ZOOPLANKTON INDICATORS FOR INTEGRATED ECOSYSTEM ASSESSMENT: SALMON FORECASTING

Hongsheng Bi[1]
William T. Peterson[2]
Alessandra Conversi[3]

1). University of Maryland, USA
2). NOAA Fisheries, USA
3). CNR - ISMAR - La Spezia, Italy

INTRODUCTION

Assessing ecosystem

Management objectives

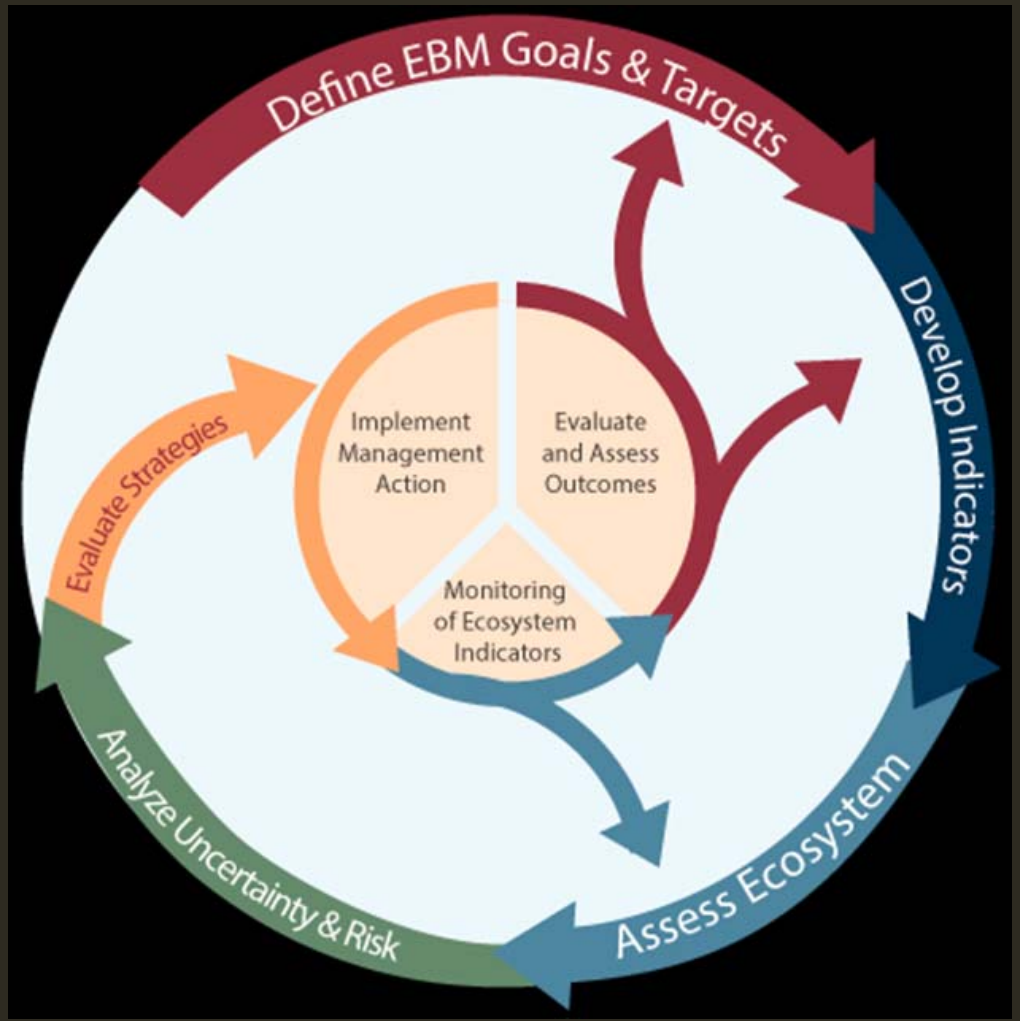
Integration of

- Physical
- Chemical
- Biological -- zooplankton
