

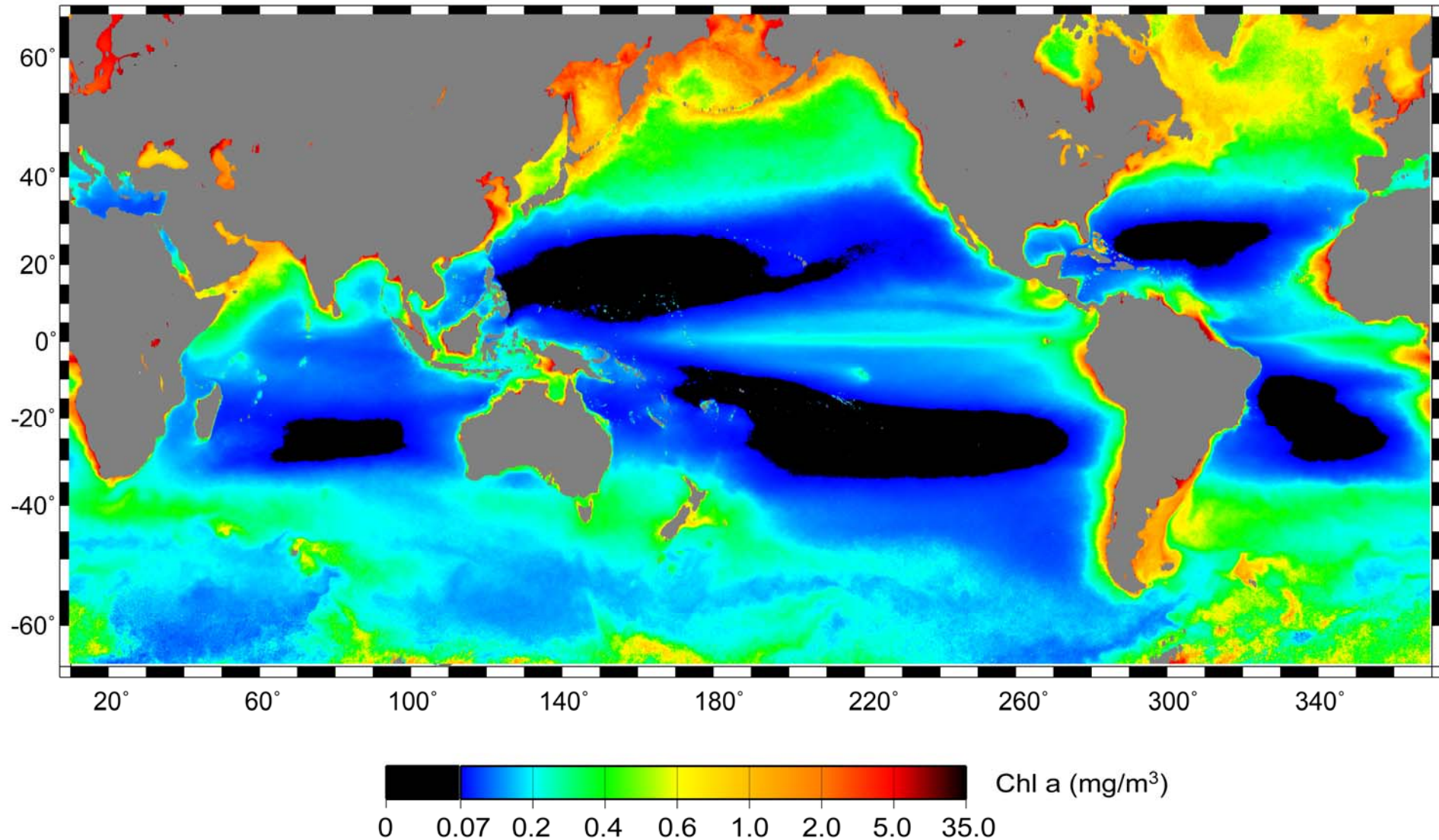
Developing an understanding of recent and future changes in the North Pacific Subtropical Gyre marine ecosystem

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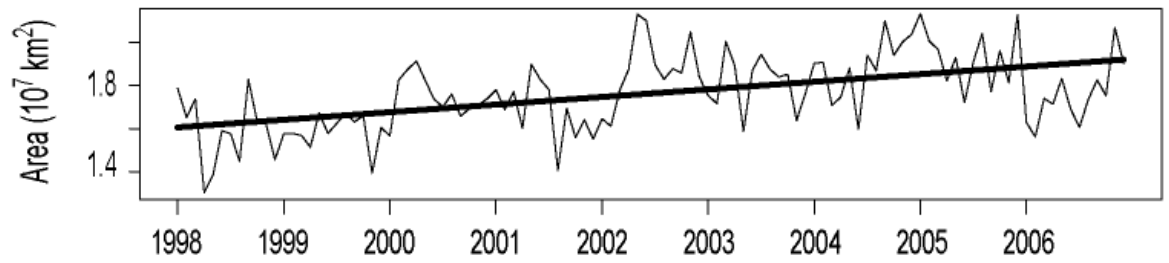
²JIMAR, University of Hawaii

