Qualities of a good indicator: Zooplankton Indices

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"Only a fool would believe that he could predict the future from history."

Why are we talking about this?

~~Because zooplankton are awesome!~~

Zooplankton are important, numerous, and responsive to their environment.

Critical links provide critical information (right???)

Why are we talking about this?

In hot water: zooplankton and climate change

Anthony J. Richardson

ICES Journal of Marine Science, 65: 279–295.

"Beacons of climate change"

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In hot water: zooplankton and climate change

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"Beacons of climate change"

- 1-3^{+} month life cycles ⇒ responsive to environmental change
- Strongly affected by advection and changes in temperature
- (Mostly) not fished
- Non-linear responses to environment ⇒ stronger signal than environmental changes
- Critical prey for many species ⇒ directly affect upper trophic success

Pressing need for accurate indicators of the environment and forecasts for fisheries

Types of zooplankton indices from observations (~easiest to hardest)

- Total zooplankton biomass trends
- Presence/absence of particular taxa
- Abundance trends of individual or a few species
- Trends in size composition

- Trends in community composition (e.g., PCA)
- Ratios of functional group(s)
- Biochemical markers (e.g., total lipids, fatty acids)

- Timing of major events
- Changes in growth rates

Types of zooplankton indices from observations (~easiest to hardest)

- Total zooplankton biomass trends

What is the question?

What type of information is needed?

- Ratios of functional group(s)
- Biochemical markers (e.g., total lipids, fatty acids)

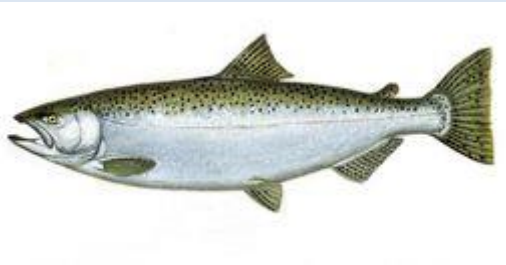
- Timing of major events
- Changes in growth rates

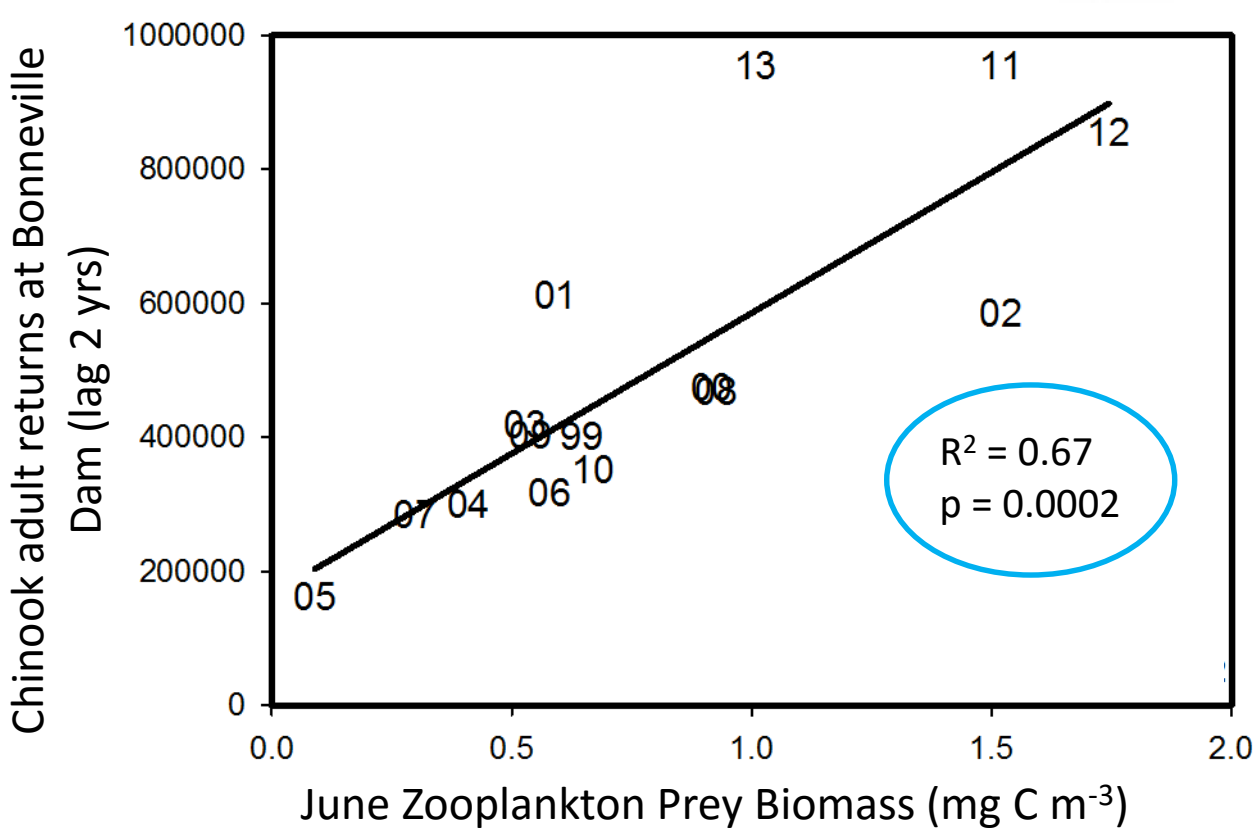
Some examples of indicators developed from observations

