

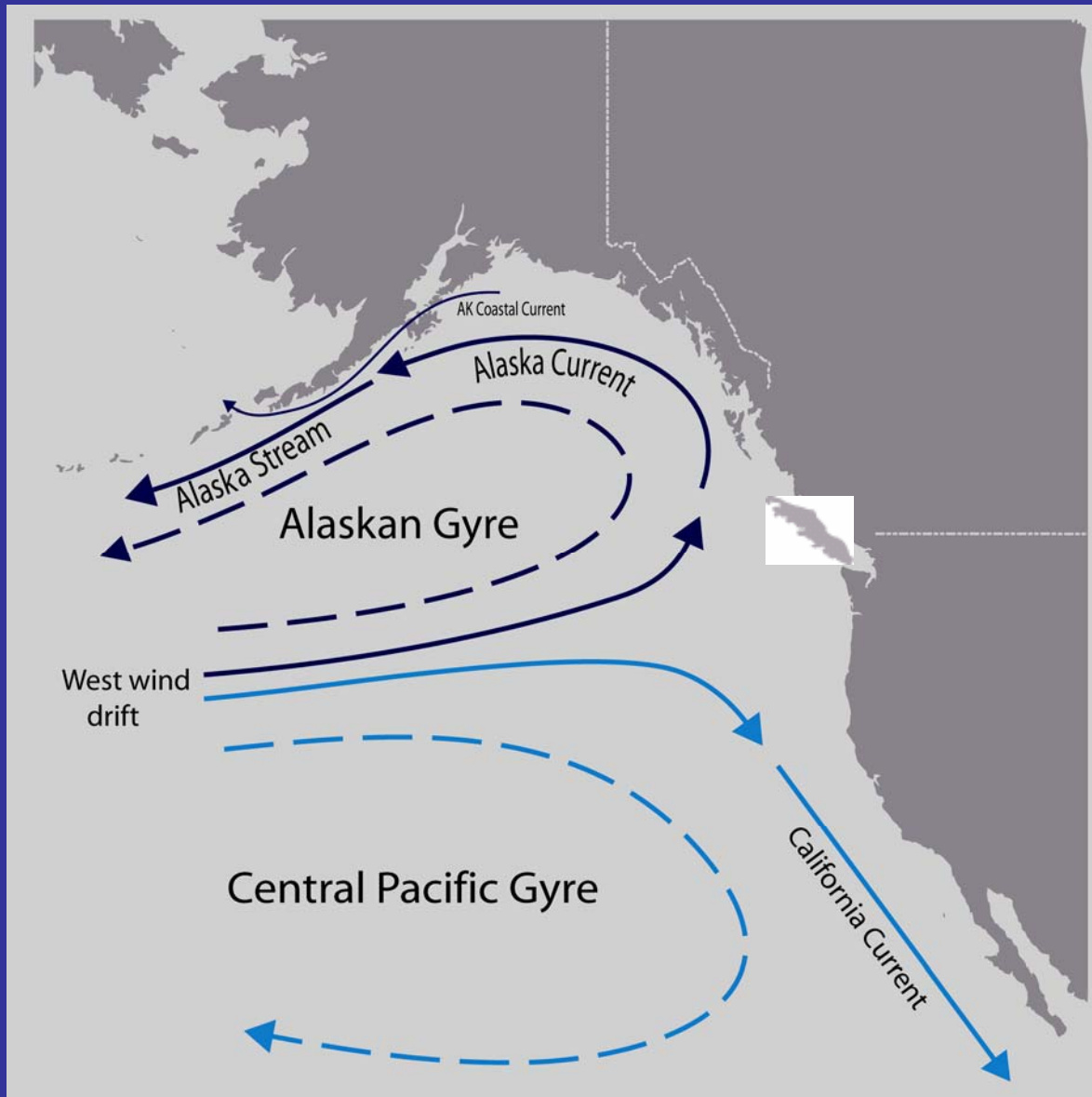
The California Current Ecosystem: an overview

In alphabetical order:

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Sea Surface Temperature (SST)

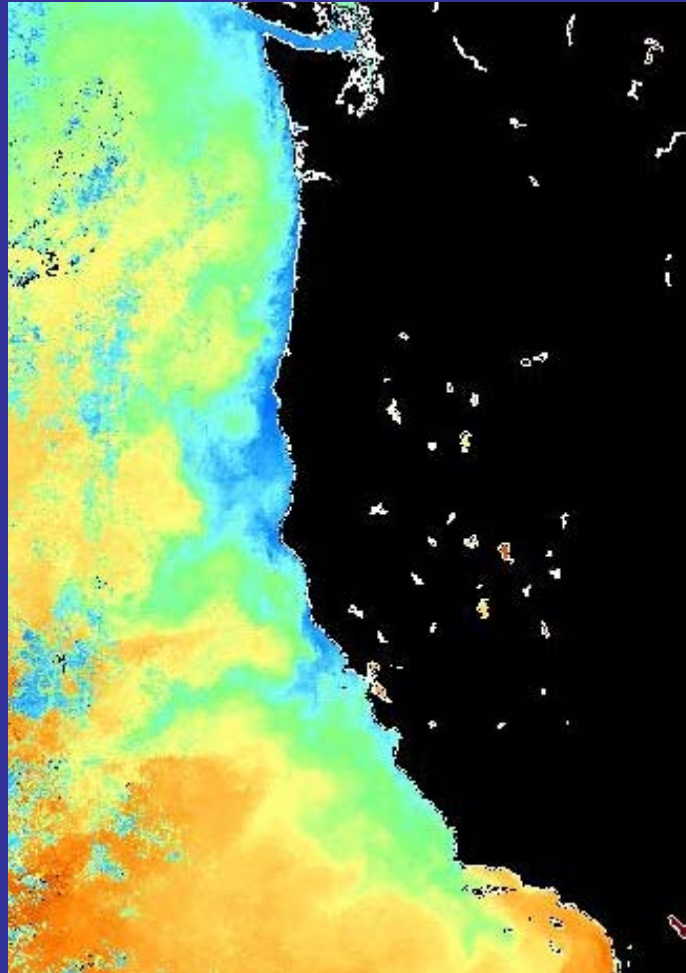


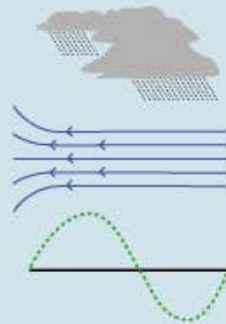
Image: NOAA-Coastwatch program (SWFSC)