SeawiFS surface chlorophyll climatology with oligotrophic gyres in black

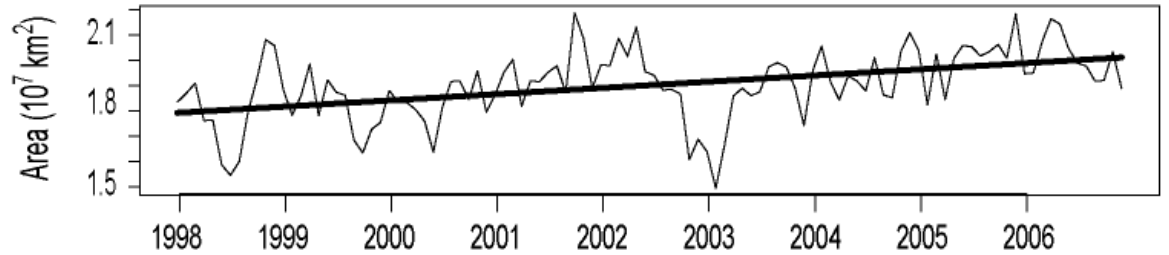


Linear term

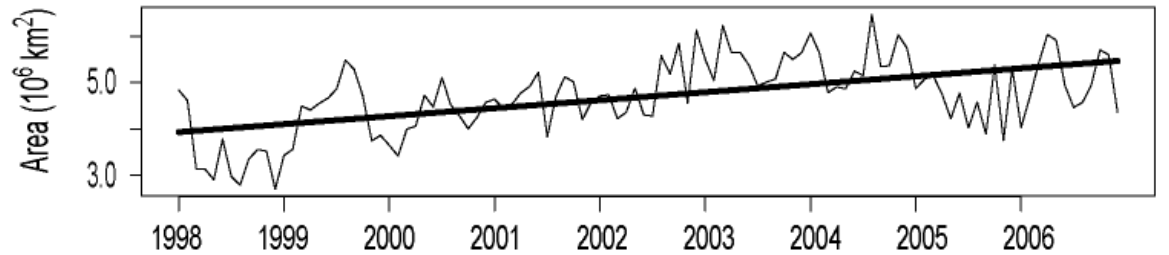
N Pacific



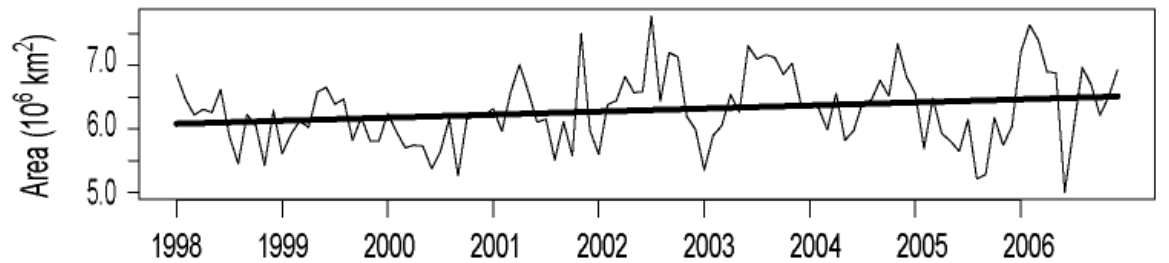
S Pacific



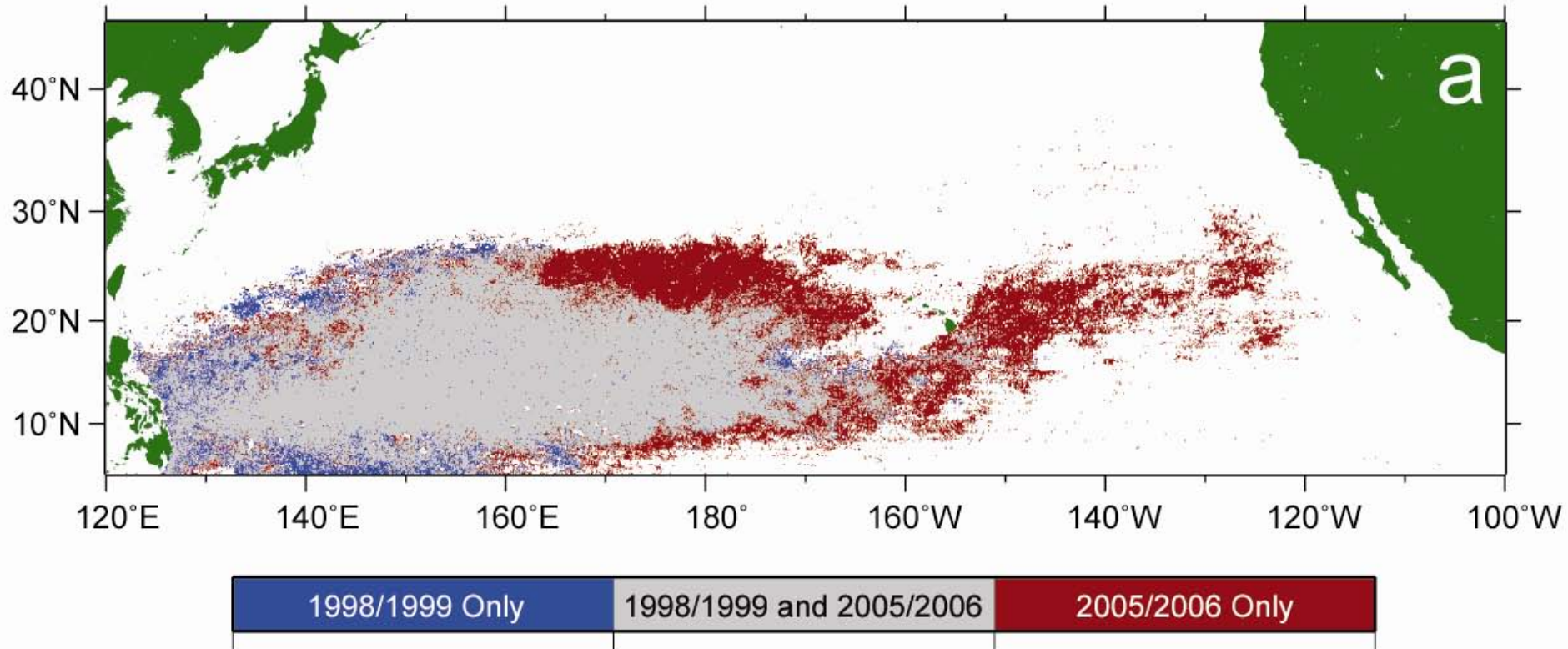
N Atlantic



S Atlantic



Expansion of low surface chlorophyll waters into the Hawaii longline fishing grounds

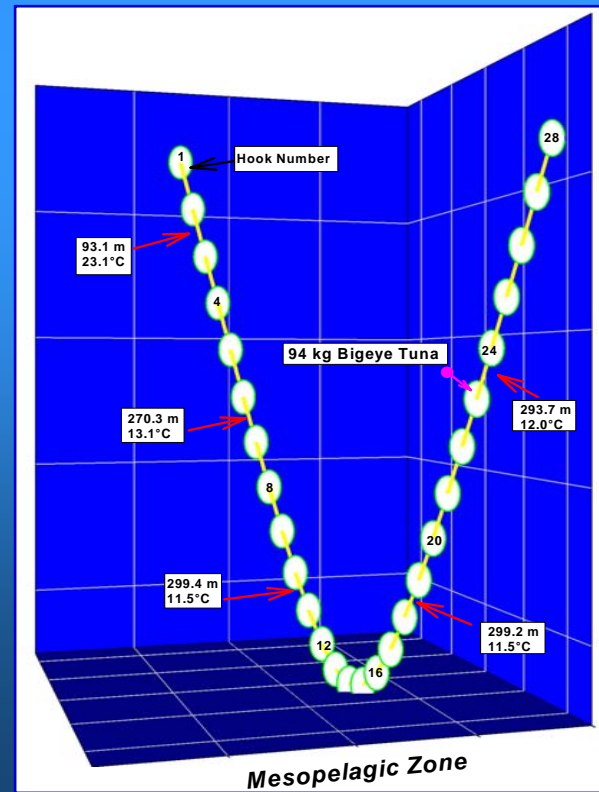
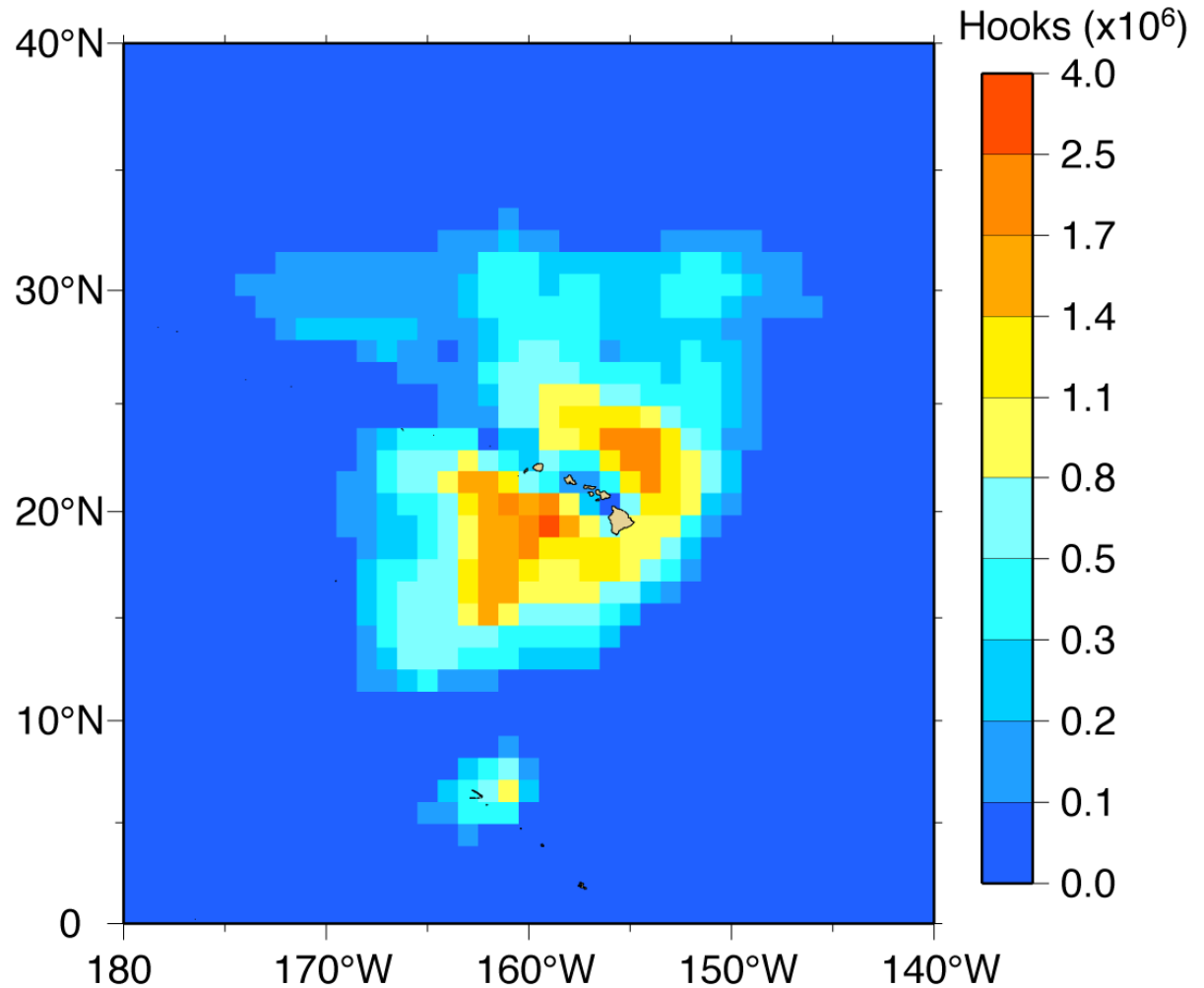