(ignoring the modeling perspectives, for now)

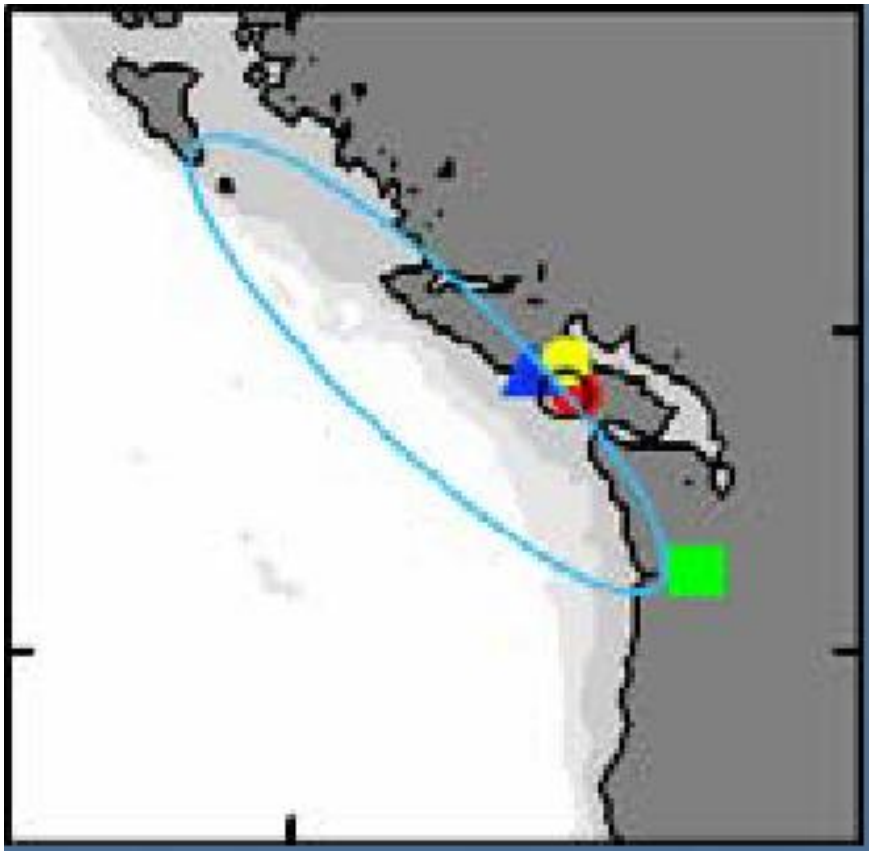
Mostly from my narrow perspective….

Biomass of selected macro-zooplankton correlates with salmon survival:

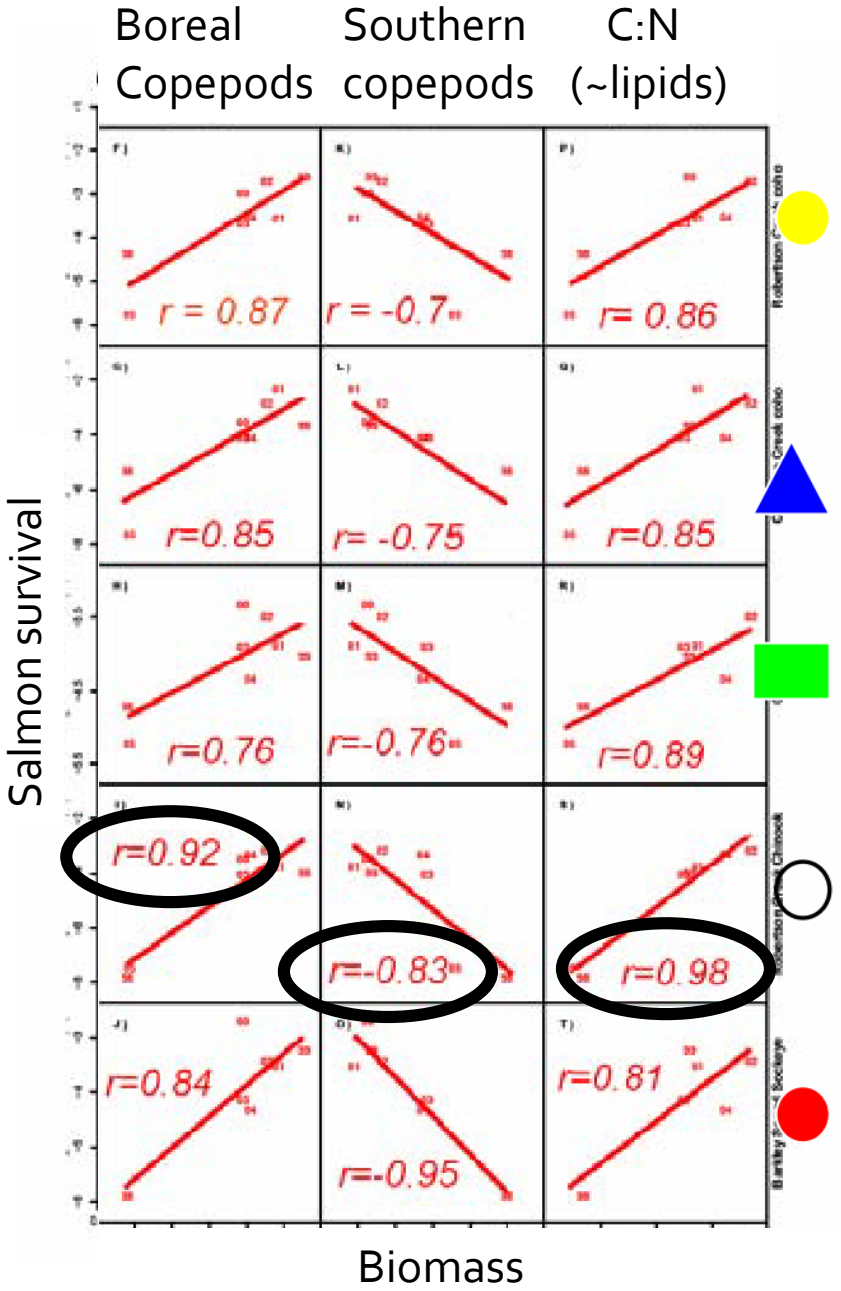




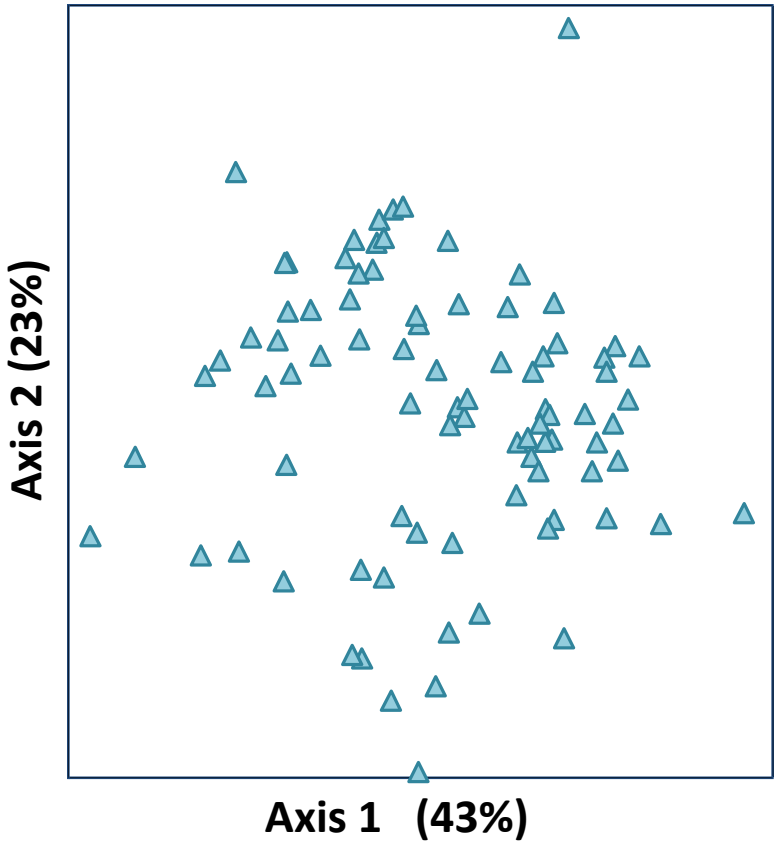
Canadian zooplankton indices correlate with survival of salmon stocks



