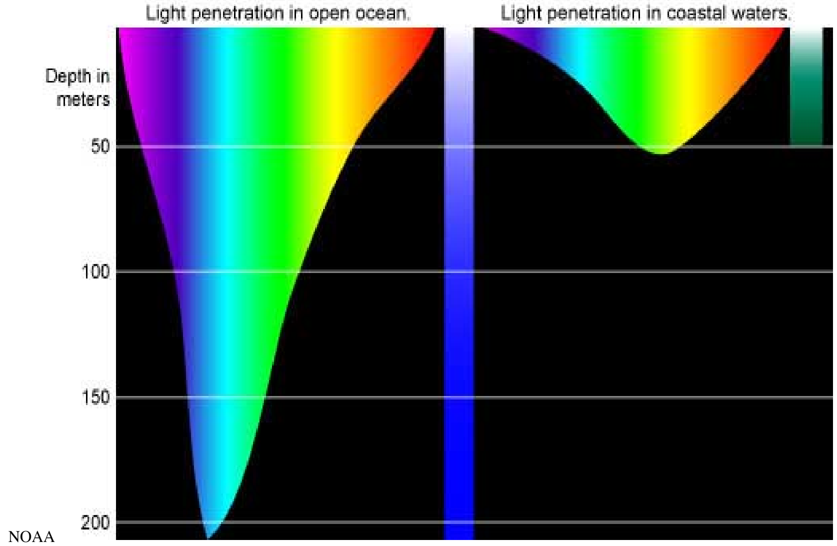
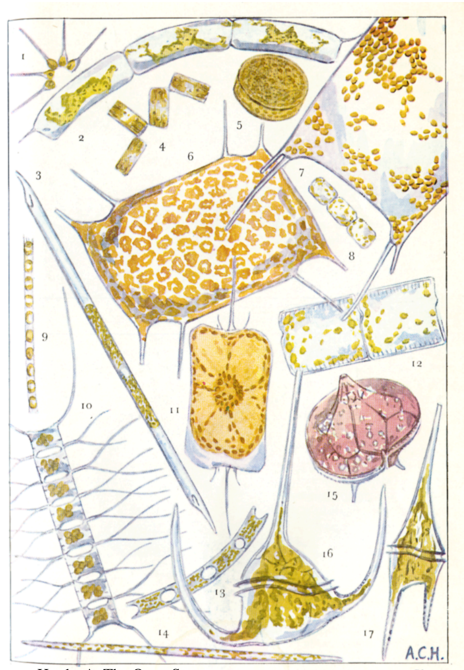

Oregon Coastal Oceanography

Light is absorbed rapidly in sea water. Even in very clear open ocean water there is only enough light for plant growth down to about 100 m. In coastal water the photic zone can be as shallow as 10 or 20 m.

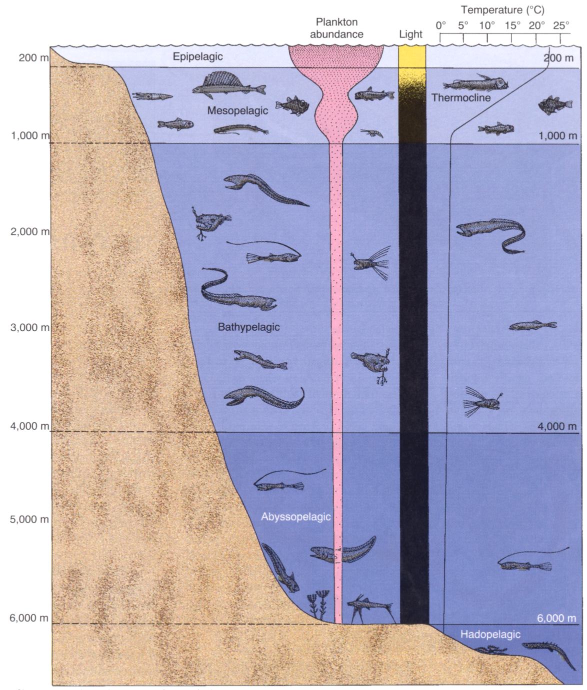




Hardy, A. The Open Sea

Plate 1

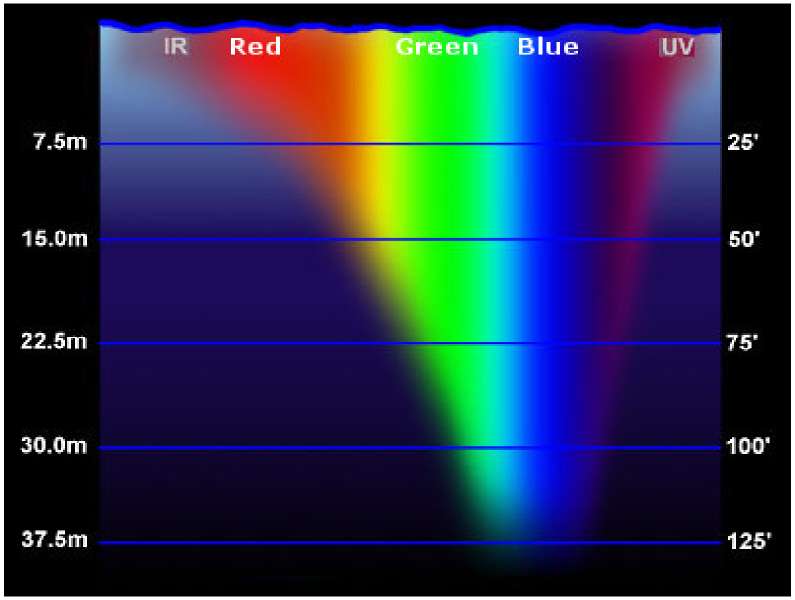
The plants of the open ocean are tiny mostly one celled creatures. These are examples of the larger varieties.



Castro and Huber, Marine Biology

The average depth of the ocean is 4 Km. Just the very surface of the ocean gets enough light for plant growth.

Water absorbs light of different wave length more or less rapidly. Blue and green light penetrate the furthest. Red light, especially Infra red light, penetrates the least.



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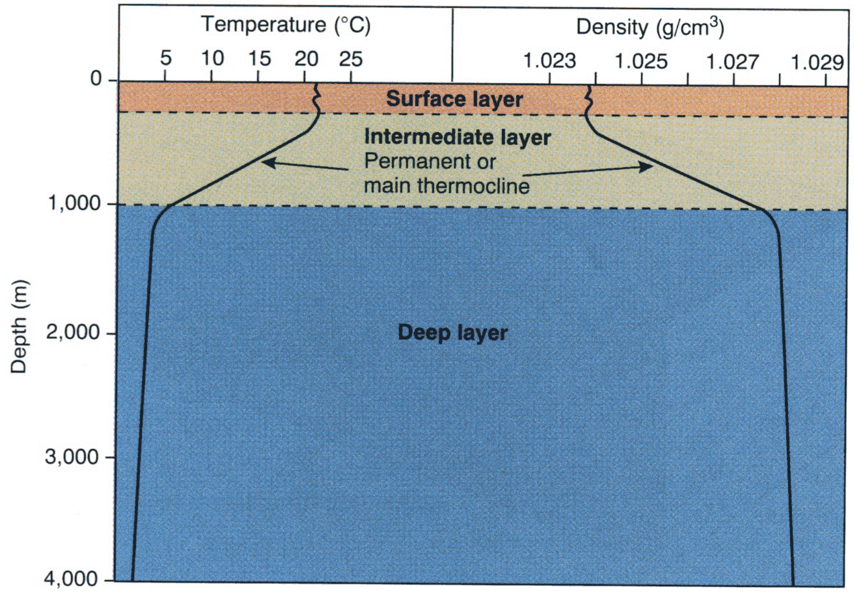
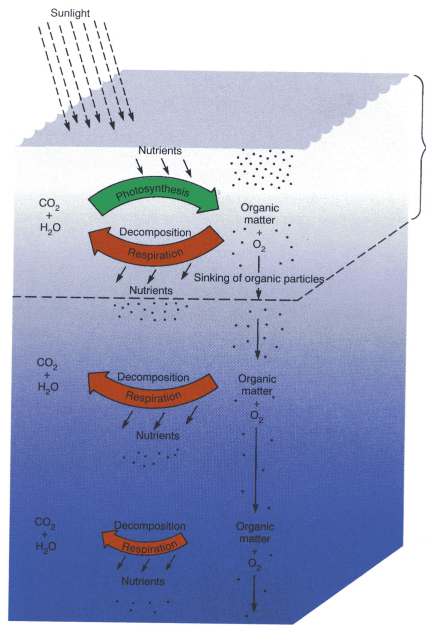
The Thermocline



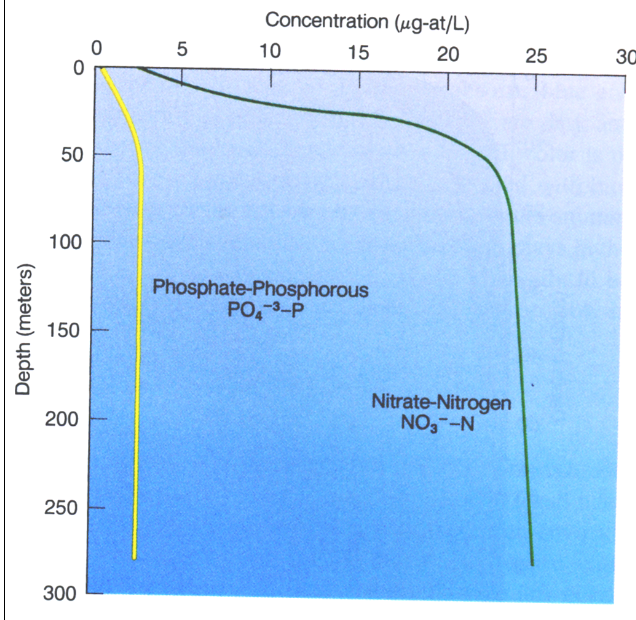
Castro and Huber, Marine Biology



Near the ocean surface there is light for plant growth. The little plants take up nutrients and grow. With time they can take up nearly all of the nutrients. At their death, the nutrients in their bodies are released by decay back into the water to be used again - recycling.