Hawaii-based longline fishery



Ex-vessel value 2007 US\$ 70 million

Total Effort of the Hawaii-based longline fishery 1990 - 2005



Top 10 most commonly caught species in the Hawaii deep-set longline fishery, 1996-2006:

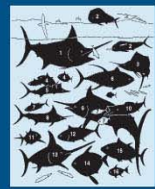
Bigeye, Blue Shark, Albacore Tuna, Yellowfin Tuna, Skipjack Tuna, Striped Marlin, Shortbill Spearfish, Mahi mahi, Ono, Monchong (*Taractichthys steindachneri*)

PELAGIC FISHES OF HAWAII



Pelagic fishes inhabit the deep blue waters of the open ocean, ranging from the surface to depths of hundreds of feet. They are remarkably well adapted to their environment; tuna and billfish are even capable of transoceanic migrations. Some, like the albacore, span the entire Pacific Ocean on their way to and from Hawaiian waters. Tuna and billfish are top predators of the pelagic realm, feeding on almost all other creatures in the open ocean, including each other. Along with other large pelagic species, they are among the most popular fish for food and recreation. Their size and strength makes them prized catches of sport fishers. They are also highly valued commercially, and command impressive prices on many international markets. From both an economic and social perspective, these are the most important fishes in Hawaii's waters.

- | | | | |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------|
| 1. Au - <i>Makaira nuxalis</i>
Pacific blue marlin, kahi | 5. Au - <i>Seriola lalandi</i>
Shortbill spearfish, kahi | 9. Au - <i>Makaira nuda</i>
Black marlin, kahi | 13. Au - <i>Xiphus gladius</i>
Broadbill swordfish, shukame |
| 2. Mahinahi - <i>Coryphaena hippurus</i>
Dorado (male, down pumping, and female) | 6. Ahi - <i>Thunnus albacares</i>
Yellowfin tuna | 10. Ono - <i>Acanthocybium solandri</i>
Wahoo | 14. Cyph - <i>Lampris guttatus</i>
Mahi-mahi |
| 3. Avalape - <i>Isopisthus platyurus</i>
Sulphur | 7. Kawakawa - <i>Lepomis affinis</i> | 11. Ahi palaha - <i>Thunnus altagladius</i>
Albacore, kumbo | 15. Maquere - <i>Thunnus thynnus</i>
Northern bluefin tuna |
| 4. Aka - <i>Katsuwonus pelamis</i>
Skipjack tuna | 8. Au - <i>Seriola lalandi</i>
Striped marlin, naitagi | 12. Ahi poromai - <i>Thunnus obesus</i>
Bigeye tuna, tokaoka | 16. Monchong - <i>Taractichthys steindachneri</i>
Eunice |



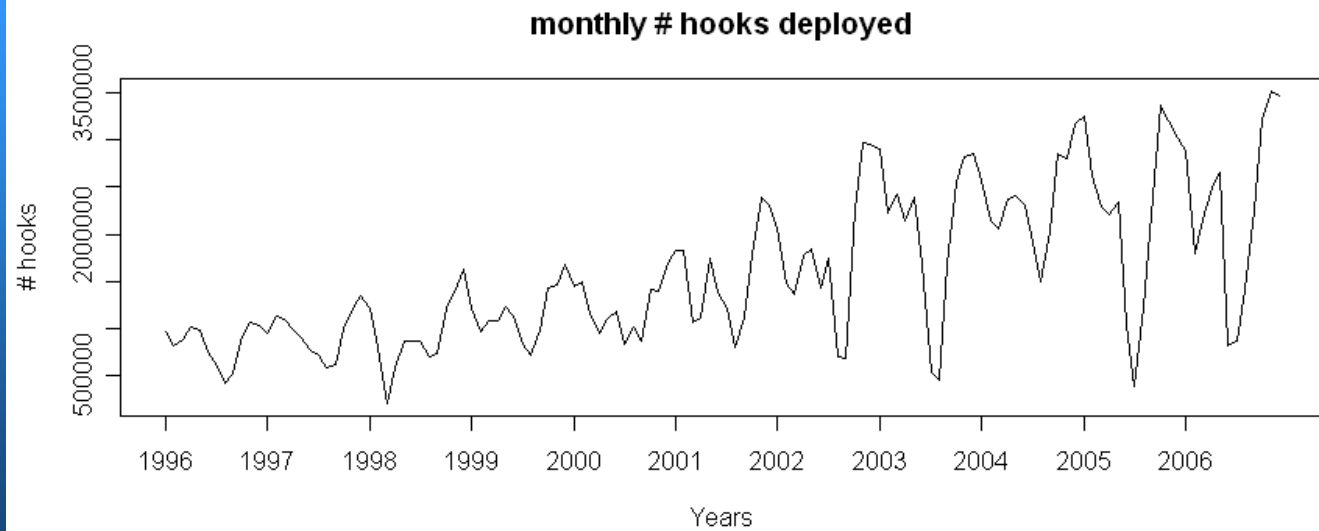
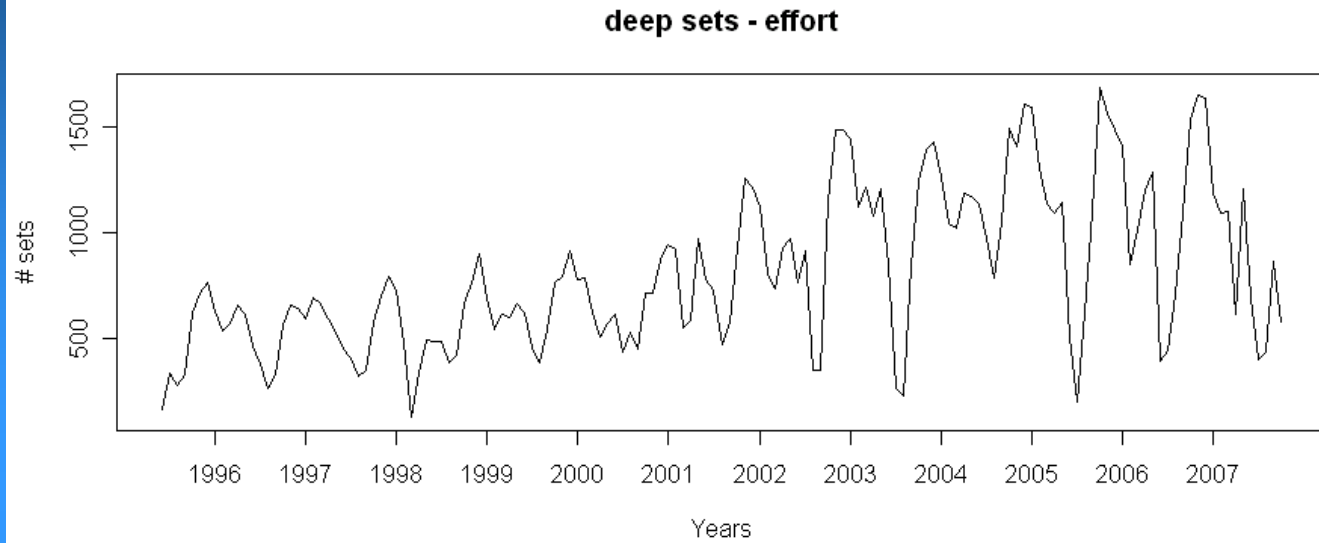
Produced by the Hawaiian Program
Department of Land and Natural Resources