Winter storms frequent and strong

Significant freshwater input

Relatively smooth coastline, large canyons in shelf

Primary productivity and zooplankton biomass strongly seasonal along shelf



Winds mostly upwelling favorable

Strongest coastal upwelling, minor freshwater input

Major coastal promontories

Primary productivity strongly seasonal
zooplankton biomass seasonal

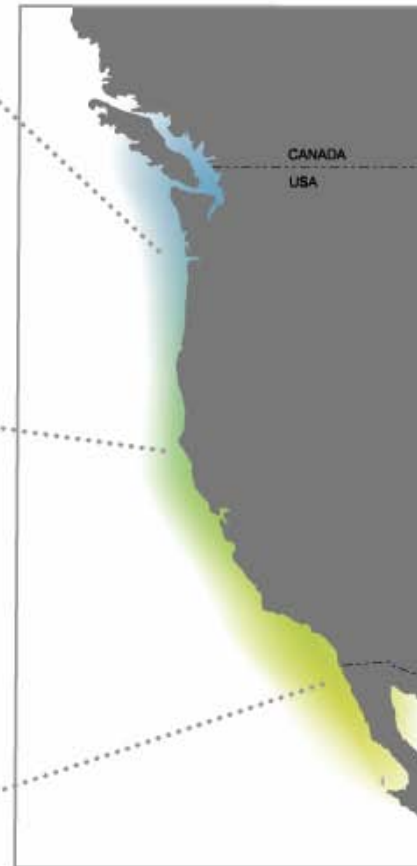


Fewer storms, weaker winds

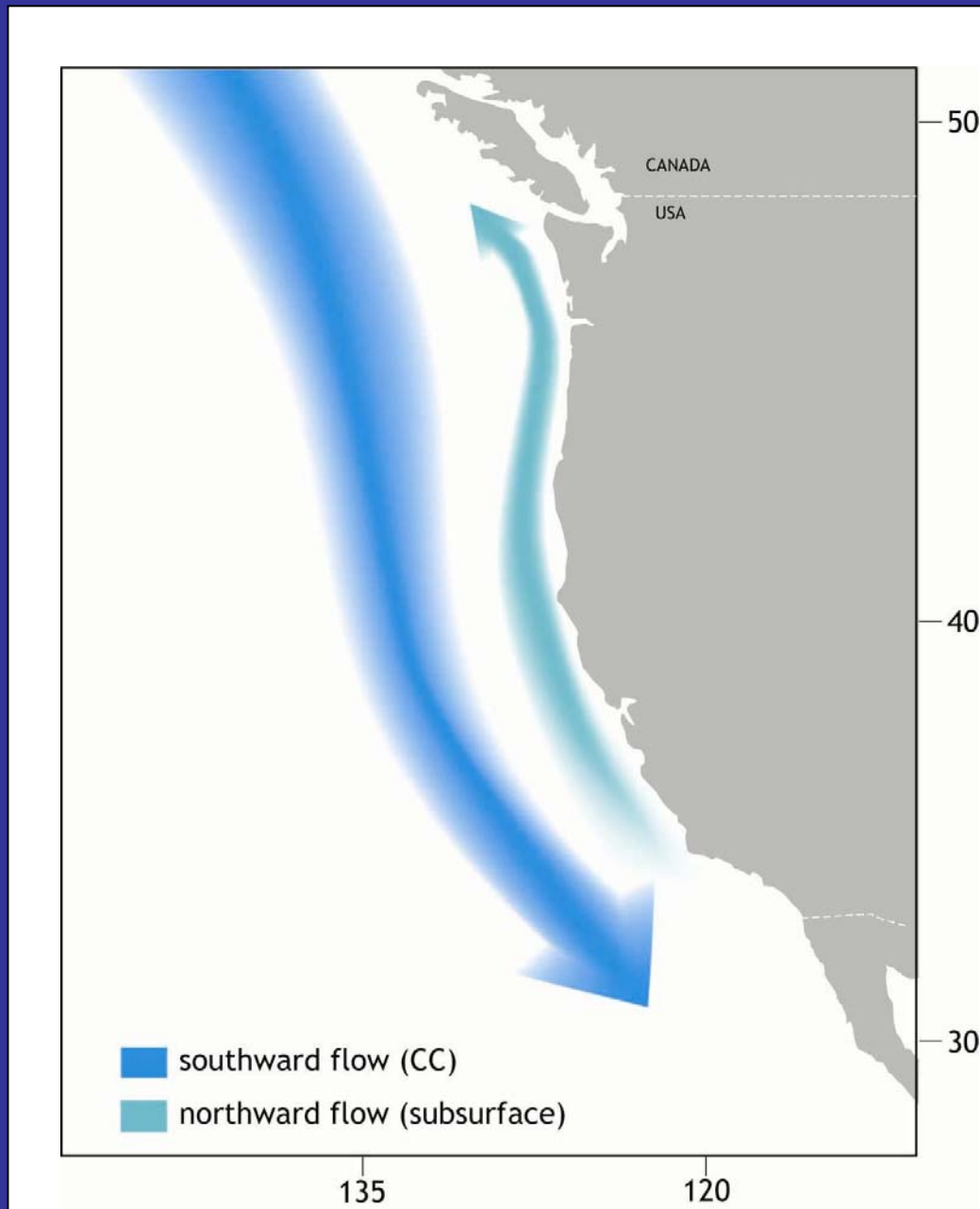
Stable stratification, weak local upwelling