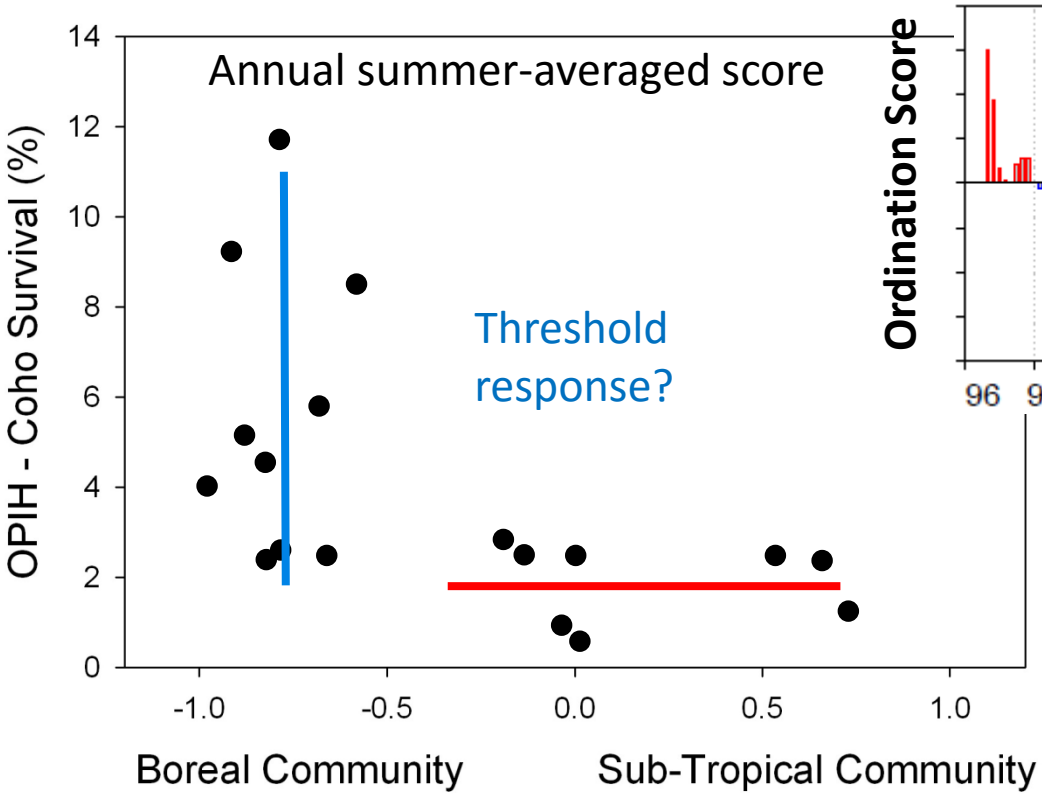
M. Trudel, DFO, PICES 2011
(sensu D. Mackas)

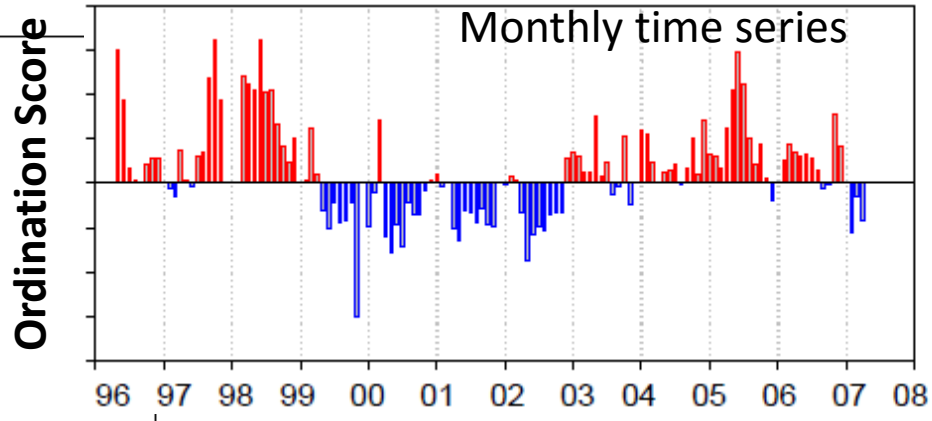


Non-Metric Multidimensional Scaling Ordination (very similar to Principal Components Analysis)