NOAA
NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

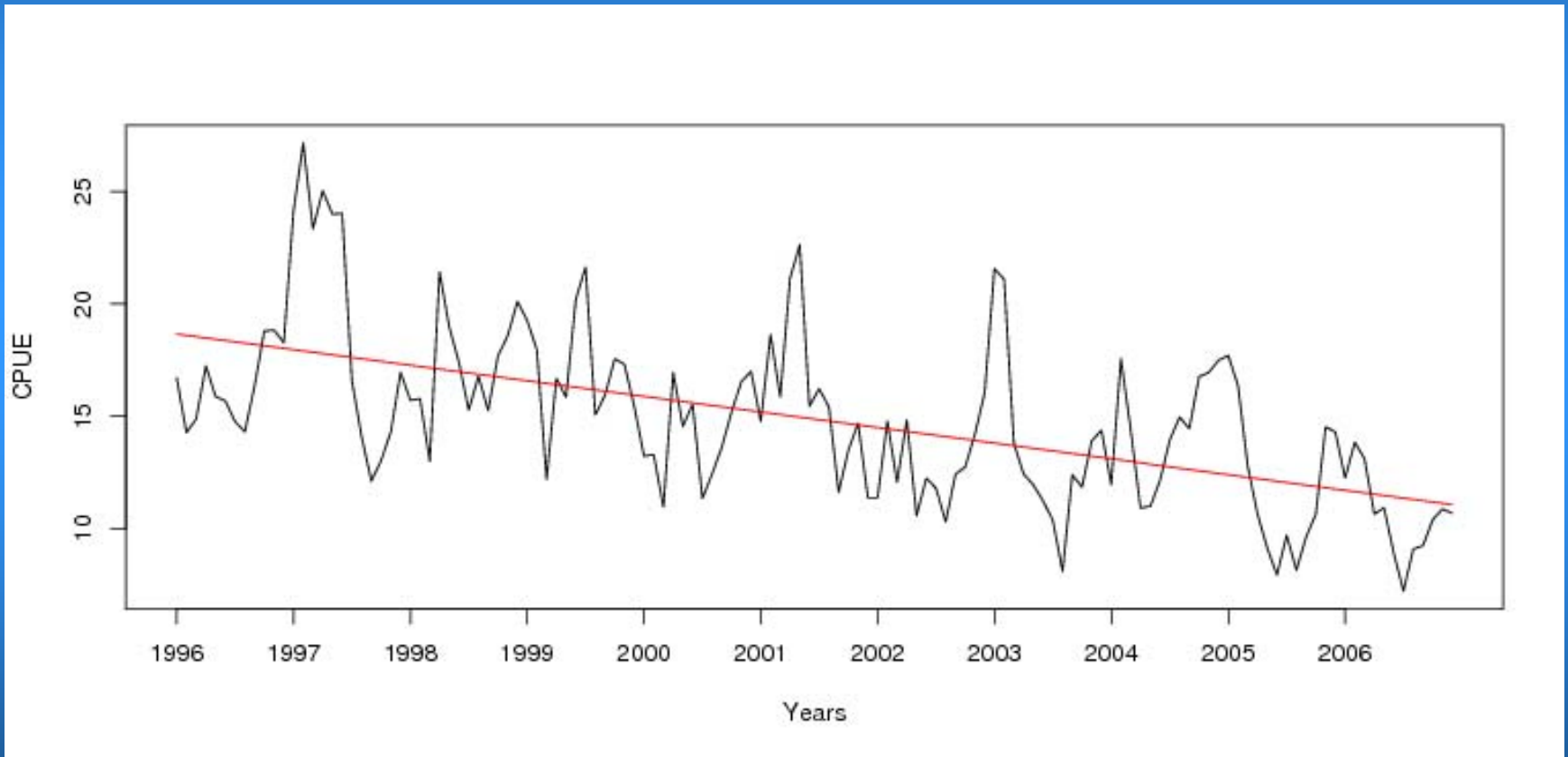
Printed in part by the Hawaii Inland Sea Grant fish
Inventory Program through the purchase
of being equipment and related fish.

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Time series of deep-set fishing effort

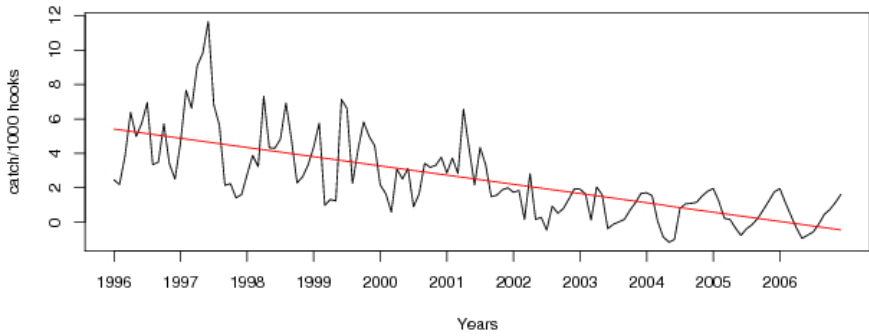


Computed catch-per unit-effort (CPUE as number of fish per 1000 hooks. Fit a GAM $CPUE = A + B*Time + S(month) + error$

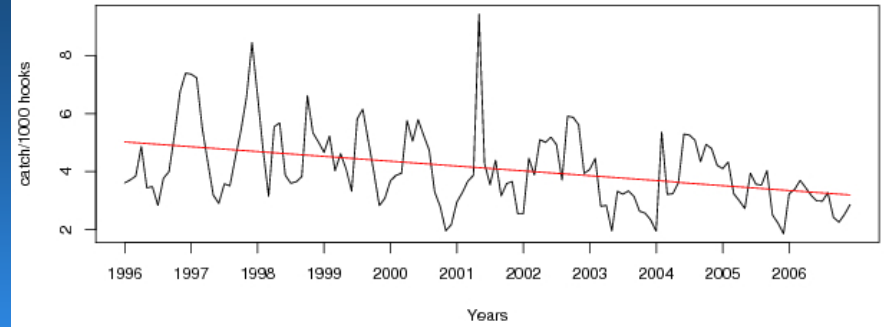


CPUE time series for top 10 species together with estimated linear trend from GAM

