Processes and patterns at oceanic “hot spots” in the subtropical North Pacific

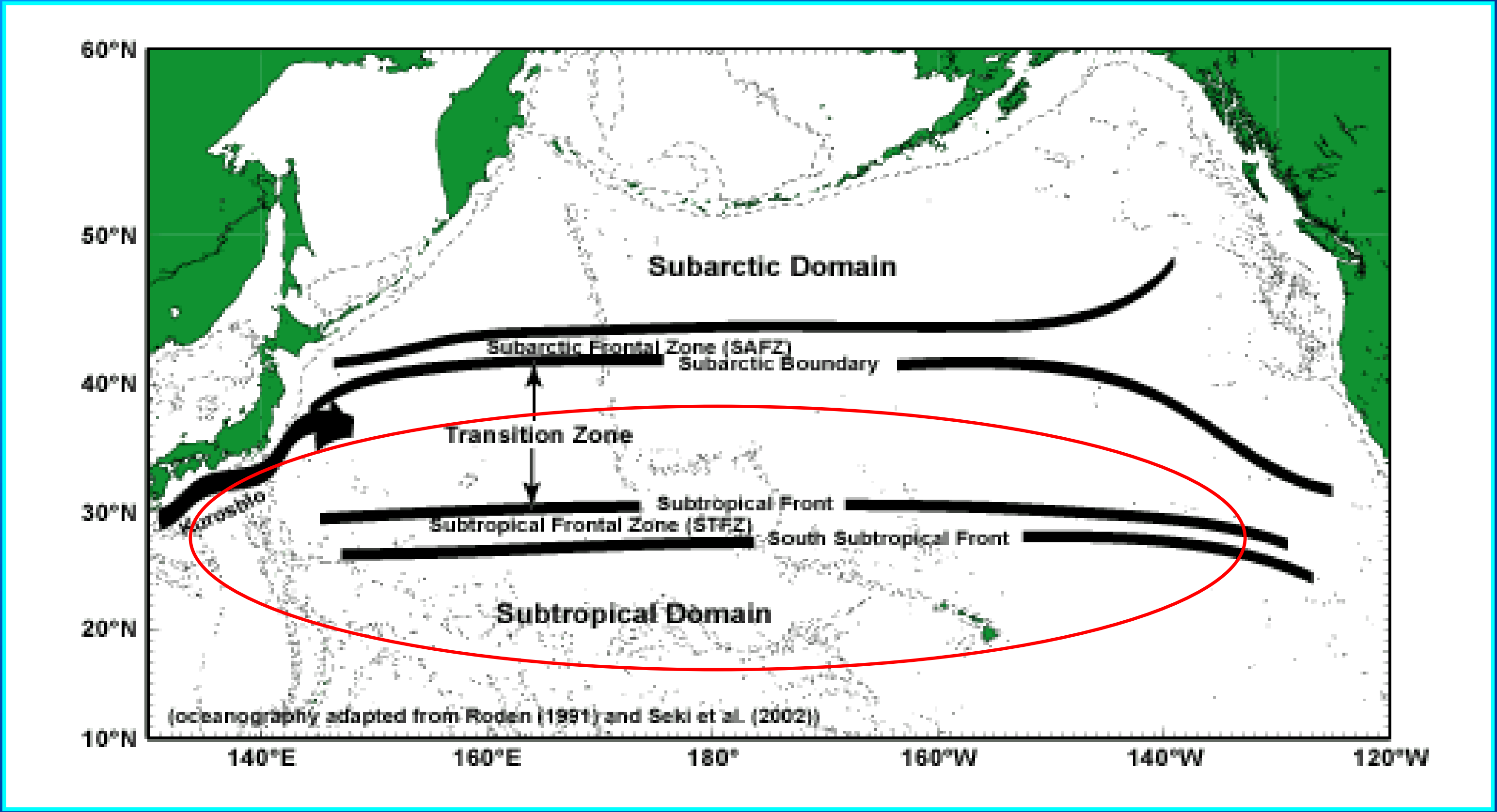
Michael P. Seki

National Marine Fisheries Service, NOAA
Pacific Islands Fisheries Science Center
2570 Dole Street, Honolulu, HI 96822-2396

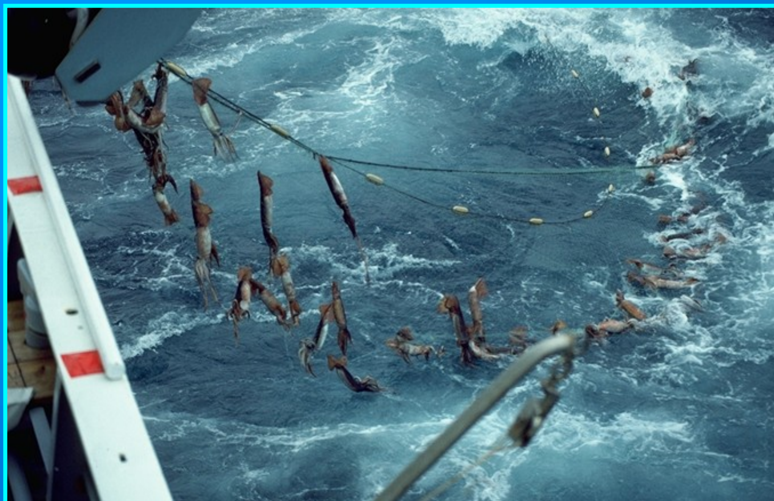
Overview

- What are "hot spots"?
  - Large scale fronts
  - Mesoscale meanders & eddies
  - Seamounts
- … and why do we care?
  - Resource population assessments
  - Natural hotbeds for fisheries interactions
  - Energy transfer dynamics

The Subtropics



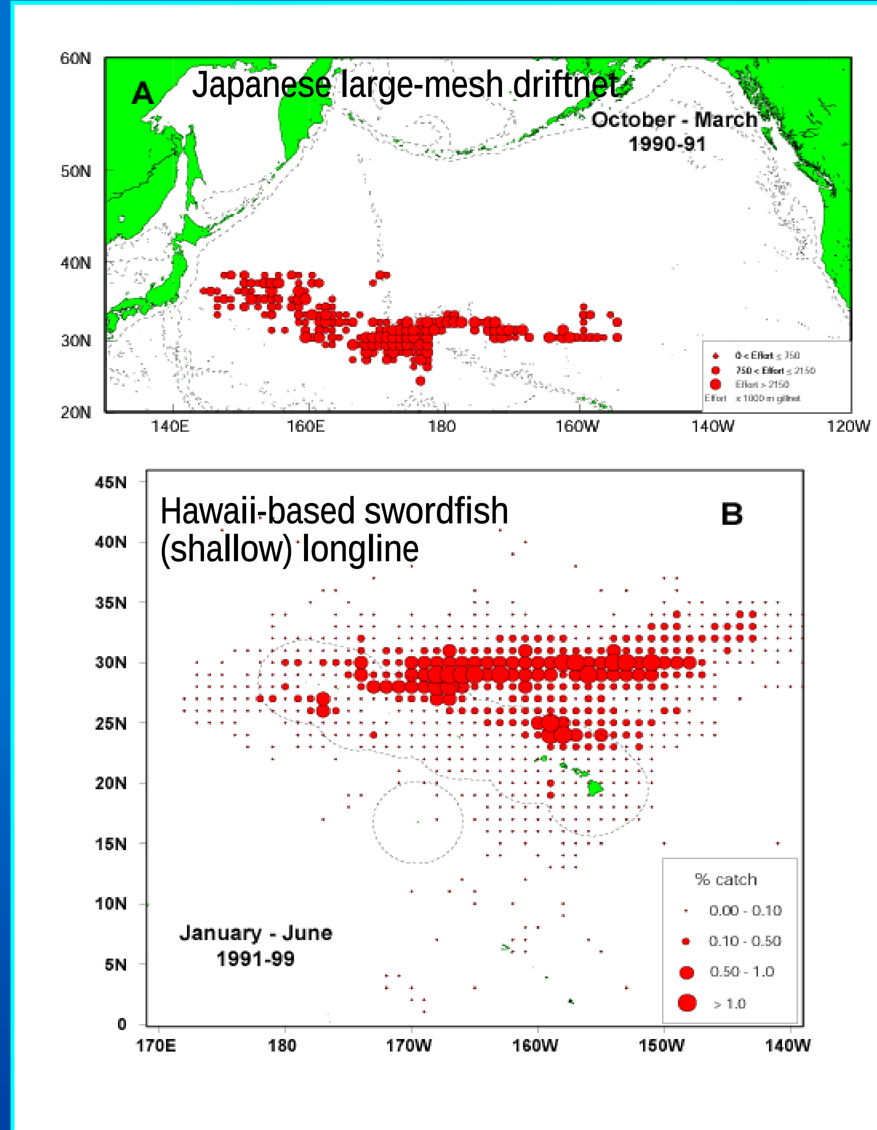
Fisheries interest at the North Pacific Subtropical Frontal Zone:



