

ECOSYSTEM

For Eastern Bering Sea Crab

CONSIDERATIONS

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NPFMC Crab Plan Team
September 19, 2017



Outline



1. 2017 climate and oceanography
2. Review of 2016 crab-relevant biological information

Current North Pacific Climate Highlights

Bond

Moderation and Transition

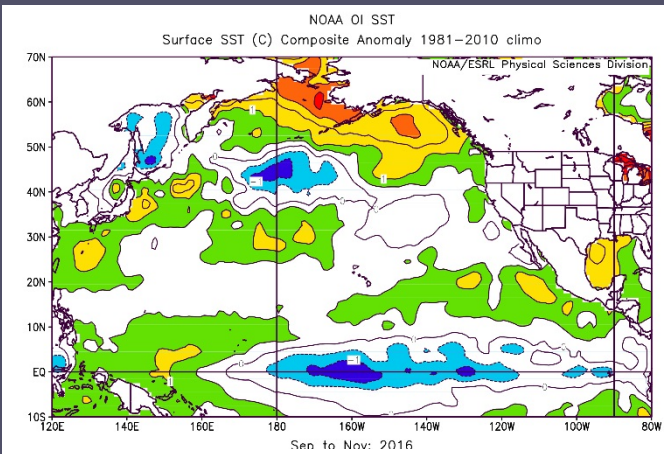
- Moderation of temperatures after marine heat wave
- High sea level pressure in winter with weak Aleutian Low, a disproportionate response to weak La Niña
- Positive but declining PDO



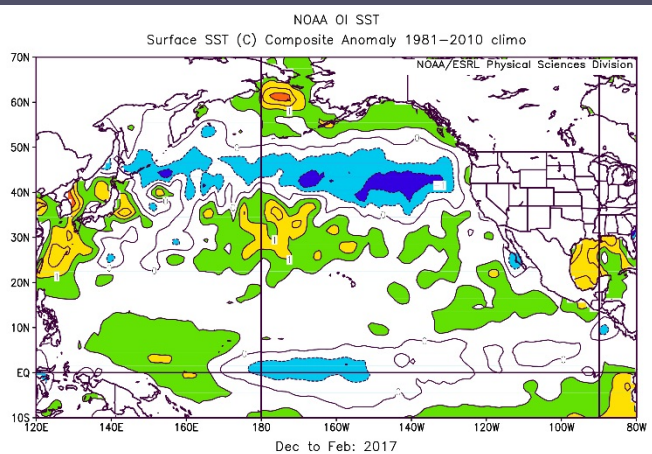
Sea Surface Temperature Anomalies

Bond

Beginning of transition from extreme heat wave to climatological normal



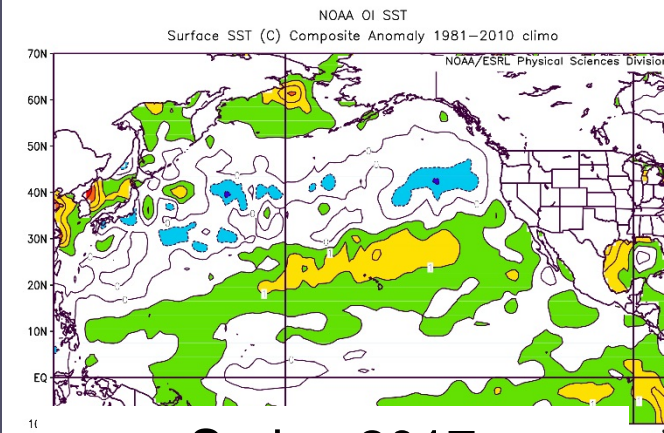
Autumn 2016



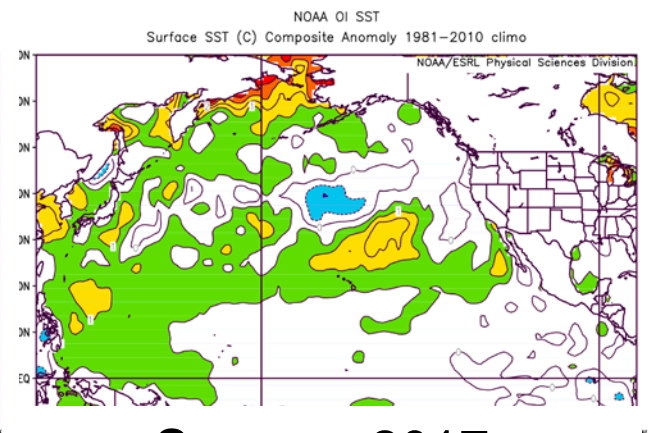
Winter 2016/7

Cooling from fall winds from the west and winter winds from W/NW

Weak positive PDO pattern

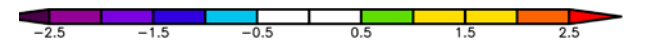
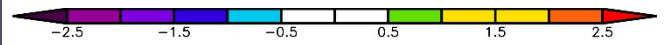


Spring 2017



Summer 2017

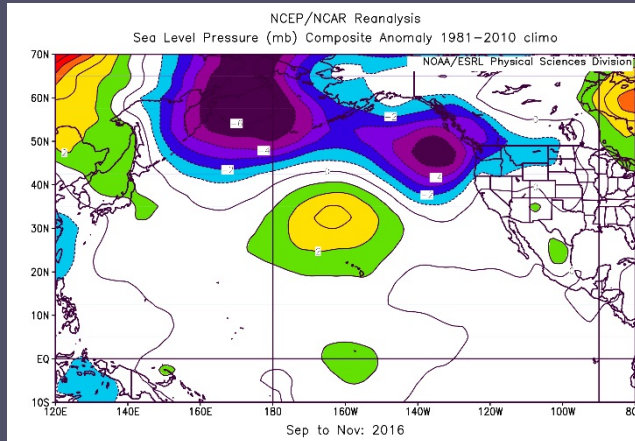
+1.5 - 2° anomaly in southern Chukchi



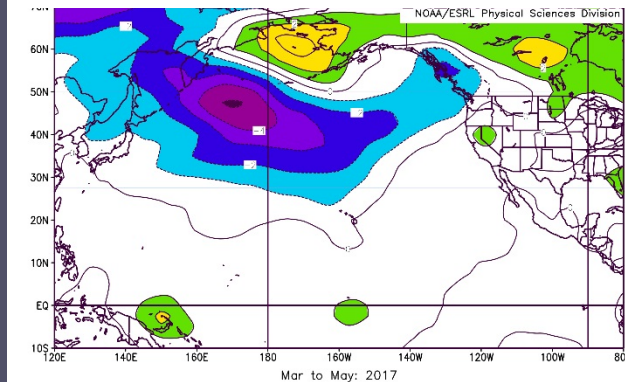
Sea Level Pressure Anomalies

Bond

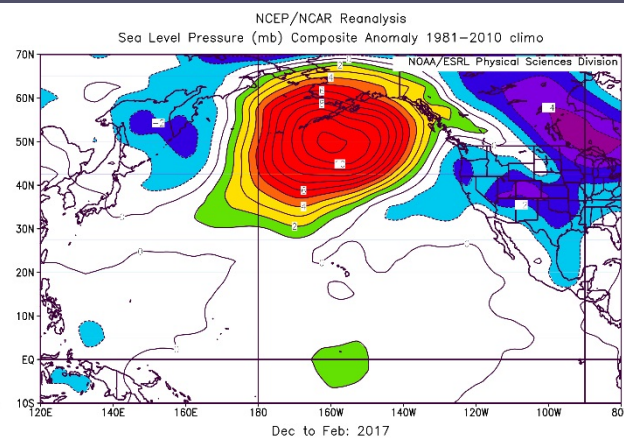
Wind anomalies from the west, enhancing cooling



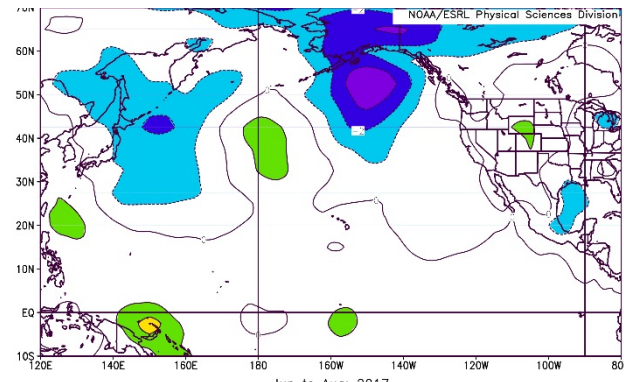
Autumn 2016



Spring 2017



Winter 2016/7



Summer 2017

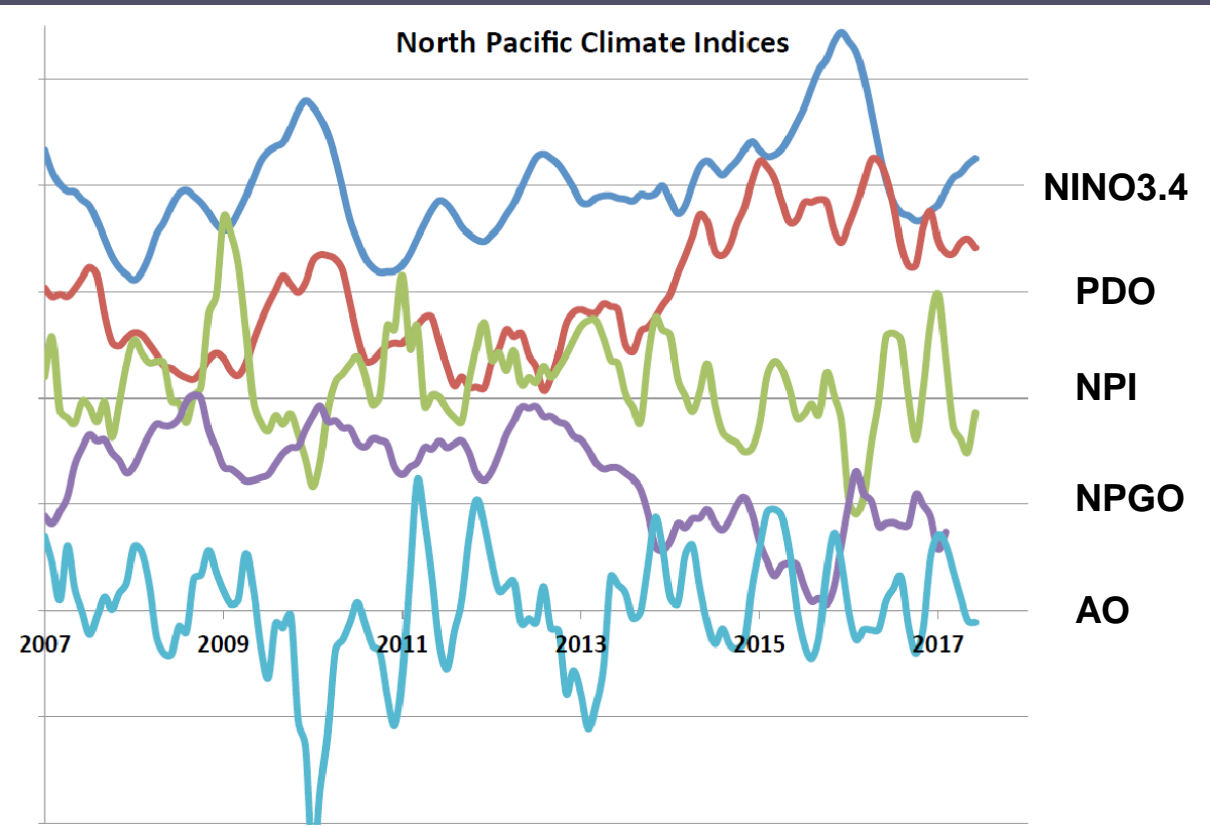
Signature of weak Aleutian Low, implies suppressed storminess, but N flow -> coldest winter in PNW

Suppressed storminess in EBS, downwelling favorable winds in GOA

Climate Indices

Bond

North Pacific atmosphere-ocean climate system
moderated relative to past 2 yrs



ENSO “quiet state” compared to recent

PDO positive with lower magnitude (related to ENSO)

NPI implies deep Aleutian Low F/S, weak during W; surprisingly strong response to weak La Nina