Narrow shelf

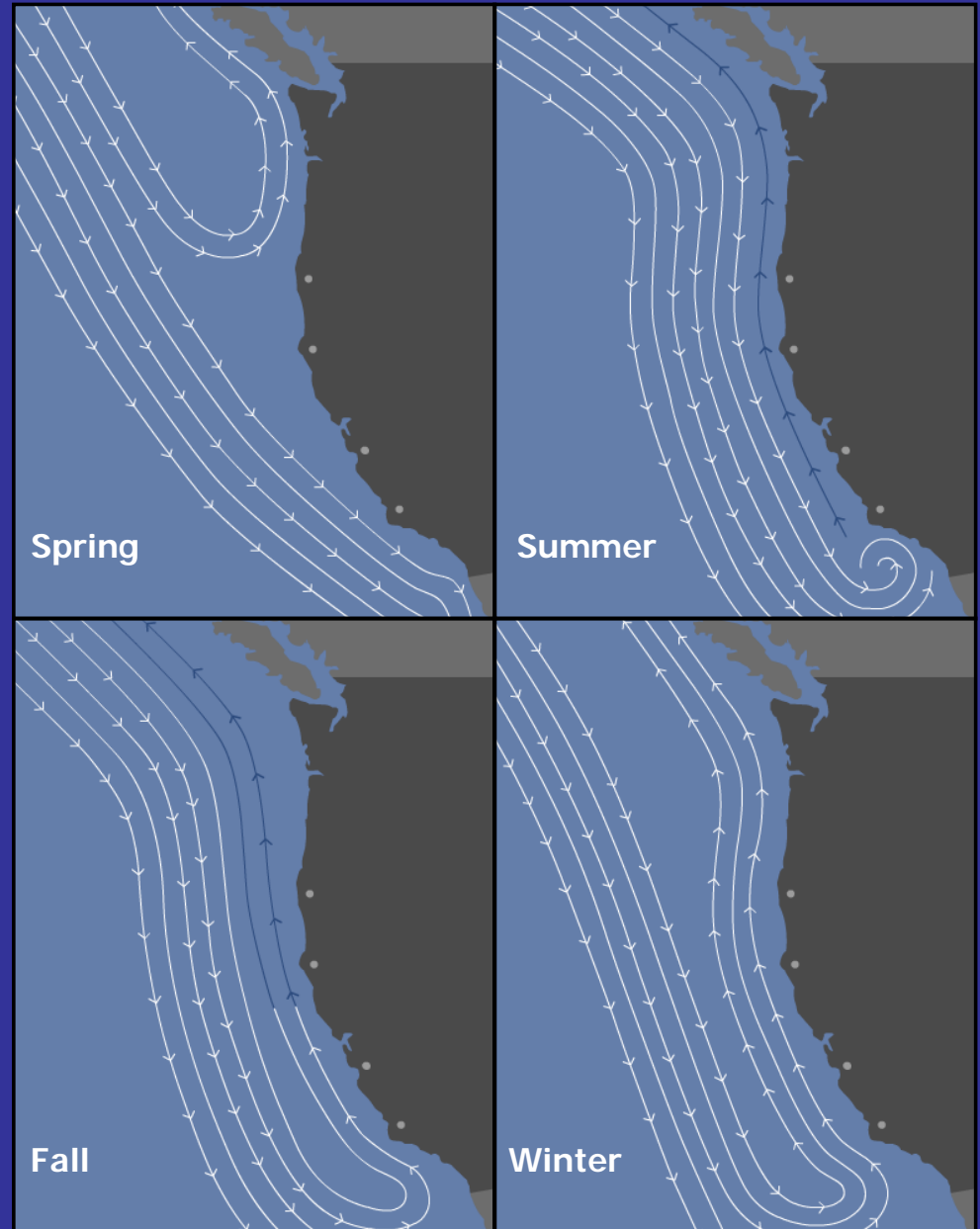
Damped seasonality in primary productivity
and zooplankton biomass



The Physics



SEASONAL CHANGES: LARGE SCALE CURRENTS



(from Femia 2003, based on Hickey 1998)

SEASONAL CHANGES: UPWELLING DYNAMICS

- Equatorward wind in the summer leads to upwelling
- No wind or onshore wind downwelling (mostly in winter)
- Both intermittent as well as persistent upwelling dynamics have been observed

INTERANNUAL TO INTERDECADAL CHANGES

El Niño Southern Oscillation

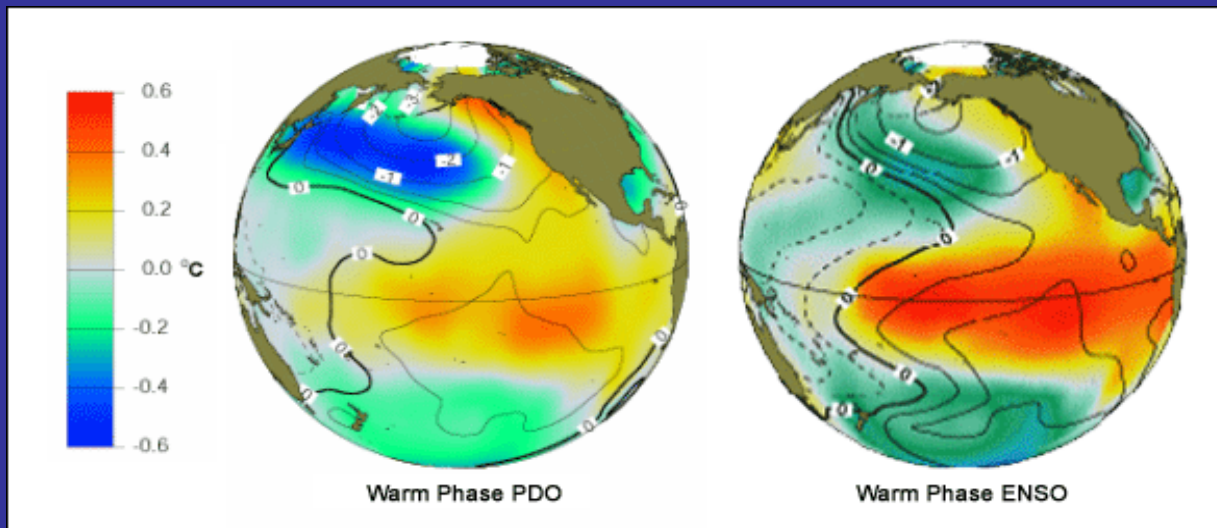
interannual

Pacific Decadal Oscillation

interdecadal (warm phase 1976-1998?) Mantua et al., 1997

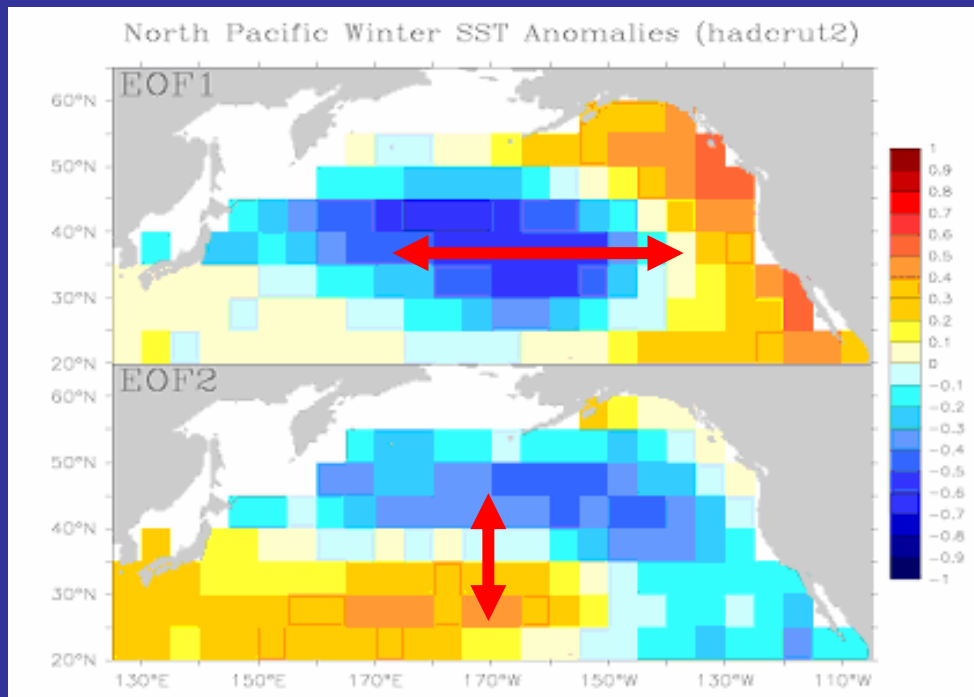
‘Victoria pattern’: interdecadal (1989-1998)