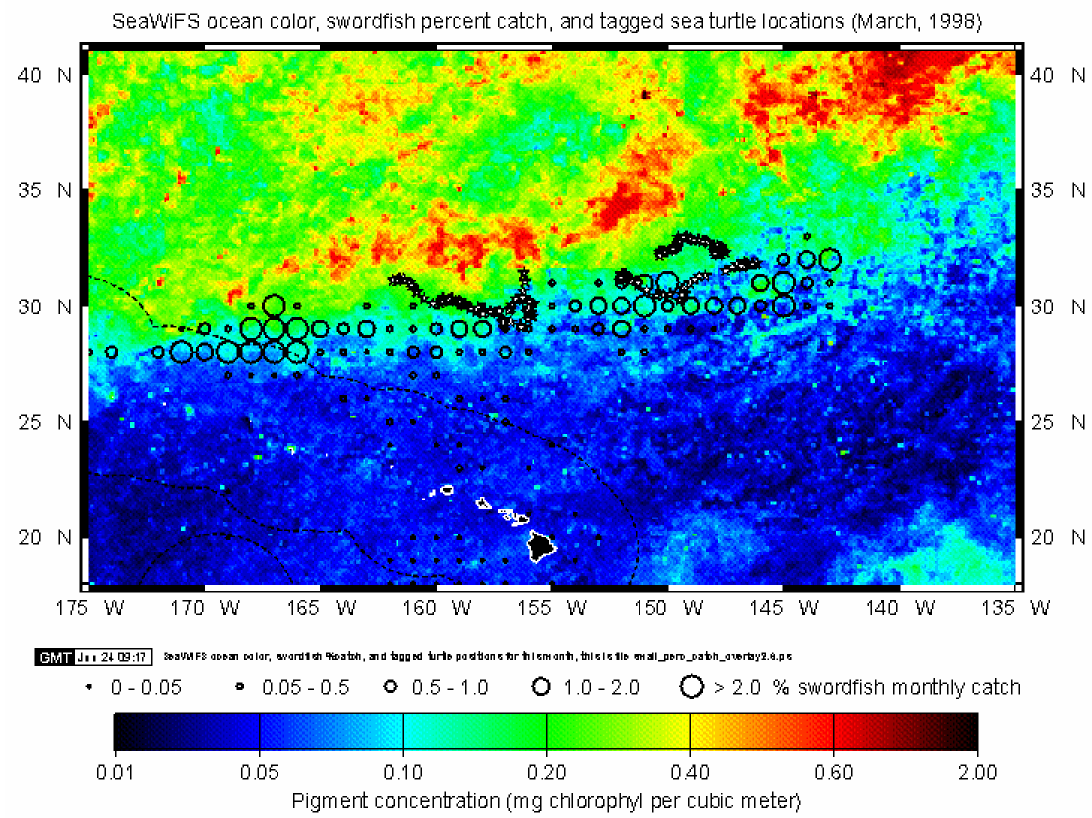
*Fisheries operating at Subtropical Frontal Zone waters:

- U.S., Japan, et al. longline fisheries
- U.S., Japan troll fisheries for tuna (tombo)
- Japan distant water squid jigging fishery
- [former] high seas Asian driftnet fisheries (squid & large mesh)

* Many Transition Zone nektonic species undergo extensive seasonal migrations bound by the STFZ