But some of the plants die and sink through the thermocline before they decay. Their nutrients are released below the thermocline and often below the photic zone. These nutrients are not used again. They accumulate until there is a reservoir of nutrients built up at depth.

Castro and Huber, Marine Biology



These are typical vertical profiles of nutrients. Most of the nutrients are at depth where they are unusable and, at the surface where there is light for plant growth there is often not enough nutrients - plant growth is limited by nutrients.

The places in the ocean where there is lots of plant growth all have currents that bring nutrients from depth to the surface.

Castro and Huber, Marine Biology

So why is this all important:

In most places in the ocean at most times plant nutrients are in such low concentrations as to limit phytoplankton growth. These low concentrations of phytoplankton support a very limited food chain.

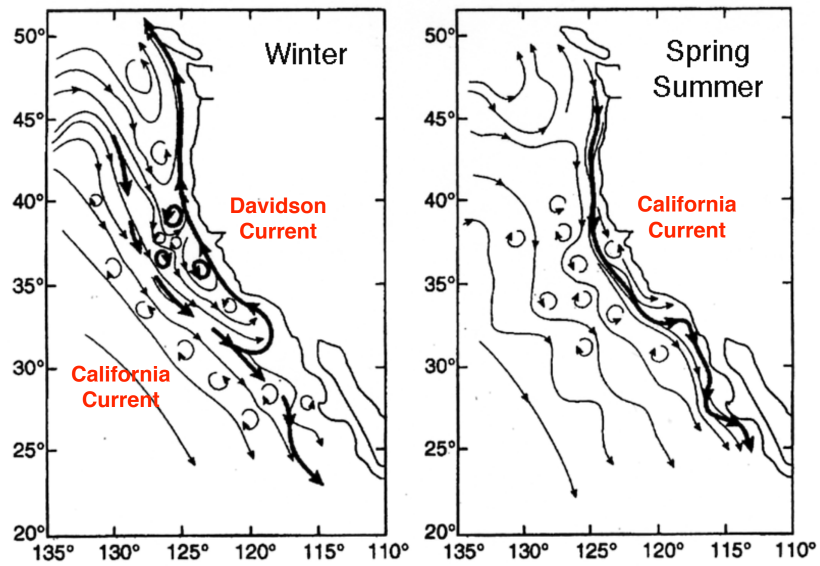
Where ocean currents bring water up from depth, water with high concentrations of nutrients, phytoplankton can grow well and support a highly productive food chain.

One can explain most of the distribution of animals and plants in the ocean by simply looking at where and when deep nutrient rich waters are brought to the surface.

The water along our coast travels across the North Pacific as the West Wind Drift. Offshore of Vancouver island the West Wind Drift splits - part goes north to become the Alaska Current and the rest turns south to become the California Current, which flows south along our coast all the way to southern Baja where it turns back out to sea and eventually becomes part of the North Equatorial Current

NOAA

The seasonal cycle of currents along the West Coast



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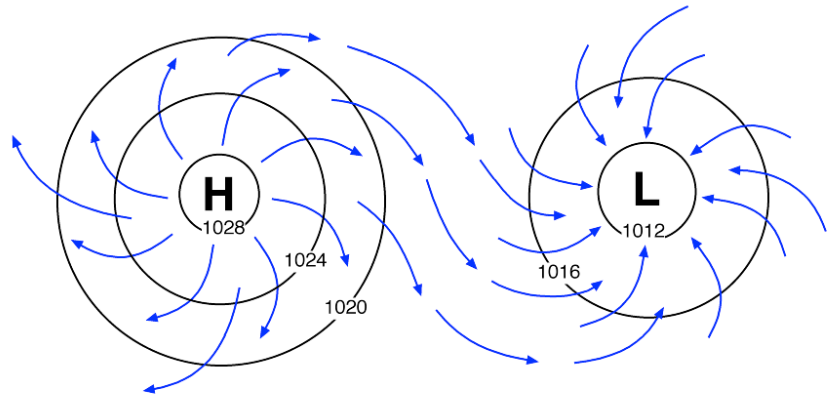

A high pressure and a low pressure center with wind directions (northern hemisphere). Circles are isobars with pressure in mb.

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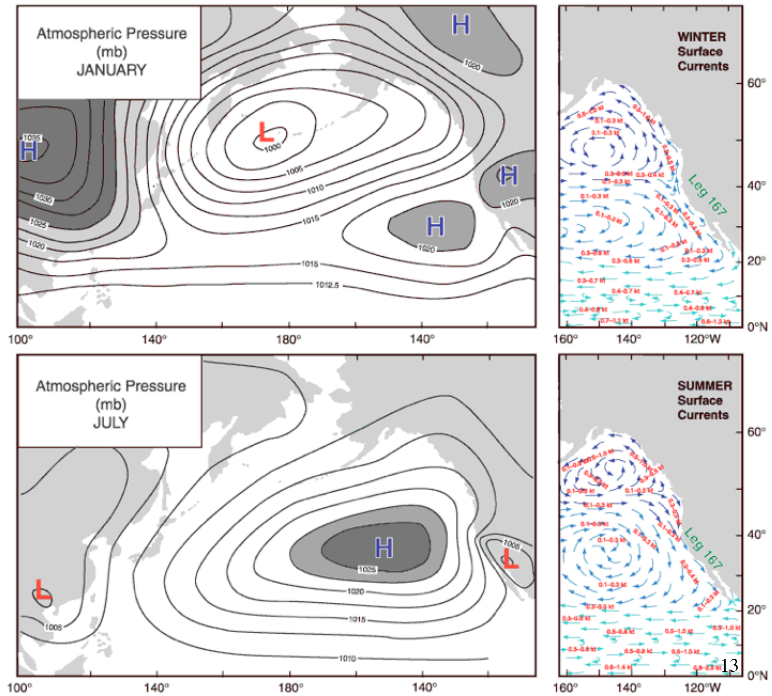
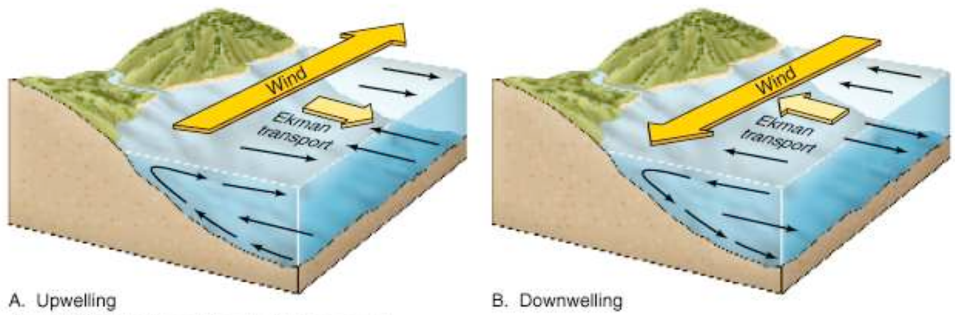


Atmospheric Pressure (mb) JANUARY
Atmospheric Pressure (mb) JULY
WINTER Surface Currents
SUMMER Surface Currents
Leg 167
100°
140°
180°
140°
160°
120°W
60°
40°
20°
0°N

NOAA

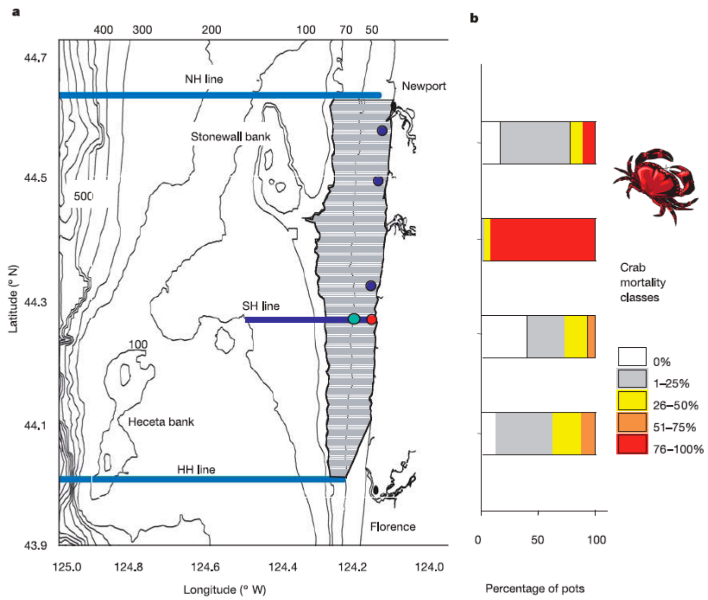
When the winds blow from the south, winter, we get downwelling. In the spring, when the winds shift, we get winds from the north and upwelling.
Upwelling brings cold, salty, nutrient rich waters up from depth. The high nutrient concentrations fuel the growth of phytoplankton leading bloom conditions.