- Human processes

Analyze uncertainty

Evaluate strategies

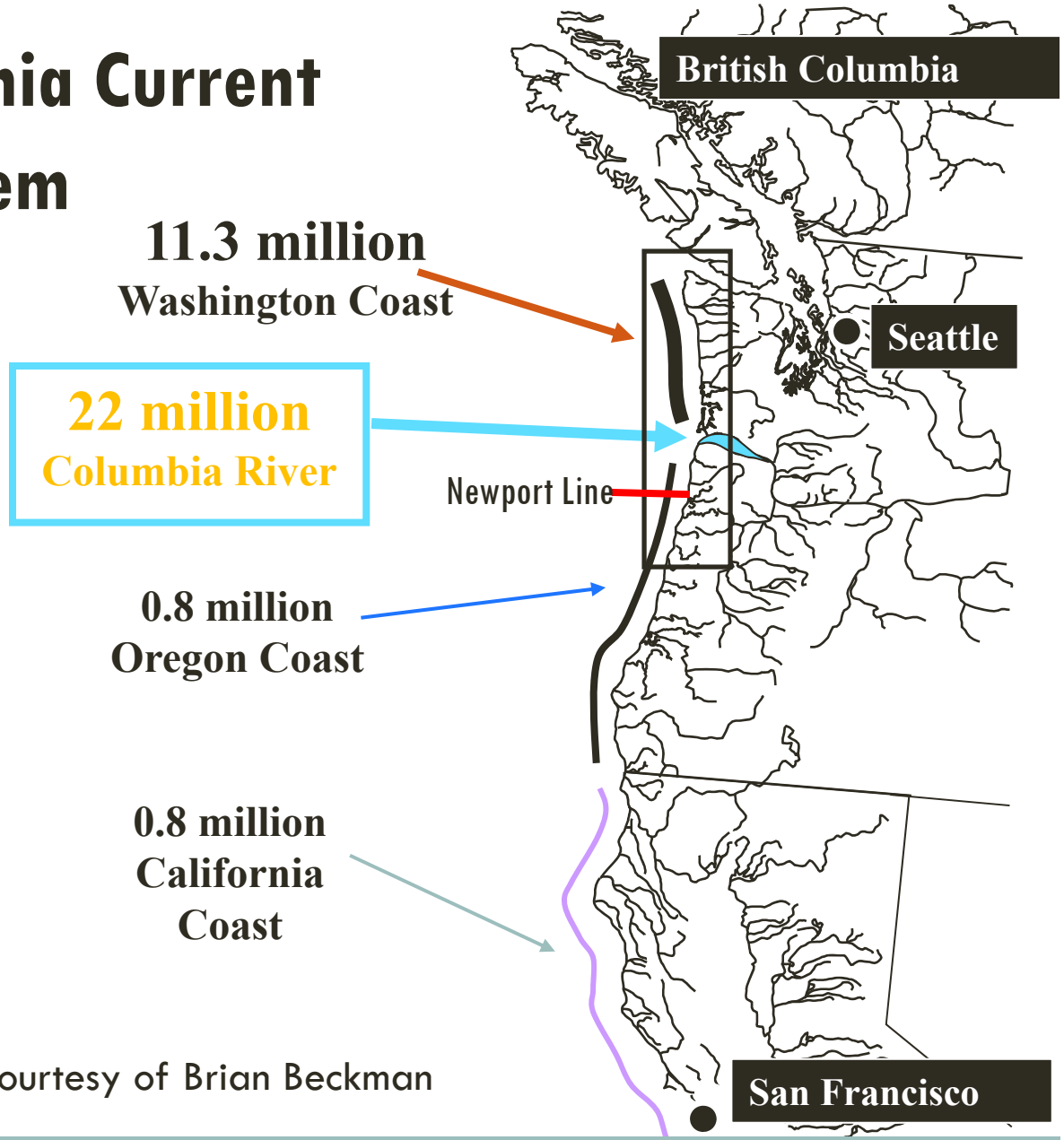
Multi-year, decadal



Source: www.noaa.gov/iea

Northern California Current Regional ecosystem

1. Zooplankton community structure was related to PDO: negative-> cold water copepods (Hooff and Peterson 2006)
2. Salmon ocean survival rate was related to PDO: negative -> higher survival (Manuta et al. 1997)