Bond et al., 2003



From:

<http://www.cses.washington.edu/cig/pnwc>



- Pacific Decadal Oscillation

- interdecadal
- switches in 1947; 1977 (Mantua et al., 1997)

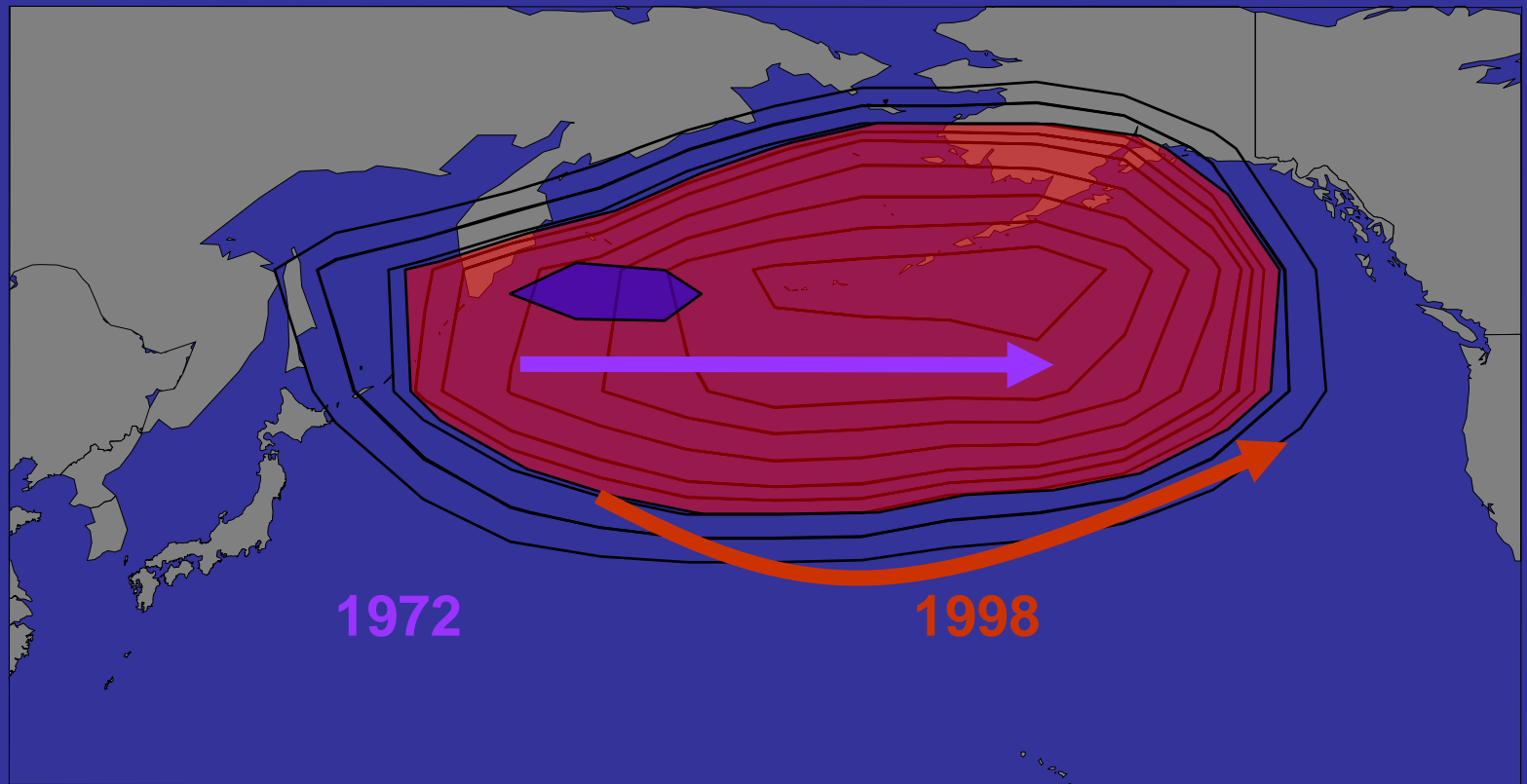
- ‘Victoria pattern’

- interdecadal
- switches in 1989 and 1998? (Bond et al., 2003)



*Indicated by area with atmospheric pressure less than or equal to 100.5 kilopascals.

VARIABILITY IN THE ALEUTIAN LOW PRESSURE SYSTEM:



Intense Aleutian Lows

(Thomson & Russian. *In press*)

1. increases poleward advection of warm, southern waters in *winter* (i.e. increases the Davidson Current)
 - warm upper waters increase water stability
 shallows the mixed layer depth
 - coupled with vertical velocity at depth
 further pushes up the mixed layer depth
 - shallow MLD
 cold, nutrient waters are available to the photic zone increasing primary productivity

Intense Aleutian Lows

(Thomson & Russian. *In press*)

2. increased onshore transport associated with downwelling
 - larvae and zooplankton retention near coastal, productive areas (particularly relevant in March)
3. spring transition to upwelling season
 - shallow mixed layer depth present
 - larvae and zooplankton onshore

Weak Aleutian Lows (Logerwell et al., 2001)

1. decreased poleward advection in *winter* leads to weak downwelling
 - Less onshore transport
 - decreased stratification next spring which influences biological effectiveness of upwelling (Gargett, 1997; Logerwell et al., 2001)

The Biology

Zooplankton communities-southern California Current

Euphasiids (Brinton and Townsend, 2003)



<i>Euphasia pacifica</i>	→	PDO / -
<i>Thysanoessa spinifera</i>	}	No rltshp.
<i>Nematoscelis difficilis</i>		
<i>Thysanoessa gregaria</i>		
<i>Euphasia recurva</i>	}	PDO /+
<i>Euphasia giboides</i>		
<i>Euphasia eximia</i>		
<i>Nictiphanes simplex</i>		