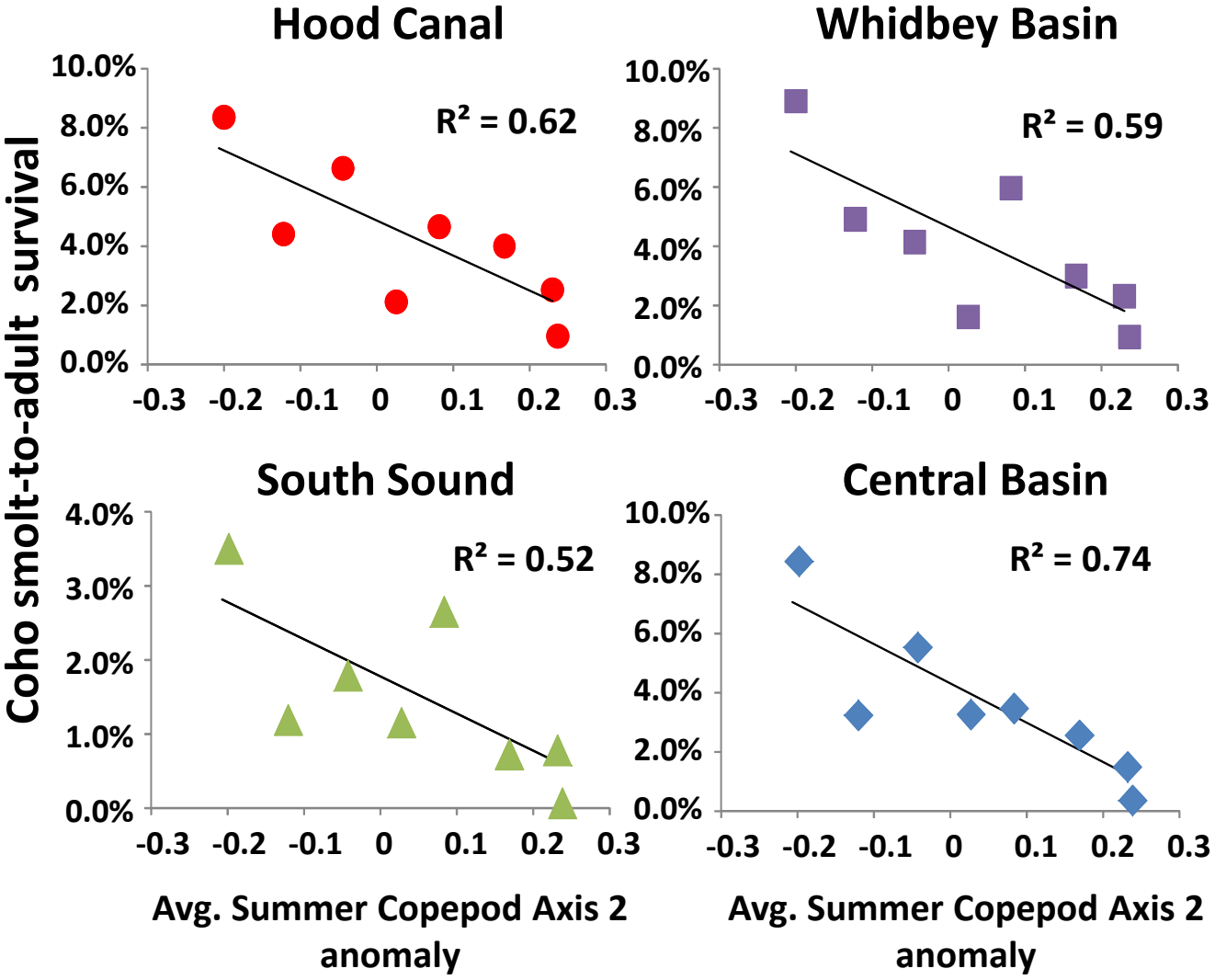
The California Current Copepod Ordination scores relates to coho salmon survival in the NCCS:

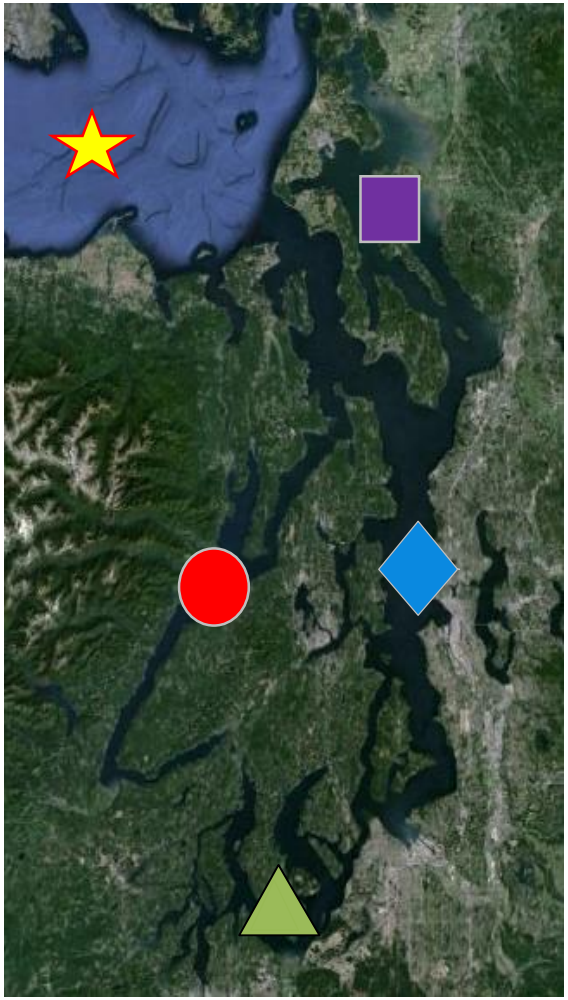




Slide courtesy of B. Peterson et al. (NOAA)