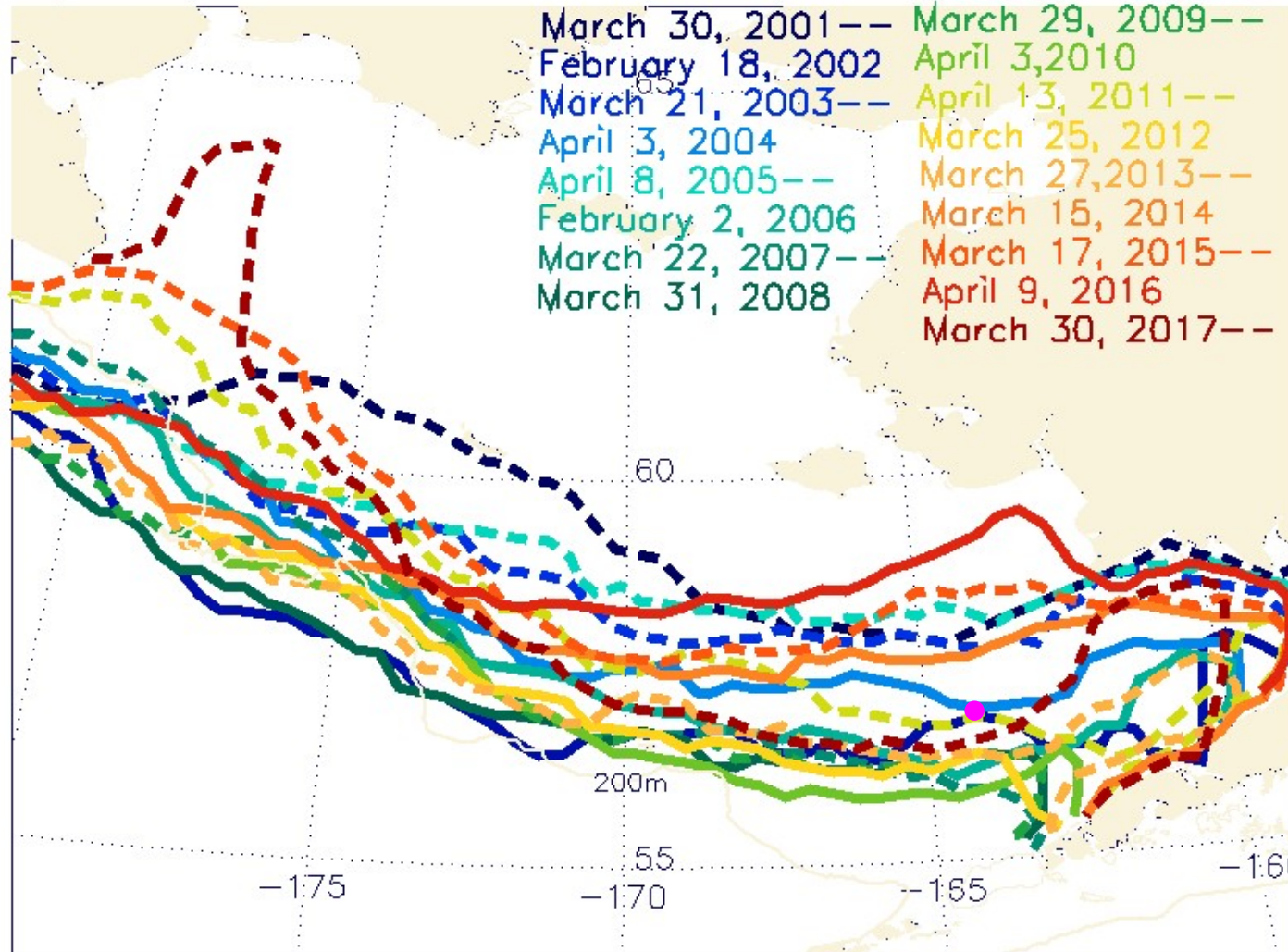
NPGO relates to chemical and biological properties in GOA and CalCOFI area. Negative → reduced flows in Alaska and CA currents

AO measures strength of polar vortex. Positive = low pressure over Arctic, high over Pacific (45°). Mostly neutral recently

Maximum Extent of Ice Edge

Overland

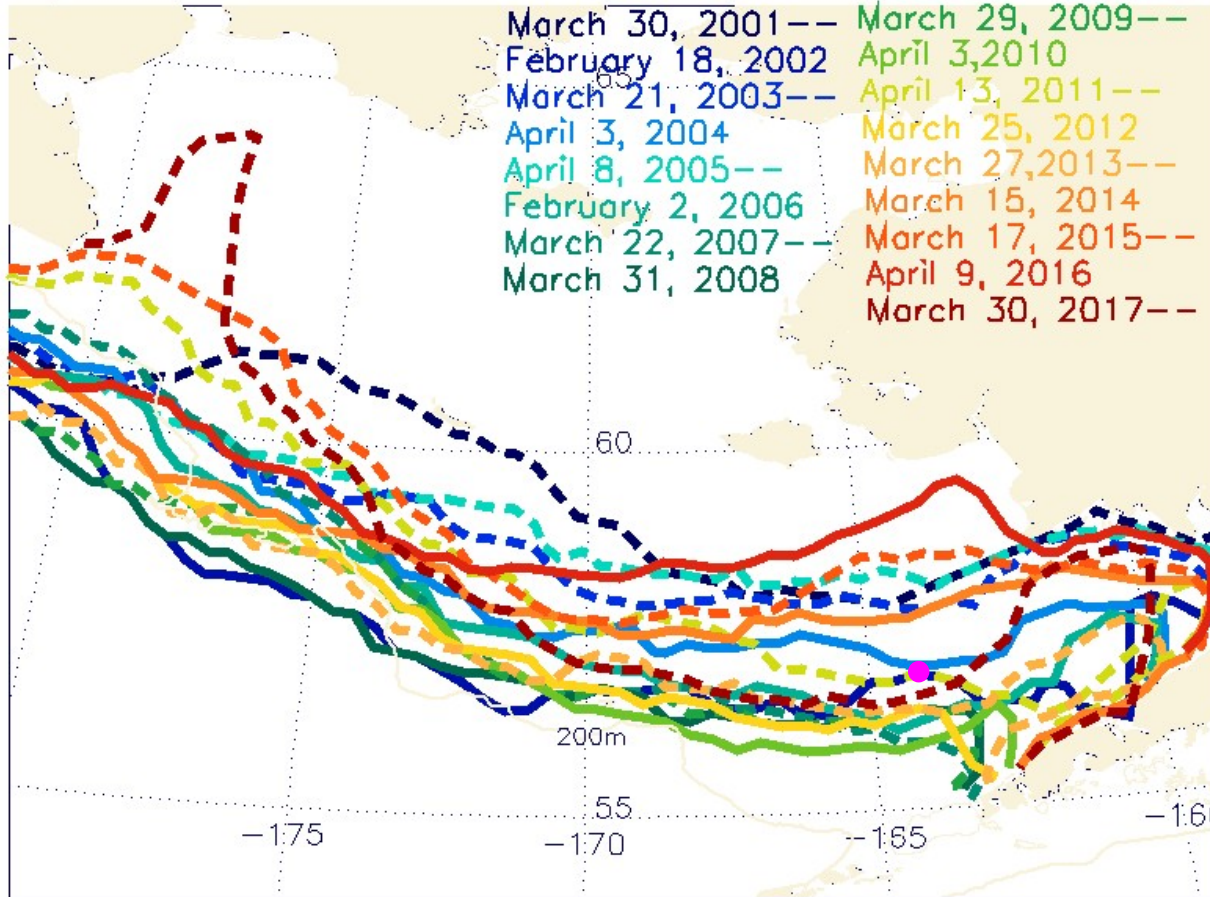
Maximum Ice Extent



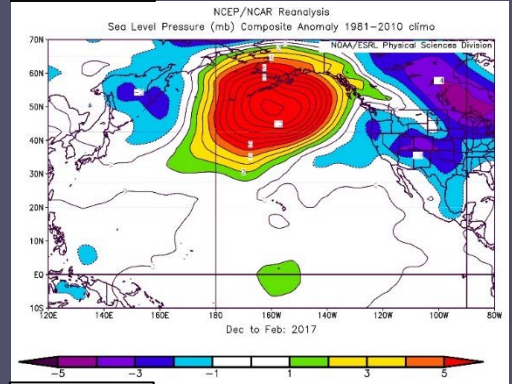
Ice reached the M2 mooring (~pink dot)

