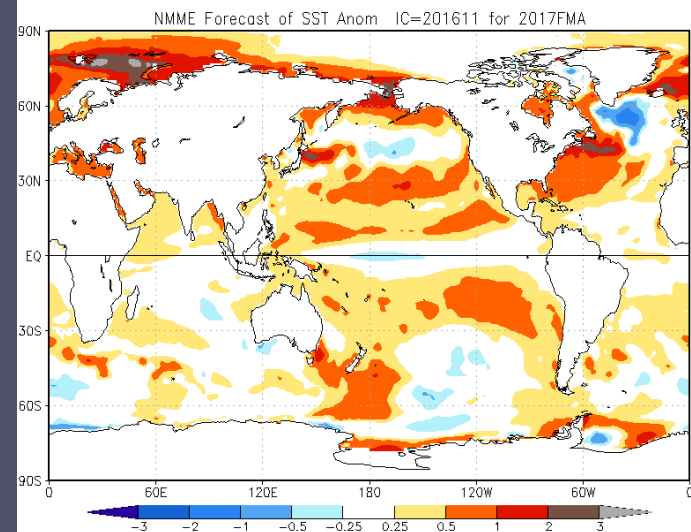


Summer 2016

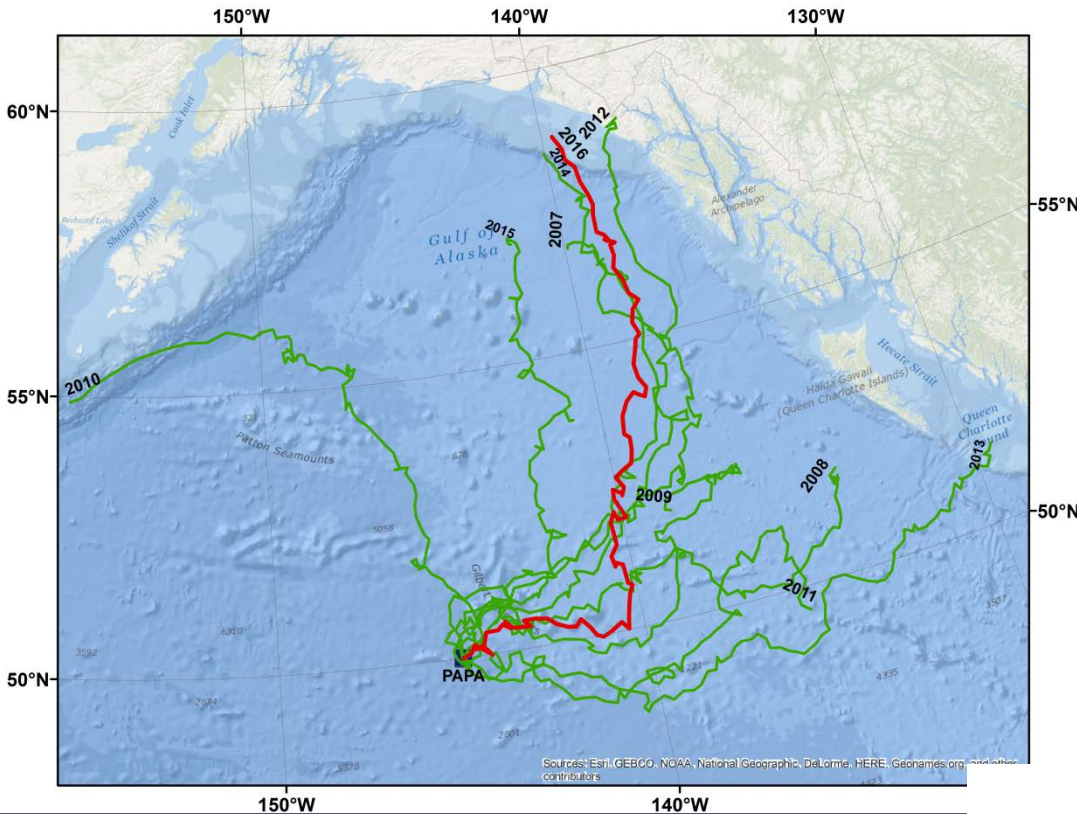
2016 Dec-Jan-Feb



2017 Feb-Mar-Apr



Ocean Surface Currents – PAPA Trajectory Index (Stockhausen and Ingraham)