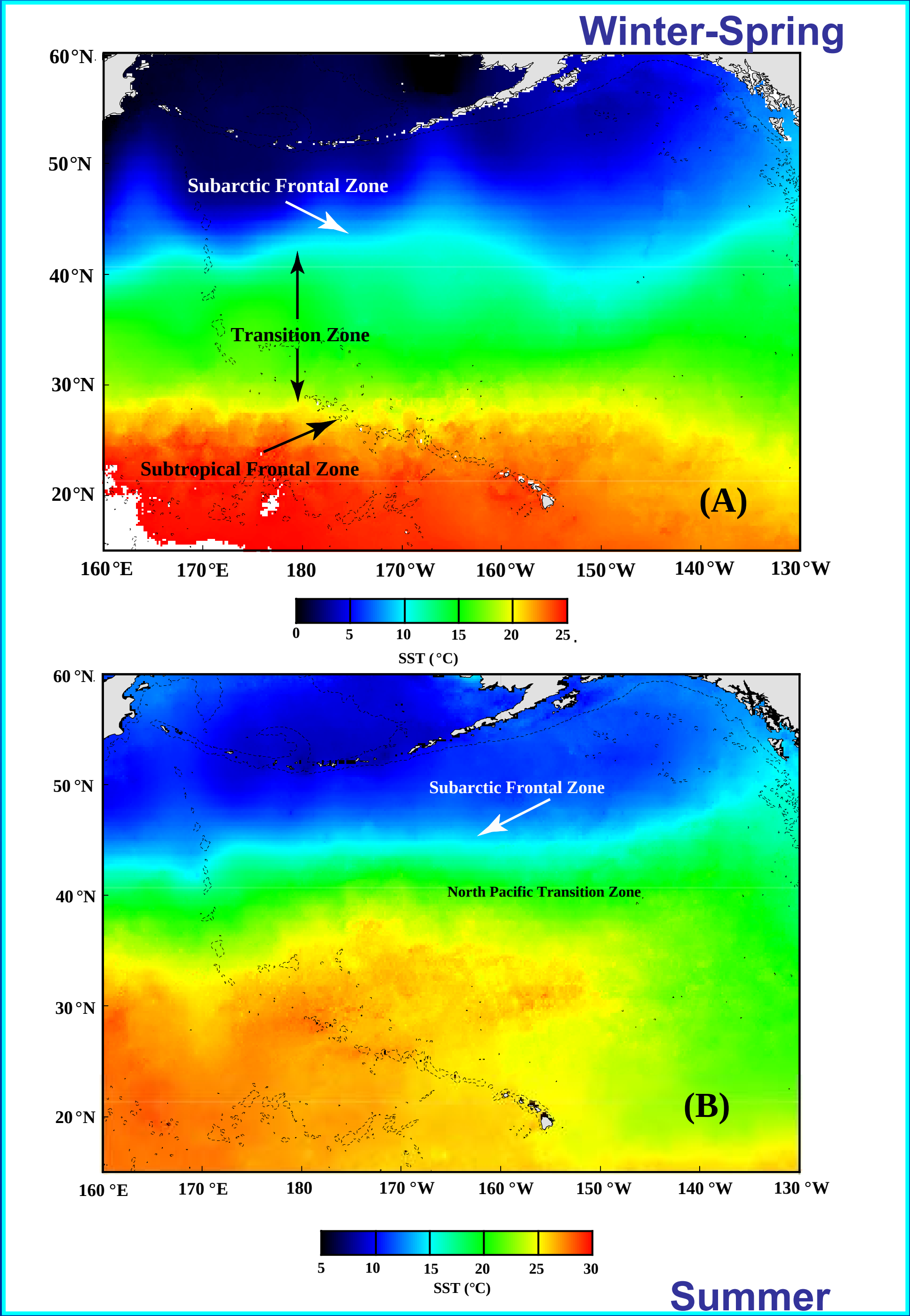


Loggerhead Turtle Movements, Swordfish Catch and Ocean Color



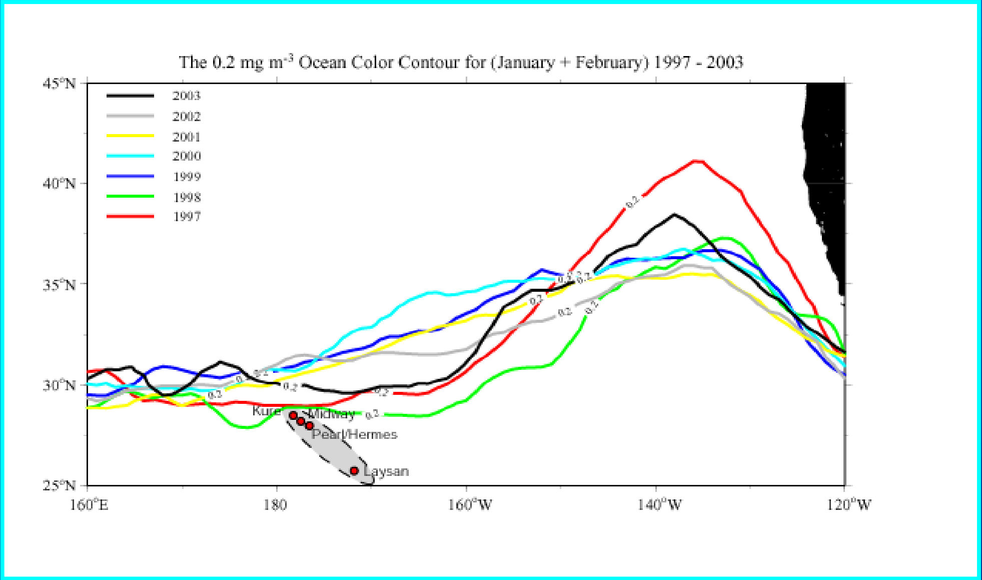
The Subtropical Frontal Zone

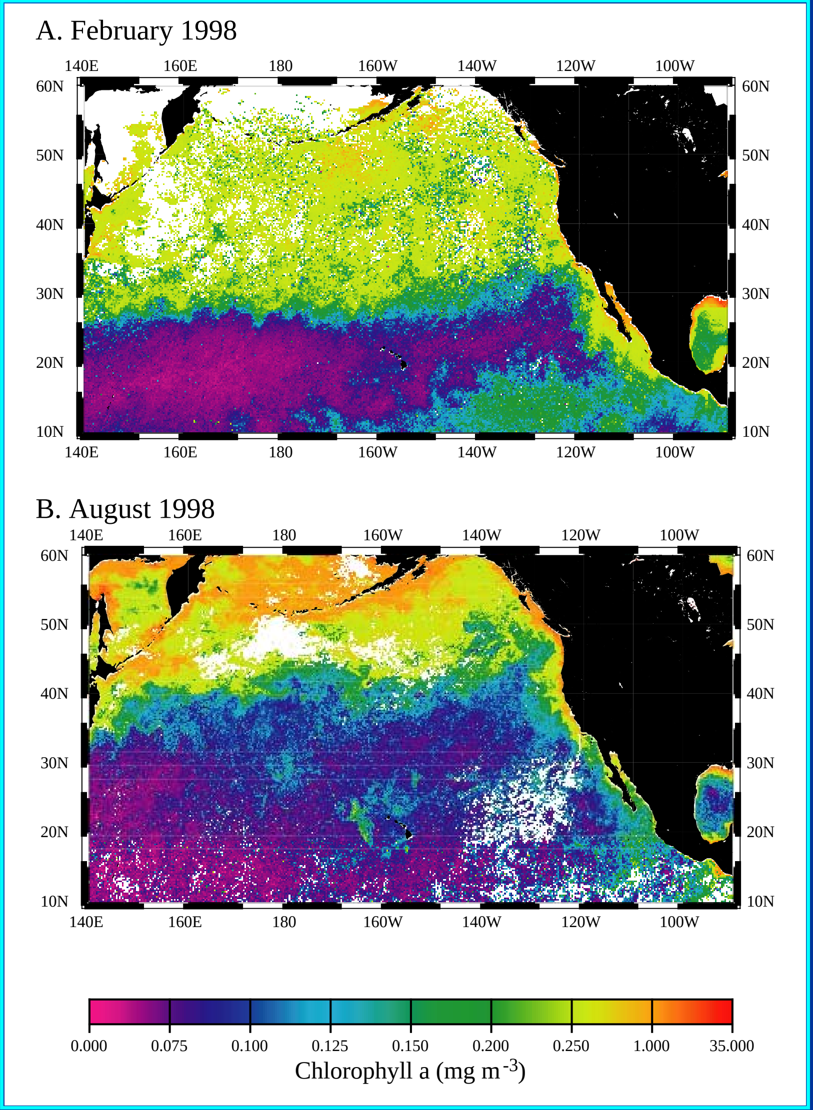
- ➢ Distinct seasonal surface signatures
- ➢ Concentration of thermohaline gradients result from convergence of Ekman flow
- ➢ Multiple large scale fronts
  - ◆ SSTF: 28°- 30°N
  - ◆ STF: 32°-34°N
- ➢ Pervasive mesoscale (10-100 km) processes on synoptic time scales
- ➢ SLH fluctuations = surface expressions readily measured by satellite altimeters



The North Pacific Transition Zone Chlorophyll Front

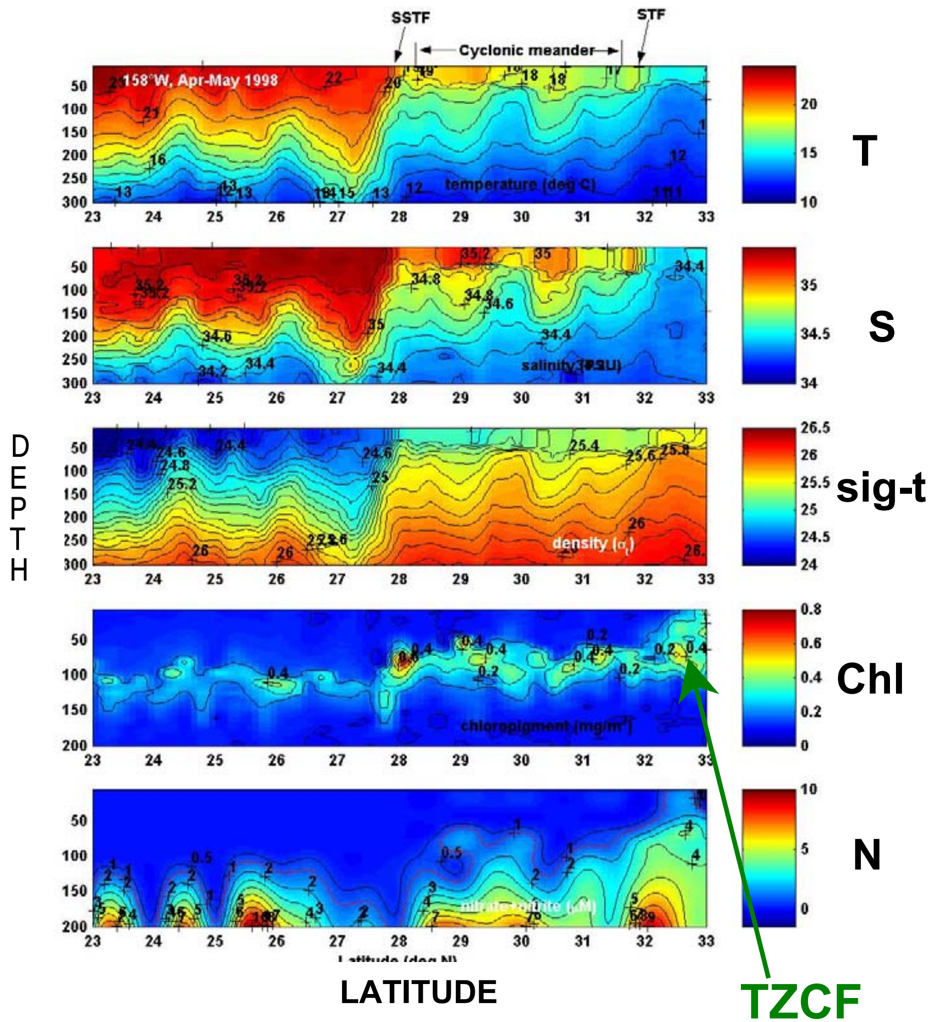
- Basin-scale feature defined by the 0.2 mg/m^3 Chl surface contour
- Seasonally oscillates north to south about 1000 km with a latitudinal minimum in January-February and maximum in July-August
- Critical habitat for animals; e.g., loggerhead sea turtles use as migration pathway