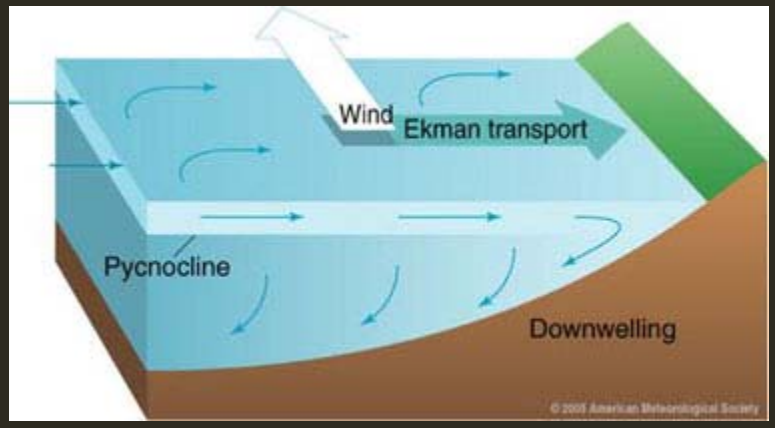


Courtesy of Brian Beckman

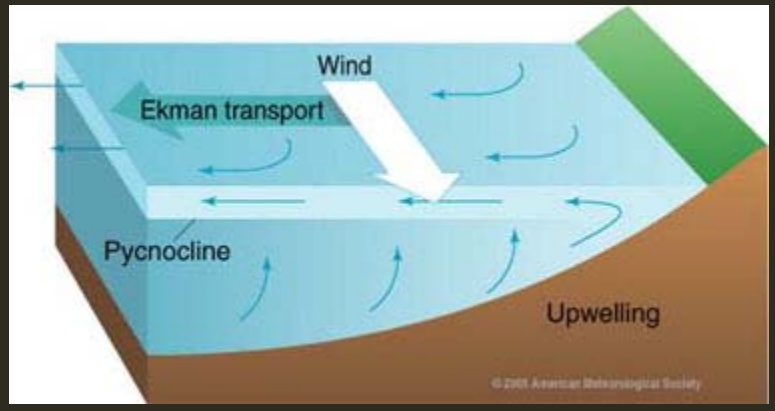
INTRODUCTION: WINDS AND CURRENT STRUCTURE

- Winter
  - Winds from the south
  - Downwelling
  - Subtropical/southern species transported northward & onshore
- Summer
  - Strong winds from the North
  - Coastal upwelling
  - Northern species transported southward

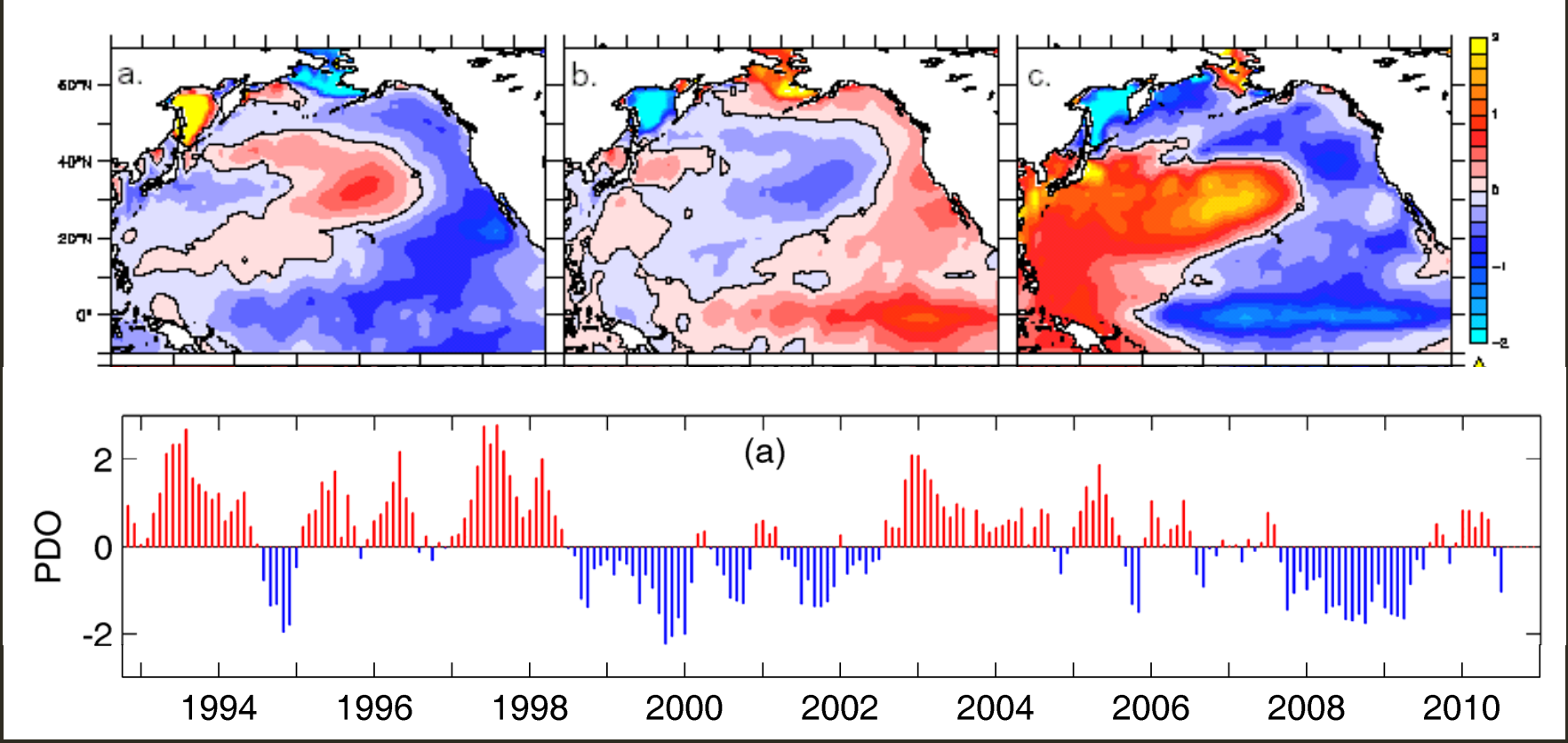
Winter:



Summer:



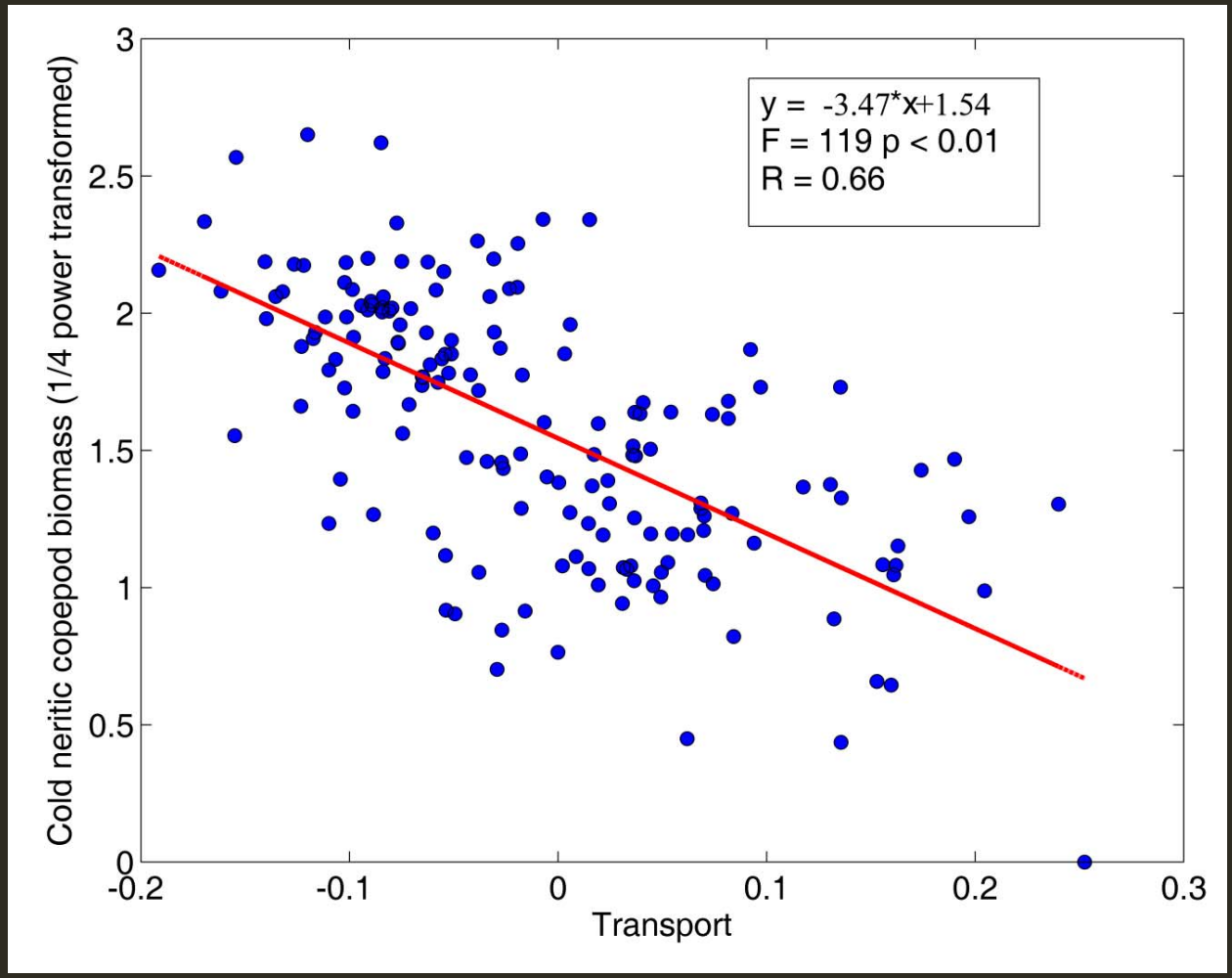
PHASE SHIFTS BY THE PACIFIC DECADAL OSCILLATION NEGATIVE = COOL; POSITIVE = WARM.