Maximum Extent of Ice Edge Overland

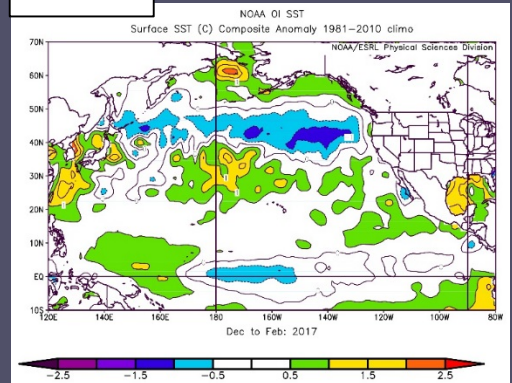
Maximum Ice Extent



SLP

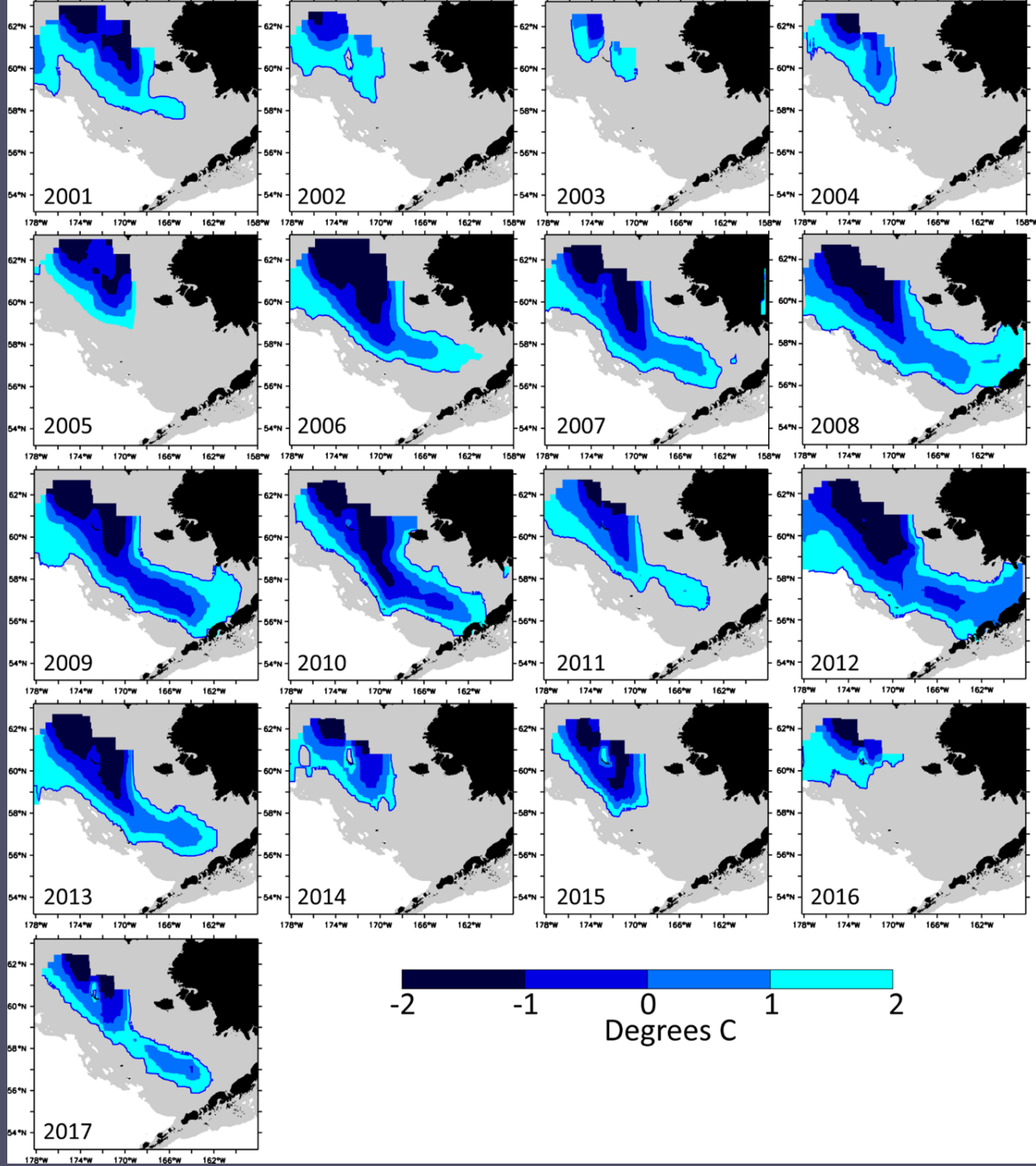


SST



Unusual lack of sea ice in NW: pre-existing warm water and winds from S

EBS Cold Pool Overland



Measured during the
bottom trawl survey

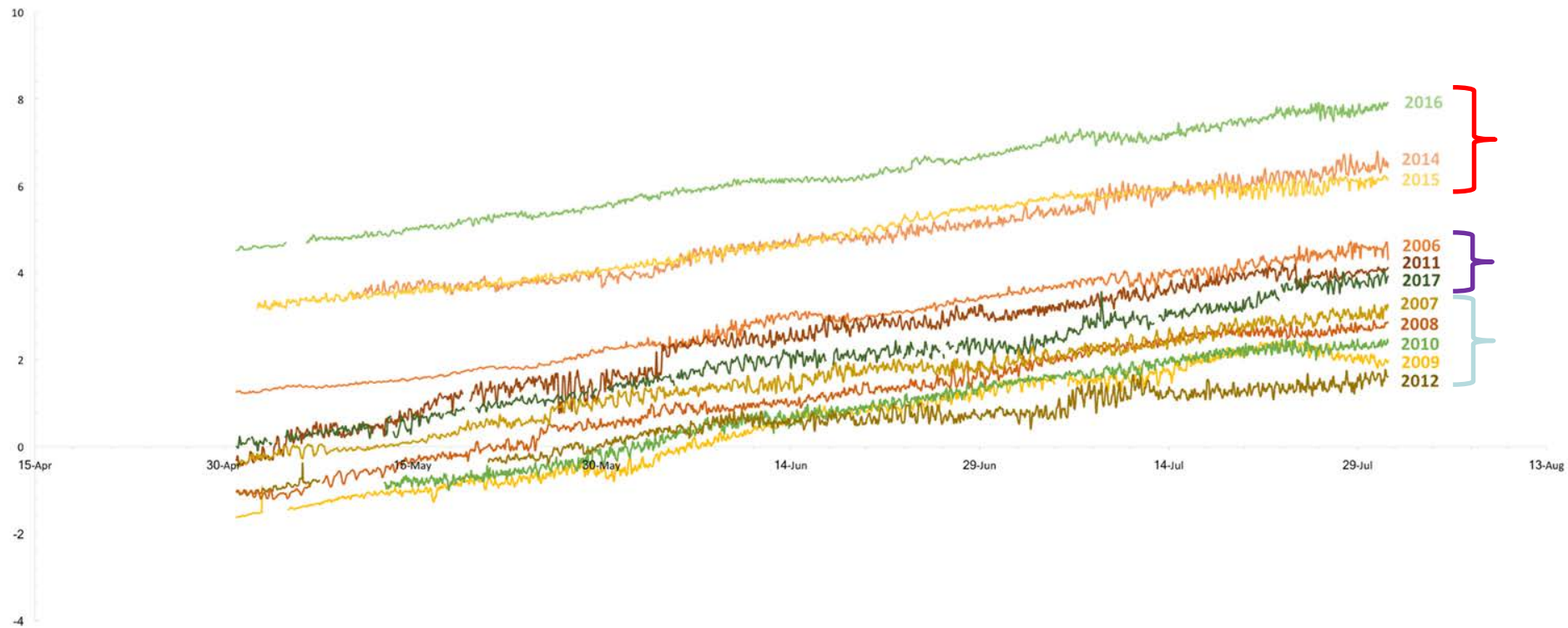
Larger extent than
previous 3 years

Similar to 2013, with
smaller overall
extent

M2 Depth-averaged Temperature

Stabeno

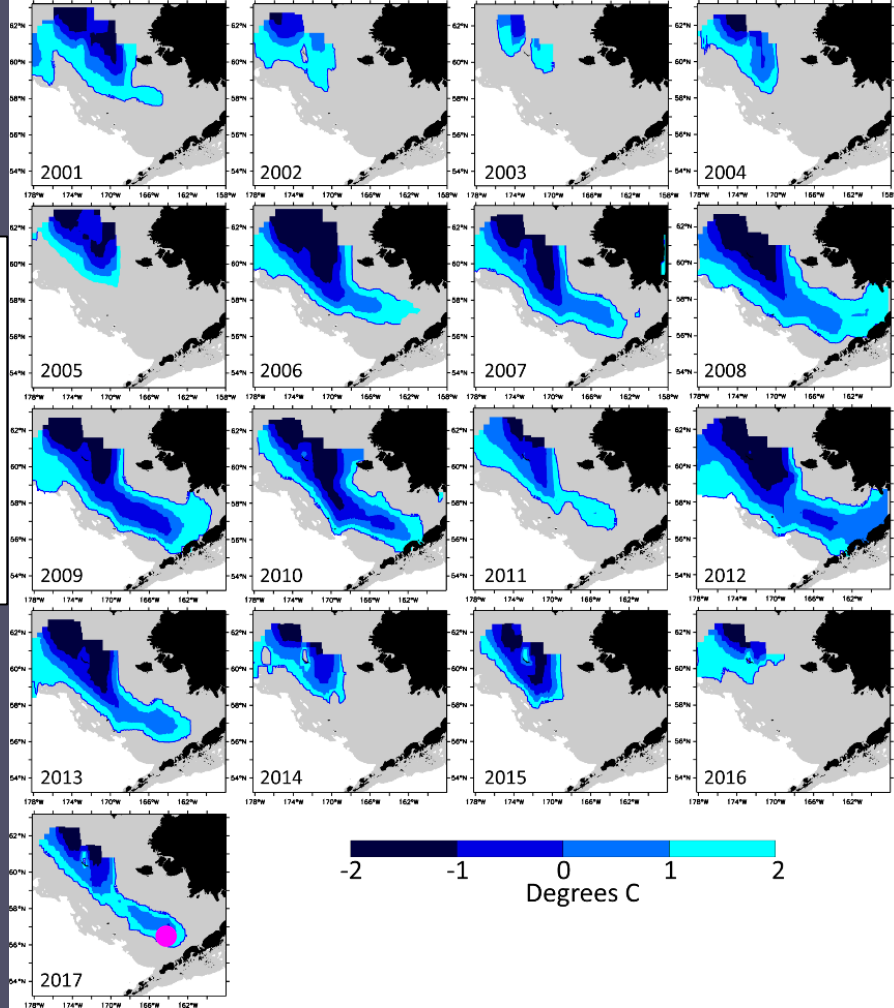
M2 Depth Averaged Temperature - May/July



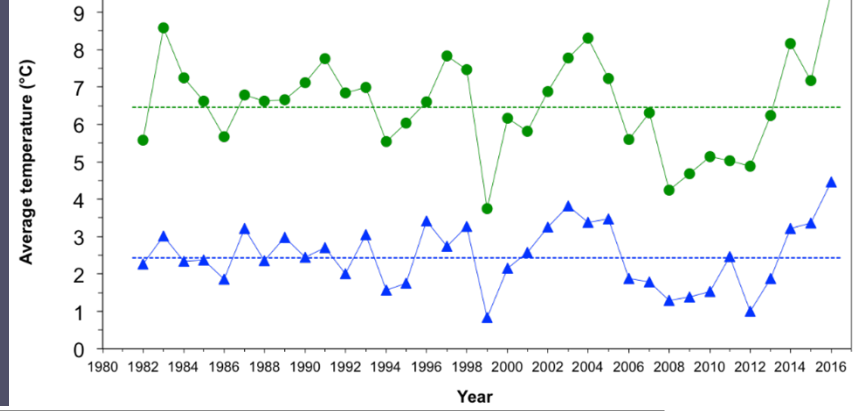
Temperature Comparisons

Stabeno, Overland, Lauth

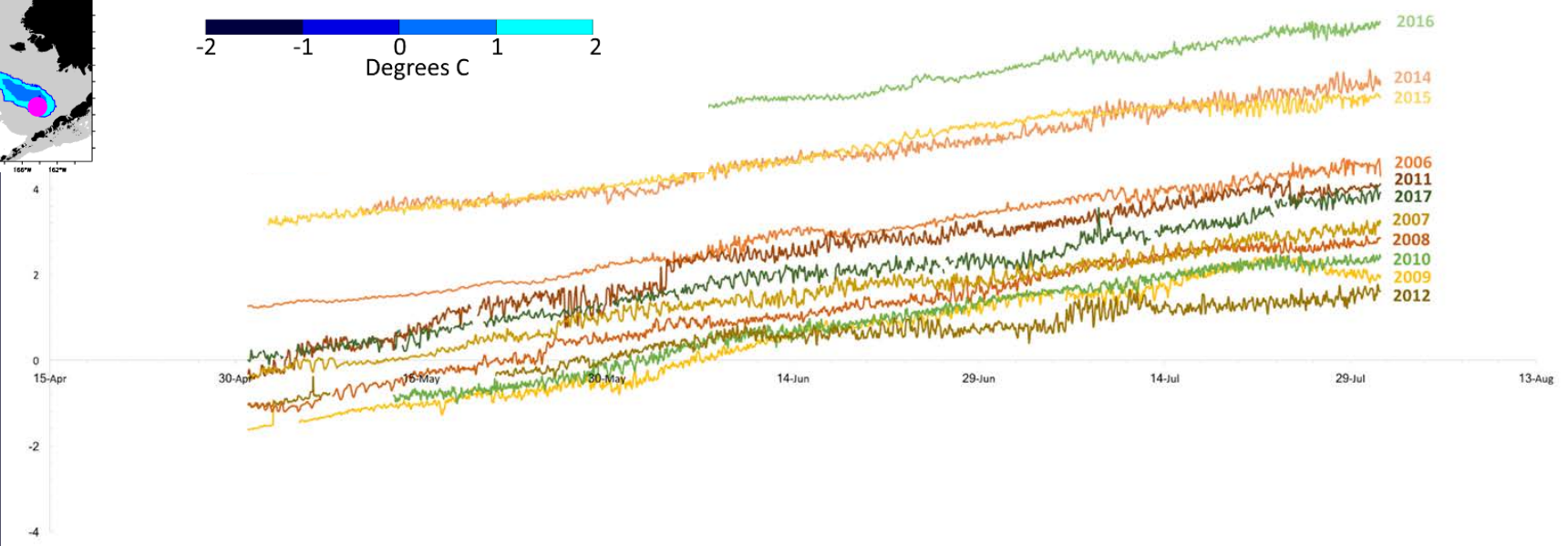
Survey Cold Pool



Survey Surface and Bottom Temps

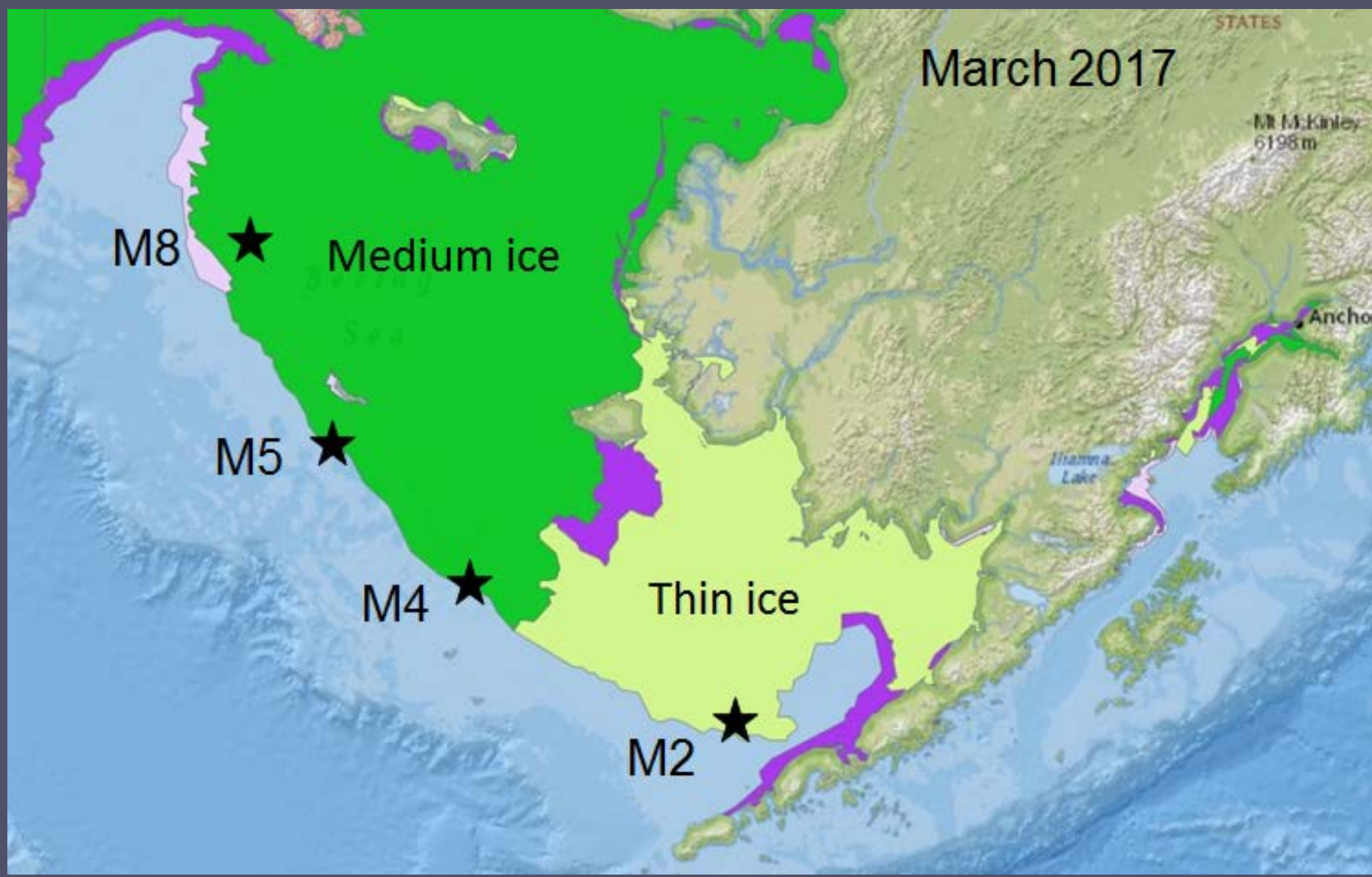


Depth-averaged at M2, May-July



March Sea Ice

Stabeno, Duffy-Anderson

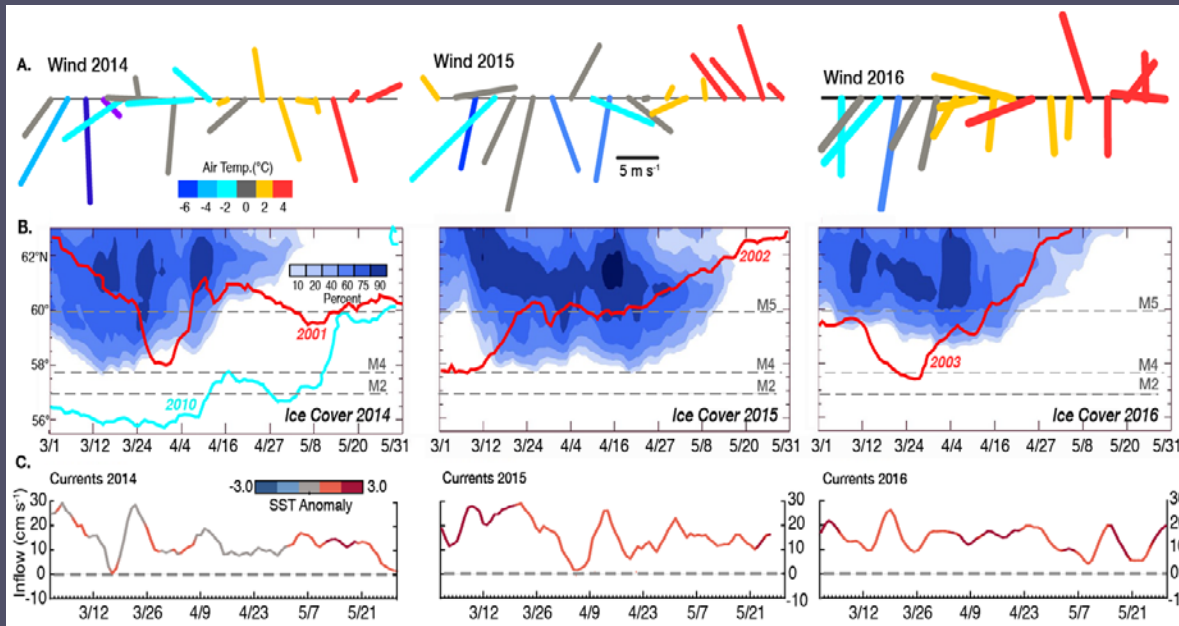


Purple is young ice, newly-formed

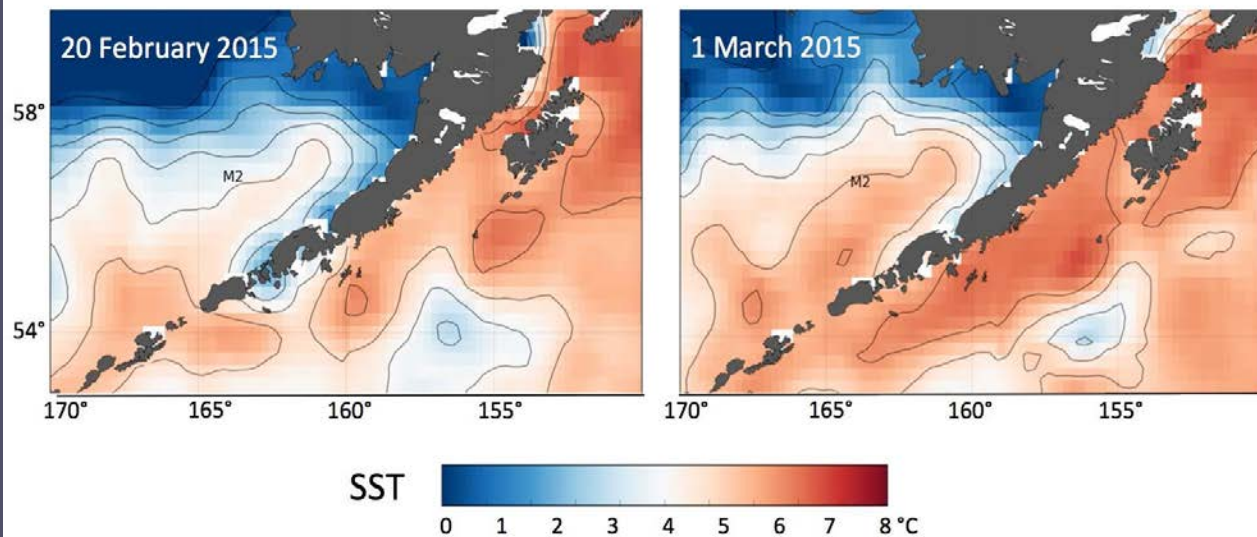
In 2015 The Blob warmed the ocean in an otherwise cold year

Duffy-Anderson, Stabeno et al.