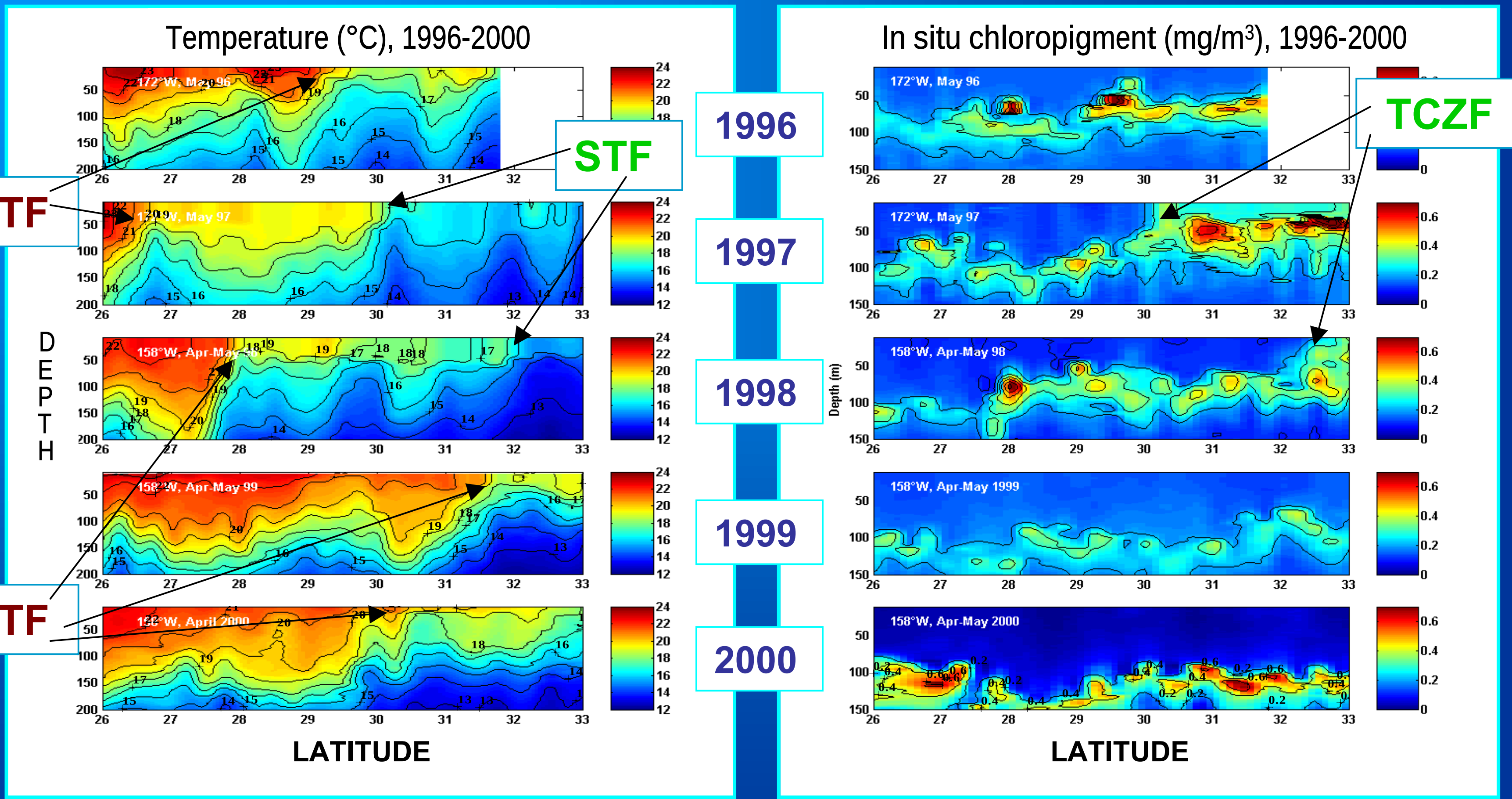


- In situ section (1,140 km) along 158°W
- SSTF near 28°N lat.; STF just north of 32°N lat.
- Cross frontal gradients steepest at SSTF where:
  - ΔT~3°C/50 km
  - ΔS~0.7/50 km
  - Δsig-t~0.6/50 km
- Cyclonic meander evident near 29°N
- Z_{SCM}, & nutricline shoaled and closely tracked corresponding density structure
- [Chl_{SCM}] > 1.0 mg/m^3 at SSTF. Note increased productivity occurs subsurface at SSTF and is not detectable by satellites
- STF marks transition from low, nutrient depleted waters to the south to 2-fold increase to the north; i.e., TZCF

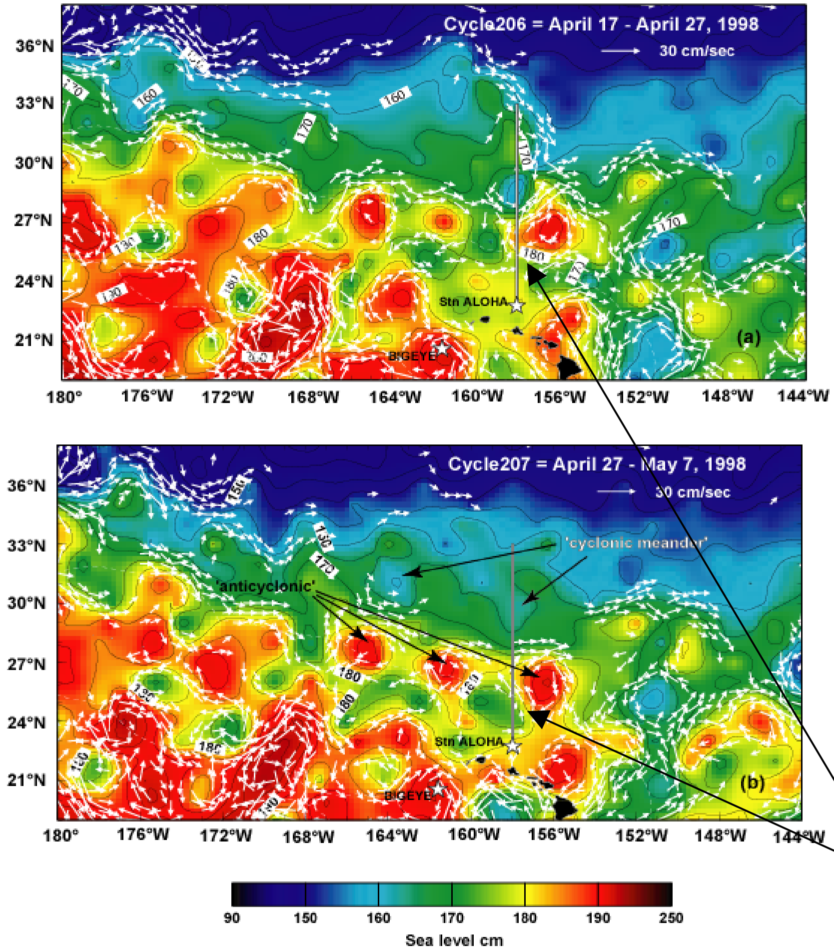
April-May 1998



Considerable interannual variability in latitudinal position and intensity of the SSTF & STF; ca. 300 km shift in frontal positions between 1996-97 at 172°W and 1998-99 at 158°W.