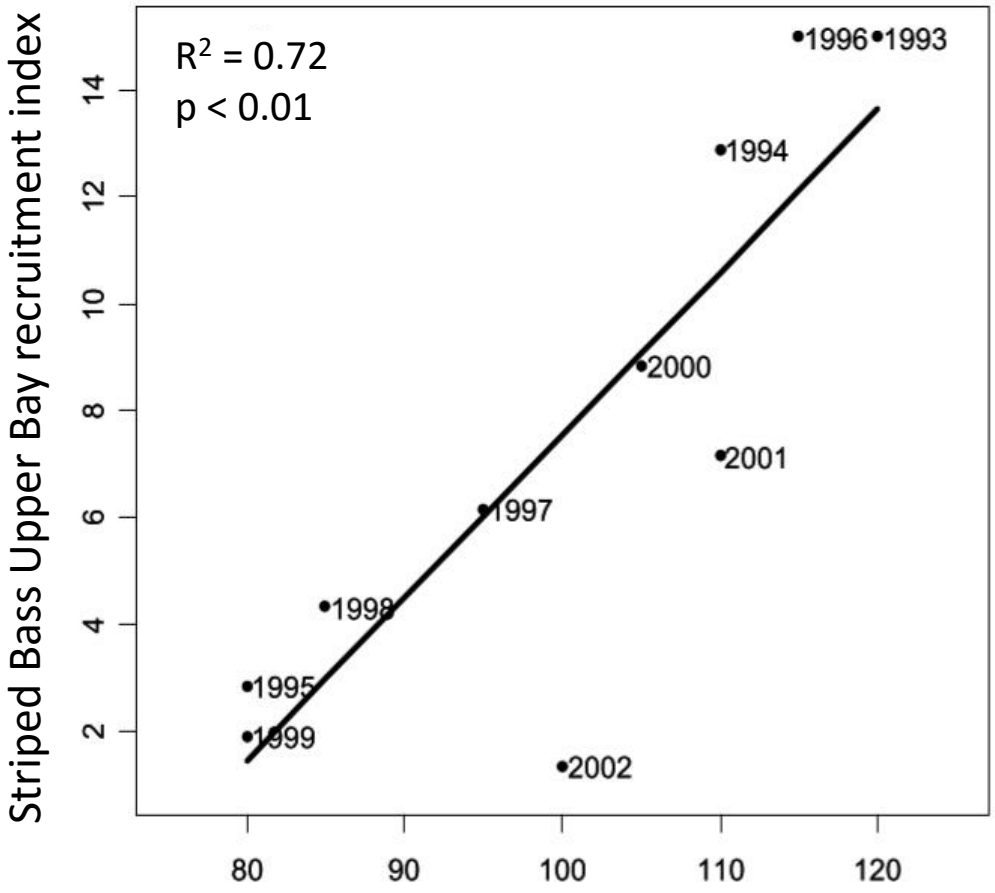
Correlations with Puget Sound coho salmon survival:





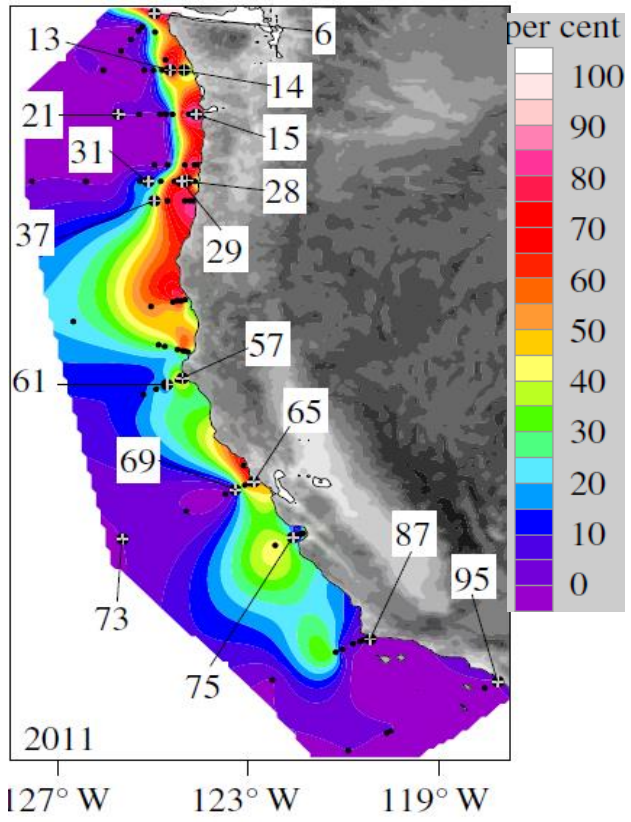
J. Keister, in prep.

Timing of zooplankton abundance correlates with fish survival:



Edward J. Martino, Ph.D., 2008

Biological index of water chemistry:



% of upper 100 m that was aragonite under-saturated.