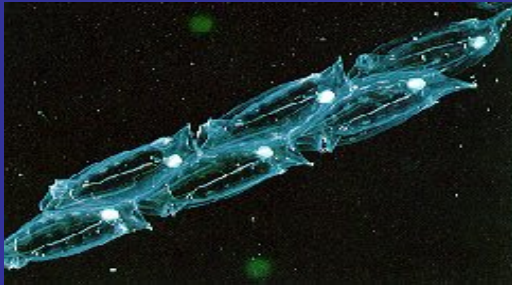
Copepods (Rebstock, 2001; 2002)



<i>Calanus Pacificus</i>	→	PDO /+
<i>Metridia Pacifica</i>	→	PDO / -

Zooplankton communities-southern California Current

Pelagic tunicates (Lavaniegos and Ohman, 2003)



Salpa fusiformis
Salpa aspera
T. Democratica
lasis zonaria

} Present throughout

Salpa maxima
Pegea socia
Cyclosalpa bakeri
C. affinis

} Disappeared after 1976

Zooplankton communities-northern California Current

Euphasiids



Euphasia pacifica
Thysanoessa spinifera

Copepods (Mackas, 2003; Peterson et al., 2003)



Pseudocalanus minimus

Calanus marshallae

Acartia longiremis

Neocalanus plumchrus

N. cristatus

Eucalanus bungii

Paracalums parvus

Ctenocalanus vanus

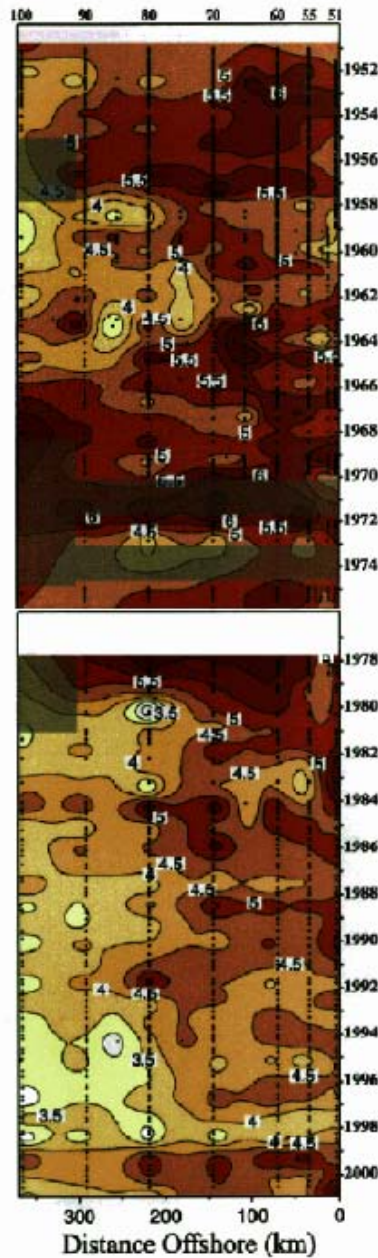
Clauscalanus

Cold water – boreal
PDO/-

Cold water – subarctic
PDO/-

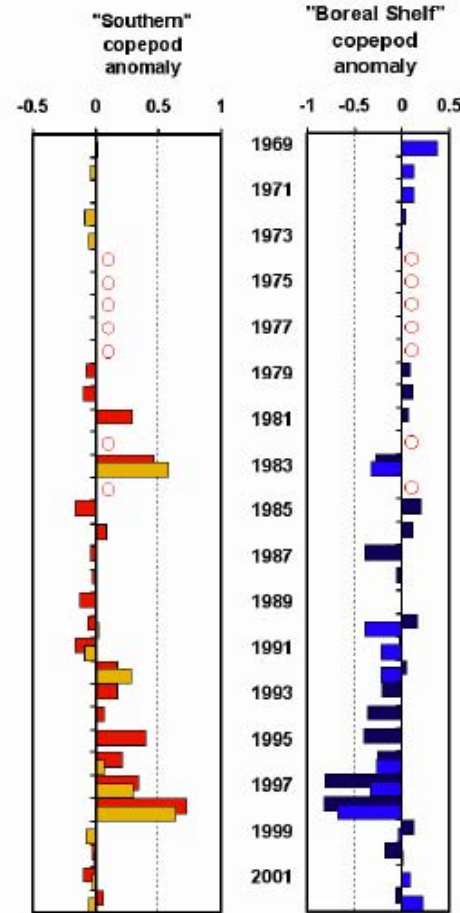
Warm water –southern
PDO/+

**ln(Zooplankton biomass)
CalCOFI Line 80**



Community Composition

**BC/OR
zooplankton**



**CCS
copepods**

**CCS
salps**

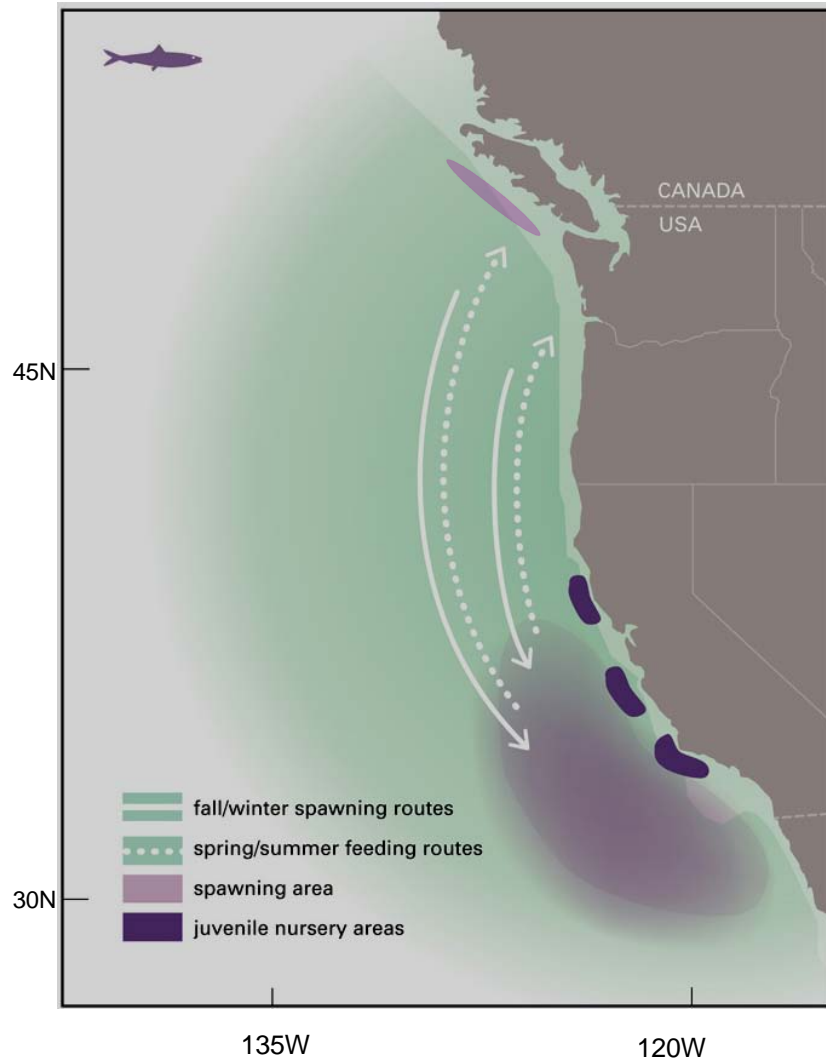
Key Fish Species #1

Pacific sardine (*Sardinops sagax*)