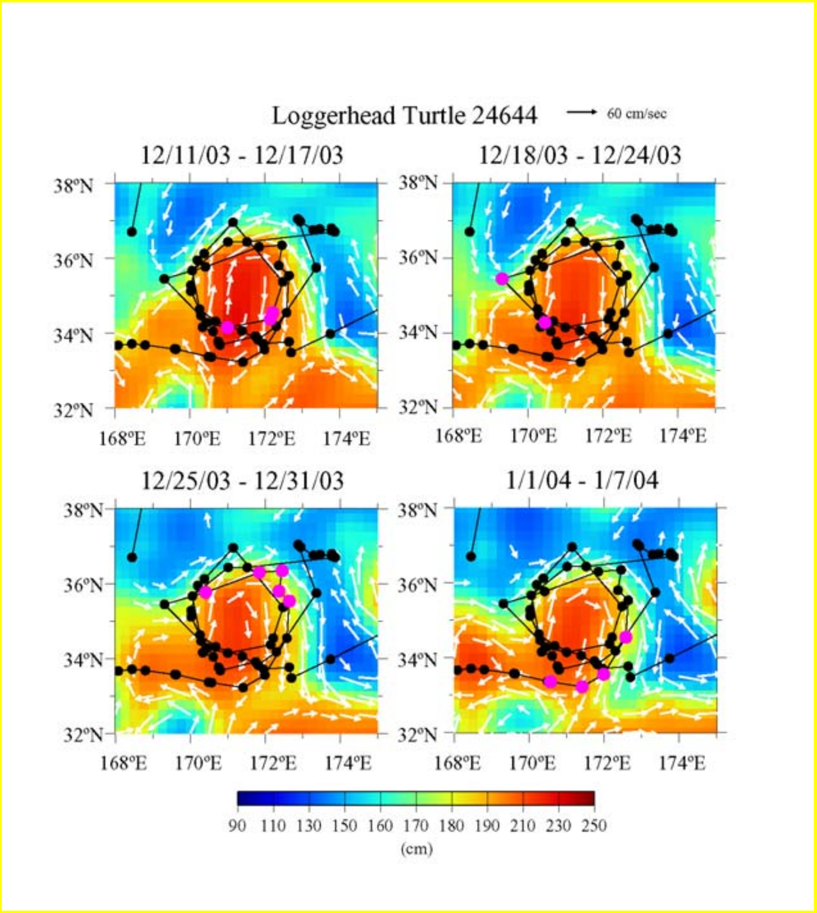
Topex altimetry – April 1998

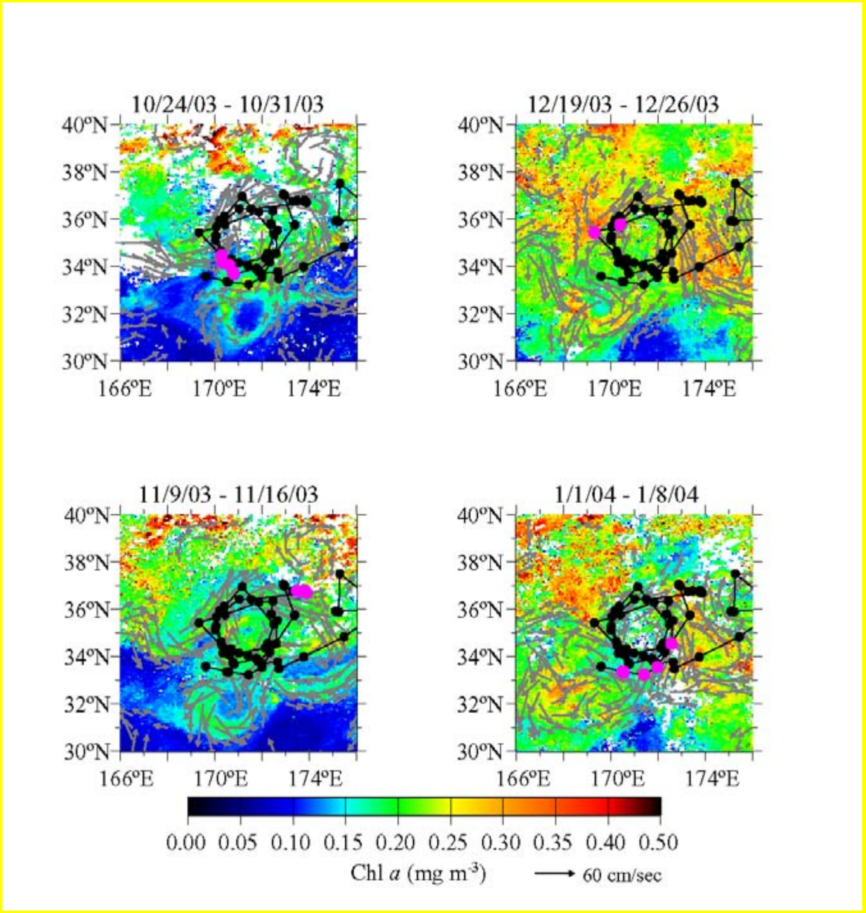


- STFZ: characterized by pervasive field of mesoscale activity in various stages of formation & decay
- Cyclonic eddies & meanders prevalent to the north of streamlines; anticyclonic to the south
- Note cyclonic meander centered near 29°N lat.

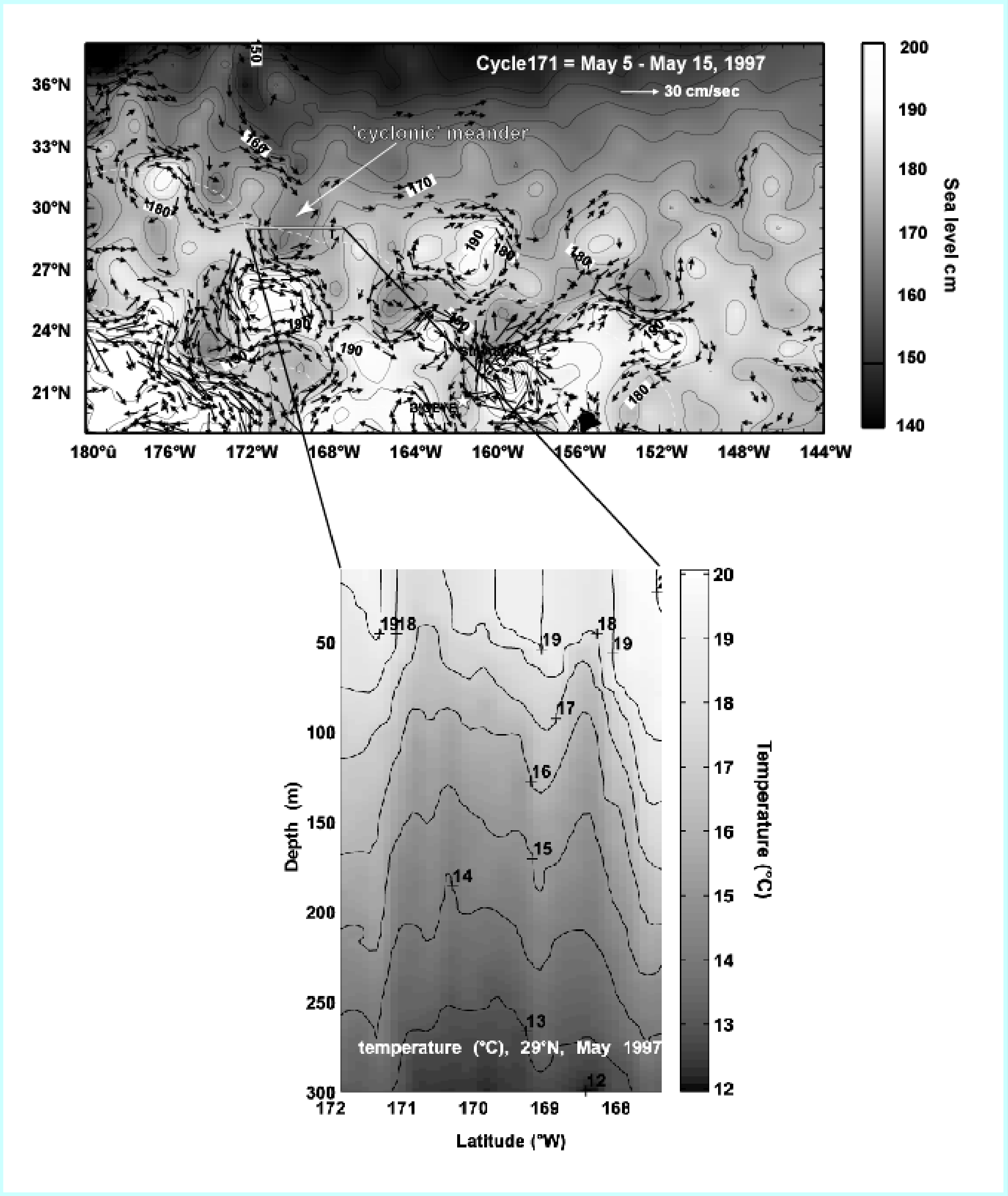
"Position of survey transect line"