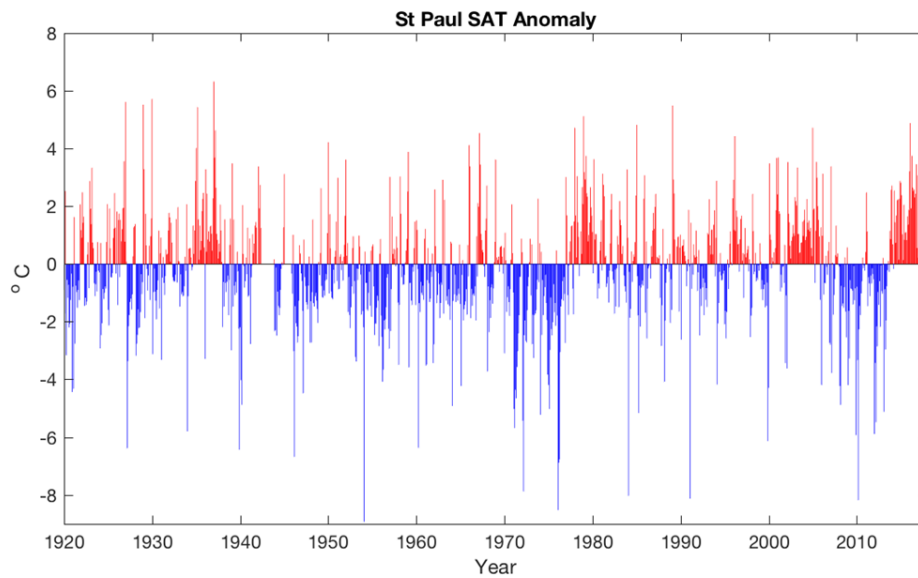
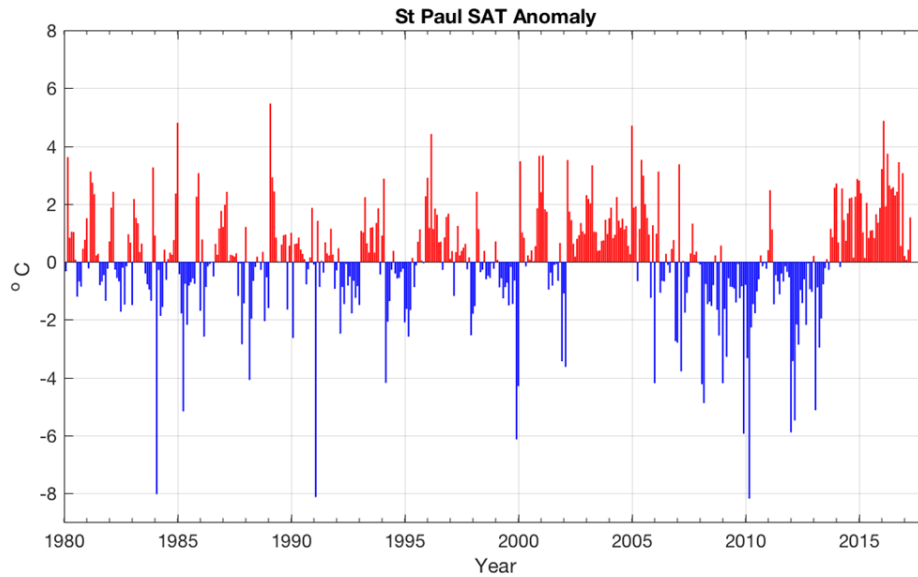
Wind and ice



Warm blob extension from Gulf of Alaska



Surface Air Temperatures on St Paul Overland



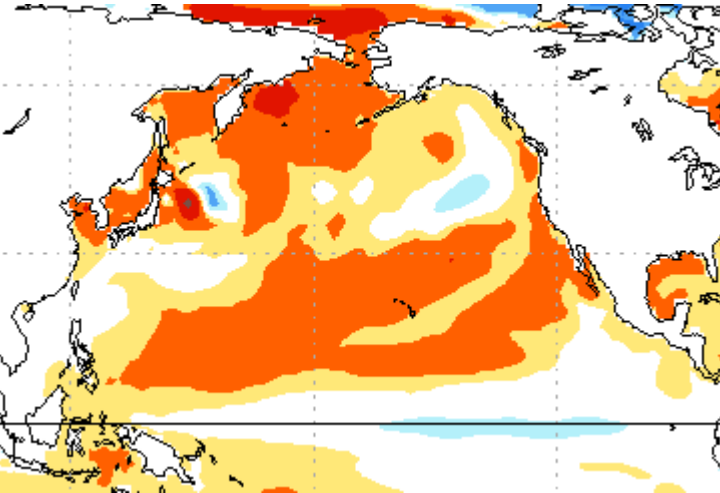
Persistent
anomalously warm
air temperatures
since 2013

2018 Sea Surface Temperature Forecasts

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

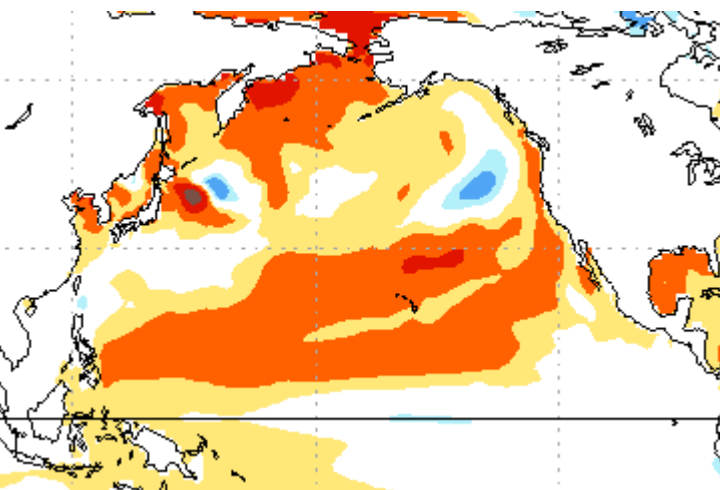
Bond

2017 Oct-Nov-Dec

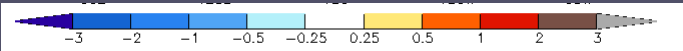
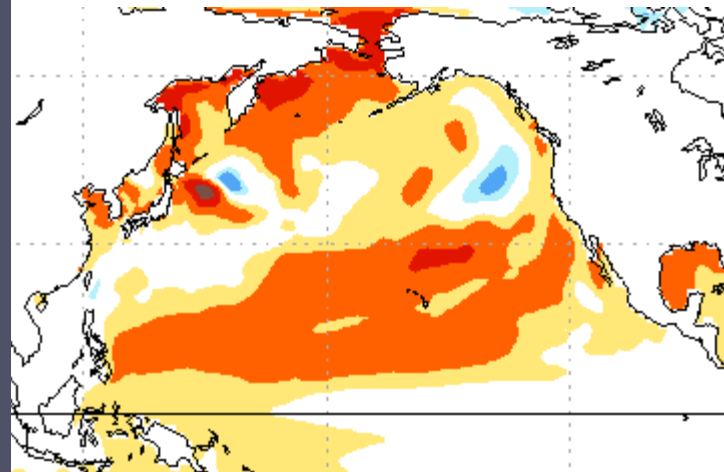


- SST projections
- NMME is average of 8 models
- Continuation of warm, with slight cooling in EBS and GOA
- Strongest positive anomalies in WBS
- 55-60% chance of La Niña, with weak PDO temp pattern

2018 Dec-Jan-Feb



2018 Jan-Feb-Mar



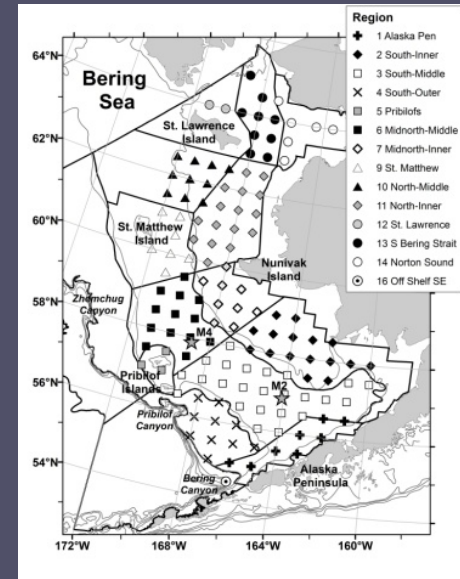
Biological observations - 2016



Variations in temp and salinity - BASIS (Eisner et al.)

Temperatures below MLD

Domain	Region Name and No.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Inner	South	2	8.7	9.3	9.5	9.2	7.9	6.3	6.5	7.3	7.1	7.0	6.5		6.3	7.3	9.0
	Mid-north	7	9.5	9.9	9.9	8.4	7.6	7.9	6.1	7.6	7.3	7.2	6.5		6.1	7.2	8.8
	North	11	7.3	7.7	9.0	7.0	6.7	7.1		6.4	6.1	6.8	6.3	5.2	8.8		9.3
Middle	AK Penn	1	7.7	7.8	7.8	7.8	7.9	5.3	6.8	7.0	6.0	6.9	5.4		7.2	7.9	7.1
	South	3	4.9	5.2	5.2	5.9	4.1	2.9	2.9	2.6	2.2	3.9	2.0		4.8	5.3	6.8
	Pribilofs	5	4.1		7.6	7.5	5.5	4.2		4.2		5.0	3.6		5.9		7.5
	Mid-north	6		5.7	4.3	5.5	2.2	2.9	1.9	3.4	1.9	3.5	2.2		3.4	3.9	5.2
	St Matthew	9	3.5	6.0	3.8	4.0	1.5	0.8		0.7	0.7	1.9	1.0		2.5		5.3
Outer	South	4	6.9	6.8	6.1	6.3	6.0	5.4		5.6	5.0	5.3		5.5	6.3	6.8	
> 63°N	St Lawrence	12	6.2	4.4	7.0		4.7	6.4		3.9	5.4	3.9	5.5				
	S Bering Strait	13	5.4	5.8	6.9	7.4	4.7	6.1		3.7	5.5	5.1	3.2	3.3	5.5	6.7	
	Norton Sound	14	7.3	10.2	11.4		8.1	10.3		8.0	8.6	7.5	6.8	8.2	8.9	6.9	
Offshore	southeast	16	5.7	6.7	5.5	6.1	6.0				5.3	5.2		4.5			



Salinity below MLD

Domain	Region Name and No.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Inner	South	2	31.40	31.25	31.05	31.17	30.96	31.30	31.18	31.07	31.26	30.90	31.30		31.90	31.82	31.60
	Mid-north	7	31.48	31.25	31.20	31.20	30.88	30.99	31.21	31.28	31.29	31.06	31.12		31.67	31.96	31.59
	North	11	30.54	30.65	30.68	31.04	30.66	30.77		30.91	30.77	30.91	30.93	30.74	30.17		30.32
Middle	AK Penn	1	32.12	31.94	32.02	32.08	32.01	32.18	31.89	32.05	31.99	32.21	32.16		32.15	32.24	32.27
	South	3	32.07	31.88	31.96	32.08	31.88	31.81	31.91	31.77	31.73	31.94	31.81		32.08	31.93	31.90
	Pribilofs	5	33.14		32.07	32.09	32.07	31.91		32.24		32.08	32.09		32.21		32.23
	Mid-north	6		32.06	31.97	32.07	31.83	31.64	31.74	31.61	31.53	31.63	31.72		32.03	32.07	32.13
	St Matthew	9	31.64	31.57	31.57	32.04	31.38	31.52		31.54	31.15	31.24	31.49		31.25		31.70
Outer	South	4	32.76	32.61	32.48	32.49	32.53	32.59		32.66	32.51	32.64	32.61		32.64	32.45	32.41
> 63°N	St Lawrence	12	32.22	31.72	32.12		31.99	31.80		31.90	31.68	32.22	31.80	31.59			
	S Bering Strait	13	31.46	31.49	31.24	31.21	31.62	31.68		31.68	31.56	31.75	32.00	31.69	31.77		30.98
	Norton Sound	14	29.11	27.95	29.80		29.69	29.15		29.98	29.80	29.51	29.71	29.92	29.66		30.96
Offshore	southeast	16	33.17	32.74	33.09	33.22	32.74				32.91	33.02		33.47			