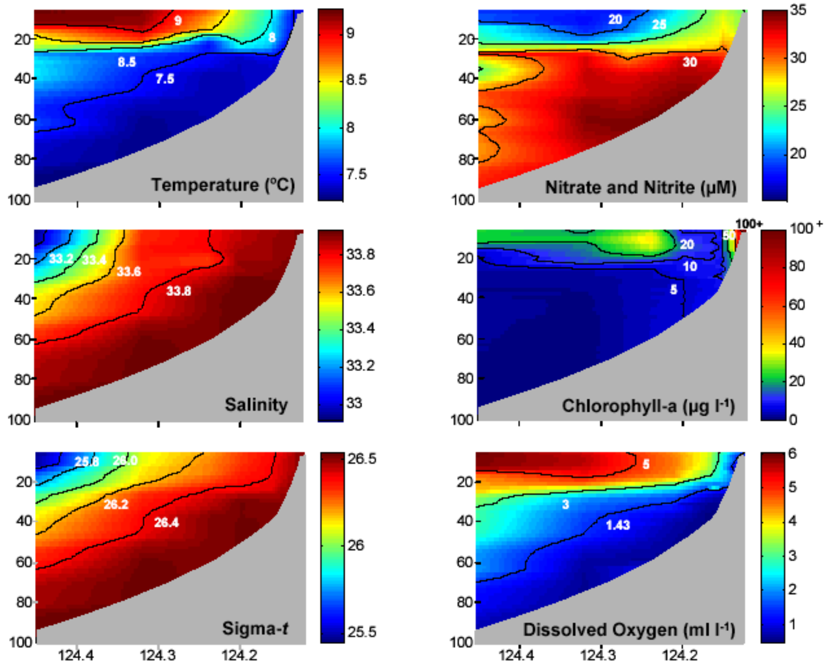
Why is this important:

Wind driven coastal upwelling brings nutrient rich waters up from depth leading to rich blooms of phytoplankton and large populations of larger organisms - ones that we fish.

The Oregon "Dead Zone"



Chan, F., J. A.Barth, J. Lubchenco, A. Kirincich, H. Weeks, W.T. Peterson, and B. A. Menge. 2008. **Emergence of Anoxia in the California Current Large Marine Ecosystem**. Science 15 February 2008 vol 319.



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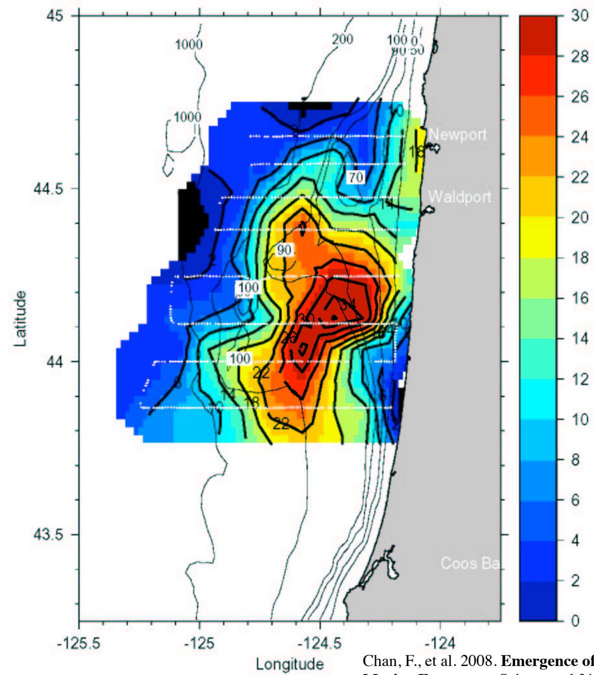
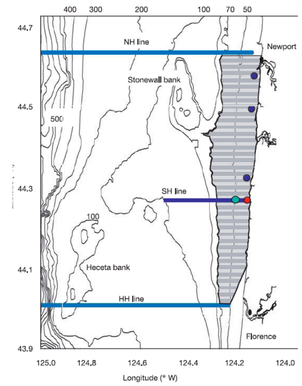


The distribution of phytoplankton over the shelf during a dead-zone event.



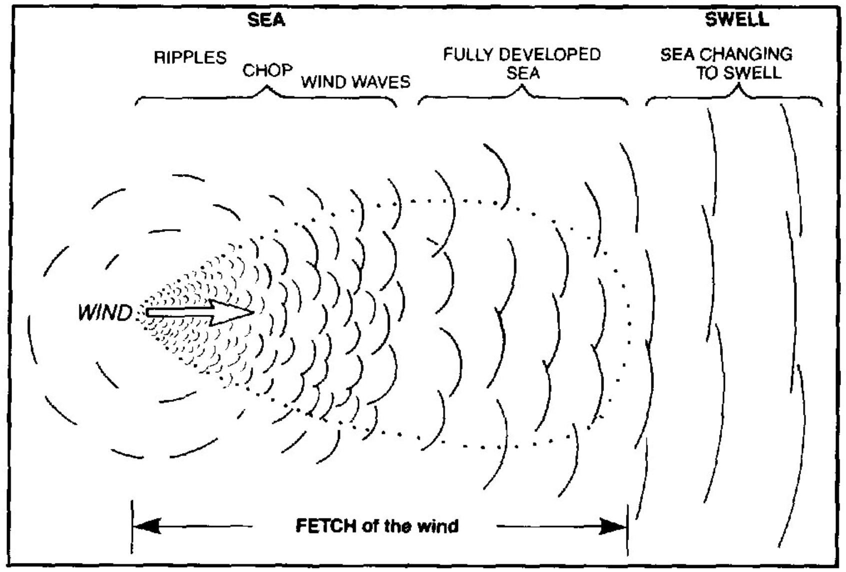
Chan, F., et al. 2008. **Emergence of Anoxia in the California Current Large Marine Ecosystem**. Science vol 319.

Why is this important:

First, I wish they had not called this a “dead zone”. This is a term associated with huge anoxic zone in the Gulf of Mexico that is for sure caused by humans.

This “dead zone” is very similar to natural ones found off Chile and South Africa also caused by a combination of upwelling bringing low oxygen water onto the shelf and high phytoplankton production. If our “dead zone” spreads it could cause serious problems to a variety of fisheries. At this time, I can’t see that it has done any measurable harm.

The formation of waves.



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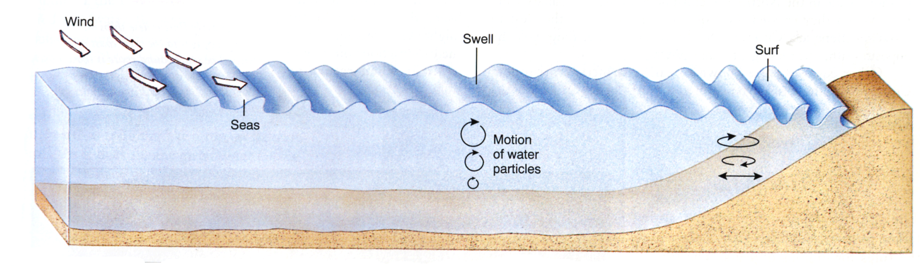
Seas, Swells and Sneaker Waves



Castro and Huber, Marine Biology

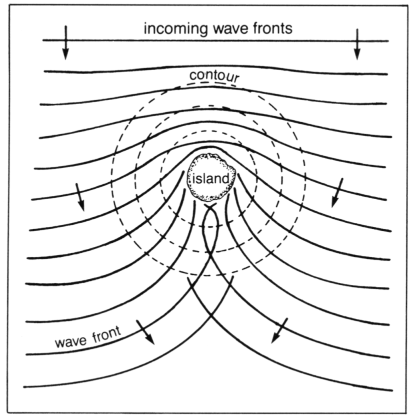


Fig. 8.3. Refraction of swell around nearly circular island forms criss-cross interference pattern in lee geometric shadow zone. Broken lines represent bottom contours with depths increasing gradually outward.

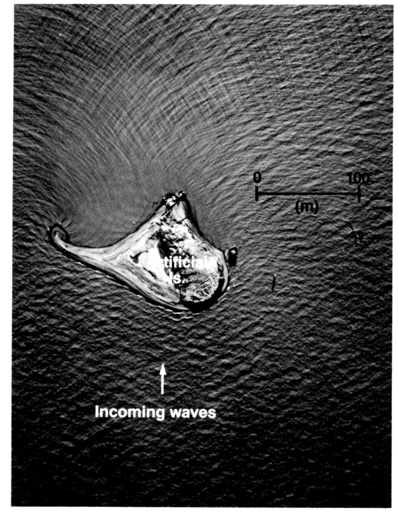


Fig. 8.4. Refraction of wind waves around artificial island (Netserk F-40) in Beaufort Sea immediately seaward of Mackenzie River delta (July 1978). Typical water depths 10 m in area. Refracted waves break parallel to shoreline and form criss-cross pattern in lee of island. Refracted waves curve sharply around to lee shore. (Courtesy F. Stephenson)

Wave Refraction: As waves enter shallow water their speed varies with water depth - slower in shallower water.

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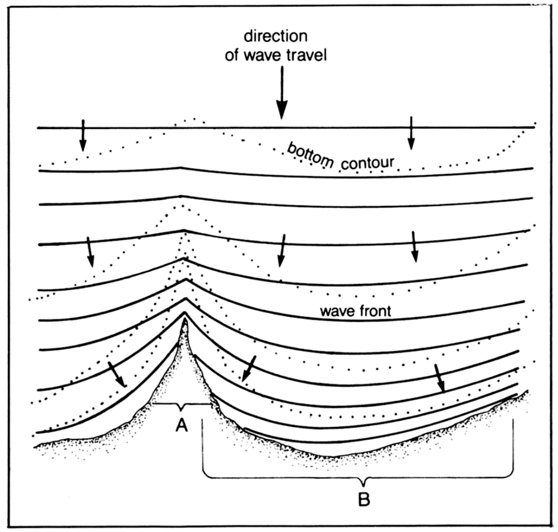

FIG. 8.2. Refraction of ocean waves approaching a coast. Bathymetric contours (dotted lines) shoal shoreward. Wave crests (solid lines) propagate in direction of arrows or "rays." Waves converge toward submarine ridge and associated point of land, A, and diverge outward within embayment, B.

There is an old saying that "points of land draw the wave". This is due to refraction. Because of refraction waves become more diffuse at the head of a bay.