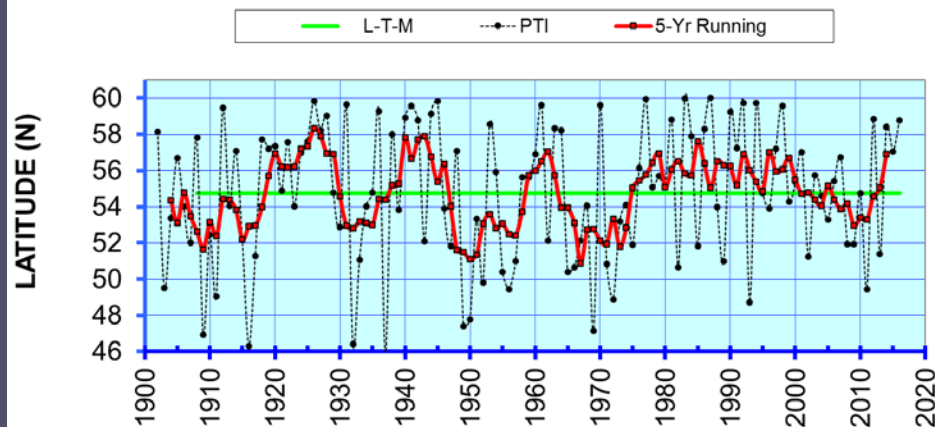


Simulated surface drifter released from Ocean Station PAPA Dec 1 90 days

2015/6 trajectory: similar to past 2 years (S wind anomalies -> “Blob”)

N-ward shift in “boundary” between sub-arctic and sub-tropical species; absence of open ocean LT organisms in SE AK

Papa Trajectory Index (PTI) End-point Latitudes (Winters 1902-2016)