- Temps and salinity above and below mixed layer depth

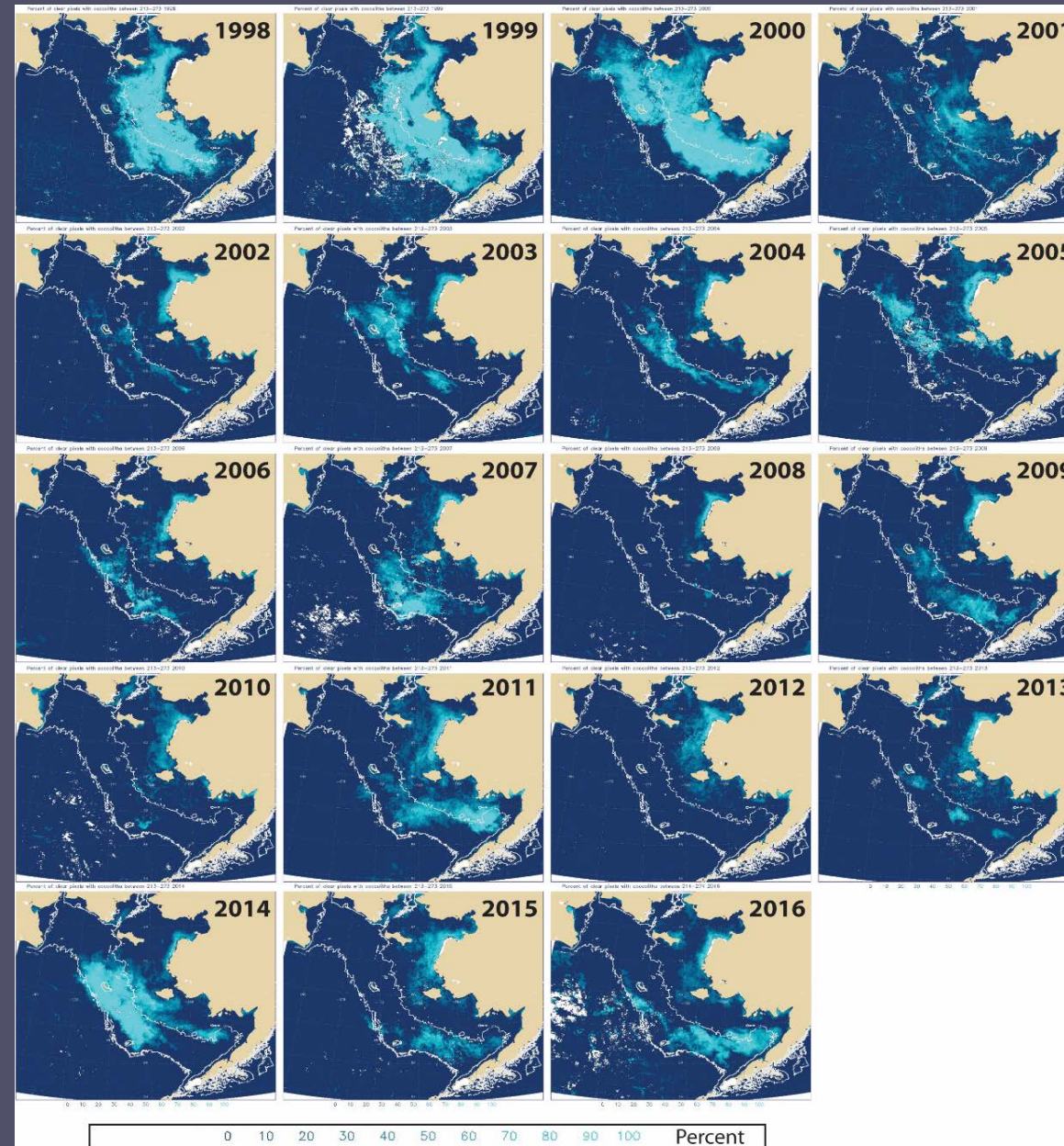
Below better reflects longer term climatic shifts

- Above influenced by episodic mixing events

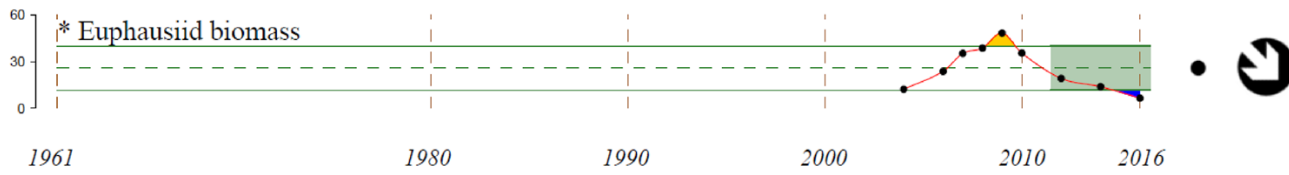
Coccolithophores

Ladd and Eisner

- Bloom in 2016
- Trophic implications – smaller than diatoms -> longer chains; less desirable for microzooplankton
- Negative impacts on visual foragers

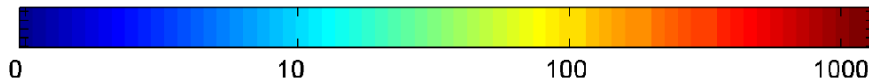
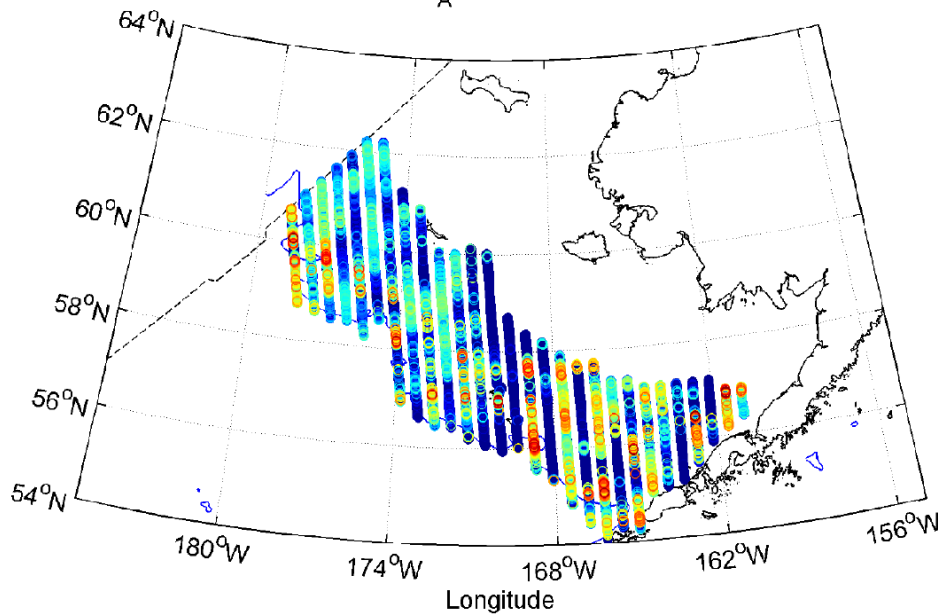


2016 EBS Zooplankton

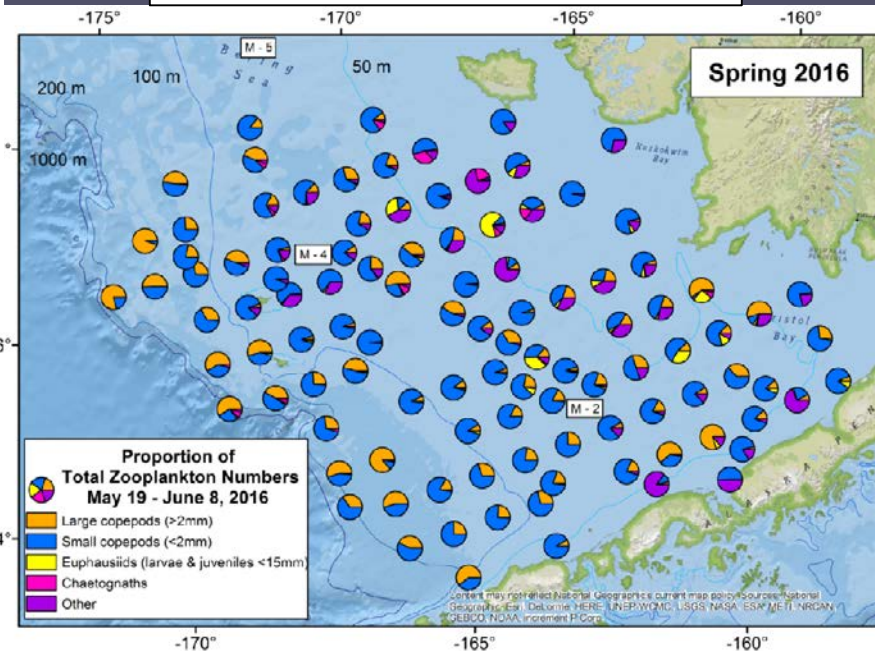


- Acoustic survey of euphausiids – preliminary estimate LOW
- Small copepods more prevalent than lipid-rich large copepods or euphausiids spring and fall

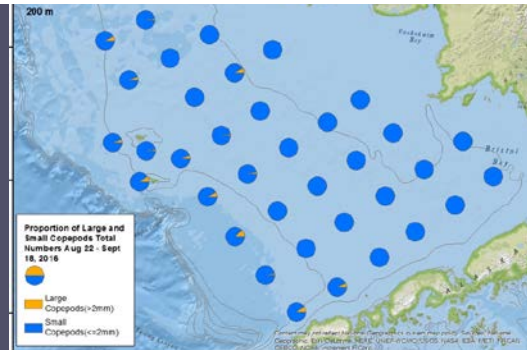
euphausiid s_A, DY1608 (preliminary)



Spring rough zoop counts



Fall rough zoop counts



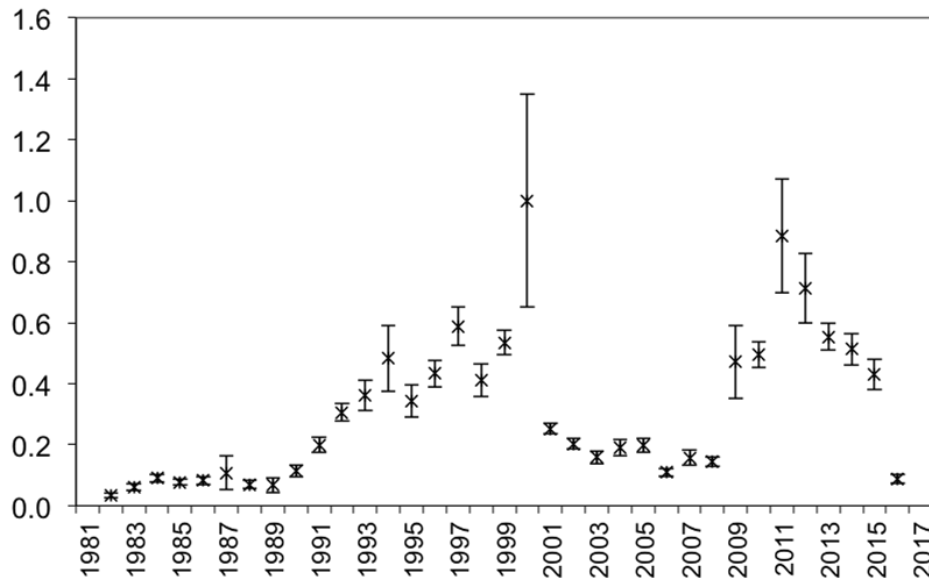


Jellyfish

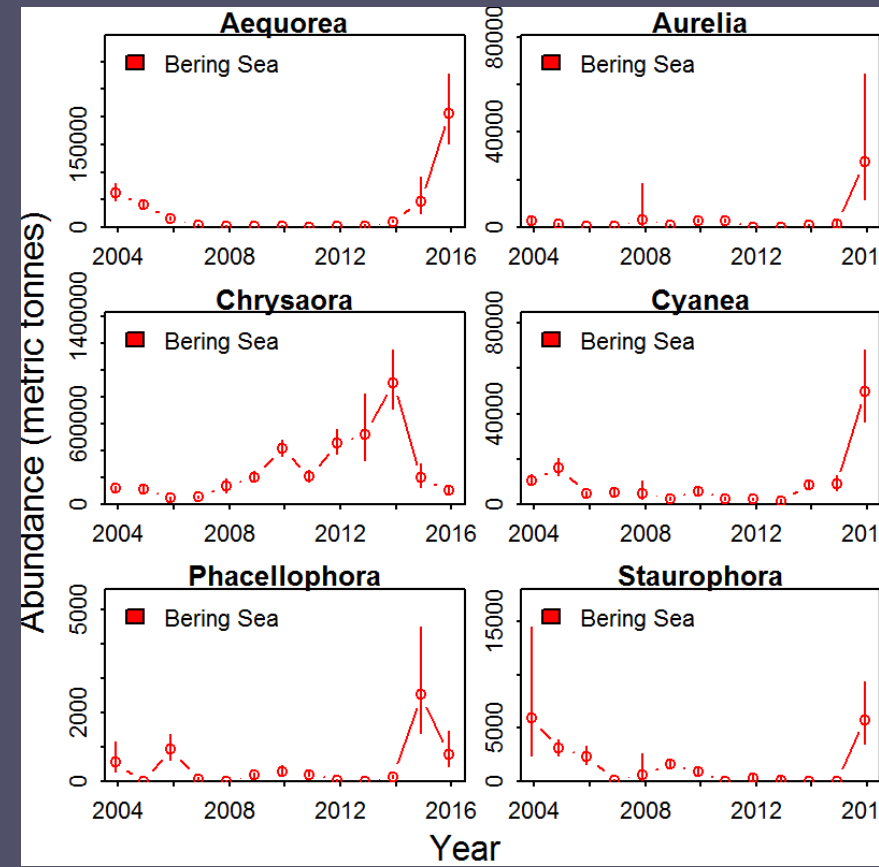
Lauth and Hoff; Cieciel et al.