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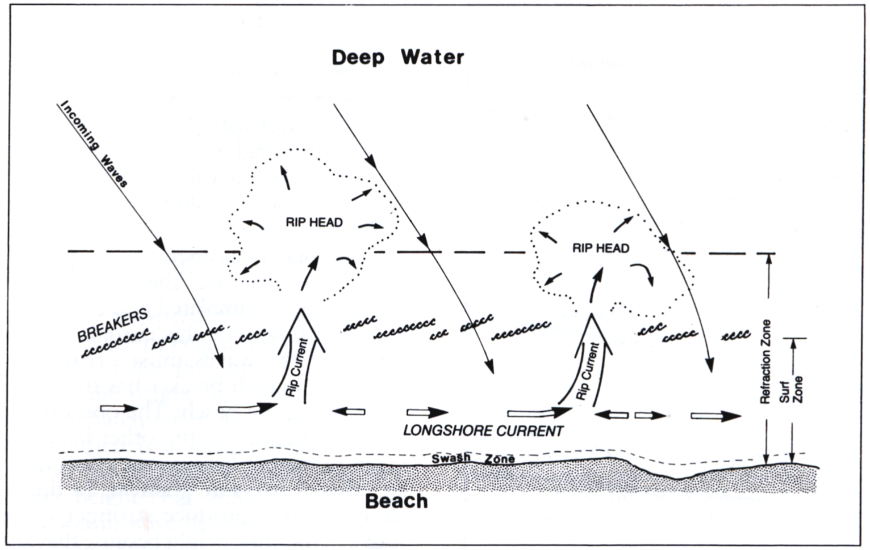
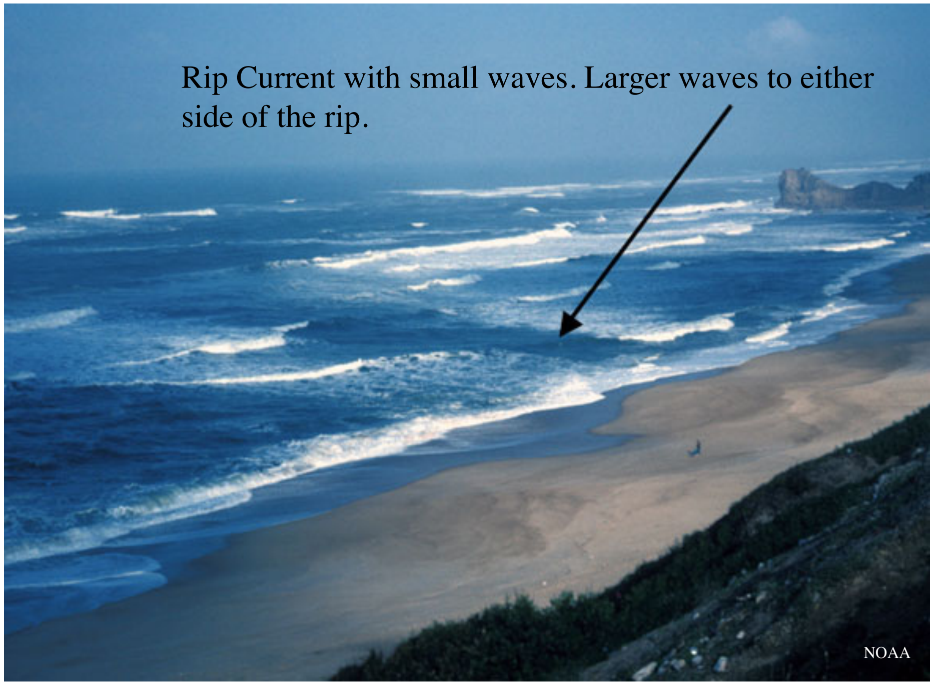
Rip Currents



Woodroffe, Coasts

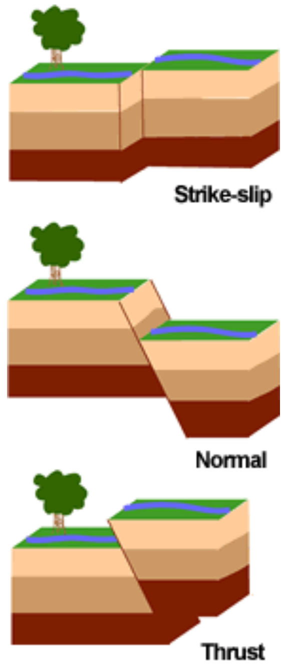

GMT-17:38:55 LAT-47:22.2N LON-124:20.3W HT:+1870 HV:196.66 GT:142.4 WAOR95 NOS ACN 09-22-95
3503
FS125 1/ 280 f/5.6 FF1.0 EC 0 * SP- v/h.04149 65% dt012.6 ds022 26.7V -61mb ER00 CAM5136


Rip Current with small waves. Larger waves to either side of the rip.
NOAA

Why is this important:

Ocean waves are extremely dangerous. Every year on the Oregon several people are washed into the ocean by waves and drown. Knowledge of how ocean waves behave can save your life.

In intertidal ecology, we talk about wave exposure and its role in governing the community structure. Intertidal communities are very different on exposed shores than on protected.



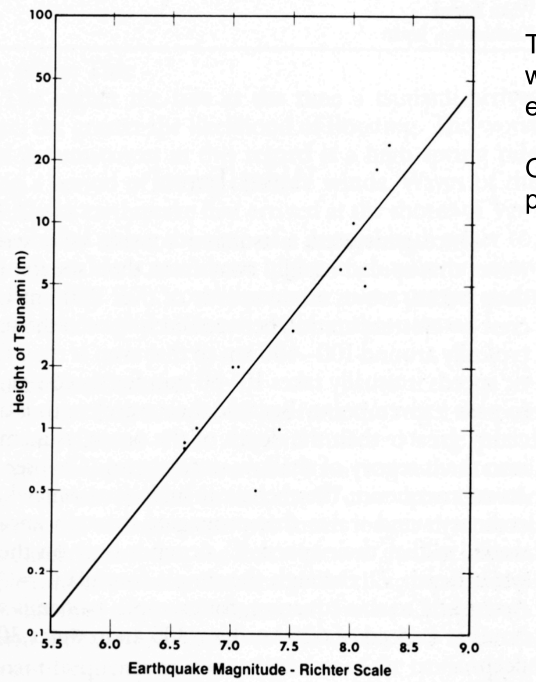
Tsunamis or Tidal waves are generated by a variety of mechanisms. The most common being earth quakes and landslides underwater.

Strike-slip earth quakes, if they do not cause slides, do not tend to form Tsunamis.

Normal or Thrust earth quakes do form tsunamis. These quakes cause the ocean surface to be displaced making a wave

The fault zone off Oregon is a Thrust fault.

NOAA



The size of the wave varies with the strength of the earthquake.

Our local fault has historically produced large earthquakes

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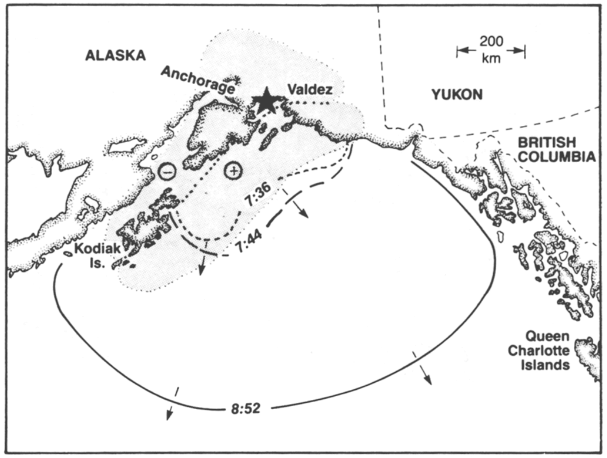

FIG. 9.1. Leading edge of 1964 Alaska tsunami beginning with inception around 7:36 p.m. 27 Mar. Star marks earthquake epicenter in Unakwik Inlet at northern end of Prince William Sound. Shaded area delineates area of crustal uplift (+) and subsidence (−) that accompanied the earthquake. Maximum uplift was about 9 m, maximum subsidence about 1½ m. (Adapted from Spaeth and Berkman 1967)

Tsunamis are very long waves with crest-to-crest distances of around 60 to 250 miles.

Everywhere in the ocean they are shallow water waves. They are refracted everywhere by the ocean floor.

They also travel very fast. They can reach speeds of 500 miles/hr.

In deep water the wave is low, 3 feet or so, but when they enter shallow water they peak up.

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Tsunamis can travel very long distances and still produce large waves when they hit shore.

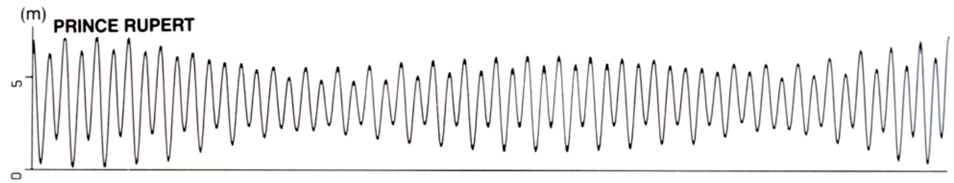
Some locations are more prone to getting hit by large waves than nearby sites. This is because of wave refraction.

Why is this important:

Off our coast is a subduction zone that does produce large earthquakes that have produced very large tsunamis!

If you live on the coast and you experience a large earthquake head for high ground immediately. Depending on where you live on the coast, you have from 5 to 20 minutes before the waves start to hit shore.

