The California Current Ecosystem: an overview

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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

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)
Aleutian low pressure system
e
1998 (strong phase)

1972 (weak phase)

BERING SEA
Aleutian Islands

West Wind Drift

Alaska Current (warm)

California Current (cold)

NORTH PACIFIC
OCEAN

*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)

- *Euphasia pacifica*
- *Thysanoessa spinifera*
- *Nematoscelis difficilis*
- *Thysanoessa gregaria*
- *Euphasia recurva*
- *Euphasia giboides*
- *Euphasia eximia*
- *Nictiphanes simplex*

PDO / -

 PDO /+

No rltshp.

**Copepods** (Rebstock, 2001; 2002)

- *Calanus Pacificus*
- *Metridia Pacifica*

PDO /+

PDO / -
Zooplankton communities - southern California Current

**Pelagic tunicates** (Lavaniegos and Ohman, 2003)

- *Salpa fusiformis*
- *Salpa aspera*
- *T. Democratica*
- *Iasis zonaria*

- *Salpa maxima*
- *Pegea socia*
- *Cyclosalpa bakeri*
- *C. affinis*

- Present throughout
- 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/+
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 triennial 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)