Loggerhead turtles response to mesoscale oceanographic features



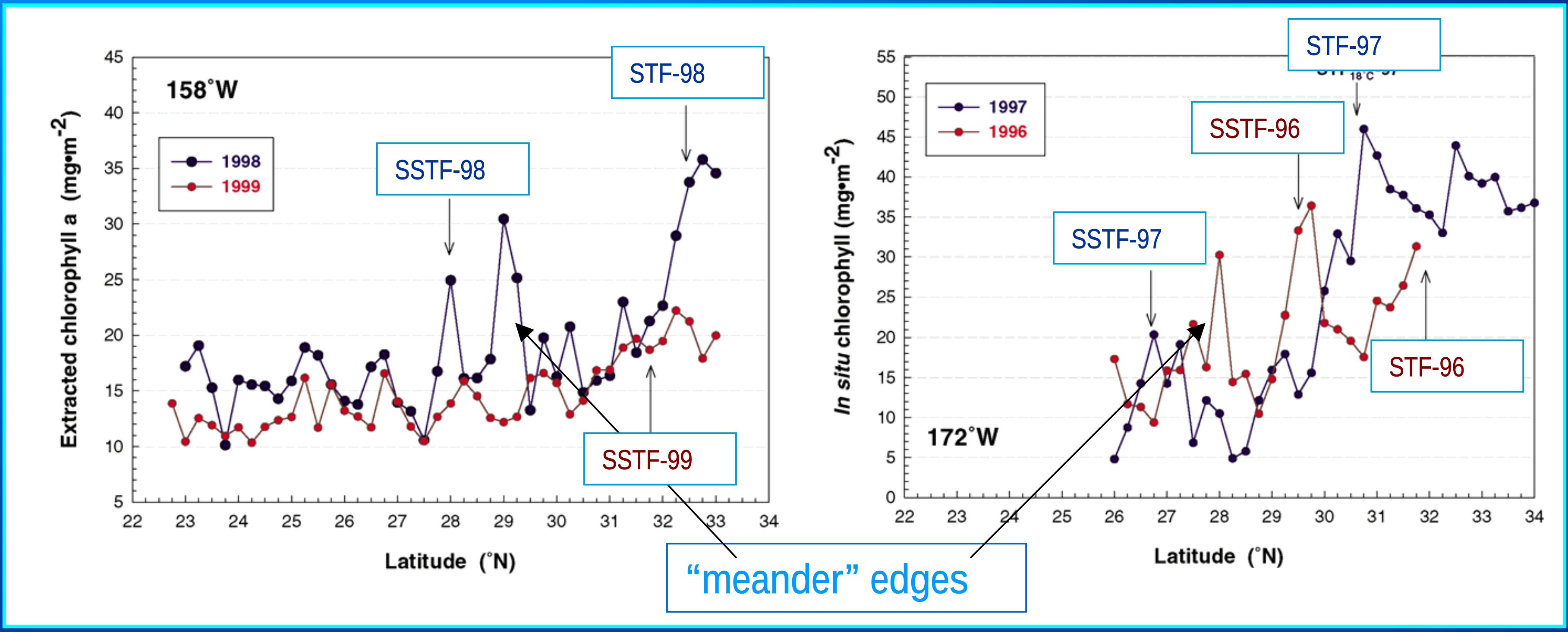


Vertical temperature (°C) distribution from zonal slice through a cyclonic meander at 29°N lat, May 1997.

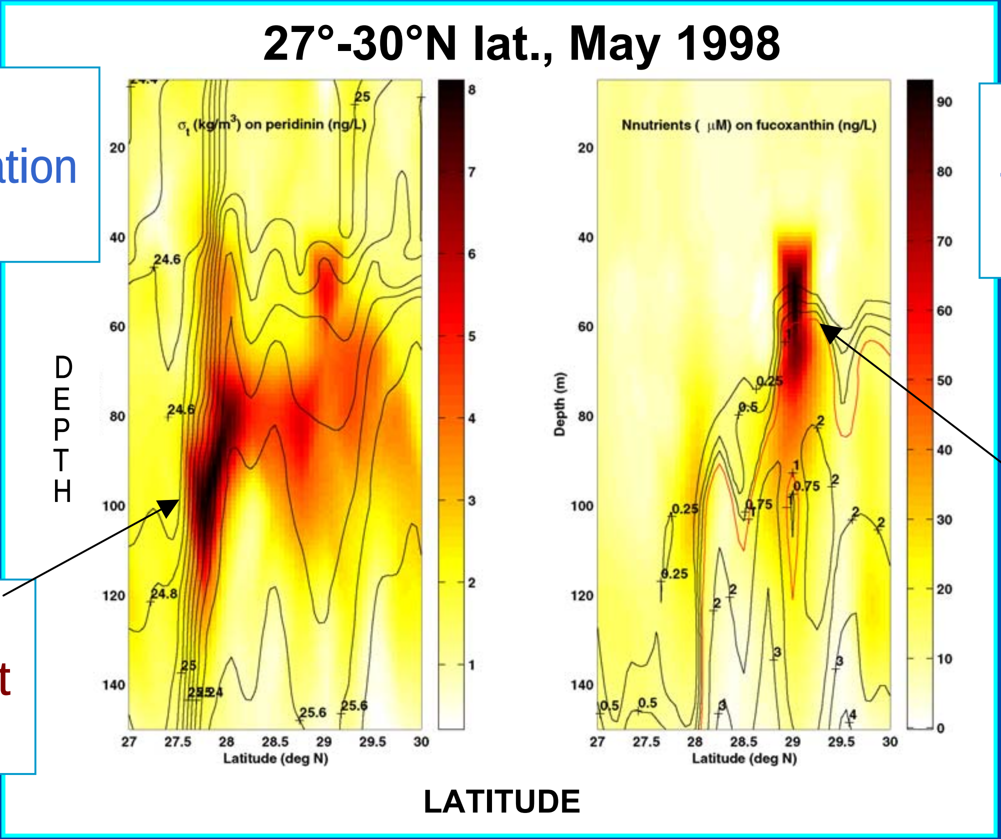


Fronts and embedded mesoscale features are key to biological enhancement:

- Integrated chloropigment exhibit distinct maxima in alignment with SSTF & STF
- Can be ascribed to increases in the concentration & thickness of SCM layer
- Chloropigment levels especially amplified by displacement of isopycnals in presence of meanders.



Enhanced chloropigment responses to physical environment also reflect substantial increases in large eukaryotic phytoplankton; namely diatoms & dinoflagellates, suggesting enhanced transfer efficiency to higher trophic levels at these dynamic areas.



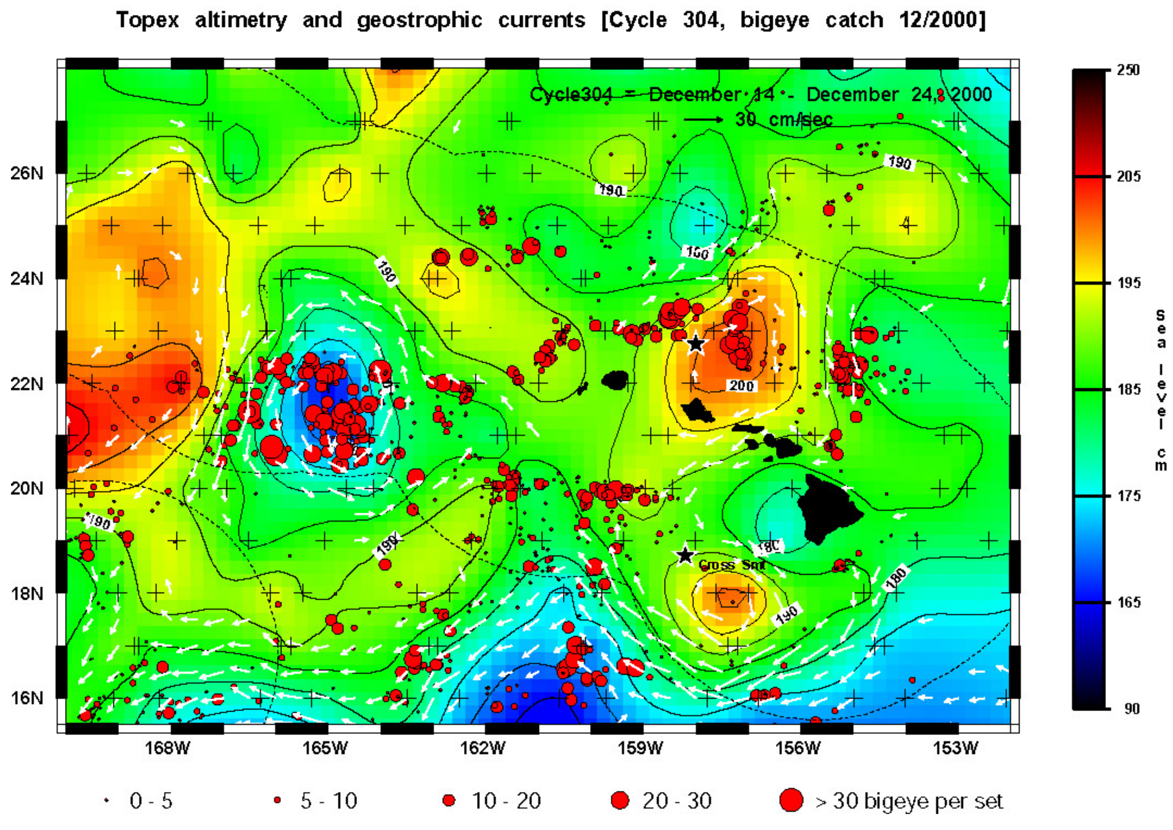
Isopycnals (σ_t) on peridinin concentration (mg/m^3)

N+N isopleths on fucoxanthin concentration (mg/m^3)