Typical Monthly Tidal Cycle



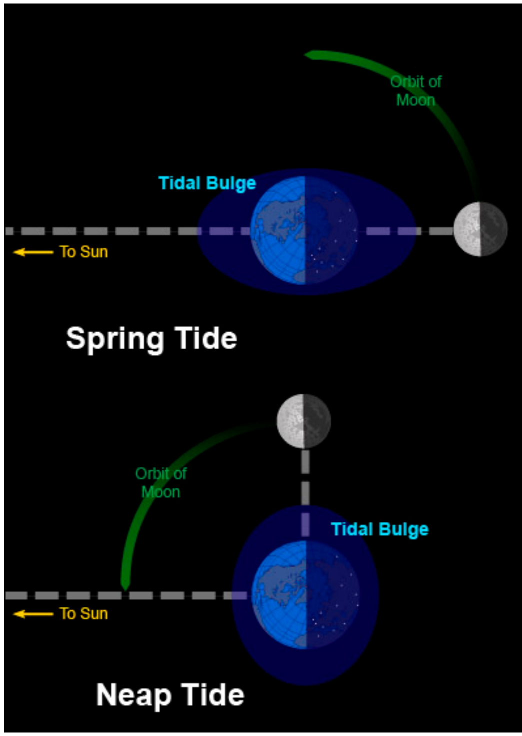
Spring Tides

Neap Tides

Spring Tides

Neap Tides

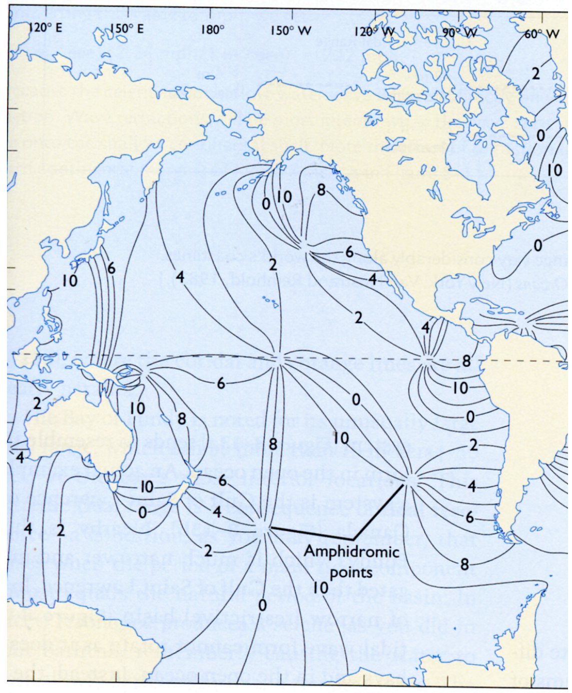
Spring Tides



The tides are caused by the combined gravitational pull of the sun and moon. When the sun and moon are lined up at the new and full moons we get large tides - the spring tides.

When they are not lined up during the quarter moons we have small tides - the neap tides.

NOAA



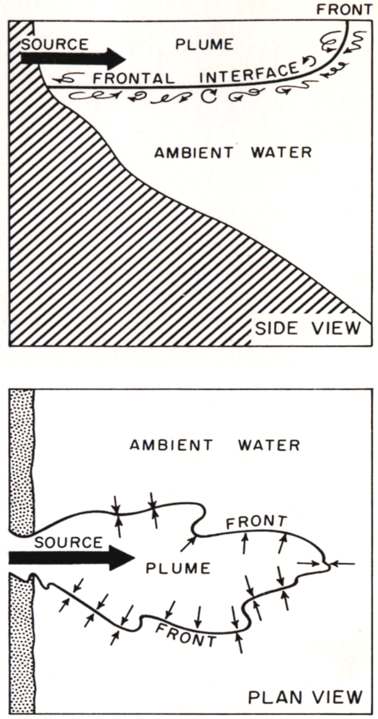
The model in the previous slide assumes we are on an earth without continents. With continents the tides get very complex. Rather than a “tidal” wave traveling around the earth we get waves traveling around amphidromic points.

TIDAL DIFFERENCES OREGON

Place	Time High	Time Low	*Height High	*Height Low
Eel River entrance	-0:49	-0:44	0.77	0.93
Trinidad Harbor	-0:43	-0:41	0.83	0.91
Crescent City	-0:44	-0:42	0.86	0.93
OREGON				
Brookings, Chetco Cove	-0:43	-0:38	0.86	0.93
Wedderburn, Rogue River	-0:35	-0:26	0.82	0.85
Port Orford	-0:31	-0:30	0.91	0.94
Bandon, Coquille River	-0:21	-0:14	0.86	0.85
Coos Bay				
Charlston	-0:14	-0:12	0.95	0.93
Empire	+0:28	+0:38	0.82	0.85
Coos Bay	+1:57	+1:16	0.91	0.85
Umpqua River				
Entrance	-0:04	-0:09	0.86	0.93
Gardiner	+0:47	+0:46	0.84	0.77
Reedsport	+1:02	+0:19	0.84	0.77
Siuslaw River				
Entrance	-0:15	-0:03	0.91	0.93
Florence	+0:35	+0:46	0.82	0.77
Waldport, Alsea Bay	+0:12	+0:19	0.96	0.93
Yaquina Bay and River				
Bar at Entrance	-0:10	-0:03	0.98	1.00
Newport (Daily Predictions)	**0:00**	**0:00**	**1:00**	**1:00**
Southbeach	-0:11	-0:11	1.04	1.00
Yaquina	+0:11	+0:13	1.03	1.00
Winant	+0:19	+0:34	1.03	0.93
Toledo	+0:45	+0:57	1.01	0.85
Taft, Siletz Bay	+0:04	+0:31	0.81	0.69
Kernville, Siletz River	+0:40	+1:11	0.74	0.62
Nestucca Bay Entrance	+0:11	+0:30	0.95	0.85
Tillamook Bay				
Barview	-0:02	+0:14	0.93	0.85
Garibaldi	+0:30	+0:34	0.97	0.93
Miami Cove	+0:31	+0:44	0.91	0.85
Bay City	+0:49	+1:28	0.88	0.77
Hoquarten Slough	+1:08	+3:53	0.81	0.54
Nehalem River				
Brighton	+0:07	+0:12	0.97	0.93
Nehalem	+0:33	+1:14	0.89	0.69
NEW TIDAL DIFFERENCES				
Seaside, 12th Avenue Bridge	+0:47	+2:07	0.81	0.37

As the “tidal” wave travels around our amphidromic point, the wave travels up our coast. Hence, a high or low tide occurs earlier in the day to the south.


The estuarine plume at the mouth of Coos Bay.
NOAA



The water leaving an estuary is fresher than the ocean - it is less salty. Hence, it is less dense and floats on top of the ocean water. As the estuary water pushes out into the ocean it pushes the ocean water aside forming a plume.

In the spring/summer, when winds are from the north the plume is pushed to the south. It looks just like the photo.

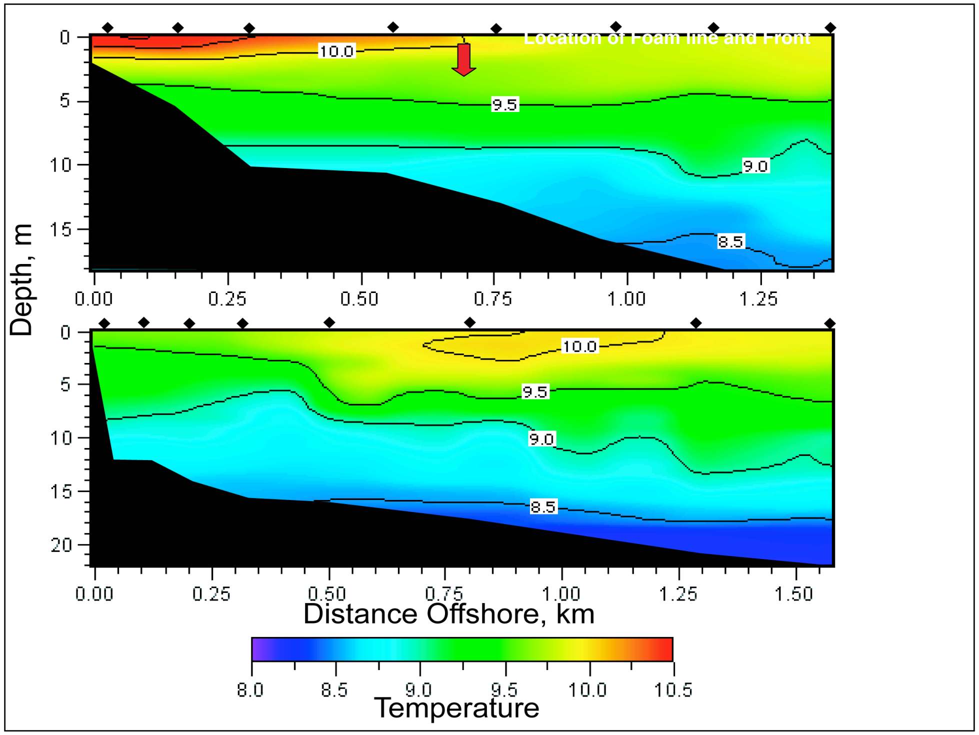
Winter winds from the south push the plume to the north. During this time of year the plume often hugs the coast as a narrow stream of low salinity water.

Why is this important:

In winter, estuarine plumes are one of the dominant features of the coastal hydrodynamics. They are poorly studied on this coast especially in winter. On the east coast, they play an important role in the dispersal of the larvae of a variety of estuarine and nearshore invertebrates.


Foam lines along the coast - what are they?