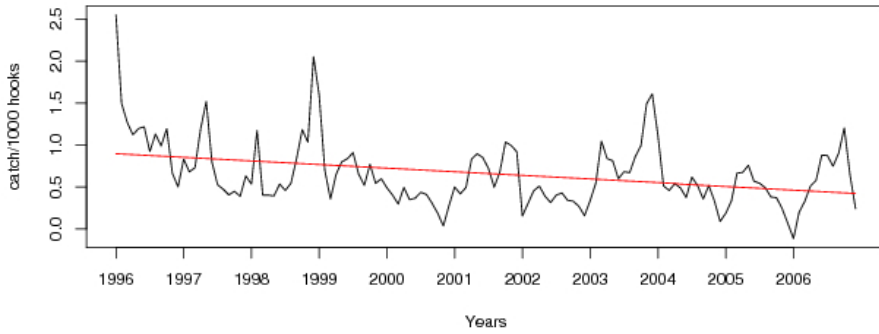
deep sets – albacore



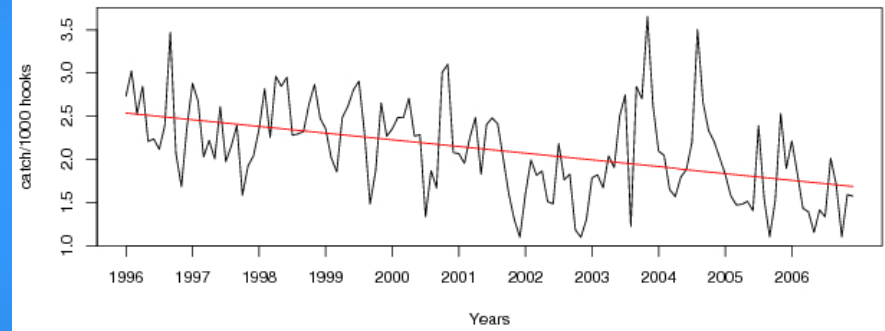
deep sets – bigeye



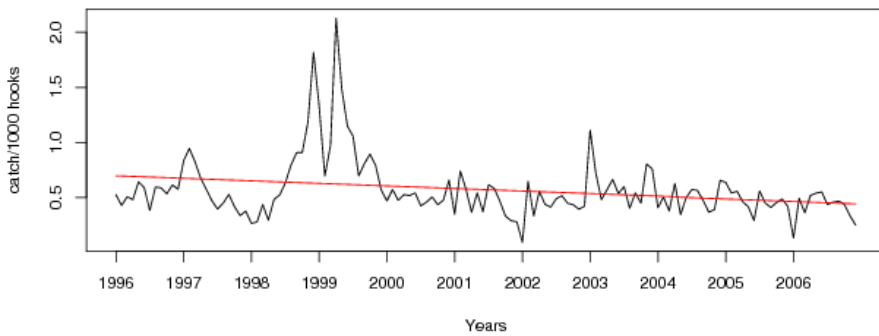
deep sets – striped marlin



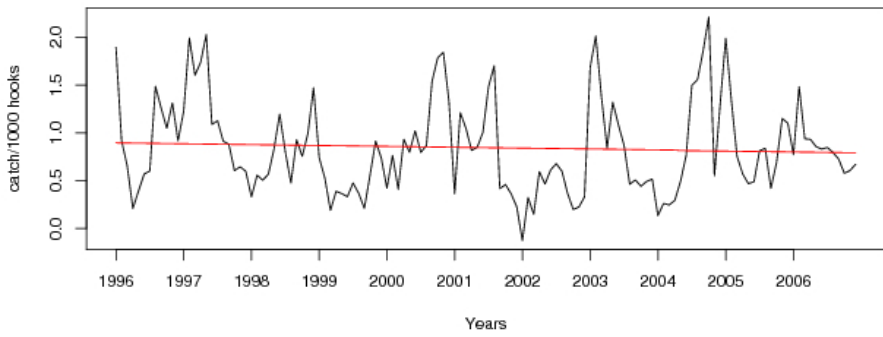
deep sets – blue shark



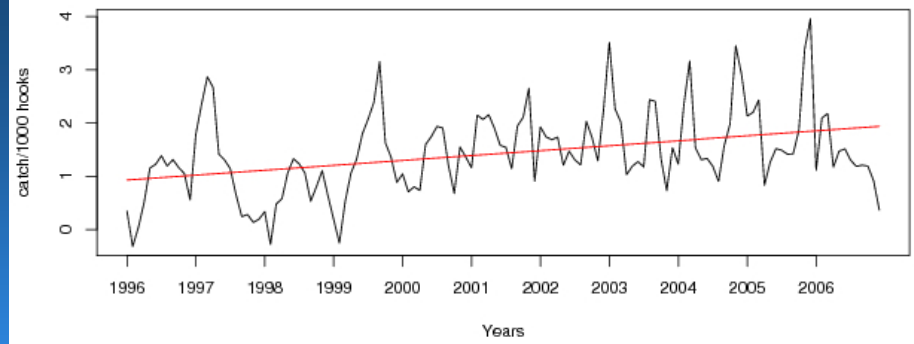
deep sets – shortbill spearfish