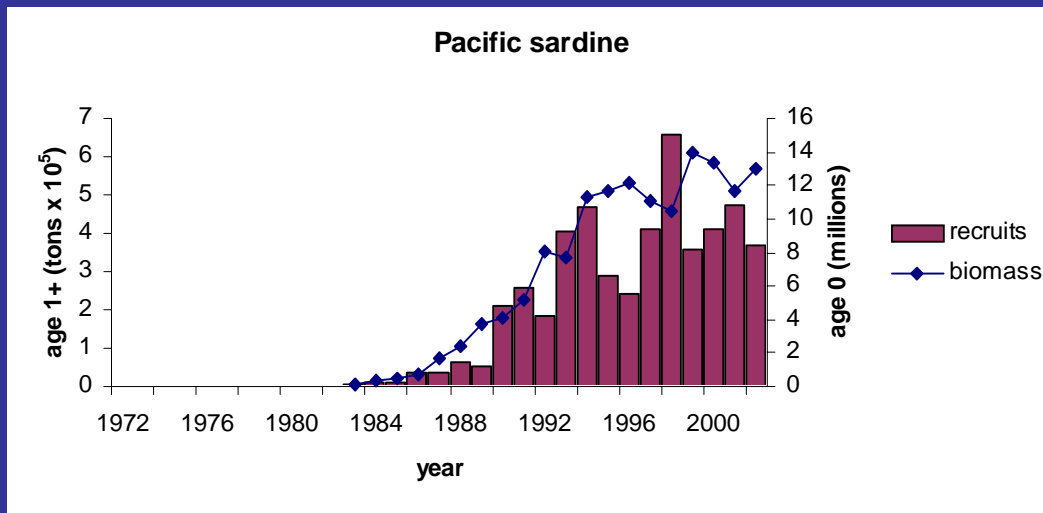
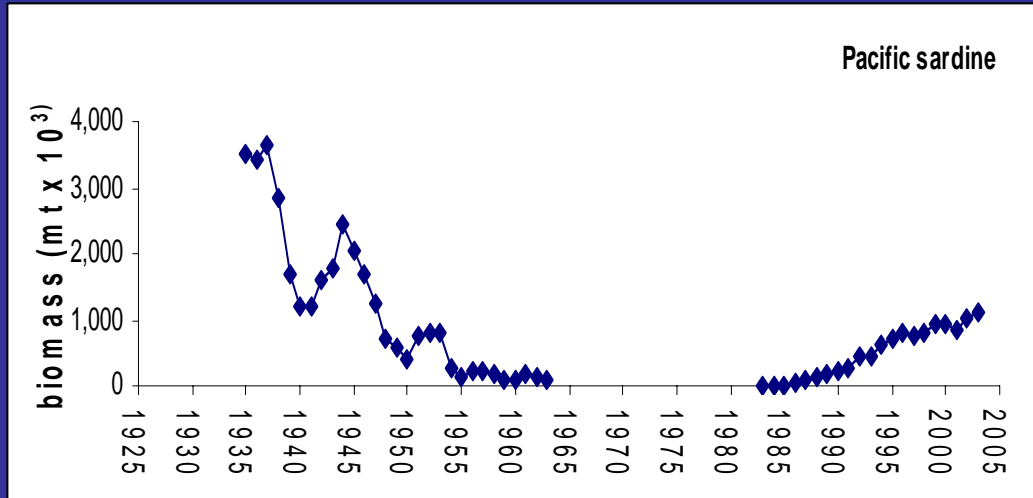
- May reach 41 cm, but seldom larger than 30
- May live as long as 13, but usually younger than 5 years
- Regional variation in size at age—older larger fish are further north
- Low biomass--age at maturity 1; high biomass--age at maturity 2-3
- Planktivores

Pacific sardine (*Sardinops sagax*)



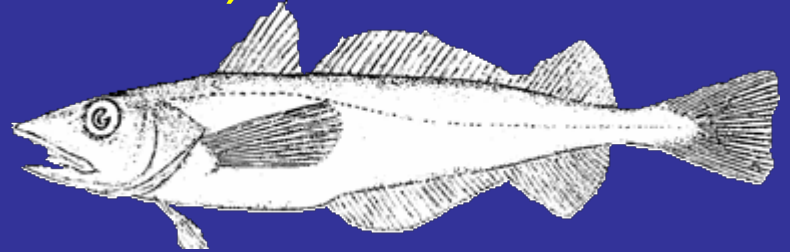
- Winter spawning off of California
- Summer feeding throughout whole CC
- Oviparous multi-batch spawners
 - Spawn in loosely aggregated schools in upper 50 m
 - Off California main spawning occurs February - April
 - Since 1997 there has been evidence of spawning off of British Columbia

Pacific sardine (*Sardinops sagax*)