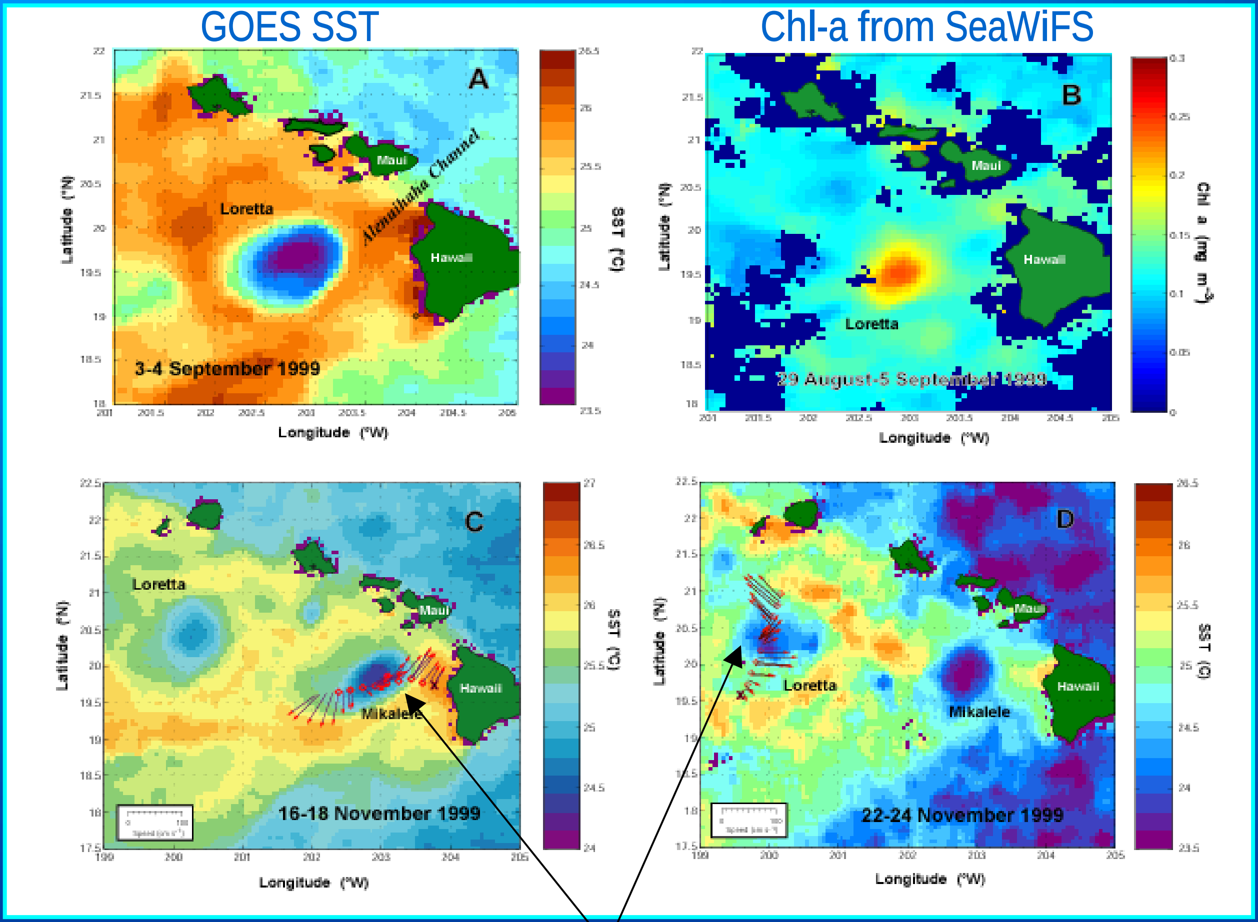
SSTF interface – note increases at depth!

Embedded cyclonic meander … red contour is nutricline defined as 1M N+N isopleth

Longline catches of bigeye tuna and Topex altimetry



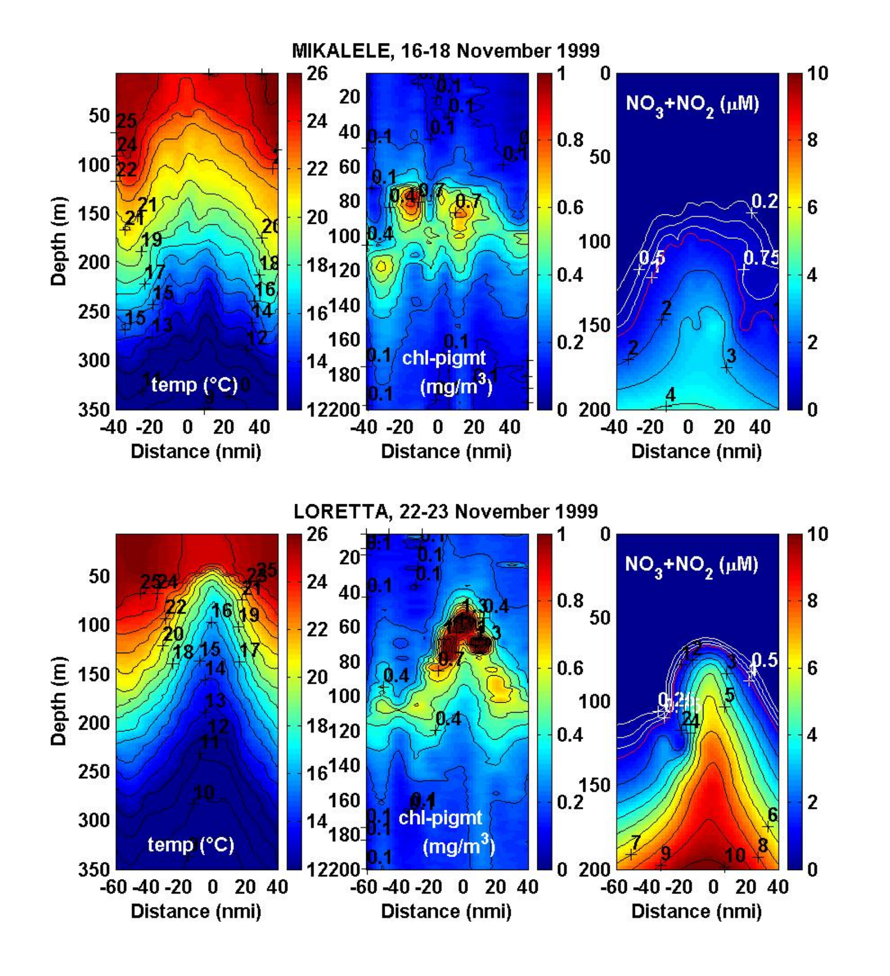
Satellite remote sensing of temperature (GOES-SST) and chlorophyll-a (SeaWiFS) for two Hawaiian eddies



In situ shipboard surveys

- GOES: geostationary, ca. 1 image/hr, helped w/ NRT & clouds ... eddies now predictable
- Loretta first spun up in May 1999
- Strongest in September 1999 (core SST=23.5°C) ... surface Chl expression
- Mikalele spun up in Oct 1999, short-lived
- Nov 1999 -- two transects, 185 km (100 mi) long
- 18 km stn. resolution
- 1000 m CTD casts

Vertical structure of temperature, chloropigments, and nutrients through the eddies



- Upper ocean doming of isopleths – eddy influence
- Magnitude of vertical displacement & compression of isopleths more pronounced in mature eddy
- Vertical distribution (chl, N+N) closely tracked isotherms
- Maximum ADCP current velocities 70 (Mikalele) and 85 (Loretta) cm s^{-1}
- Nutrients (N+N) 3 to 15 fold higher than control stns.
- Modeled 1° production increased 65% in Mikalele, 2-fold in Loretta