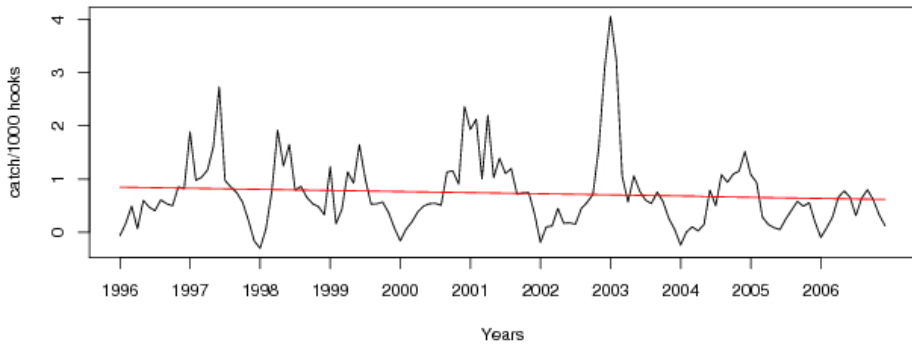
deep sets – yellowfin



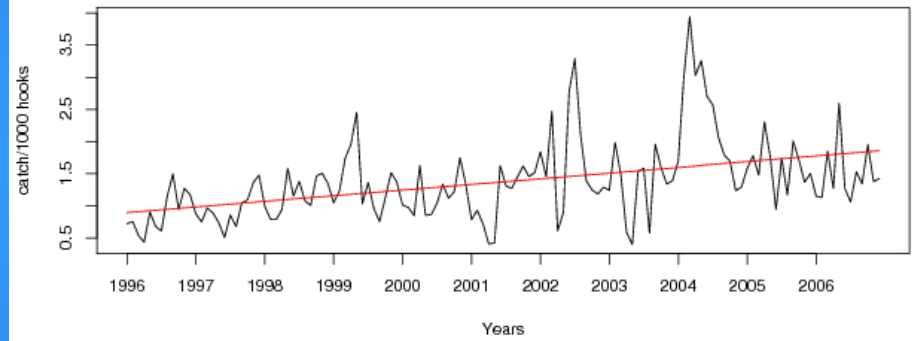
deep sets – mahi



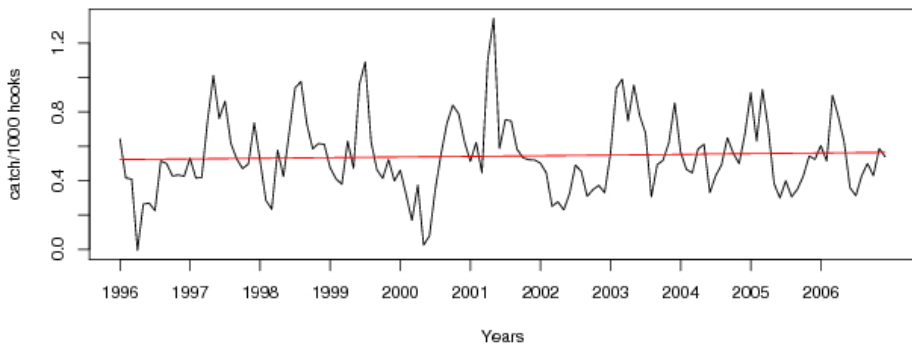
deep sets – skipjack



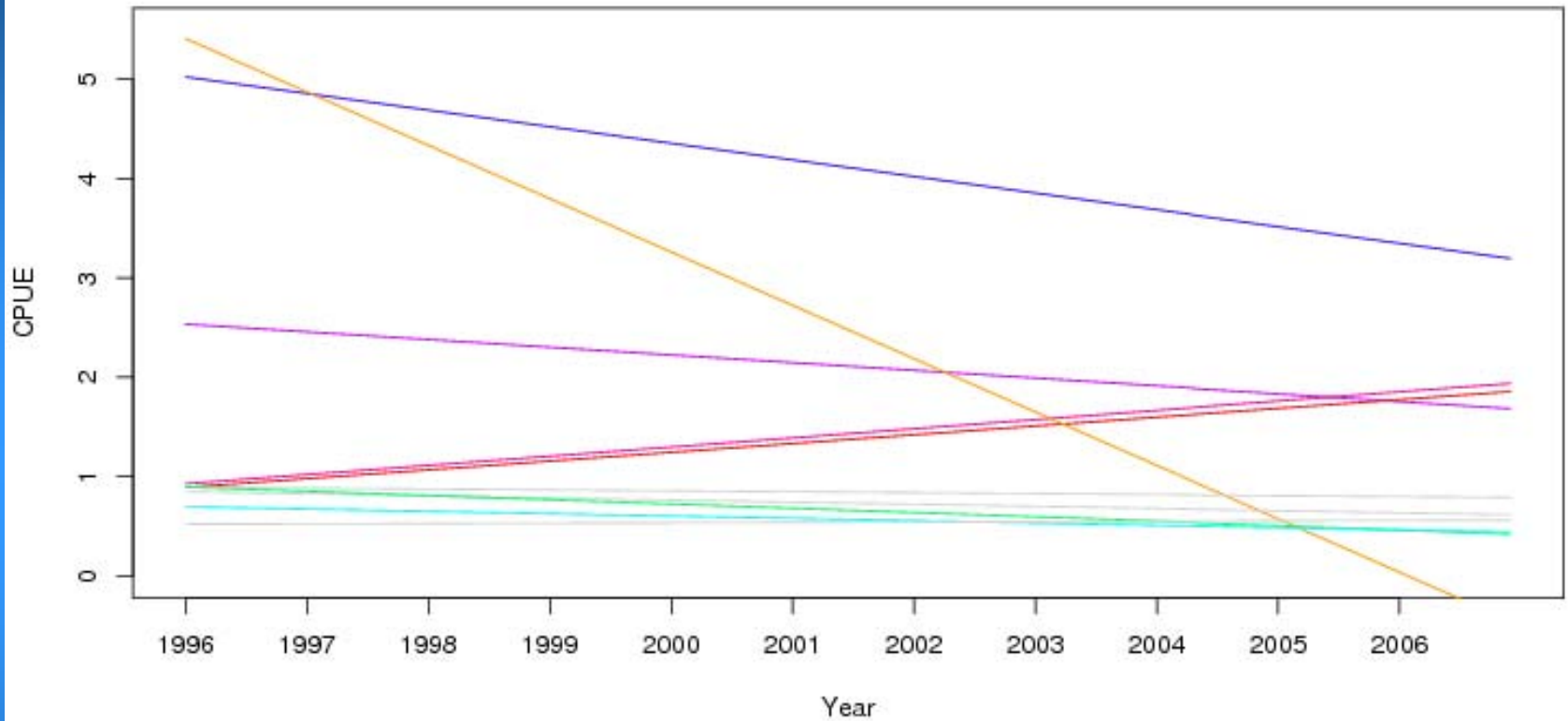
deep sets – monchong



deep sets – ono



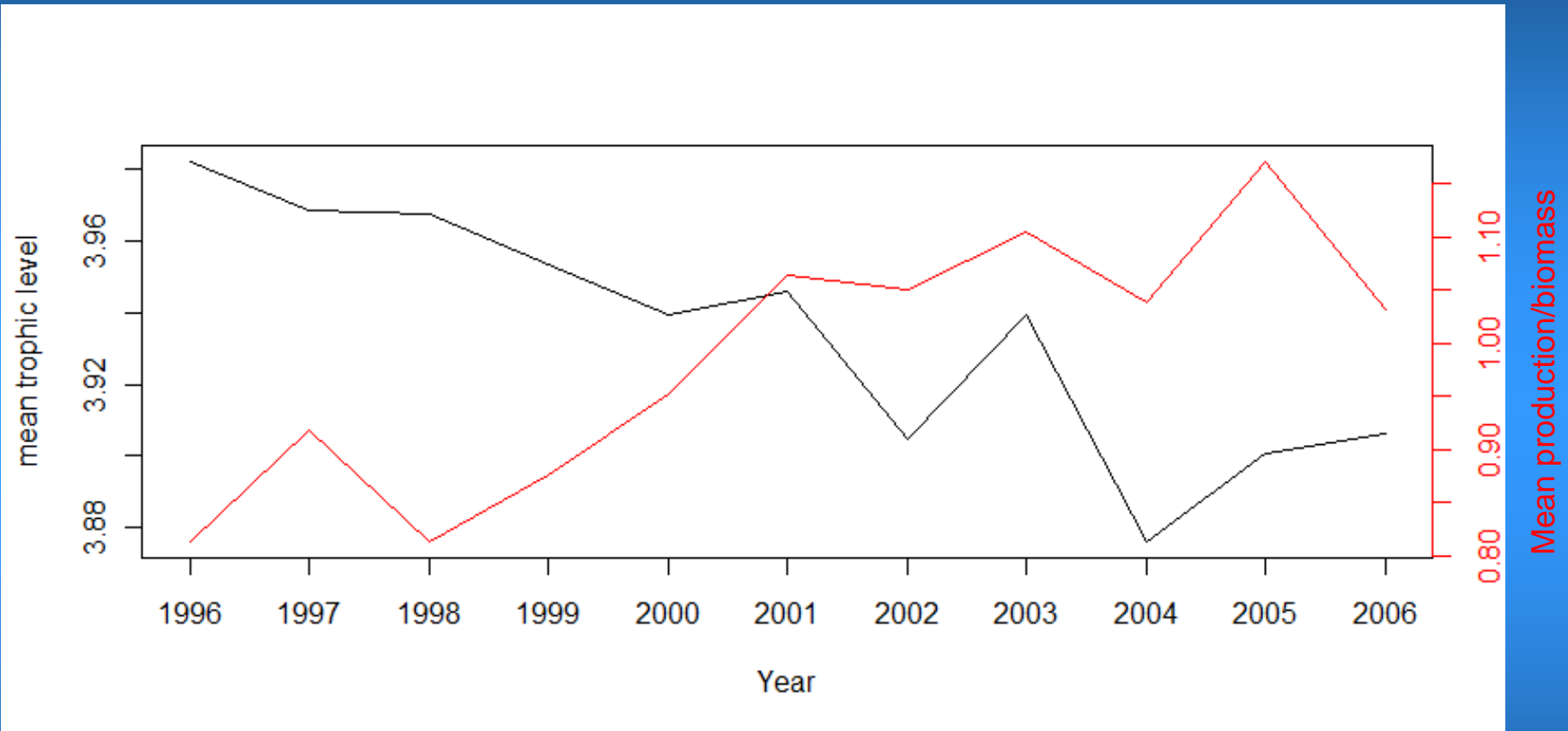
Linear trends in CPUE by species from GAM