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

Summer 2016

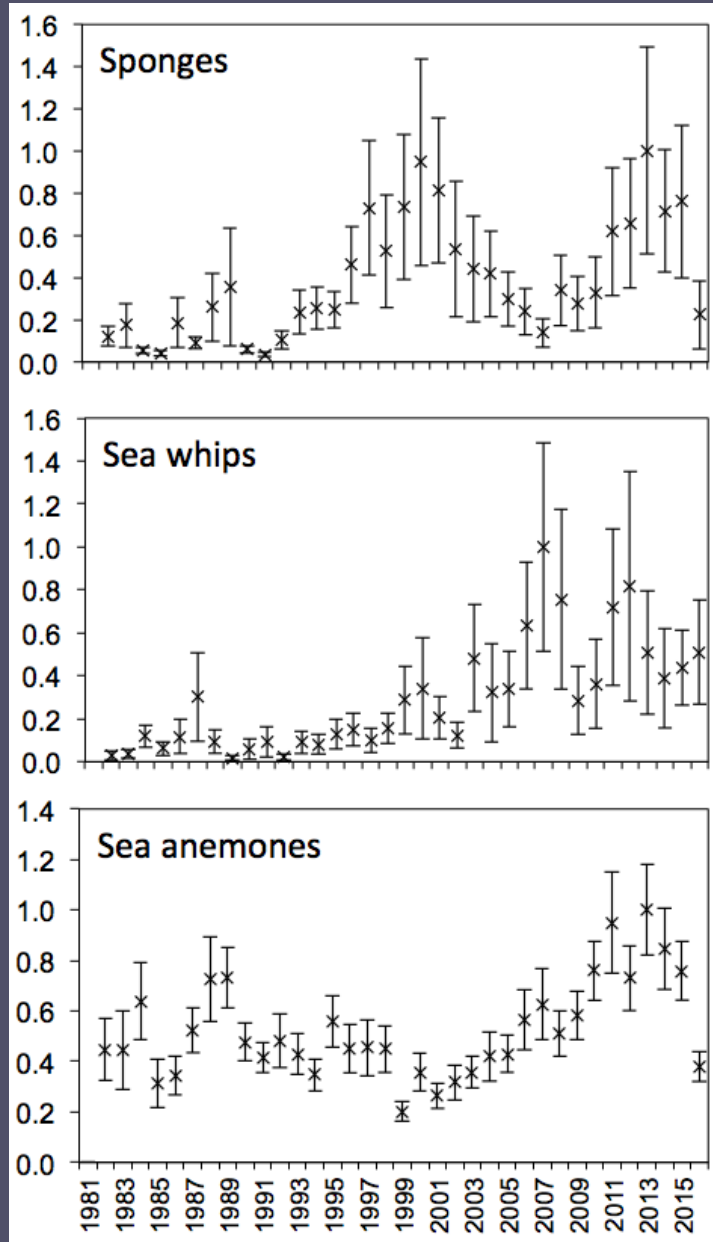


Fall 2016



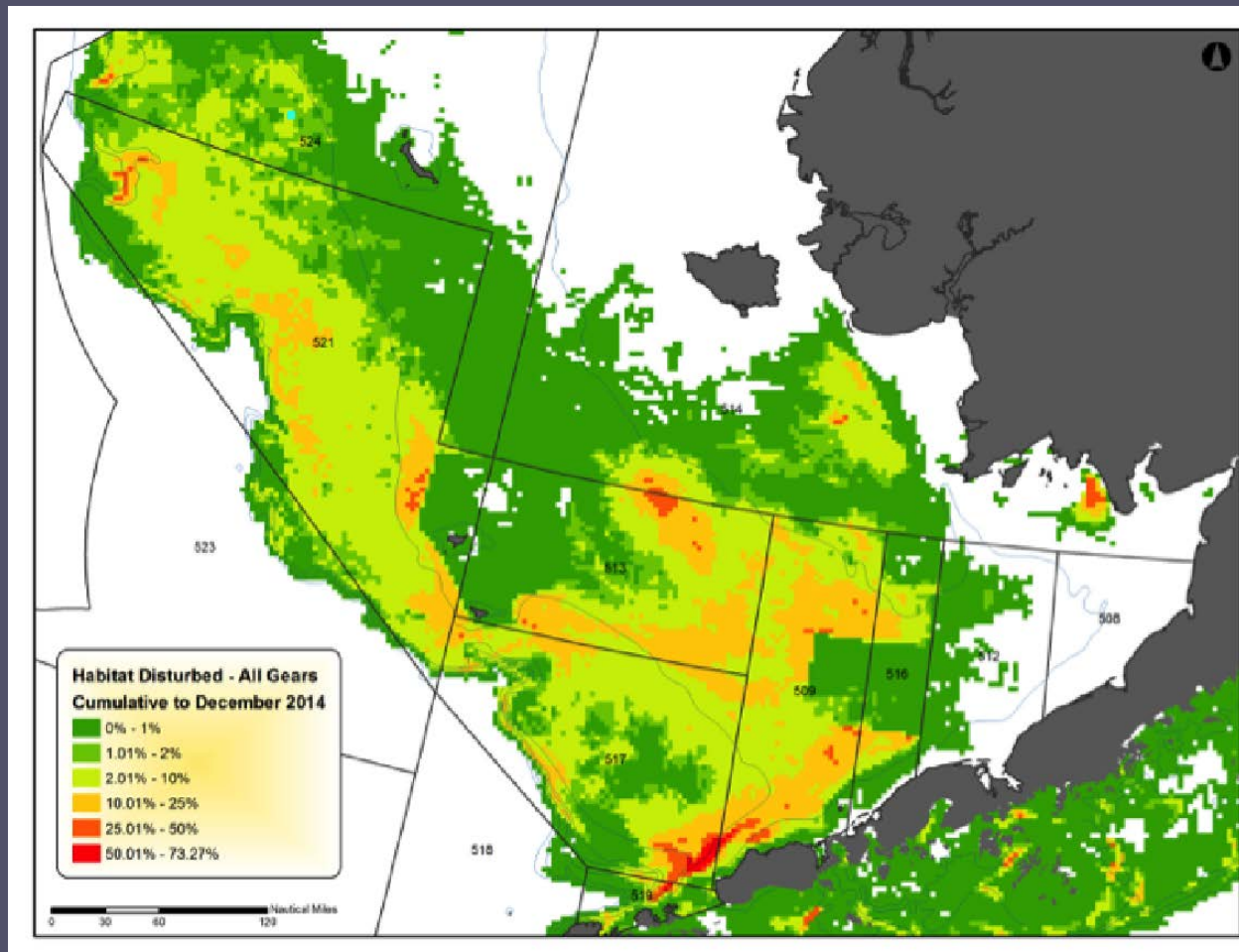
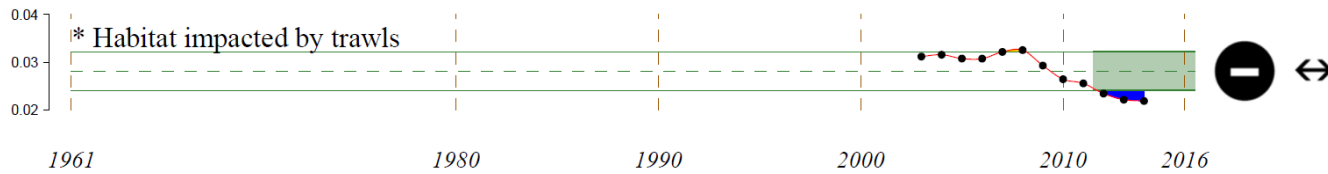
2016 Structural epifauna (HAPC biota) – survey

Lauth and Hoff



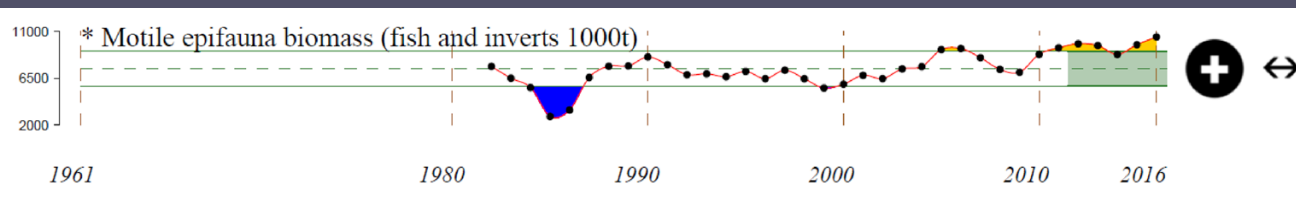
- Difficult to detect trends due to taxonomic uncertainty within groups
- May represent changes in habitat or variable field ID
- Sponges correlated with jellyfish?

(2014) EBS Fishing impacts

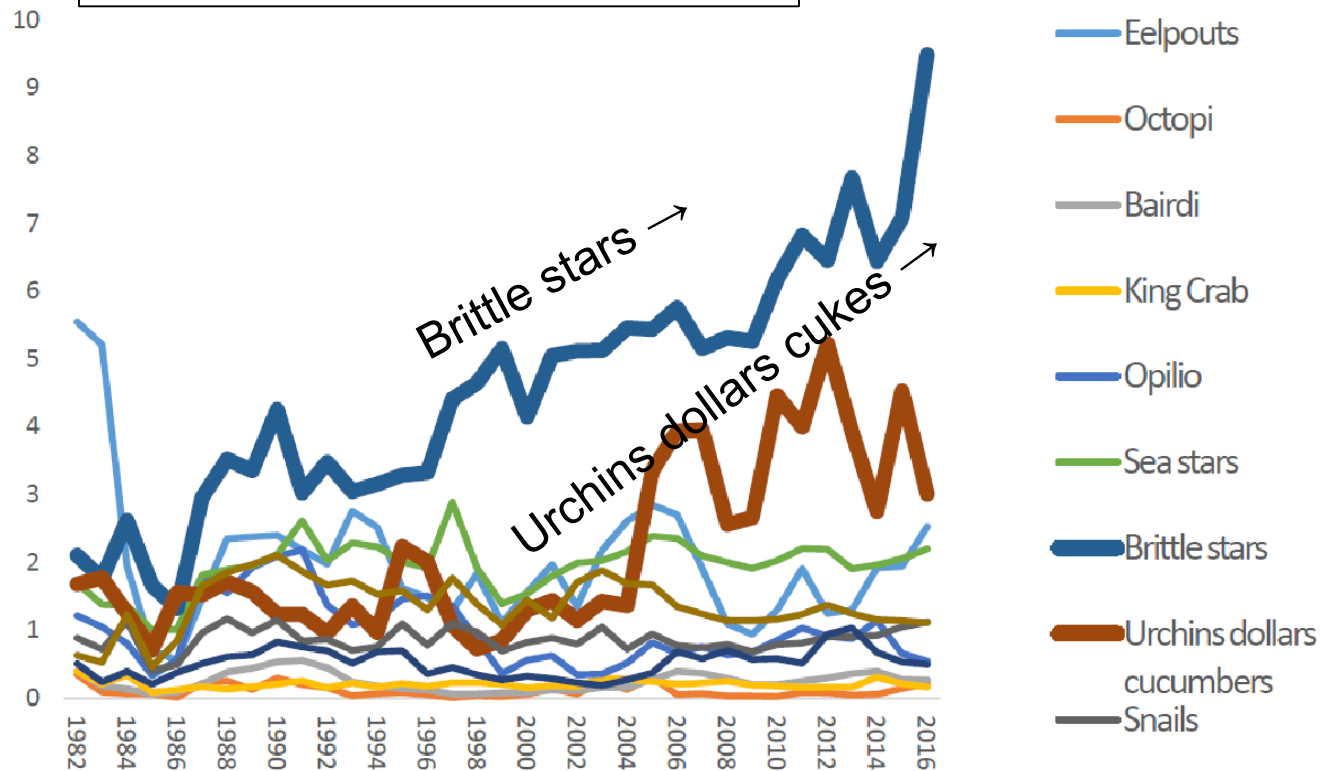


- New indicator
- Based on Fishing Effects model
- Effects are cumulative
- All gear types
- Considers impacts and recovery