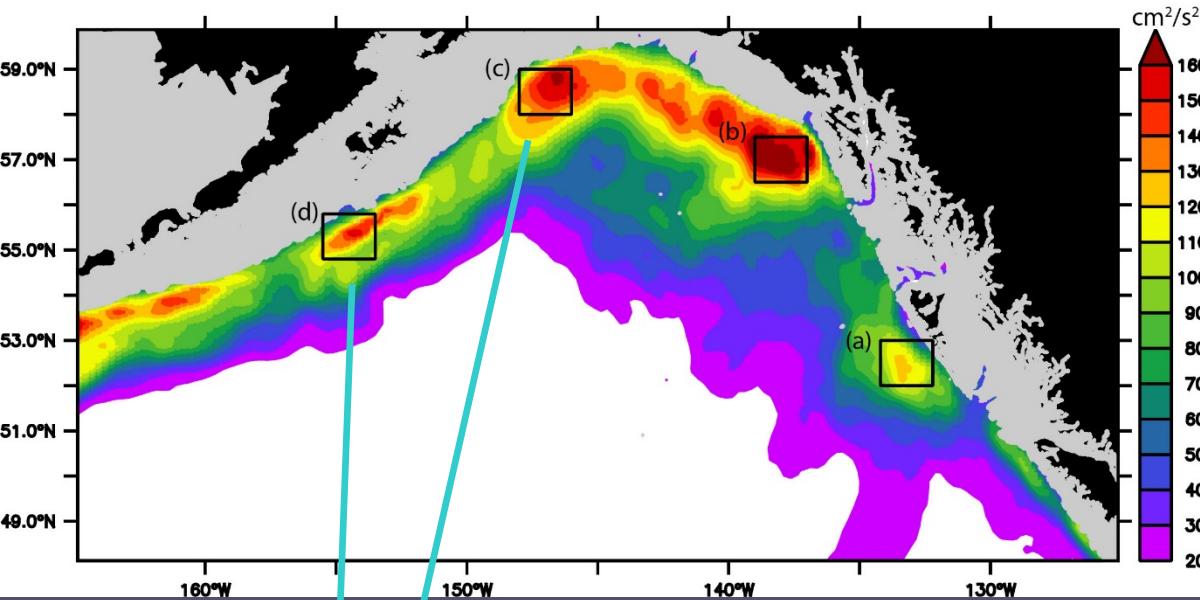


- Changed little from last 2 years - rare
- Recent period of mostly southerly flow is shortest in time-series
- Does **not** indicate return to surface drift conditions similar to <1977 regime shift

Eddies in the Gulf of Alaska

(Ladd)

Average Eddy Kinetic Energy Oct 1993 - 2014



Seasonal cycles:

(c) High EKE in spring

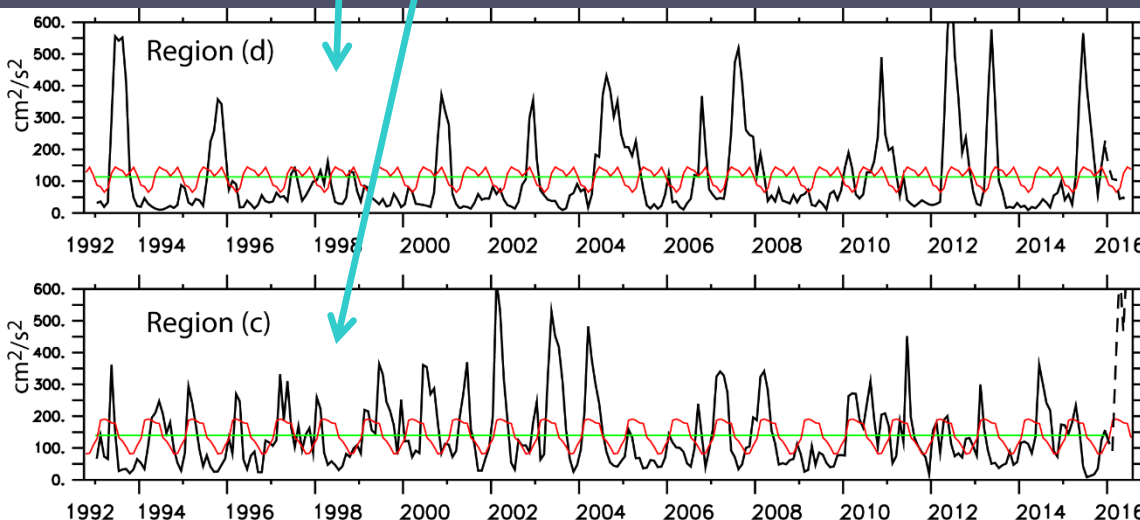
(d) High EKE in fall

(c) → strong eddy started in Yakutat, Jan 2016; enhanced cross-shelf exchange

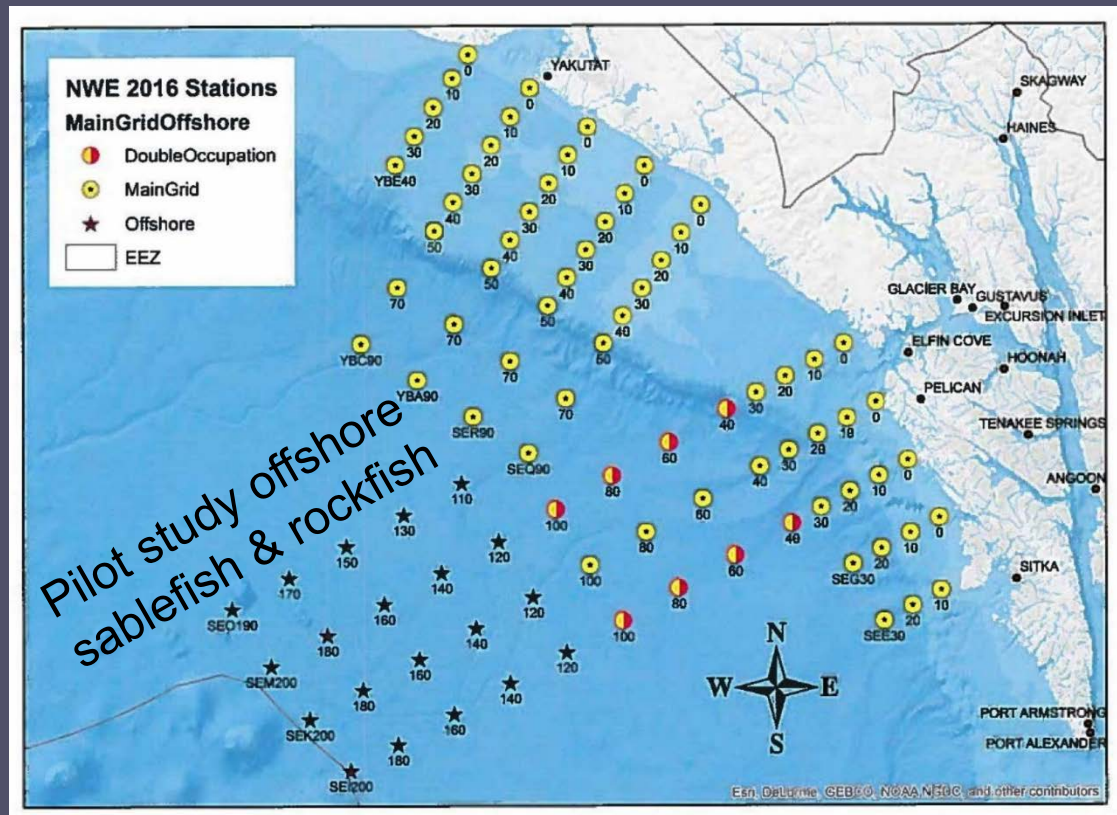
(d) → Currently weak, after recent strong ones in 2012, 2013, 2015

E GOA: influenced by winds (climate and gap scale)