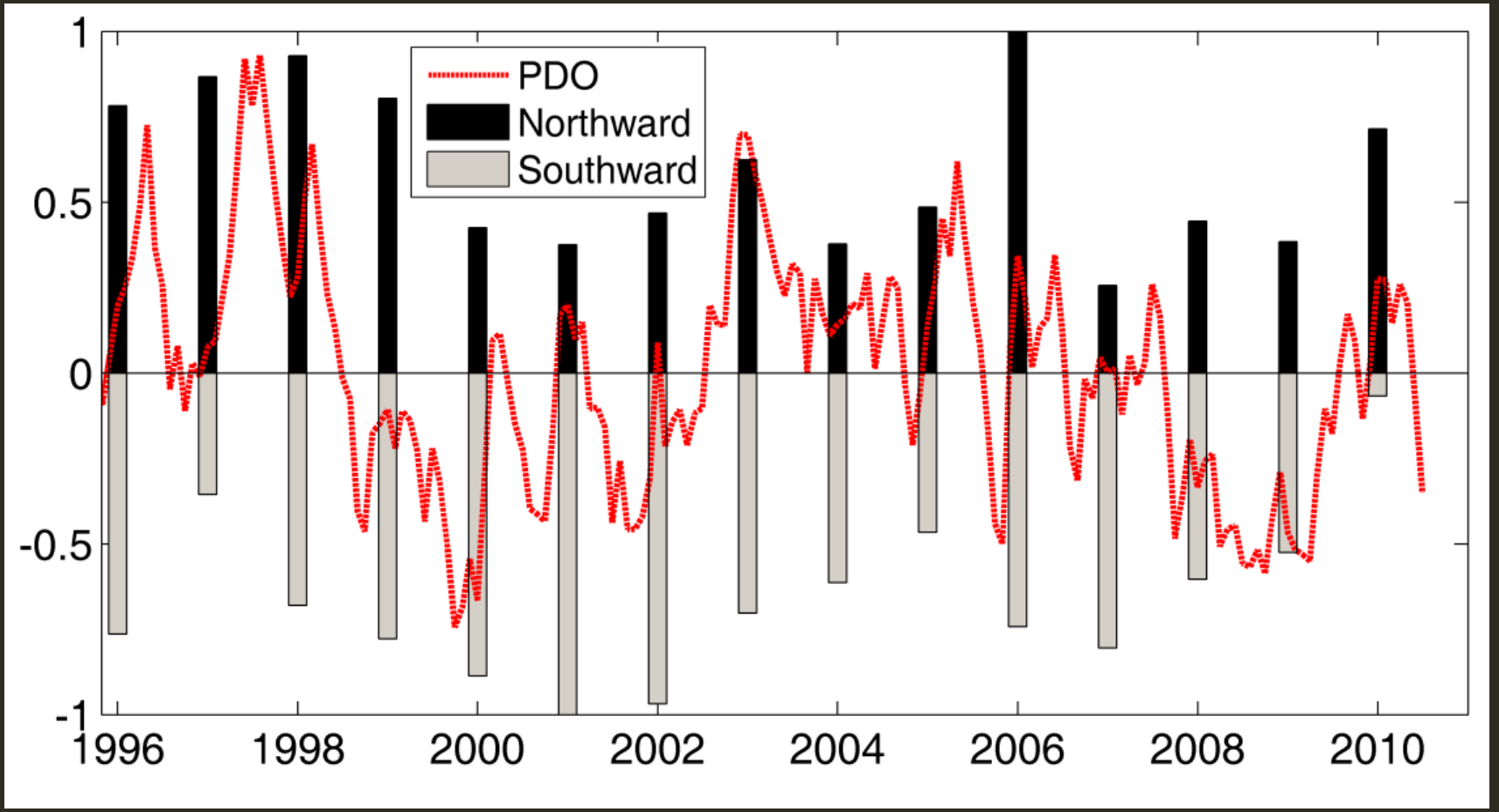
Peterson and Schwing (2003)