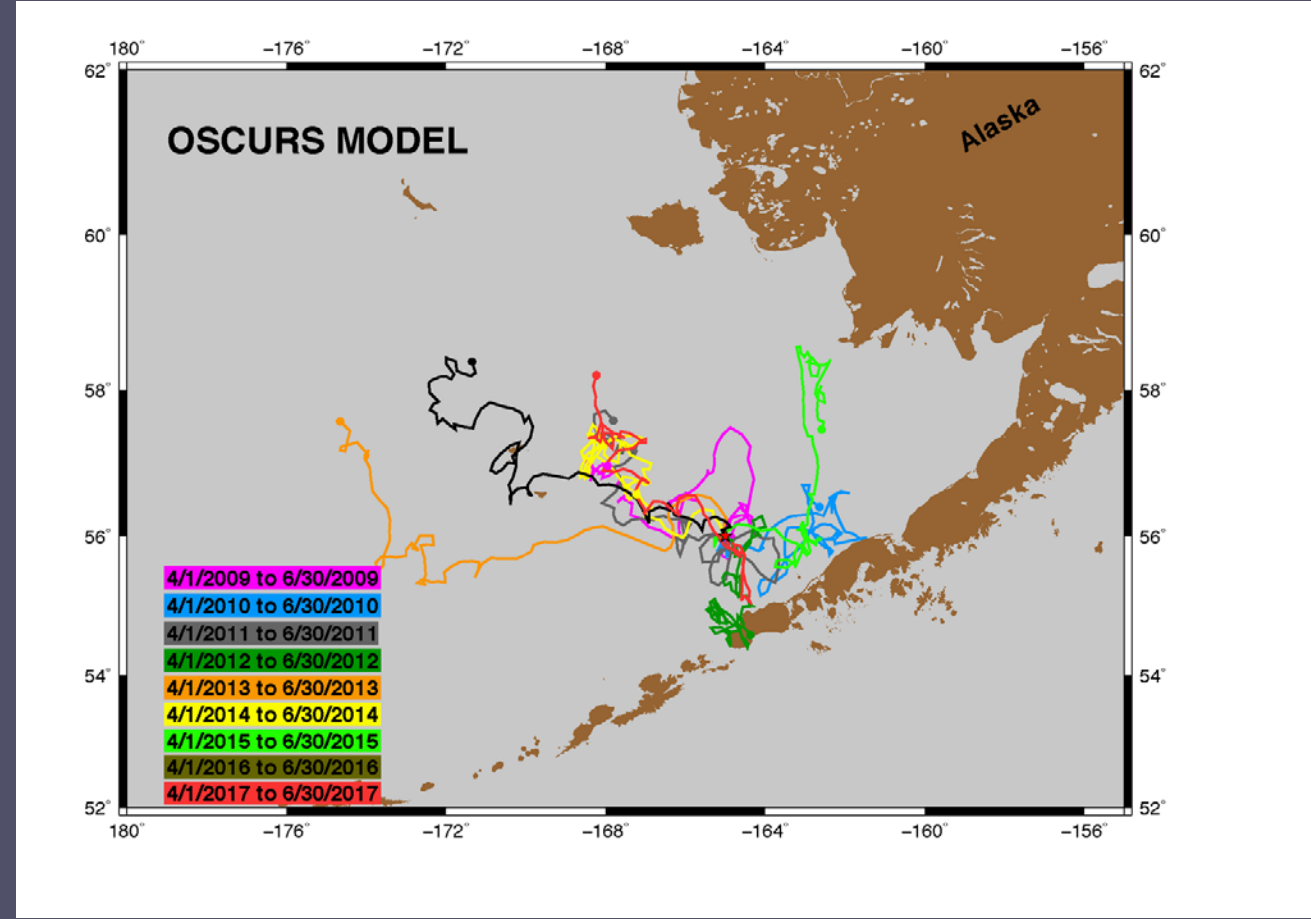
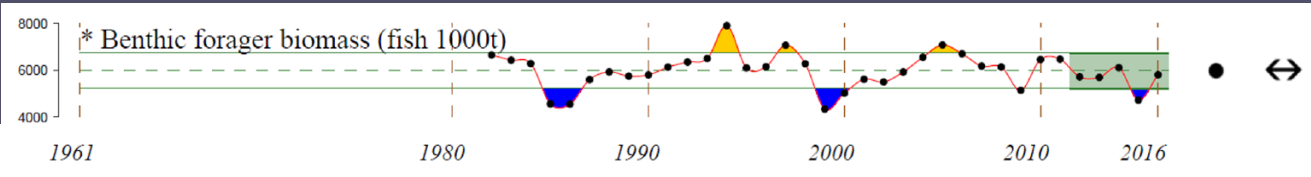
2016 EBS Motile Epifauna



Motile Epifauna survey biomass



2016 EBS Benthic foragers

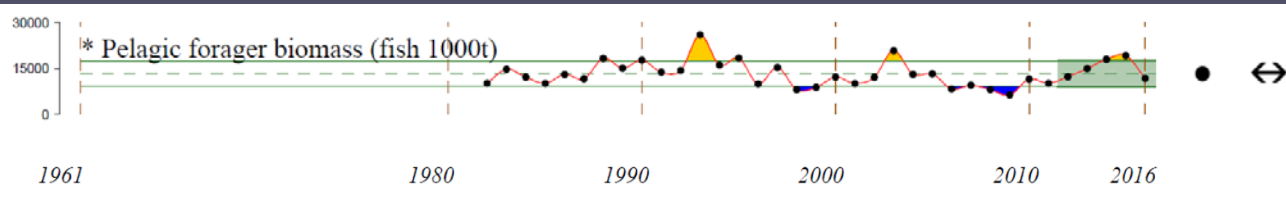


- Spring wind forcing
- 2017 drift pattern was mixed:
 - off-shore (unfav.)
 - then on-shore
- more consistent with below-average recruitment years
- Only 2 years (2008 & 2015) with above-average predicted recruitment

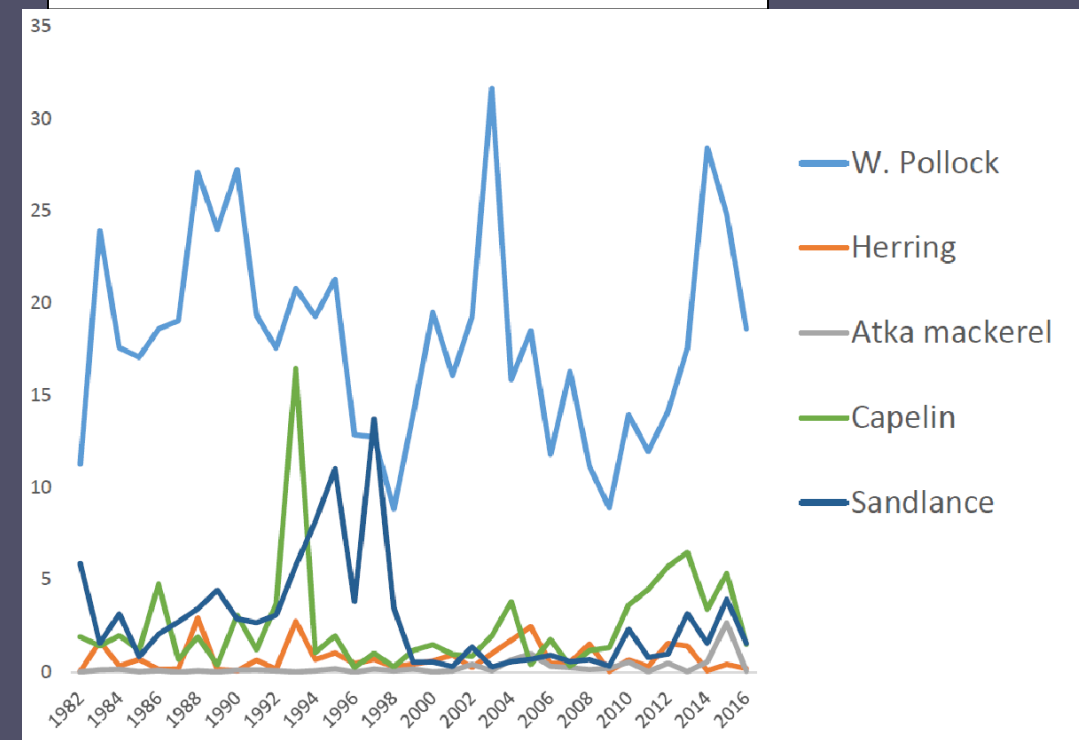
2011-2015 Trend

- ⤴ increase by 1 s.d. over time window
- ⤵ decrease by 1 s.d. over time window
- ↔ change <1 s.d. over window
- x fewer than 3 data points

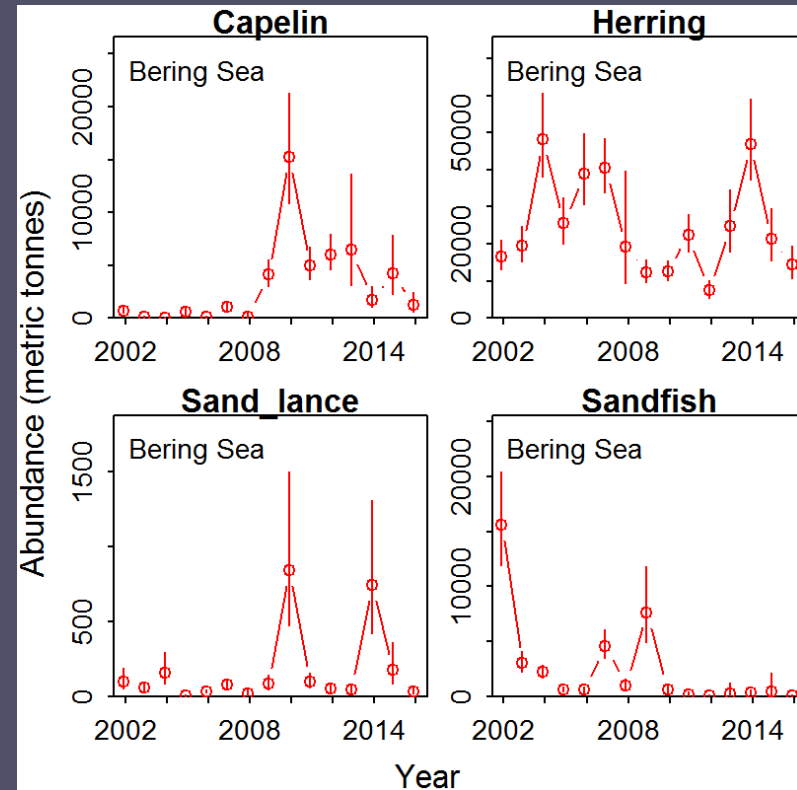
2016 EBS Pelagic foragers



Pelagic forager survey biomass



- Declined 2016
- Due to pollock and capelin

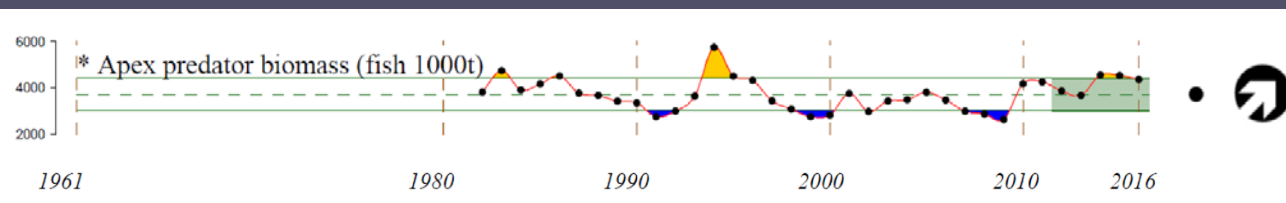


2011-2015 Trend

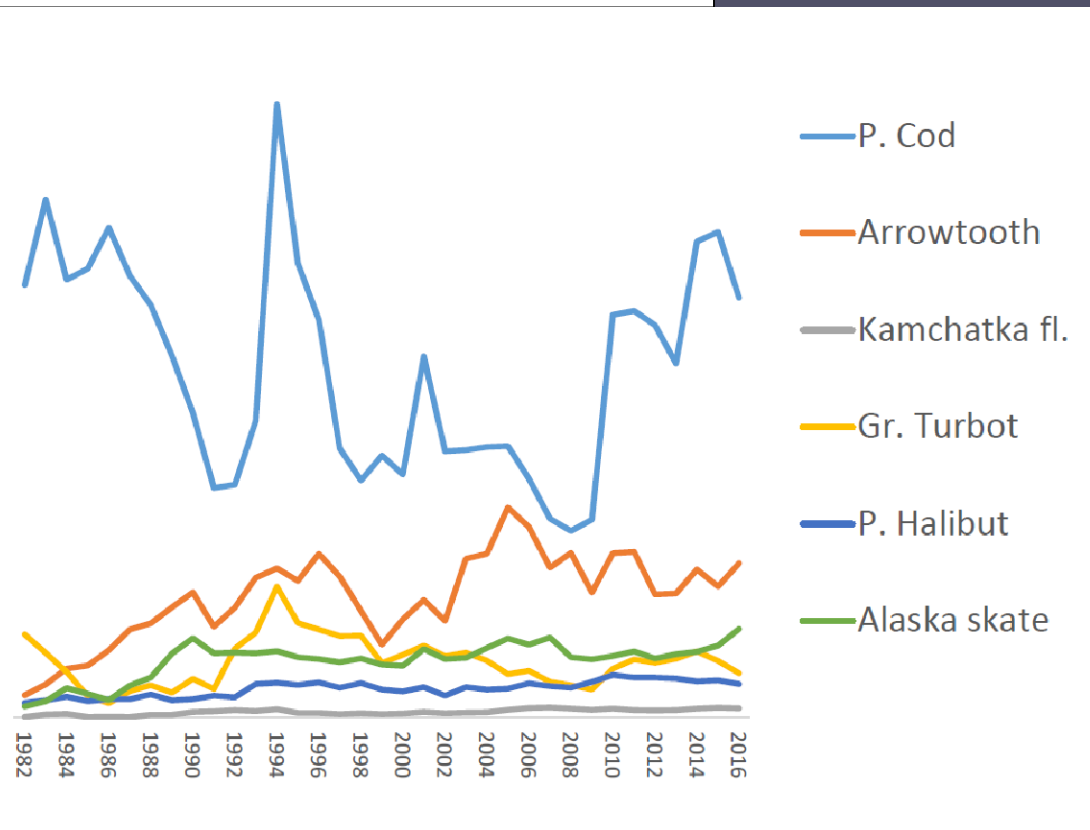
- ↻ increase by 1 s.d. over time window
- ↻ decrease by 1 s.d. over time window
- ↔ change <1 s.d. over window
- x fewer than 3 data points

New indicator
Yasumiishi et al.
Forage fish abundance

2016 EBS Apex fish



Apex fish survey biomass



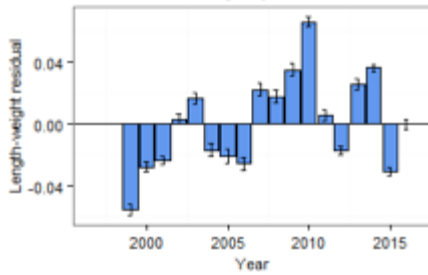
- Above 30 year mean
- Trend changed to increasing
- Increase from 2009 driven by P cod