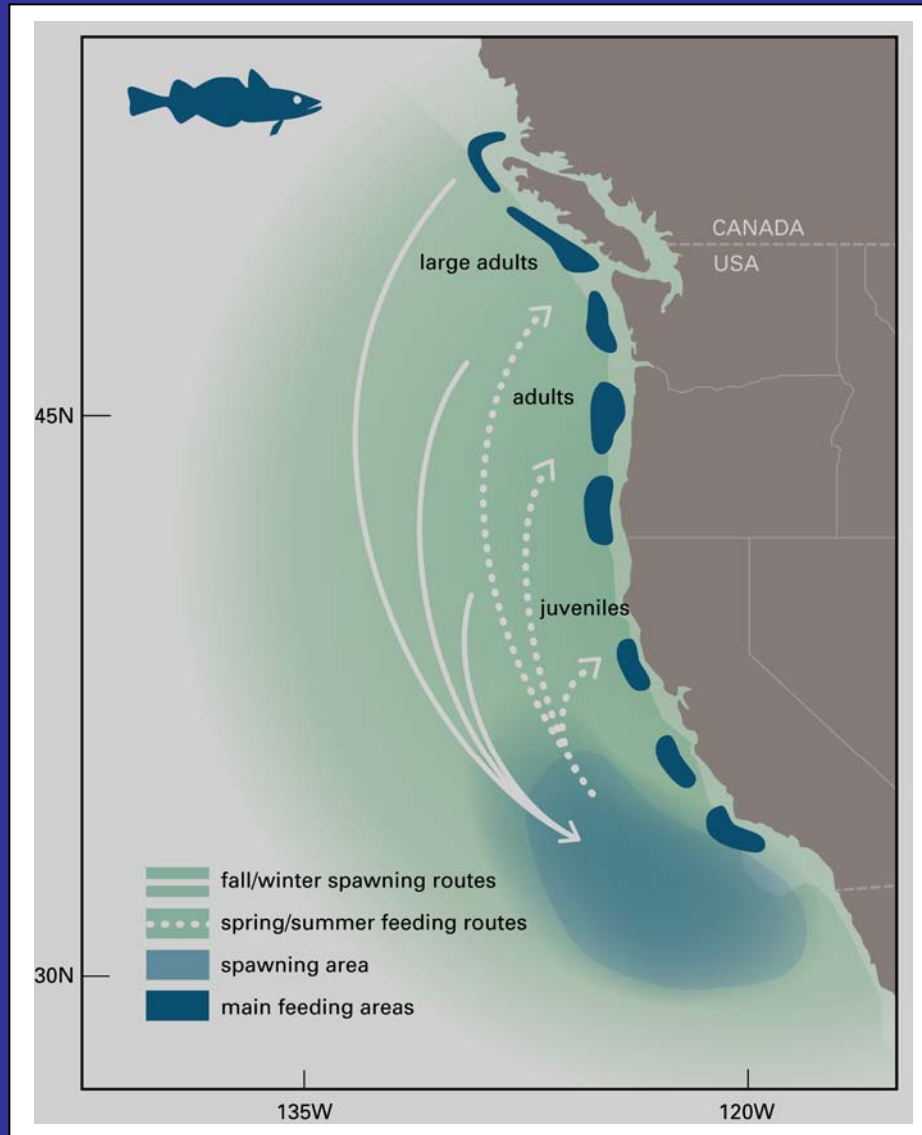
Key Fish Species #2

Pacific hake (*Merluccius productus*)



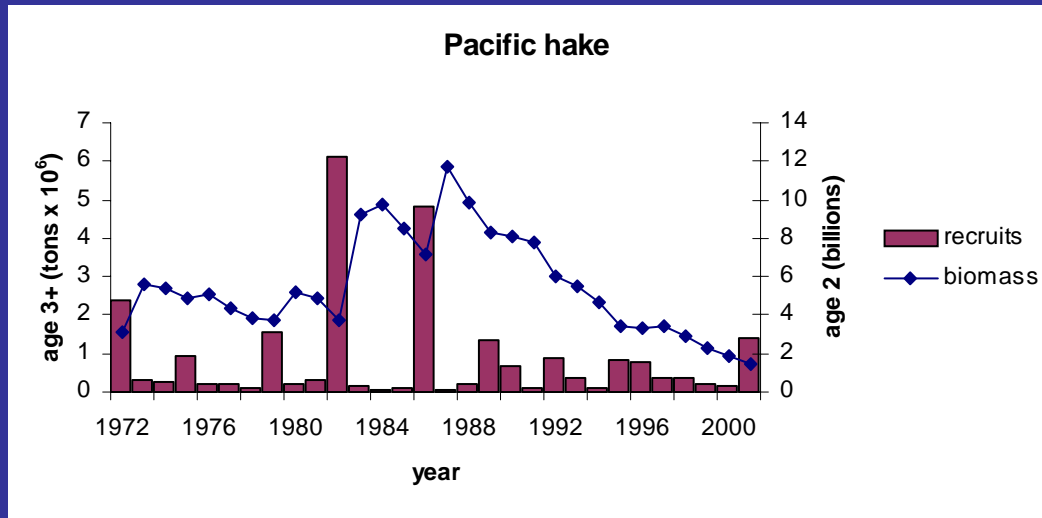
- Can live up to 27 years, but most not older than 15
- Sexually mature at age 3
- Regional variation in size at age—older larger fish further north
- Eat zooplankton (.e. euphausiids) and small fish

Pacific hake (*Merluccius productus*)



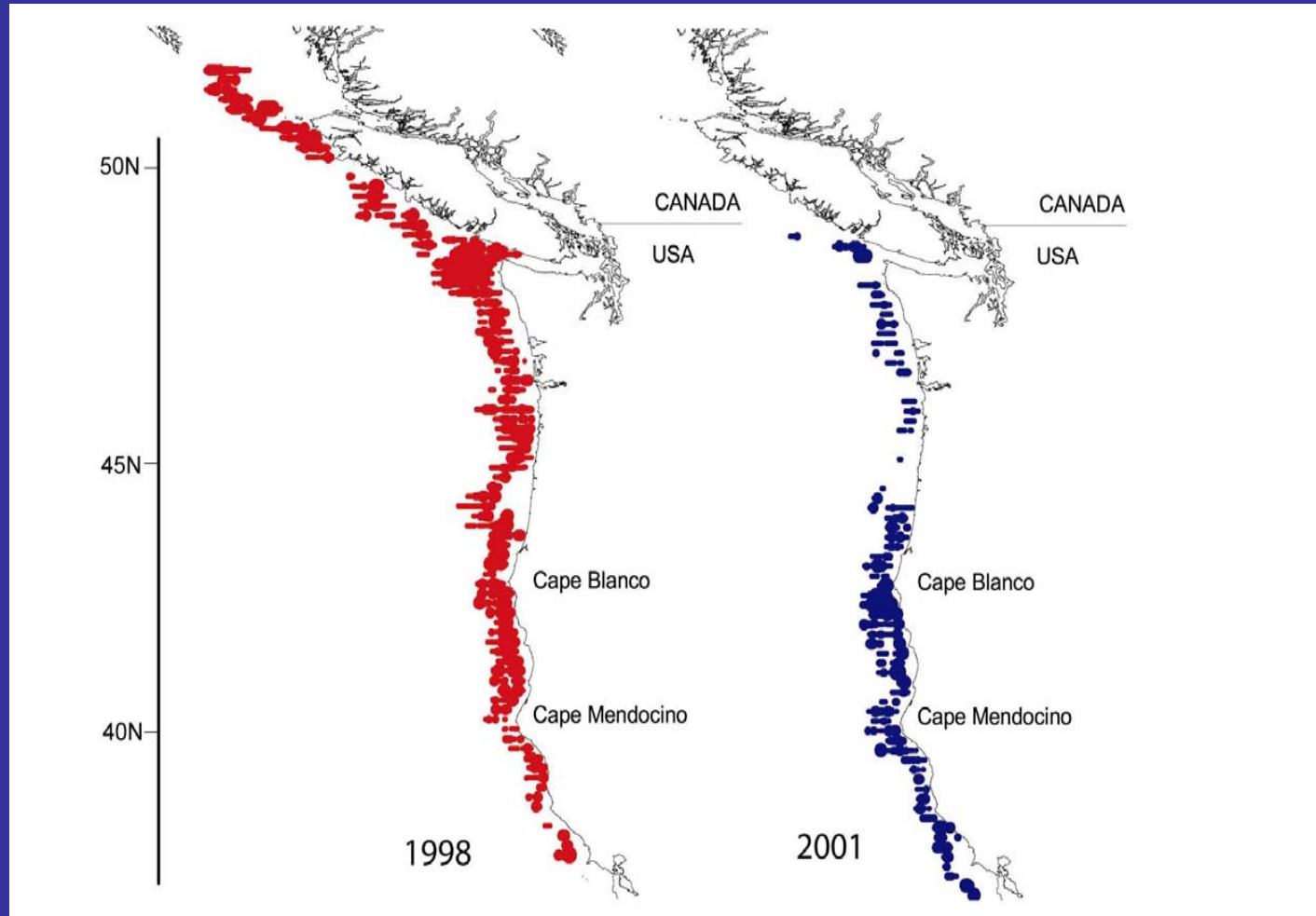
- Winter spawning off of California
- Summer feeding throughout whole CC
- Oviparous batch spawners
 - Spawn in aggregated schools at depth (200 m)
 - Off California, spawning occurs January - March
 - Since 1994, have spawned off the west coast of Canada