COLD WATER COPEPODS AND TRANSPORT

Bi et al. GRL 2011



TRANSPORT AND PDO



FUZZY LOGIC

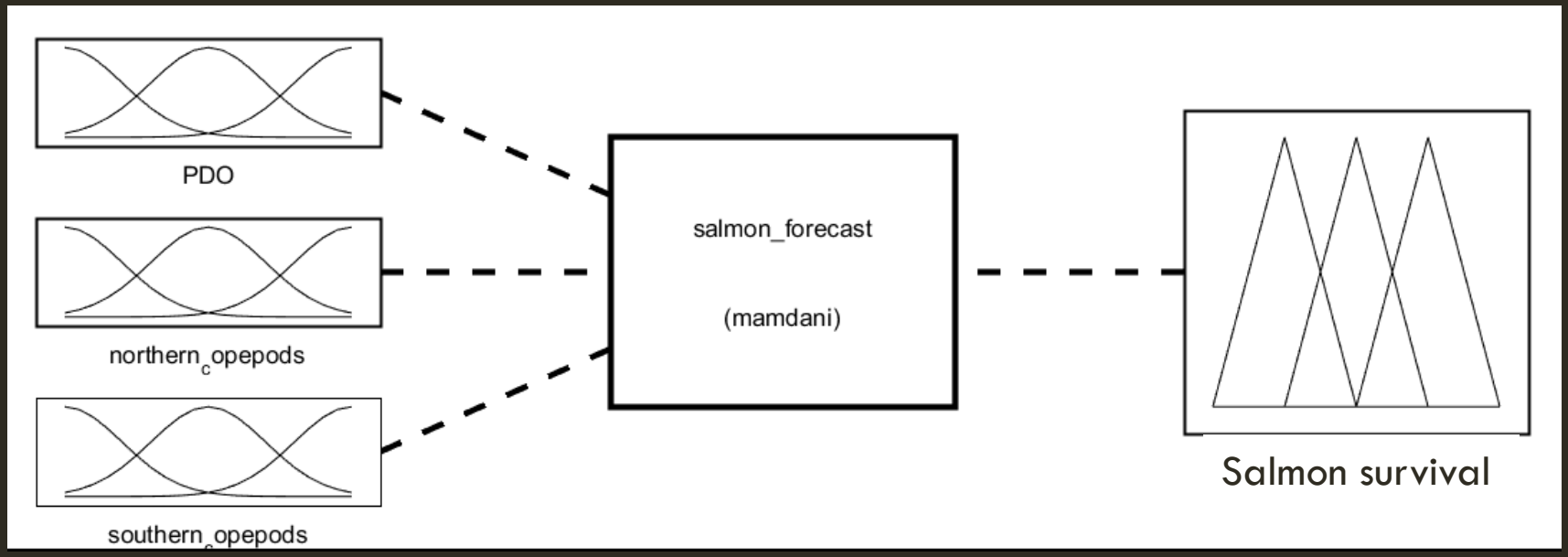
1. Use uncertain information such as individual knowledge and experience;
2. Combine quantitative and qualitative data;
3. Avoid artificial precision
4. Produce results that are found more often in the real world

osystem Indicators	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PDO (Sum Dec-March)	16	6	3	12	7	17	11	15	13	9	5	1	14	4	2	8	10	18
PDO (Sum May-Sept)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17	18
ONI (Average Jan-June)	18	1	1	6	12	14	13	15	8	11	3	10	16	4	5	7	9	17
46050 SST (°C; May-Sept)	15	8	3	4	1	7	18	14	5	16	2	9	6	10	11	12	13	17
Upper 20 m T (°C; Nov-Mar)	17	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	18
Upper 20 m T (°C; May-Sept)	14	11	13	4	1	3	18	16	7	8	2	5	12	10	6	15	17	9
Deep temperature (°C; May-Sept)	18	6	8	4	1	9	12	14	10	5	2	7	13	11	3	17	16	15
Deep salinity (May-Sept)	18	3	7	4	5	14	15	8	6	1	2	11	16	10	9	13	17	12
epod richness anom. . species; May-Sept)	17	3	1	7	6	13	12	16	14	11	8	10	15	4	5	2	9	18
pepod biomass anom. ng C m^{-3}; May-Sept)	17	13	9	10	3	15	12	18	14	11	6	8	7	1	2	4	5	16
pepod biomass anom. ng C m^{-3}; May-Sept)	18	2	5	4	3	13	14	17	12	10	1	7	15	9	8	6	11	16
iological transition (day of year)	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13	18
hyoplankton biomass C 1000 m^{-3}; Jan-Mar)	18	9	2	5	7	16	15	11	14	13	1	10	3	12	8	6	17	4
hook salmon juvenile ches (no. km^{-2}; June)	17	4	5	15	10	12	16	18	11	8	1	6	7	14	3	2	9	13
oho salmon juvenile ches (no. km^{-2}; June)	17	7	12	5	6	2	14	18	15	3	4	9	10	13	16	1	11	8
Mean of ranks	16.5	6.6	5.9	6.8	5.8	11.7	13.9	14.9	11.3	8.5	2.7	7.5	11.4	7.5	6.1	7.5	11.7	14.5
nk of the mean rank	18	5	3	6	2	13	15	17	11	10	1	7	12	7	4	7	13	16
stem Indicators not included in the mean of ranks or statistical analyses																		
hysical Spring Trans l based (day of year)	3	6	17	14	4	11	13	18	11	1	5	2	7	10	15	8	16	9
hysical Spring Trans rographic (day of year)	17	3	13	8	5	12	14	18	6	9	1	9	16	3	11	2	15	7
Upwelling Anomaly (April-May)	8	2	15	4	7	12	11	18	8	3	5	6	13	15	13	10	17	1
th of Upwelling Season UI based (days)	6	2	16	10	1	11	8	18	5	3	7	3	13	15	13	12	17	9
1-5 (°C; May-Sept)	8	6	5	4	1	3	18	15	9	16	2	17	10	7	13	12	14	11
epod Community Index MDS axis 1 scores)	18	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11	17
Coho Juv Catches no. fish km^{-2}; Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA	NA	NA