W GOA: influenced by propagation and intrinsic variability



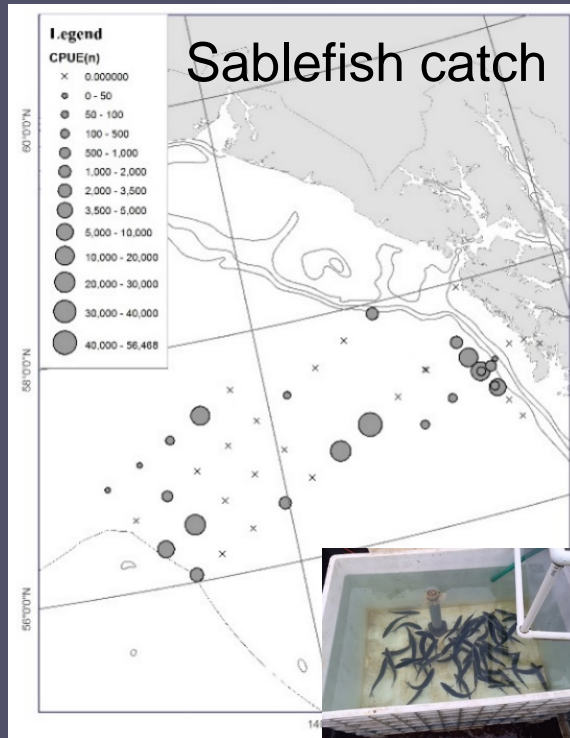
2016 Observations: EGOA shelf



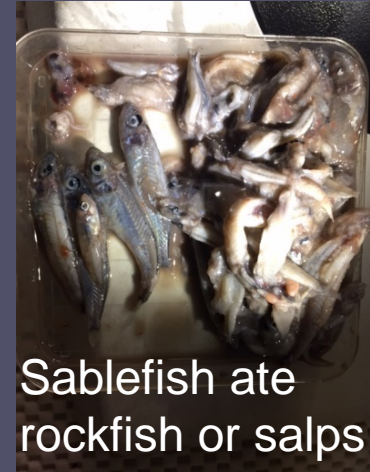
- Low crustacean zooplankton biomass
- High catches
 - Salps
 - Age-0 rockfish (highest, 3 species)
 - Market squid
 - Pacific saury
- Low catches
 - Pacific pomfret
 - Age-0 pollock

Contact: Jamal Moss and Wes Strasburger

2016 Observations: Pilot Study



- Age-0 sablefish in surface waters.
- Age-0 rockfish appear to use dense layers of jellyfish (> 30 m) as refuge habitat offshore.



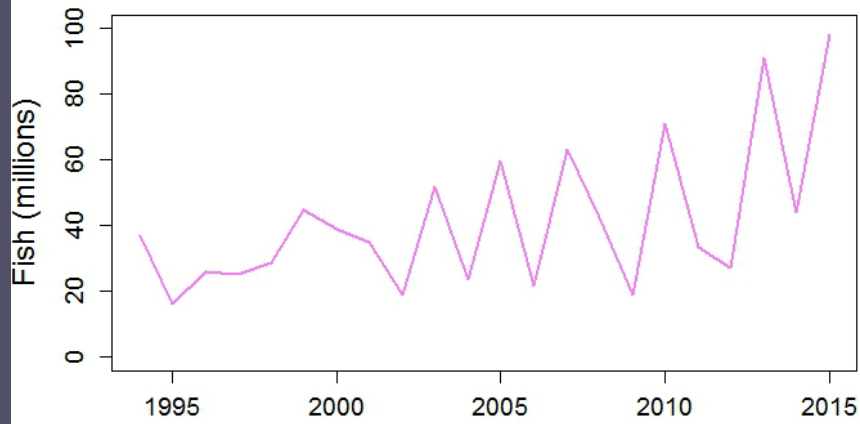
- AFSC proposal for EGOA spring and summer surveys to study sablefish recruitment.
- Include energetics, tagging studies in the lab.
- Provide indicators and mechanisms that influence YOY sablefish survival.