Pacific hake (*Merluccius productus*)



Pacific hake (*Merluccius productus*)

distribution in tri-ennial NMFS survey



Data from NMFS/AKFSC

The links

The **interannual** and **interdecadal** influences on the CCS

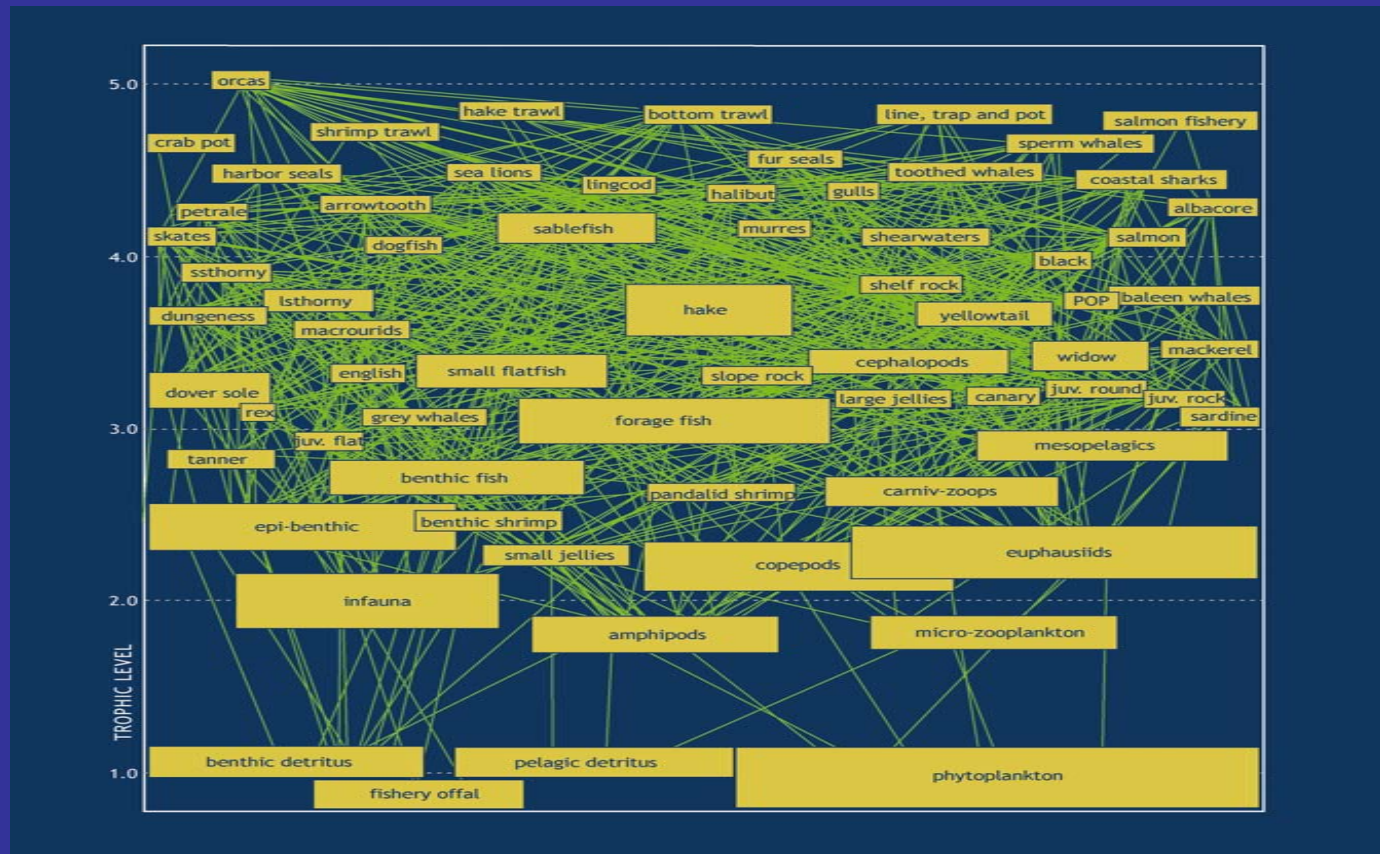
- observed as changes in upwelling or transport
- observed as changes in zooplankton community structure

coincide with **changes in recruitment and abundance** of a number of species including:

- sablefish (*Anoplopoma fimbria*)
- Pacific salmon (mainly coho and chinook; *O. kisutch* and *O. tshawytscha*)
- rockfish species (*Sebastes* spp. e.g. California juvenile abundance of 14 species)
- Pacific cod (*Gadus macrocephalus*) off of west coast VI
- Pacific halibut (*Hipoglossus stenolepis*)

as well as **changes in migratory** patterns (e.g. Pacific hake and sardine)

.....and the ecosystem?



(Modified from Field, 2004)