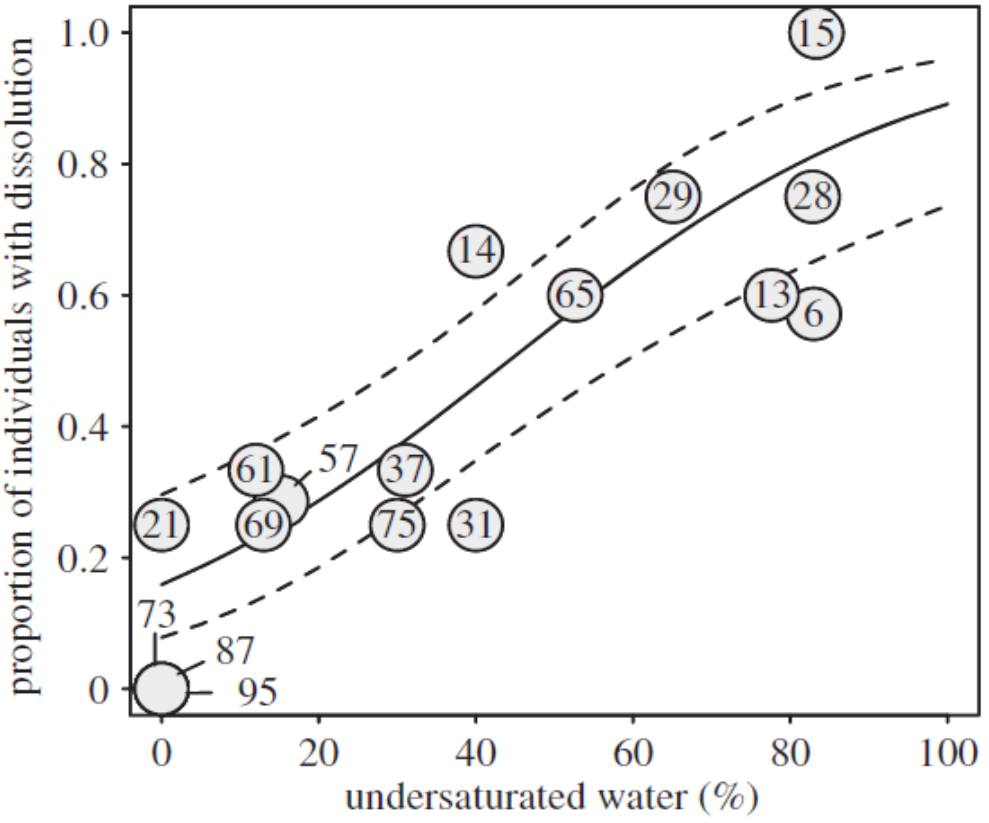


Figure 3. Proportion of pteropods with severe shell dissolution as a function of the percentage of the water column in the upper 100 m that is under-saturated with respect to aragonite.

Bednarsek et al 2014

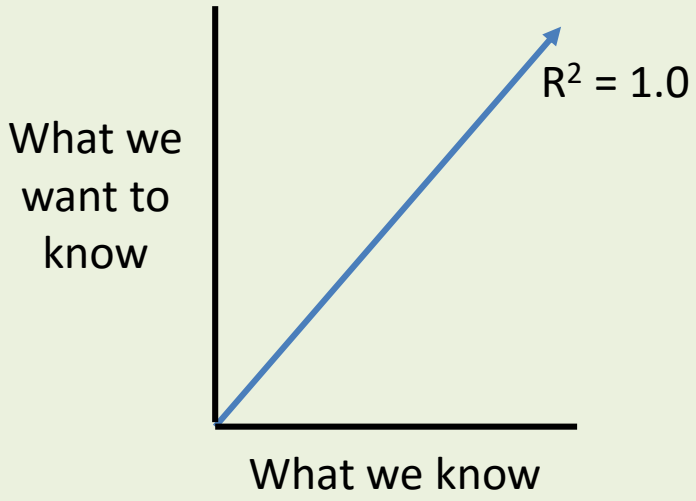
NOAA - Ocean ecosystem indicators of the Northern California Current

Qualitative salmon return forecasts

Ecosystem Indicators	1998	1999	2000	2001	2002	2003	2004	2005	2013
PDO (December-March)	15	6	3	11	7	16	10	14	8
PDO (May-September)	10	4	6	5	11	15	14	16	8
ONI Jan-June	16	2	1	5	12	13	11	14	7
46050 SST (May-Sept)	14	8	3	4	1	7	16	13	12
NH 05 Upper 20 m T winter prior (Nov-Mar)	16	10	7	9	5	13	14	11	6
NH 05 Upper 20 m T (May-Sept)	13	10	12	4	1	3	16	15	14
NH 05 Deep Temperature	16	6	8	4	1	9	12	14	15
NH 05 Deep Salinity	16	3	7	4	5	13	14	8	12
Copepod Richness Anomaly	16	3	1	7	6	12	11	15	2
N. Copepod Biomass Anomaly	15	12	7	8	5	14	13	16	3
S. Copepod Biomass Anomaly	16	3	5	4	2	11	13	15	6
Biological Transition	16	11	7	3	8	12	10	15	6
Winter Ichthyoplankton	16	8	2	4	6	15	14	10	5
Chinook Juv Catches (June)	15	4	5	13	9	11	14	16	2
Coho Juv Catches (Sept)	11	2	1	4	3	6	12	14	NA
Mean of Ranks	14.7	6.1	5.0	5.9	5.5	11.3	12.9	13.7	7.6
RANK of the Mean Rank	16	6	2	5	3	13	14	15	8
Principle Component Scores (PC1)	6.58	-2.18	-2.93	-1.56	-2.07	2.19	3.11	4.28	-1.01
Principle Component Scores (PC2)	0.04	0.21	0.42	-1.04	-2.20	-1.73	2.24	-0.73	2.16