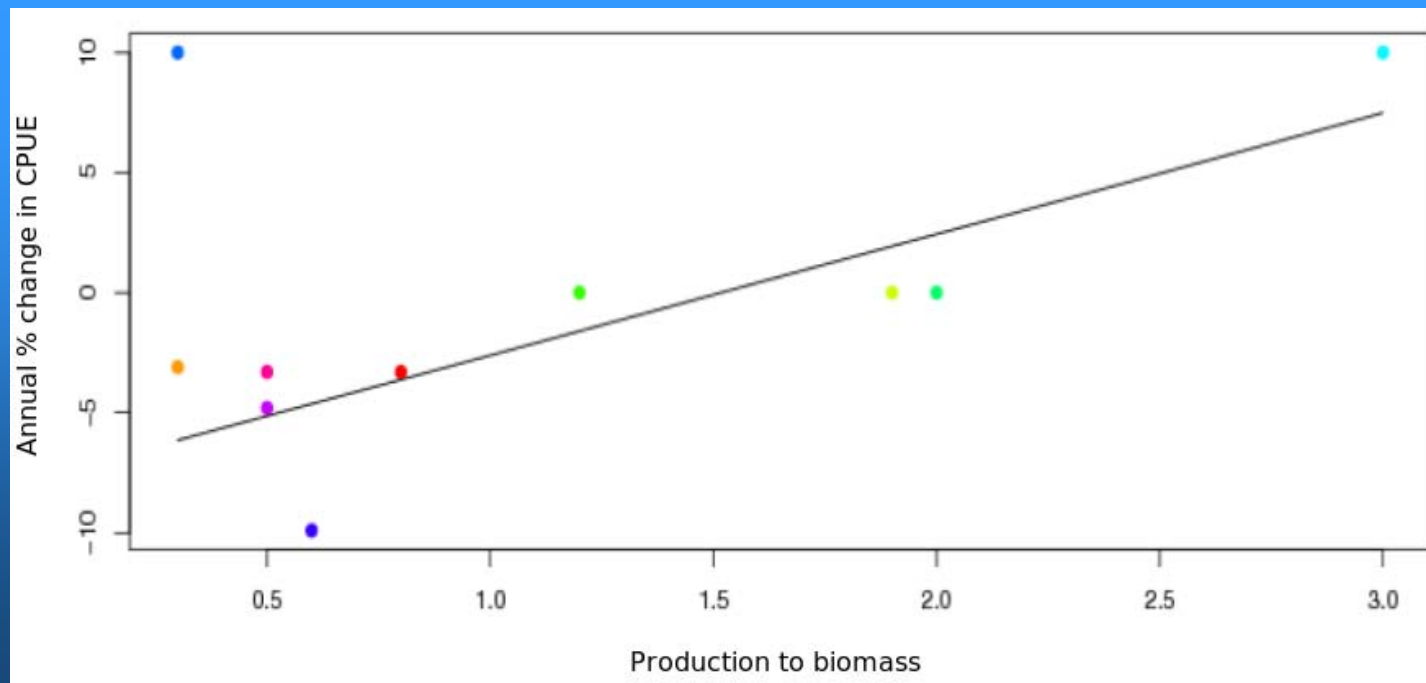
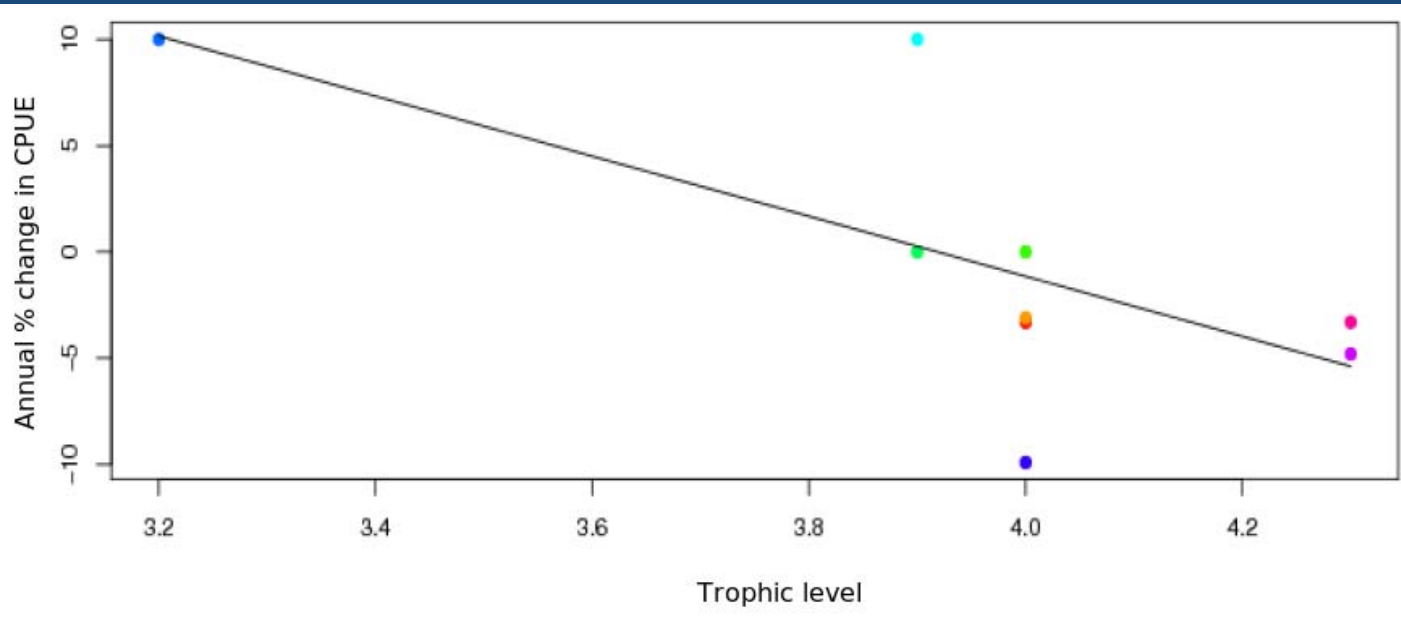
- bigeye
- blue shark
- mahi
- monchong
- albacore
- yellowfin
- skipjack
- striped marlin
- shortbill spearfish
- ono

species	% of total catch		annual percent change in CPUE	Production/biomass	Trophic level
	1996	2006			
albacore tuna	24	3	-9.9	0.6	4.0
striped marlin	7	5	-4.8	0.5	4.3
shortbill spearfish	3	3	-3.3	0.5	4.3
bigeye tuna	24	24	-3.3	0.8	4.0
blue shark	14	14	-3.1	0.3	4.0
skipjack tuna	3	4	0.0	1.9	3.9
yellowfin tuna	5	7	0.0	1.2	4.0
ono	2	5	0.0	2.0	3.9
mahi	4	10	10.0	3.0	3.9
Monchong	5	12	10.0	0.3	3.2
Total	91	87	-3.7	-	-

Mean annual trophic level and P/B ratio of the catch of the top 10 species in the deep-set longline fishery