2016 Groundfish Condition

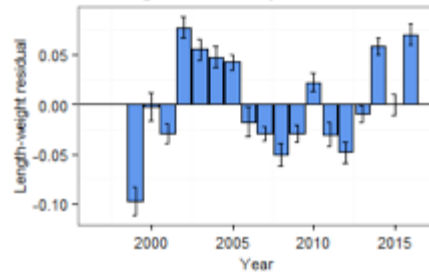
Boldt, Rooper et al

Length-weight residuals

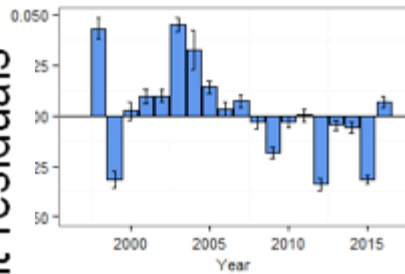
Walleye pollock



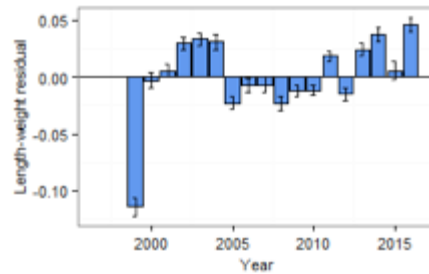
Age 1 Walleye Pollock



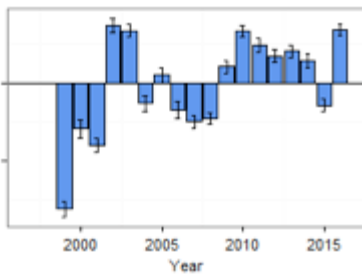
Pacific cod



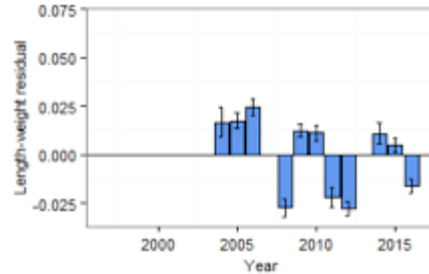
Northern rock sole



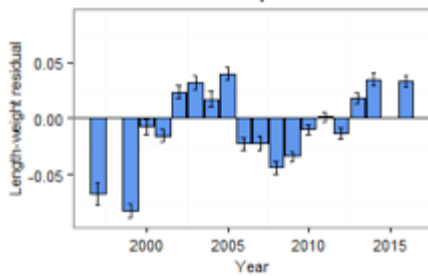
Yellowfin sole



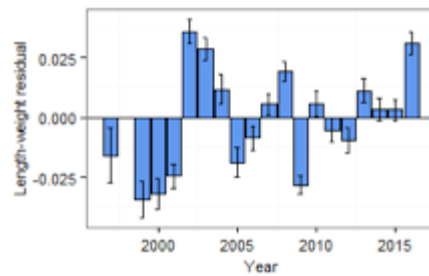
Arrowtooth flounder



Alaska plaice



Flathead sole

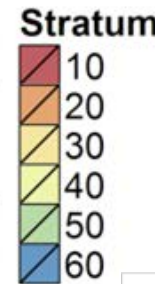
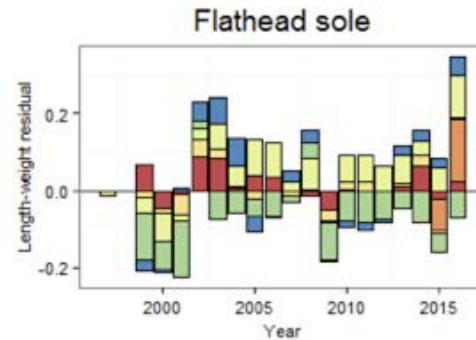
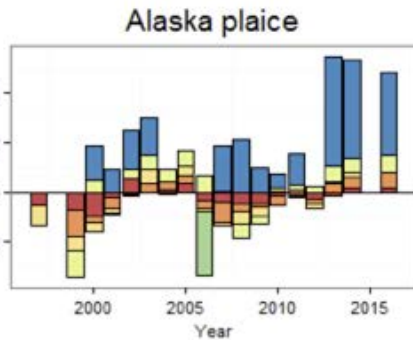
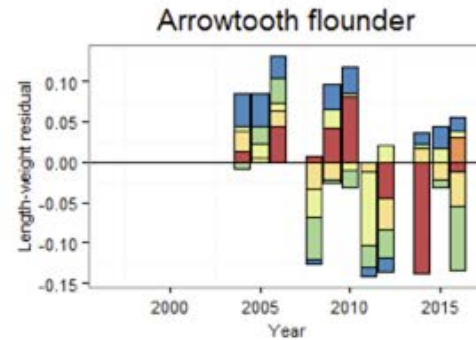
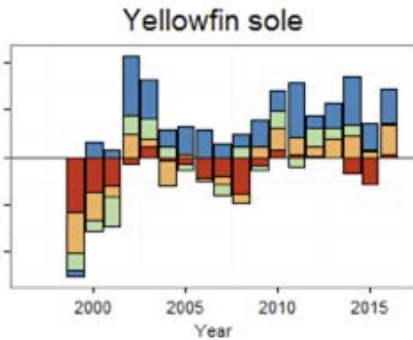
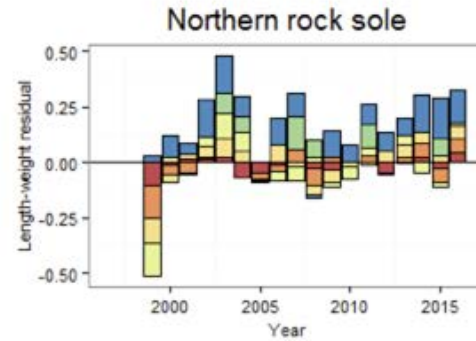
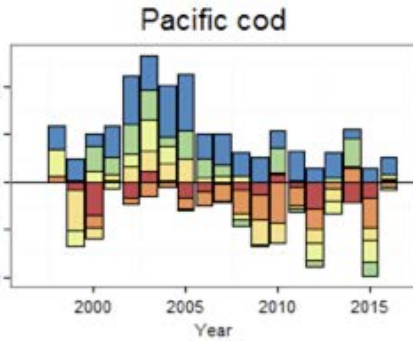
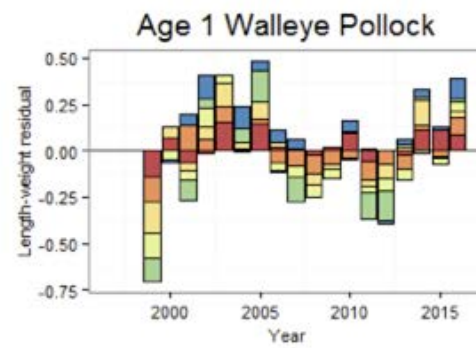
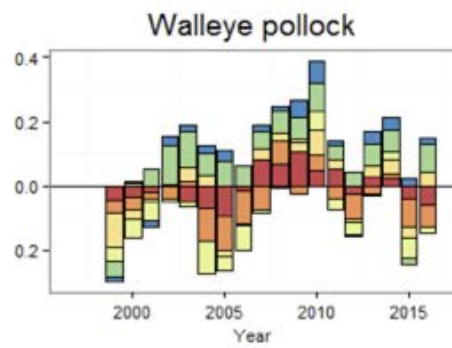


- Length-weight residuals from survey
- Negative trend in cod since 2003 slowing?
- Residuals positive for all but ATF and pollock (average)
- Age-1 and age-2+ pollock not well correlated

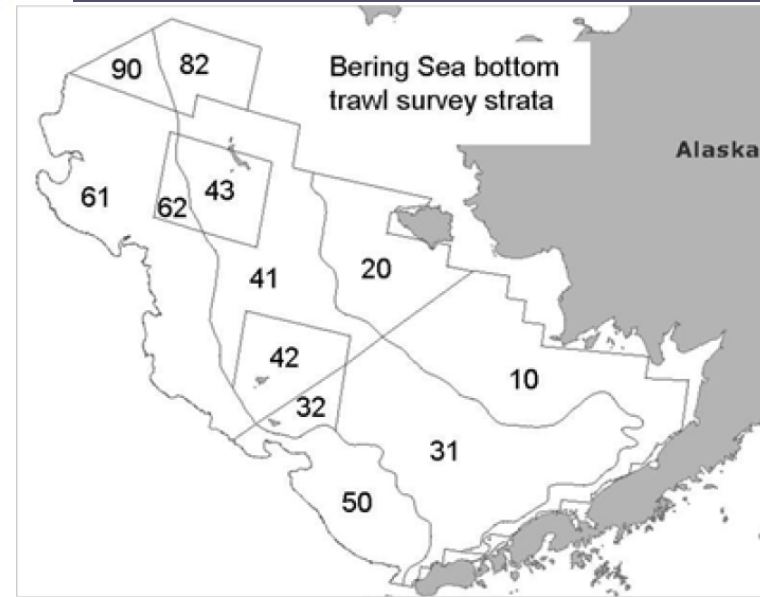
2016 Groundfish Condition

Boldt et al

Length-weight residuals

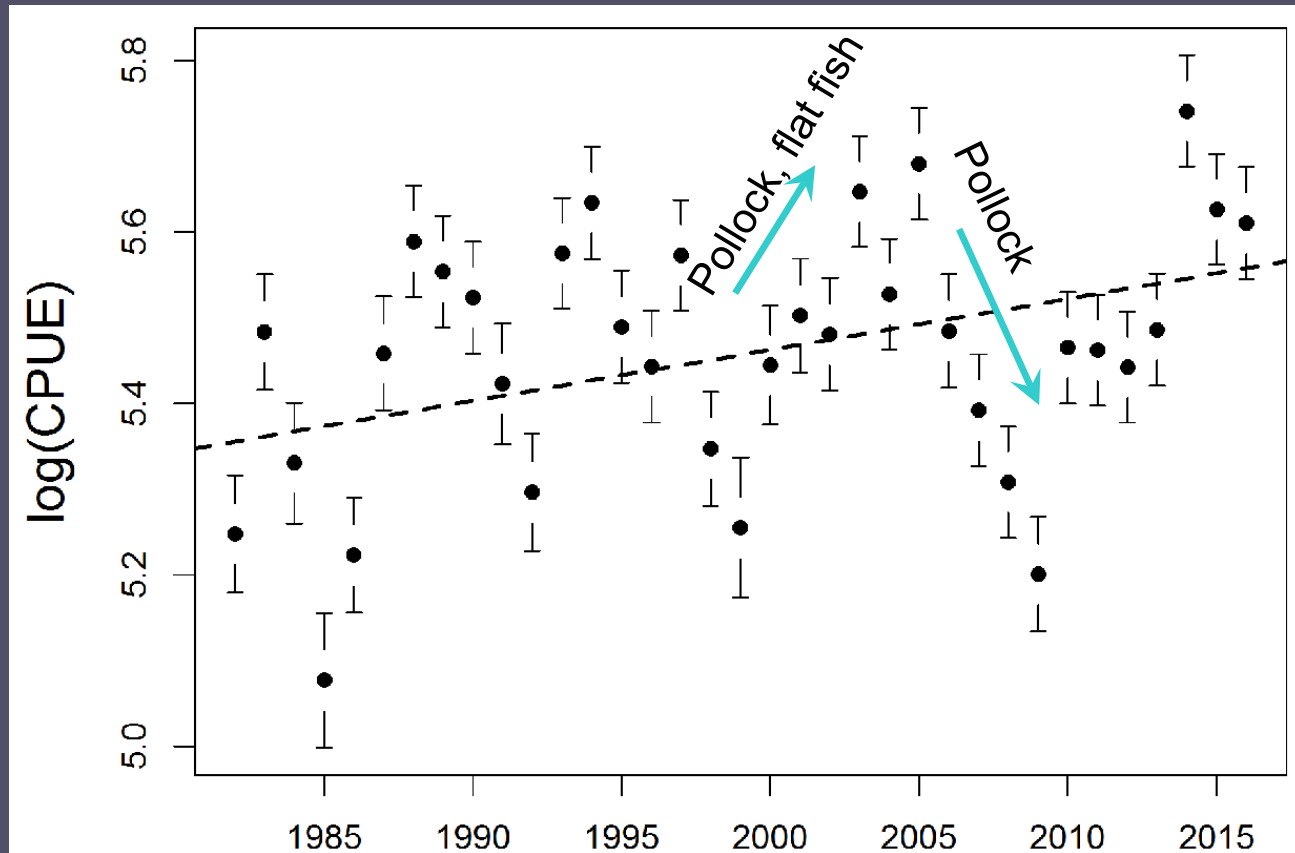


- Usually positive on outer, especially northern outer, shelf
- Influential factors: temperature, survey timing, fish migration.



Aggregated CPUE of fish and invertebrates in bottom trawl surveys

Mueter

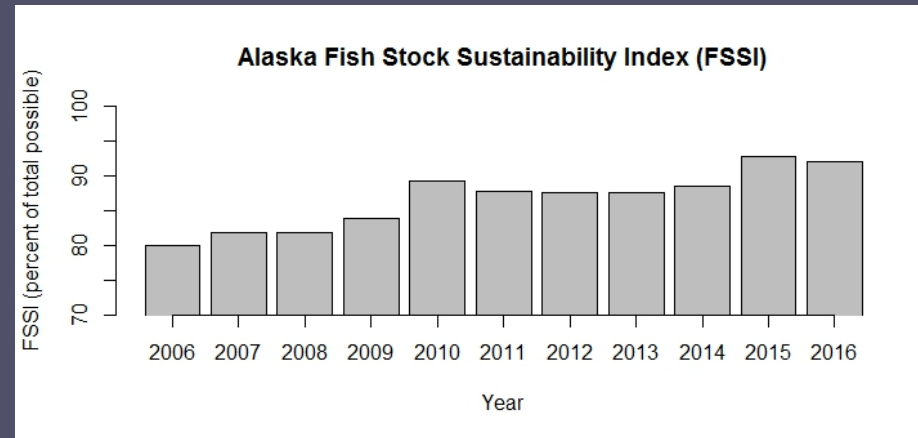


- Sum of CPUEs of taxa, area-weighted, smoothed with GAMS – 1982-2016
- 2014 was highest observed (pollock)
- Temperature influences abundance, catchability and/or distribution of taxa

2016 Fish Stock Sustainability Index

Whitehouse

- Performance measure for sustainability of stocks selected for importance to commercial and recreational fishing
- No *groundfish* stock or stock complexes are overfished or subject to overfishing
- Overfished: Pribilof Island blue king crab



Jurisdiction	Stock Group	Number of Stocks	Overfishing				Overfished				Approaching Overfished Condition
			Yes	No	Unk	Undef	Yes	No	Unk	Undef	
NPFMC	FSSI	36	0	36	0	0	1	32	3	0	0
NPFMC	NonFSSI	29	0	29	0	0	0	3	26	0	0
	Total	65	0	65	1	0	1	35	29	0	0

- Total possible score = 144
- BSAI = 85.5/92

- Point lost for St Matthew blue king dropping below 80% Bmsy