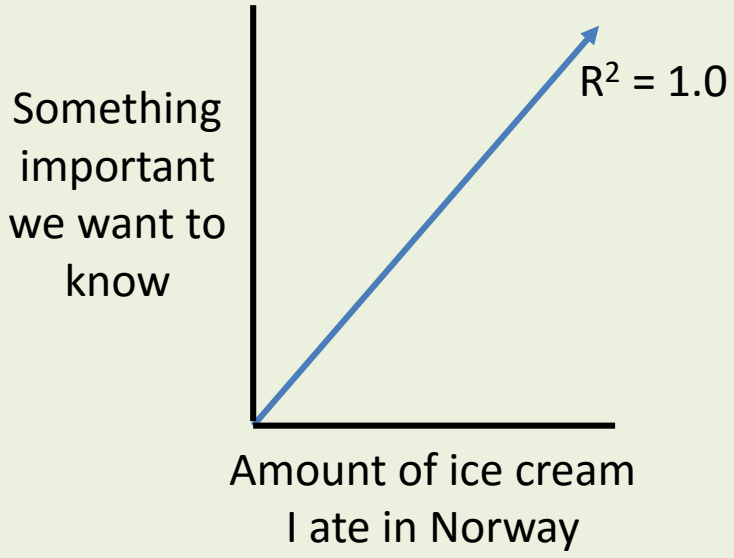
Qualities of a good indicator

- Has a strong relationship with the variable of interest



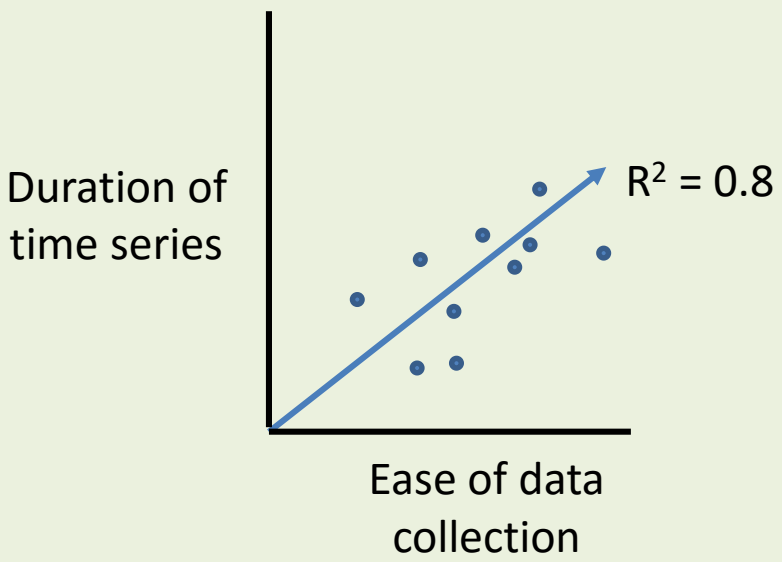
Qualities of a good indicator

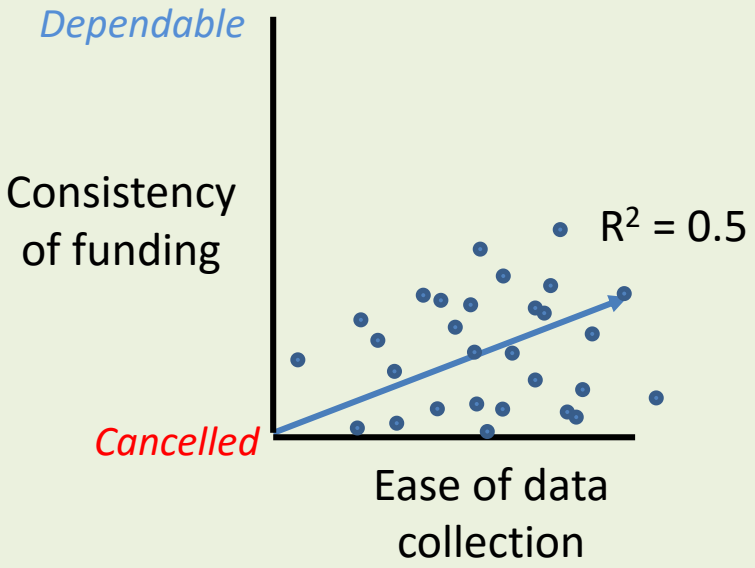
- Has an underlying, understood, mechanistic relationship to the property of interest.



Qualities of a good indicator

- Is easy and inexpensive to measure (at least relative to the property of interest).





Other desirable aspects of a good indicator

- Indexes the system/property/process that we think they do!
- Maintains predictability over time.
- Has been collected over, and indexes, relevant (preferably large) spatial and temporal scales.

Potential issues (a.k.a. serious challenges)

- Non-linear relationships in biology
  - E.g.: Biological response to physics, and especially among trophic levels within biology.
  - However: strong threshold responses can be particularly useful as indicators (all or nothing response).
- Decoupling of relationships over time.
  - E.g., Relationship to eutrophication established, but altered by climate warming or CO_2.

Thought/Discussion Questions:

- How can zooplankton data best be used as bioindices?
- Why are so few used in management so far?
- What do we need to move the science forward?