Foam line at the mouth of Playa Canelo, Chile



Location of Foam line and Front
10.0
9.5
9.0
8.5
Depth, m
0
5
10
15
20
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Distance Offshore, km
8.0
8.5
9.0
9.5
10.0
10.5
Temperature

Why is this important:

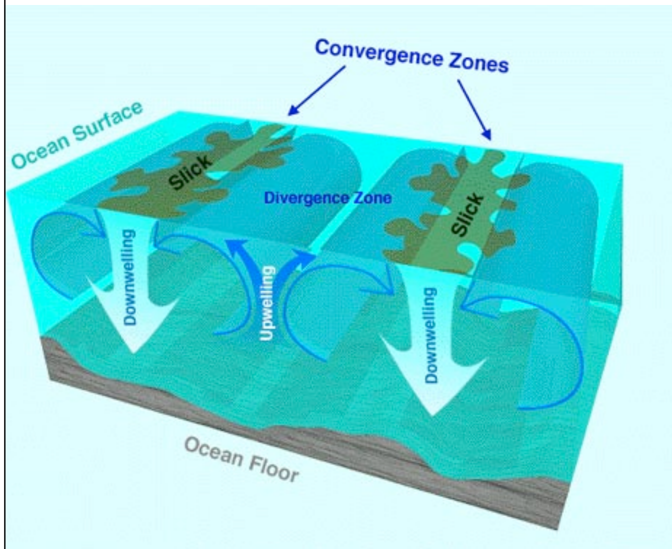
Larvae of creatures that live on the shore and develop in the coastal ocean must pass through the nearshore waters to get to sea and, when they are ready to settle, they must pass through these waters to get back to shore. They must interact with the nearshore hydrodynamics.

Larvae of creatures that live on the shore and develop right next to shore may use the nearshore hydrodynamics to stay close to shore.

This is an area of study that is just starting.


Streaks on the Ocean - Langmuir Circulation
NOAA


http://www.esoxhunter.com/WalleyeWind.php



Wind blowing on water produces Langmuir Circulation.

The water is covered by parallel circulation cells with the water in each cell moving in a helix. Flow in adjacent cells rotates in opposite directions.

The flow forms zones of Divergence and Convergence.

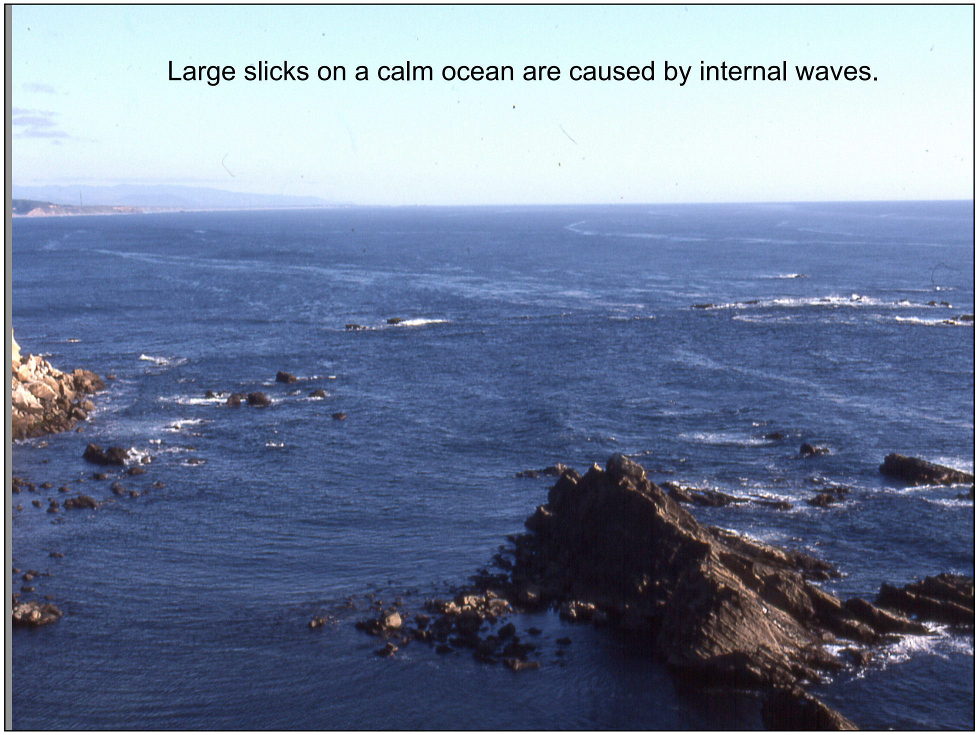
The form lines form at the convergence.

NOAA

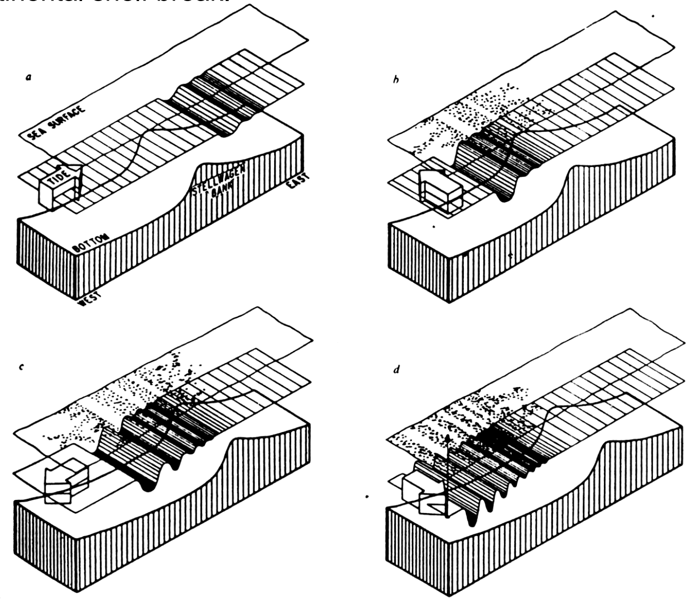
Why is this important:

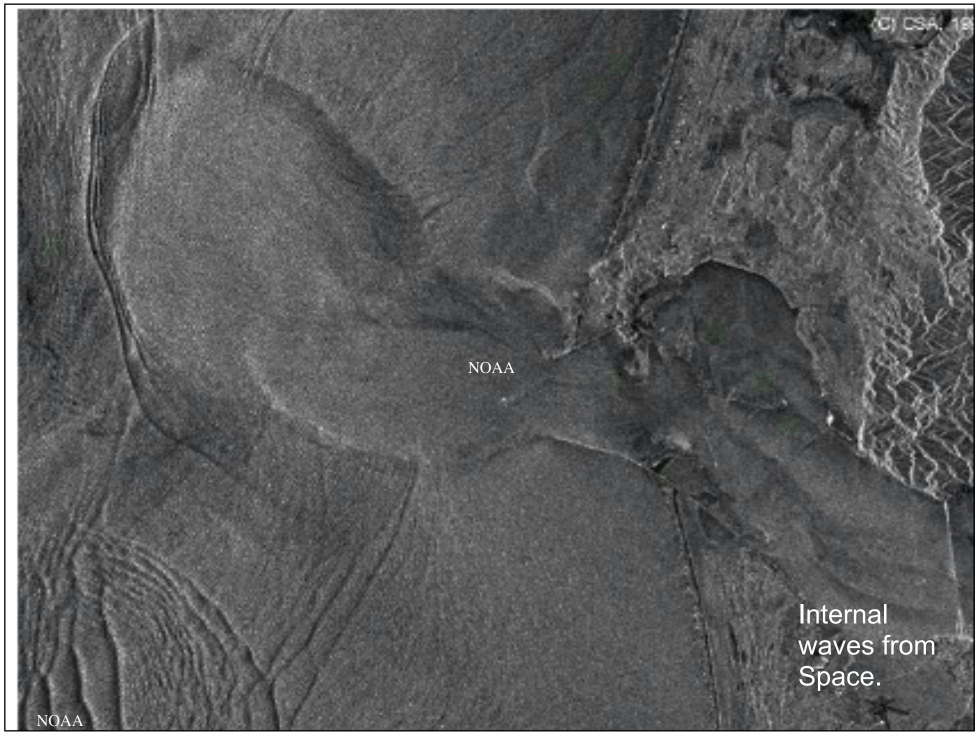
Langmuir circulation is how heat and wind momentum that has entered the ocean at the surface is mixed into the body of the ocean.

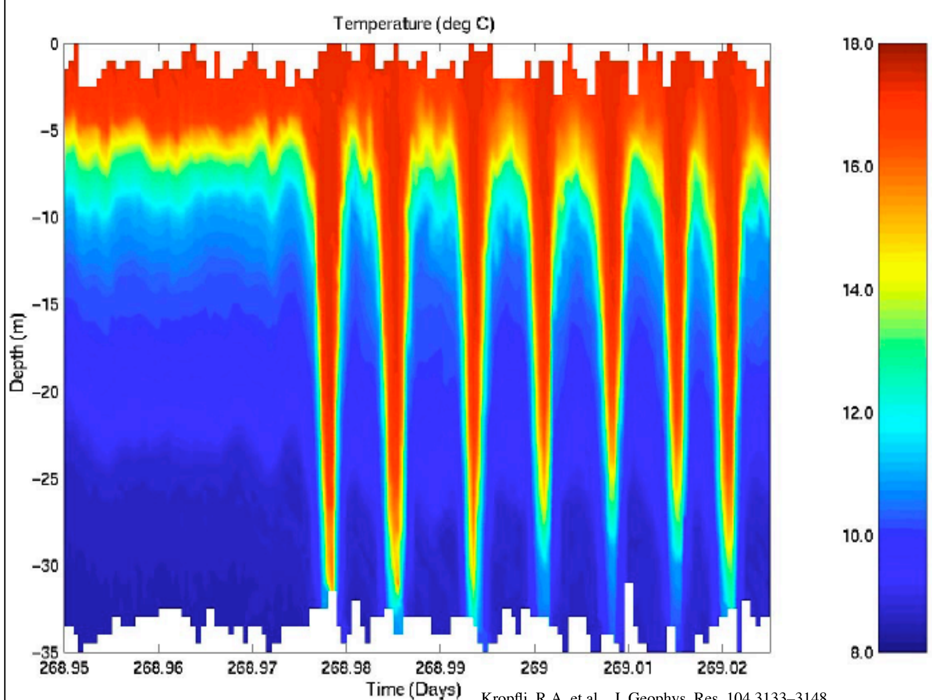
Langmuir circulation often sets the depth of the mixed layer.


Large slicks on a calm ocean are caused by internal waves.

Large internal waves are formed when tidal currents flow over areas where the bottom relief changes rapidly - e.g., submarine bumps or the continental shelf break.