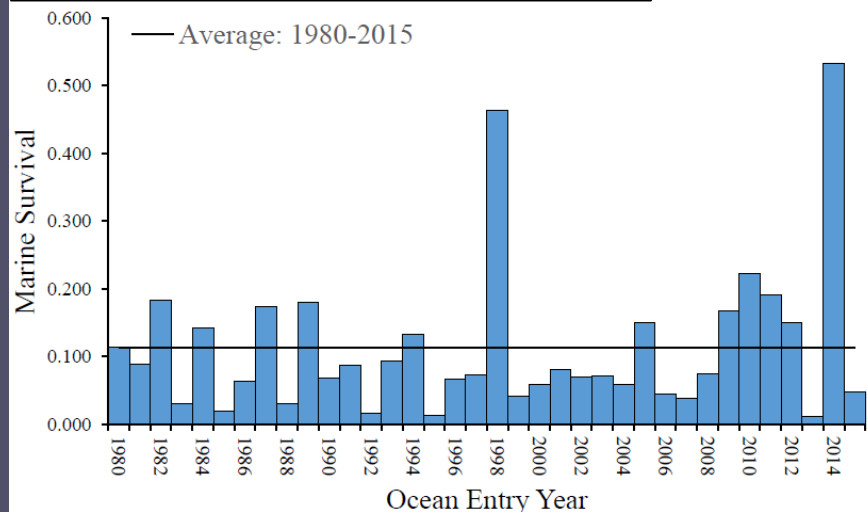
GOA Pink Salmon

Whitehouse, Vulstek, Orsi et al

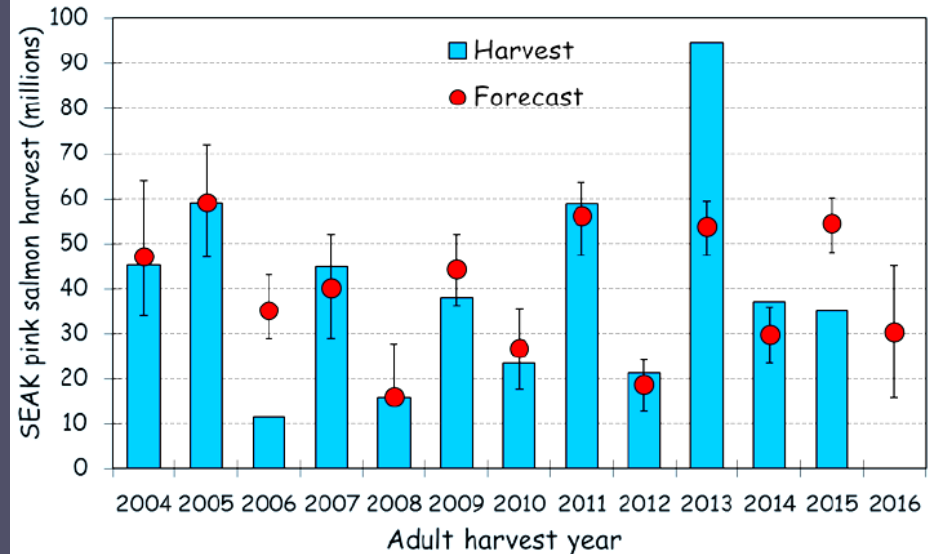
PWS pink harvest



Auke Creek marine survival

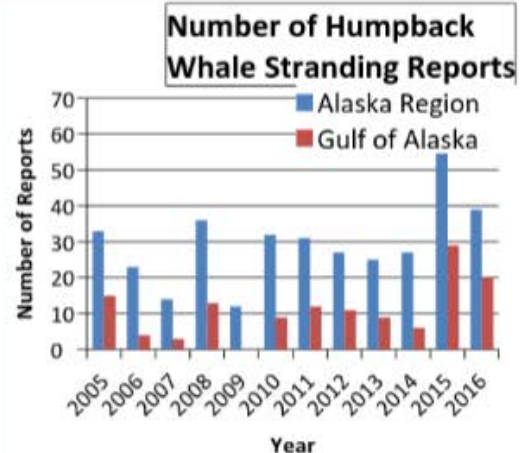
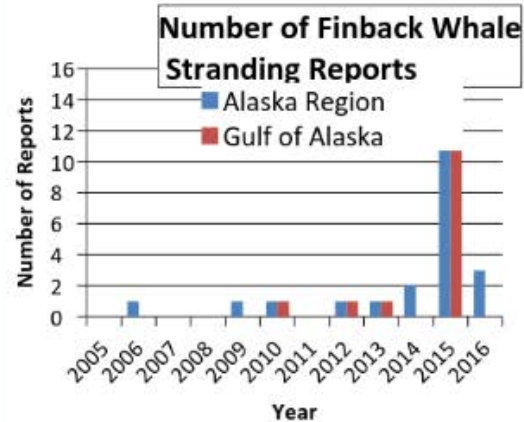


SEAK harvest forecast



- Large 2015 return in north, but less than expected in South
- 2016 return low: 18 M in SE, 13 M in PWS
- Many juvenile pinks observed in 2016

Rise in Unusual Mortality Events



The Cause Remains Uncertain

Changes in HABS, infections, predators, prey, vessel strikes, fisheries interactions, sonar