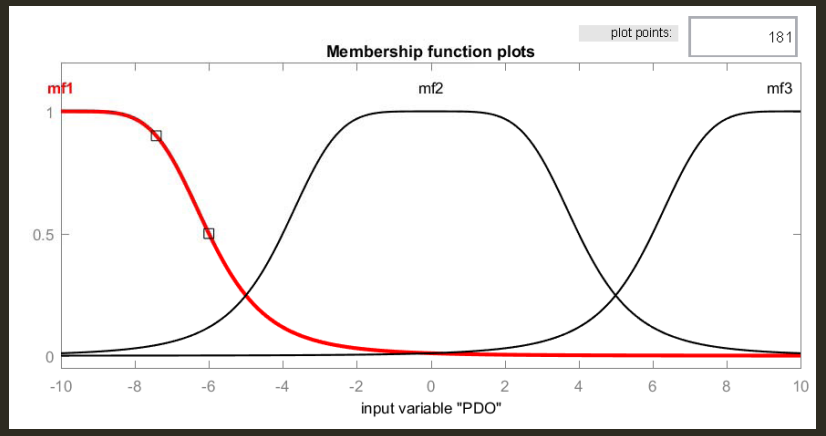
- Difference between physical and biological indicators
  - 2015
  - 2012
- Difference within one biological indicators
  - 2013, 2007
  - Very difficult to make the call

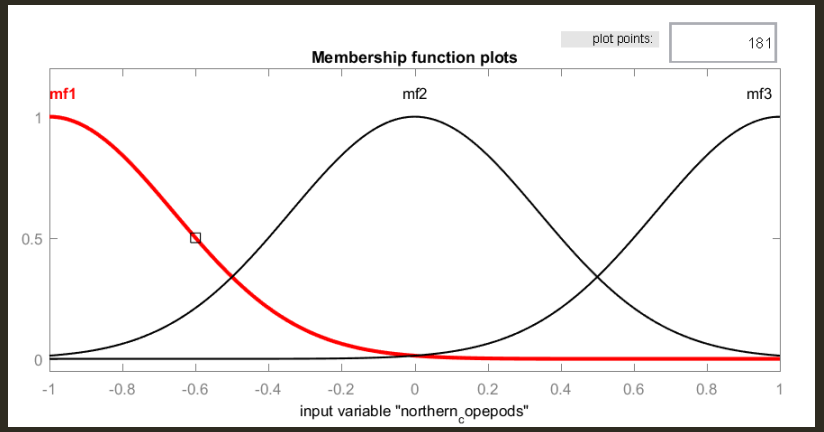
FUZZY LOGIC SYSTEM

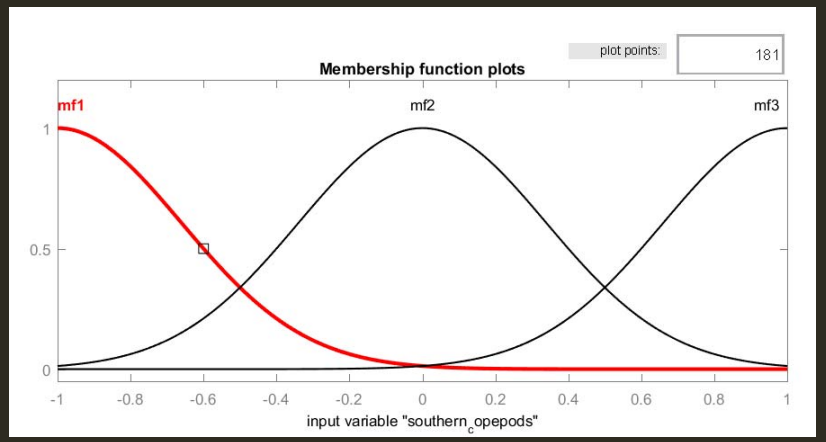
Started from three input variables: PDO, Nothern Copepods, Southern copepods, one output variable: salmon survival rate