(C) CSA
NOAA
Internal
waves from
Space.
NOAA



Kropfli, R.A.,et al., J. Geophys. Res. 104,3133–3148.

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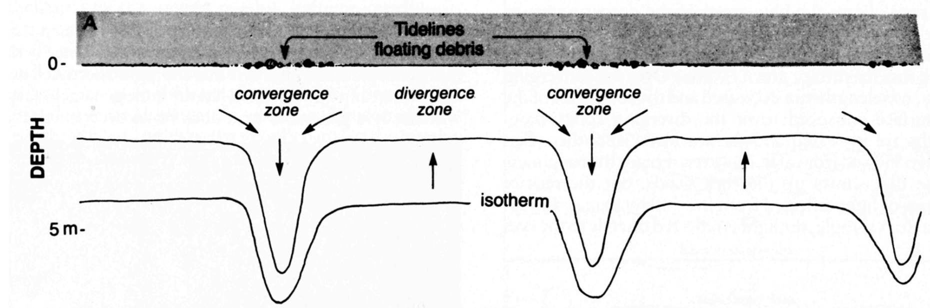
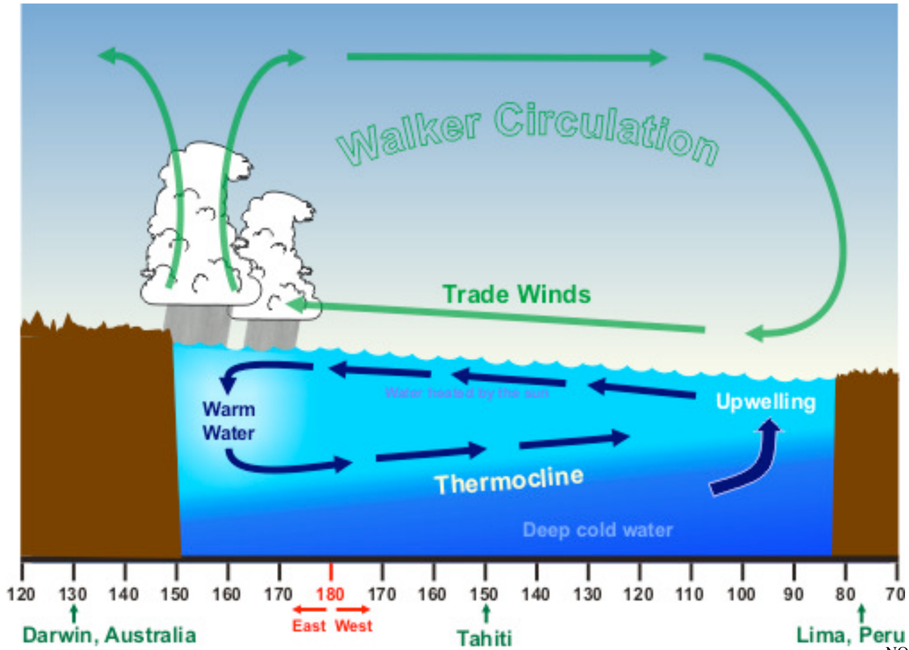


Flow over the top of large internal waves produces convergence zones. Floating debris and oil accumulate in the convergence zones. The oil dampens small waves and that is what makes the slicks visible at low wind speeds.

Why is this important:

The internal tides are one of the most energetic components of coastal hydrodynamics. They cause significant mixing of the coastal ocean, they can transport larvae of fish and invertebrates to shore (Dungeness crab megalopae are probably transported to shore this way, they can transport offshore blooms of phytoplankton, including toxic phytoplankton, to shore, and they can cause a form of upwelling.

El Nino - What causes an El Nino?



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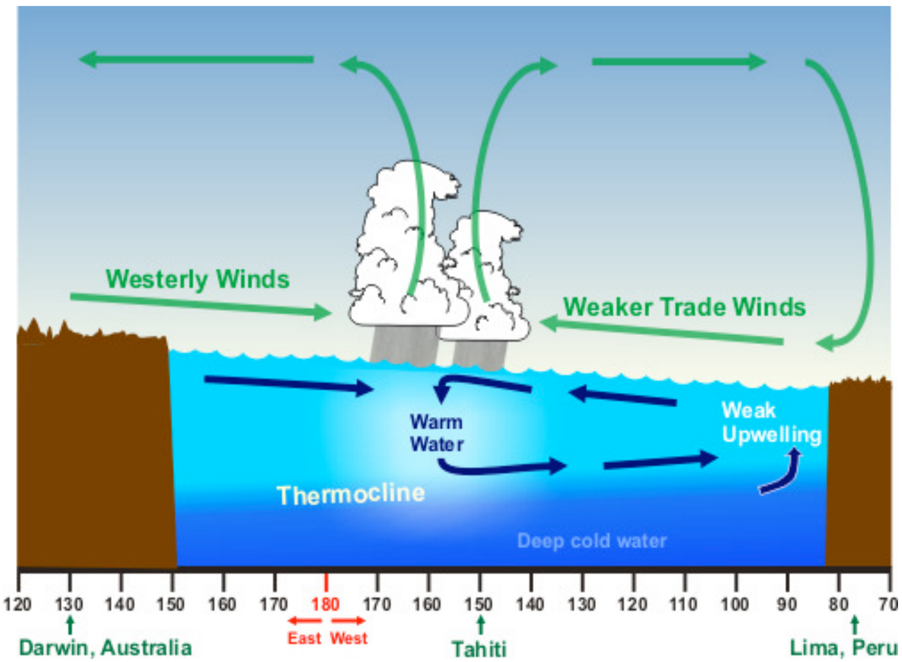
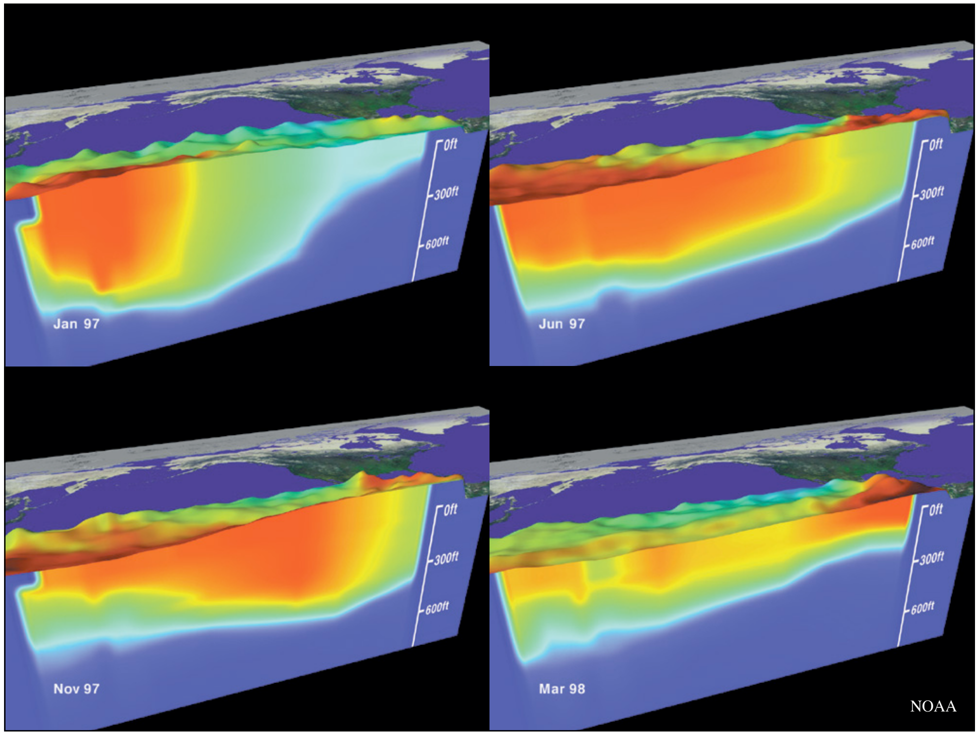
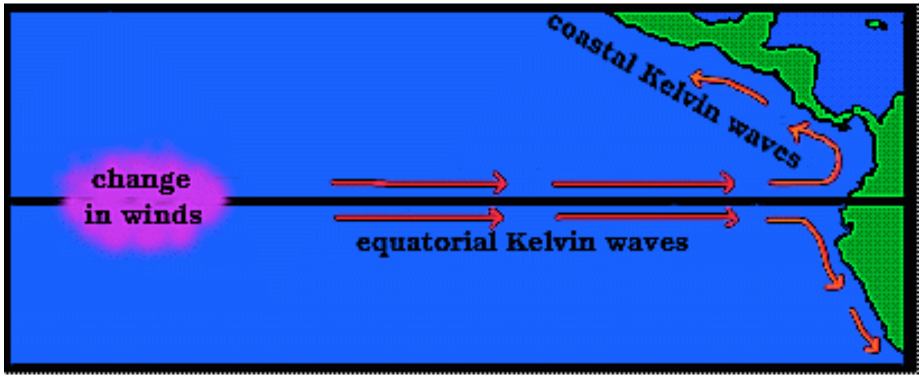


Westerly Winds
Weaker Trade Winds
Warm Water
Weak Upwelling
Thermocline
Deep cold water
120 130 140 150 160 170 180 170 160 150 140 130 120 110 100 90 80 70
East West
Darwin, Australia
Tahiti
Lima, Peru

NOAA


Jan 97
Jun 97
Nov 97
Mar 98
0ft
300ft
600ft
NOAA

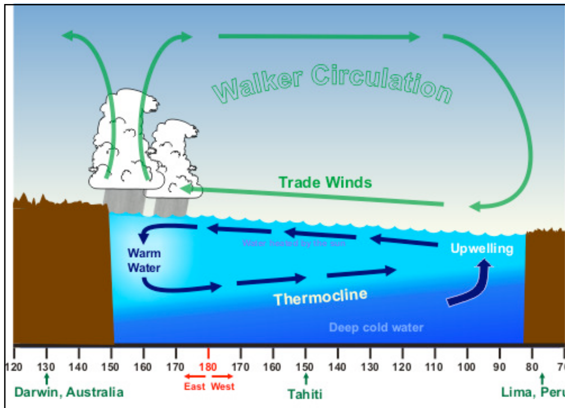
As the warm water travels eastward it travels as a Kelvin wave and these waves have strange properties.