2016: killer whales killed 8 humpbacks whales

John Moran

2016 Observations: Is Whale Stress on the Rise?

Cyamid “Whale Lice”



Calf Presence



Adult condition – “skinny”



Diet shifts: krill-salmon



Low #s in Hawaii last winter



Evaluating historic observations
to develop context

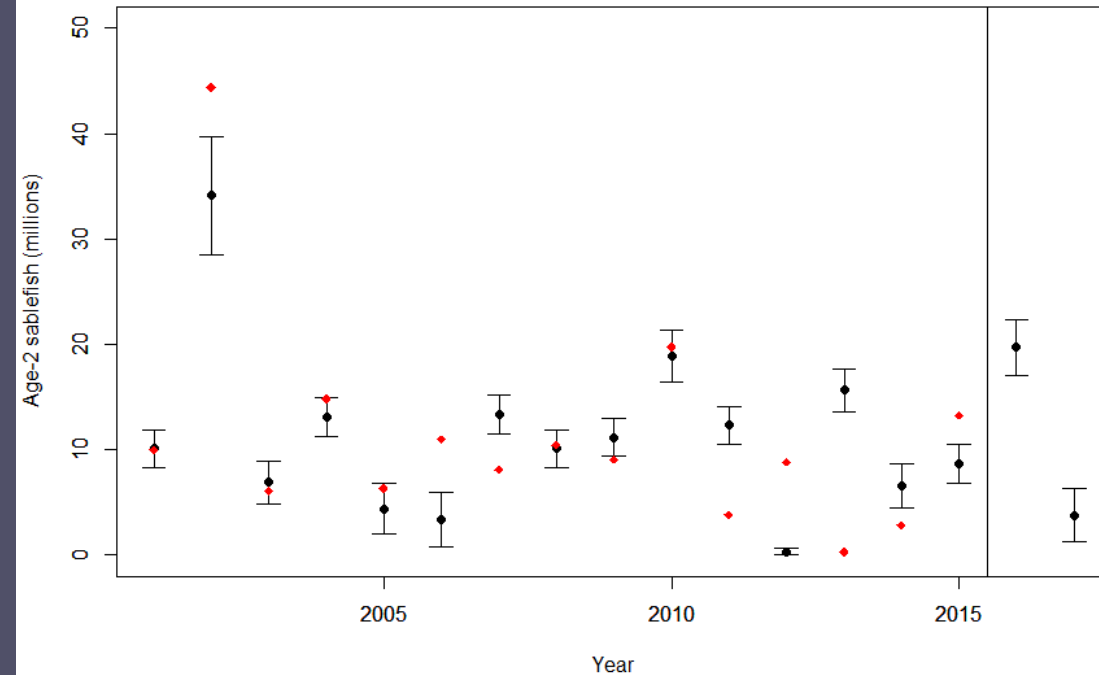


John Moran

Southeast coastal monitoring survey indices and the recruitment of GOA sablefish

(Yasumiishi et al)

Age-2 sablefish



Icy Strait

Data: temperature, chl a, pink salmon productivity

Provides: rearing habitat for sablefish

Higher recruitment appears to be a function of more late August chl a during age-0 stage (BIC)

Chl a $R^2 = 0.59$, $p = 0.0008$

Prediction: below-average age-2 recruitment in 2017.



Summary - GOA

2015

- Continuation of warm conditions
- Average to poor productivity
- Die-offs for birds and whales

2016

- Continuation of warm conditions
- **Poor** conditions with **some improvement** during spring/summer?
- Low zooplankton biomass and lower-lipid taxa in EGOA
- Reoccurrence of salps and mushy halibut syndrome
- High catches of juvenile pink and chum salmon in the EGOA
- Abundant age-0 forage fish in Kachemak Bay
- Small age-4 pollock in winter, caught up over spring

Website

Contributors

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Thank you!

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