Seamounts

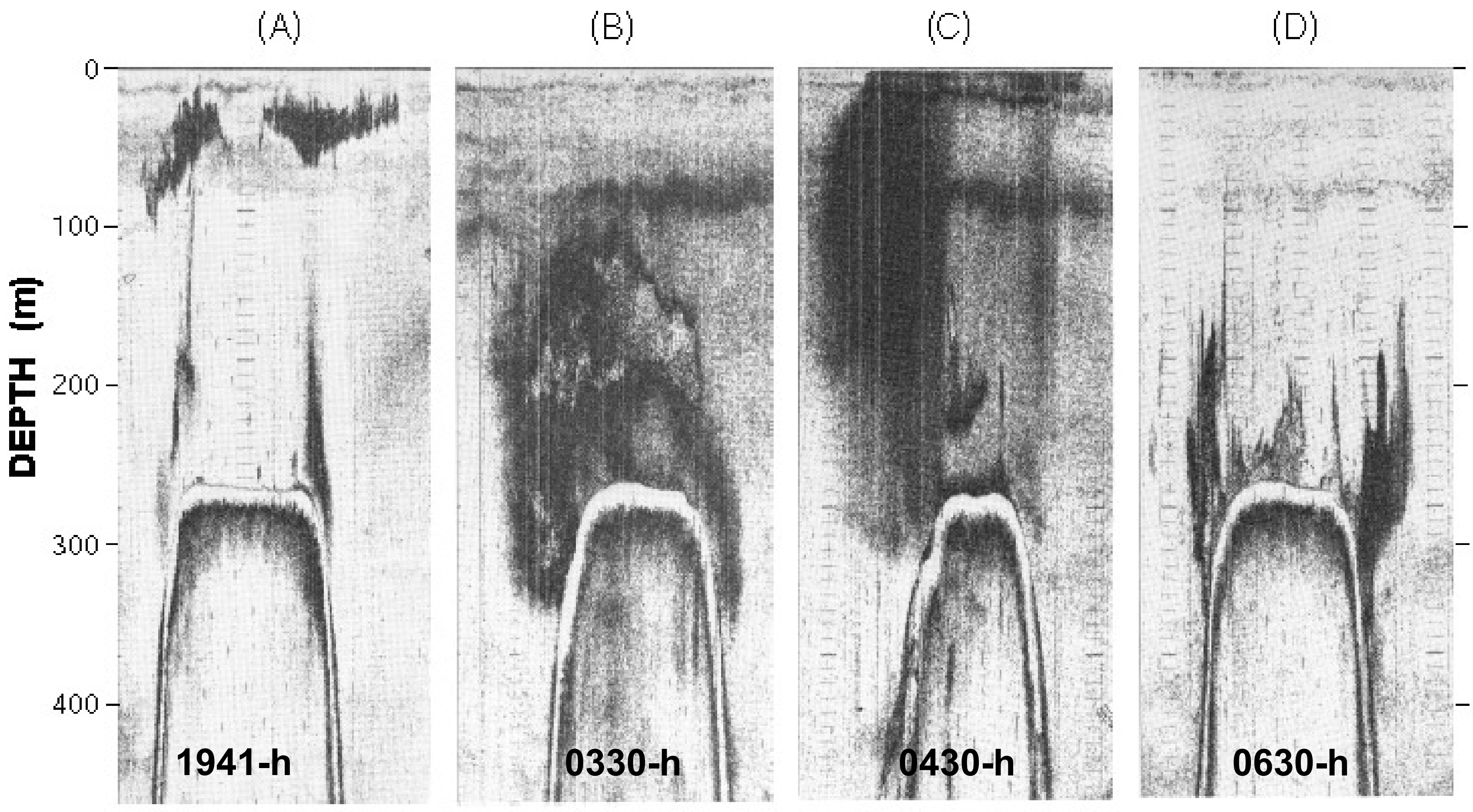
During 1967-75, commerical fisheries took nearly a million MT of demersal fish from the seamounts.

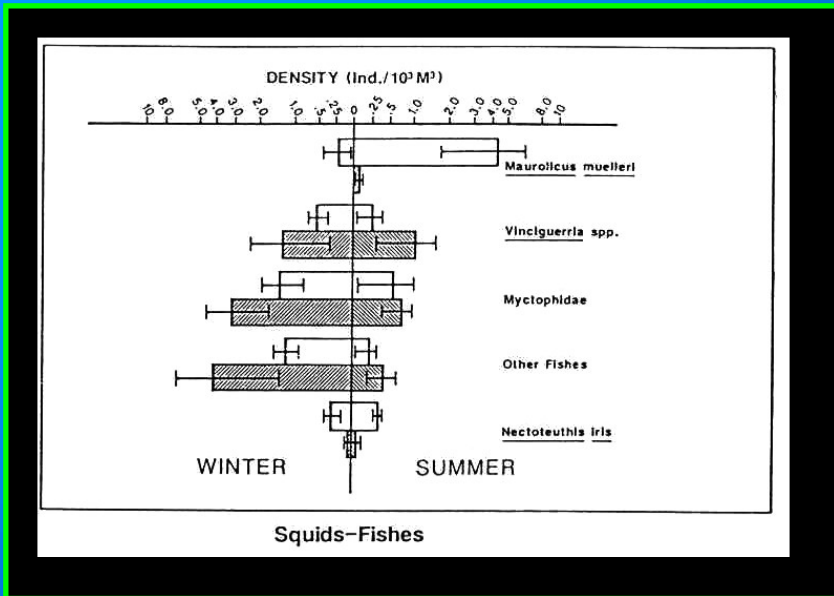
Seamounts frequented for harvesting of pelagic resources (e.g., tunas @ Emperors, Cross Smts)

Seamounts

- Seamounts are found throughout the North Pacific basin and can have a strong influence on adjacent open-ocean food webs
- Ocean currents impinging on topographic obstacles such as seamounts may create a high level variability in the physical environment and thus the biological.
- 1984-85 surveys at SE Hancock Smt – early efforts that first examined oceanic micronekton communities over and adjacent to an isolated mid-Pacific seamount and evidence for a truly unique ecosystem.

Acoustic transects at SE Hancock Smt, July 1984
(38 kHz Simrad echo sounder)



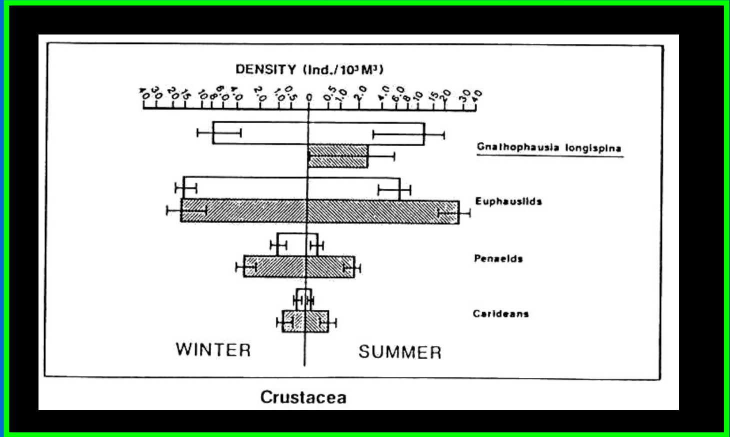


Fishes & Squid

Mean densities (individuals/1000 m^3 water filtered)
of selected micronekton species in the vicinity of SE Hancock
(number in parentheses indicate rank among top five species)

	Summer (Jul-Aug '84)		Winter (Jan-Feb '85)	
Species	**"on"**	**"off"**	**"on"**	**"off"**
Maurolicus muelleri	4.19 (2)	0.06	0.17	--
Lampanyctus alatus	0.03	0.02	0.09	0.90 (5)
Ceratoscopelus townsendi	0.20	0.20	0.20	0.60
Vinciguerria nimbaria	0.80	0.03	0.39	0.73
Vinciguerria attenuata	0.17	0.93	0.02	0.16
Iridoteuthis iris	0.35	0.03	0.25	--
Onychoteuthis n. sp. D	--	--	0.24	0.46
Megalocranchia cf. fisheri	--	--	0.10	0.20

Crustaceans



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	Summer (Jul-Aug '84)		Winter (Jan-Feb '85)	
Species	"on"	"off"	"on"	"off"
Gnathophausia longispina	11.60 (1)	2.59 (4)	7.26 (1)	--
Euphausia gibboides	1.23 (4)	5.50 (1)	6.98 (2)	3.27 (2)
Euphausia hemigibba	0.82 (5)	1.93	2.65 (3)	4.28 (1)
Euphausia mutica	1.38 (3)	2.24 (5)	0.24	0.28
Thysanopoda monacantha	0.07	2.81 (3)	0.37	1.09 (4)
Thysanopoda orientalis	0.15	3.75 (2)	--	0.06
Thysanopoda tricuspidata	--	0.02	0.50	0.29
Stylocheiron abbreviatum	0.19	0.91	0.76	1.57 (3)
Thysanoessa gregaria	--	--	0.10	0.01
Gennadas incertus	--	0.2	--	0.6 (5)
Oplophorus spinosus	0.01	0.29	0.03	0.29

Closing comments

- Oceanic "hot spots" are generally highly dynamic areas where considerable transfer of energy occurs.
- While the importance of "hot spots" are well recognized, much of what we know still centers on the identification of patterns.
- The underlying processes (physical, geochemical, and biological) that drive these unique ecosystems remain little understood and would benefit from considerable further study.