http://www.oc.nps.edu/webmodules/ENSO/kelvin.html

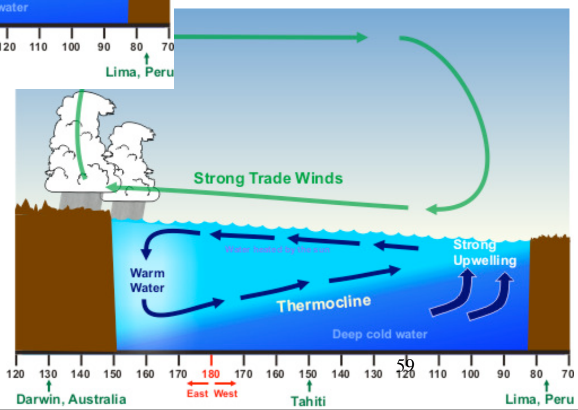
Why is this important:

El Ninos are one of the dominant variables in the “climate” of the coastal ocean. They can profoundly affect our weather and the success of a diversity of coastal marine organisms. Bird colonies can fail to produce chicks, Dungeness crab megalopae do not return to shore in high numbers, species that live to the south of use are transported north, for some species their northern range limit is set by transport of their larvae northward by El Ninos, and etc.



“Normal”

La Nina:
the eastern tropical Pacific is cooler than normal



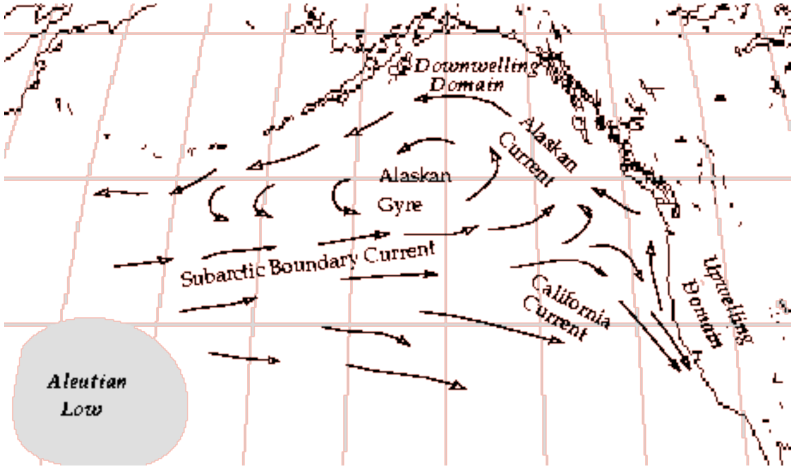
NOAA

The PDO - The Pacific Decadal Oscillation

What is this and how does it affect our coast?

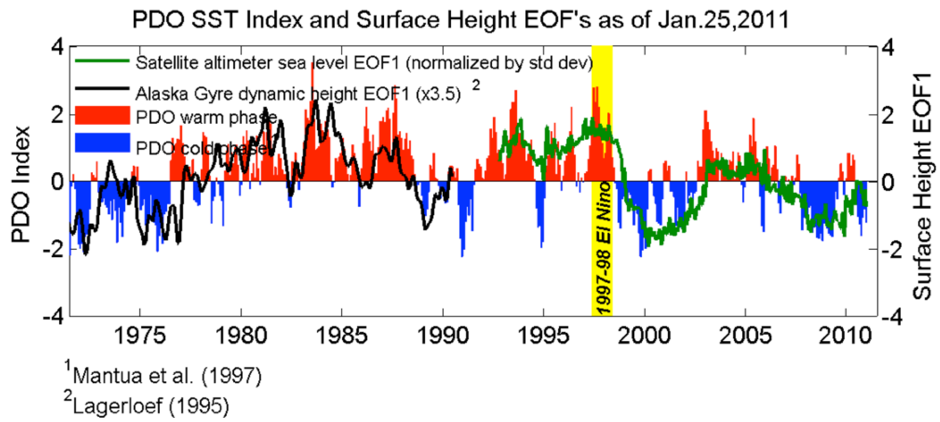
Like El Nino it is a form of variation in the Pacific Ocean climate.

NOAA



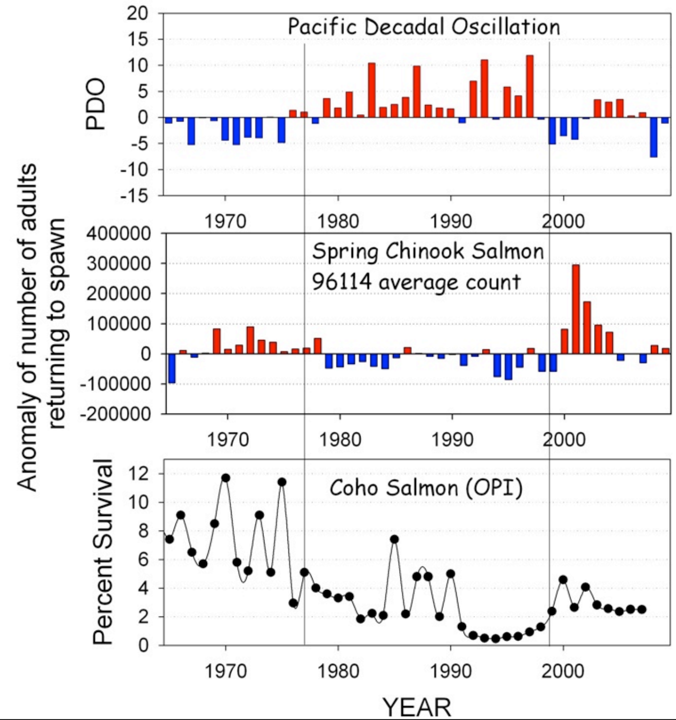
A complex set of variables drives the PDO, but it appears as more or water from the Subarctic Boundary Current moving into the California Current.

NOAA

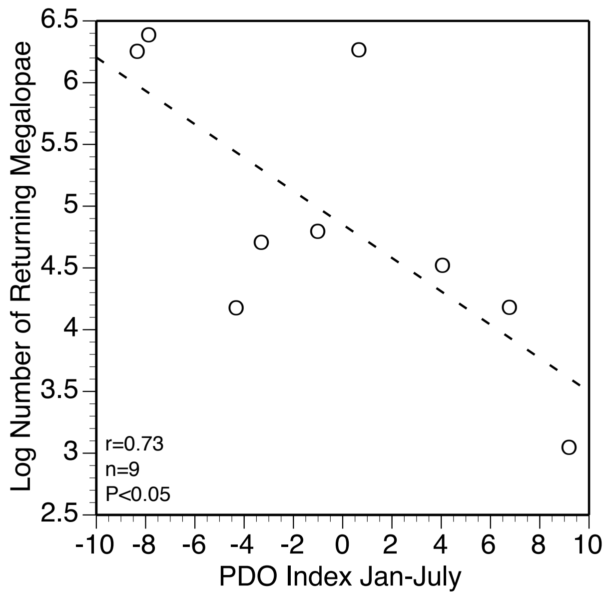


When more water goes into the Alaska Gyre then sea level there is higher and North Pacific water is warmer; this is the warm phase. When more water enters the California Current the reverse is true; lower sea level in the Gulf of Alaska and cooler water in the North Pacific.

NOAA

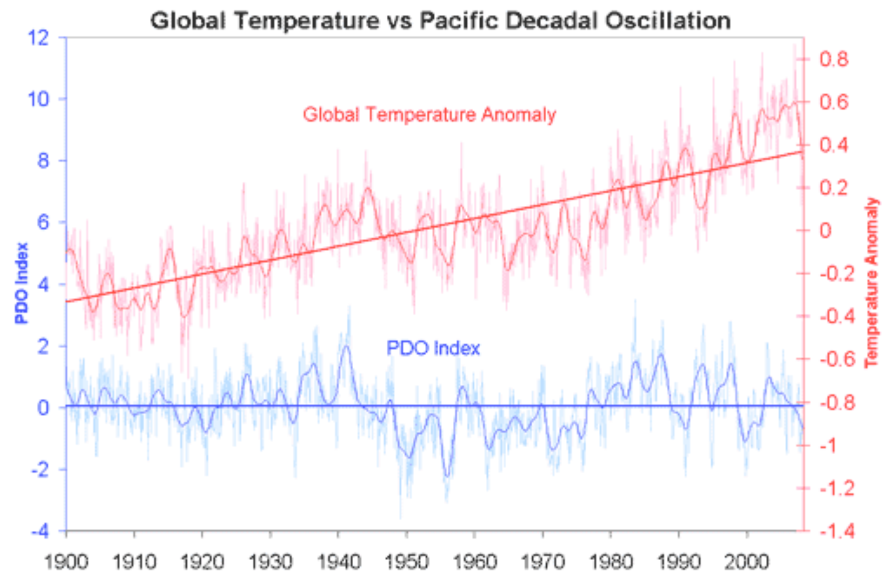

Pacific Decadal Oscillation
PDO
Spring Chinook Salmon
96114 average count
Anomaly of number of adults returning to spawn
Coho Salmon (OPI)
Percent Survival
YEAR

NOAA



The number of Dungeness crab megalopae returning to shore varies with the PDO and the number of adult crabs varies with the number of megalopae returning.


The End


Global Temperature vs Pacific Decadal Oscillation
Global Temperature Anomaly
PDO Index
PDO Index
Temperature Anomaly
12
10
8
6
4
2
0
-2
-4
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000