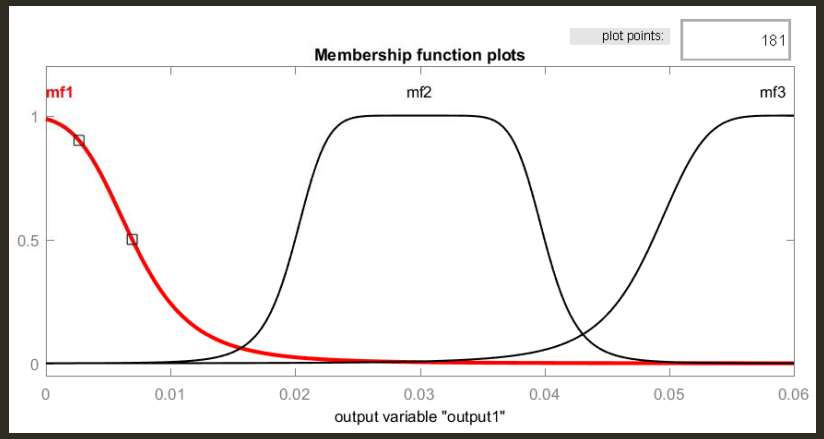


MEMBERSHIP FUNCTIONS



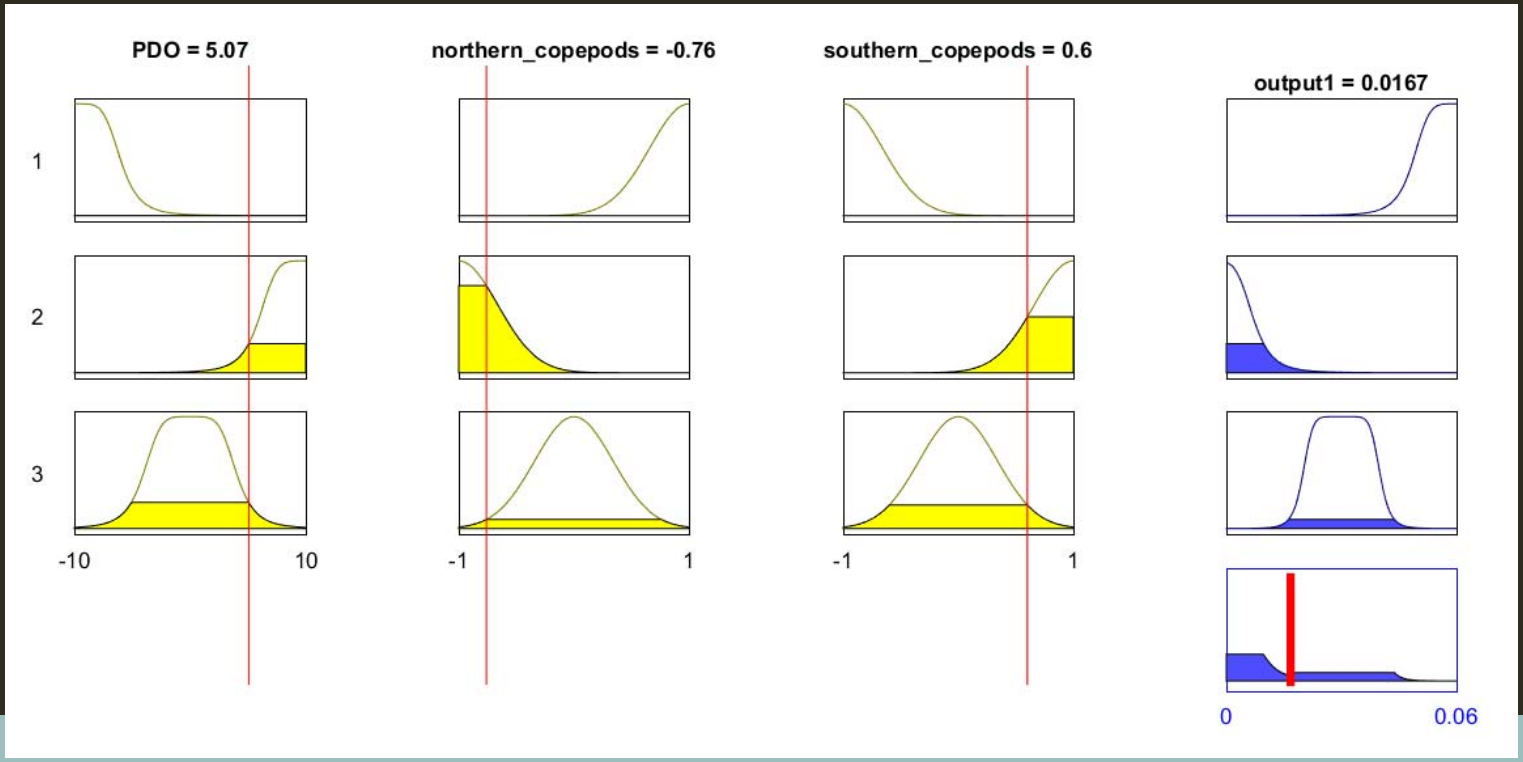






RULES

1. positive PDO, less northern copepods, more southern copepods, survival low
2. negative PDO, more northern copepods, leas southern copepods, high survival,
3. mid-range PDO, northern copepods, southern copepods, medium level survival



SUMMARY

It overcomes the uncertainties in the empirical relationships, interactions among different variables.

It works in general, but it requires more training for better results.

Flexibility in setting up membership functions, but more objective approaches would be better.