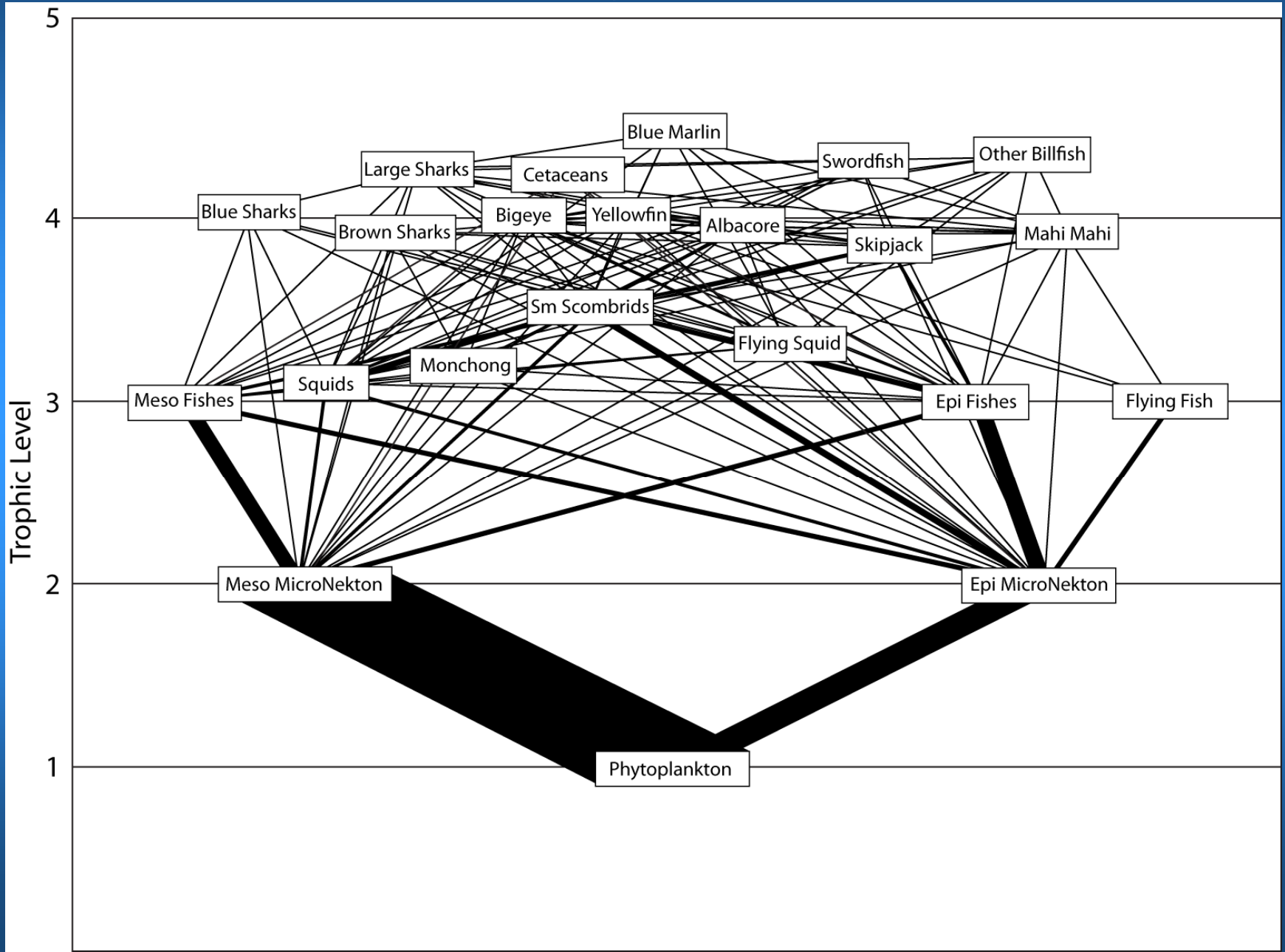


P/B and Trophic level estimates from Ecopath Model in Kitchell et al. (2002)



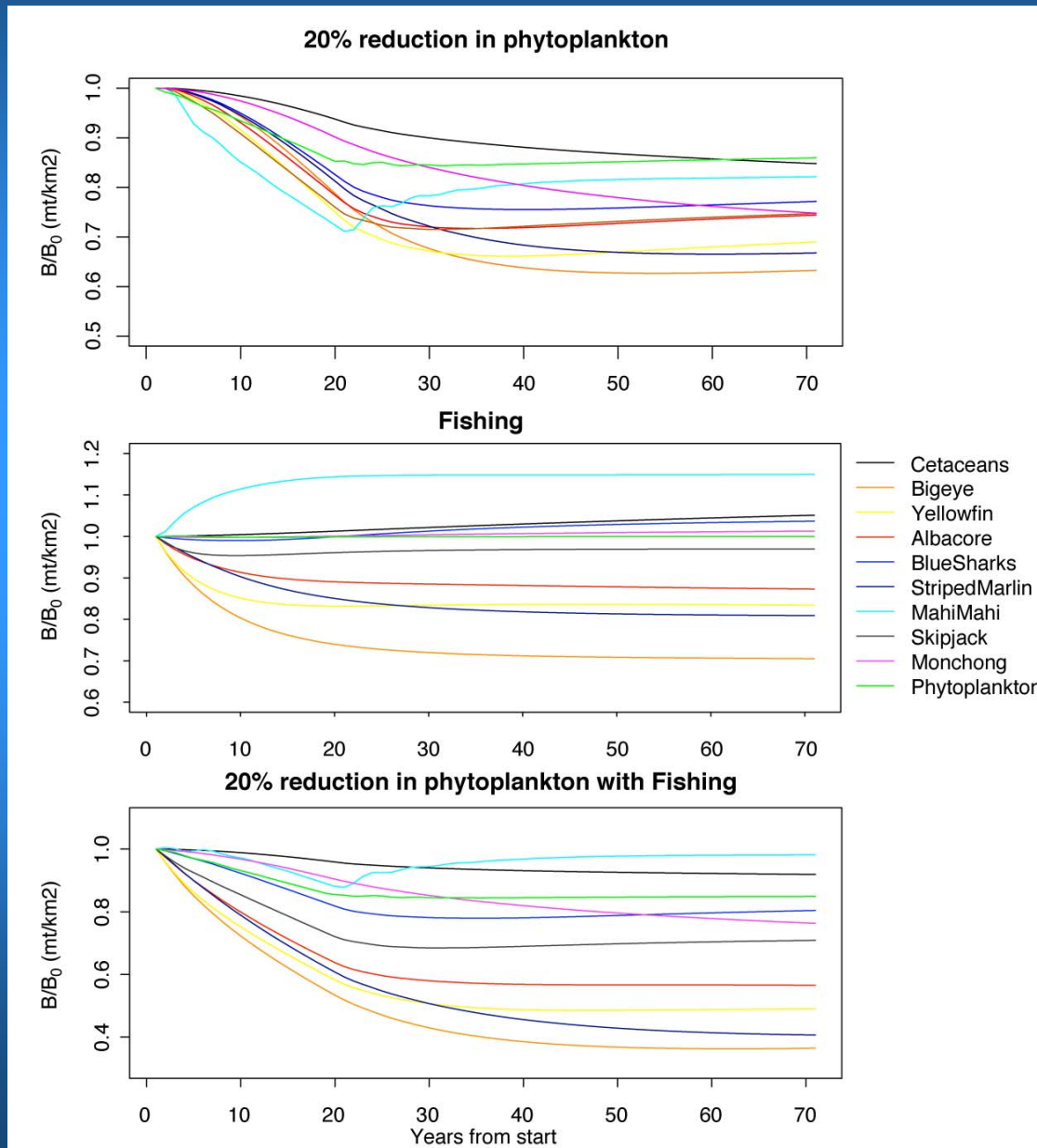
- albacore
- Striped-marlin
- Shortbill-spearfish
- bigeye
- Blue-shark
- skipjack
- yellowfin
- ono
- mahi
- monchong

Schematic energy flow in Ecopath/Ecosim pelagic model based on CNP8(Kitchell et al. 2002)



Application of Ecopath with Ecosim for central North Pacific

Kitchell et al. 2002, Model CNP8

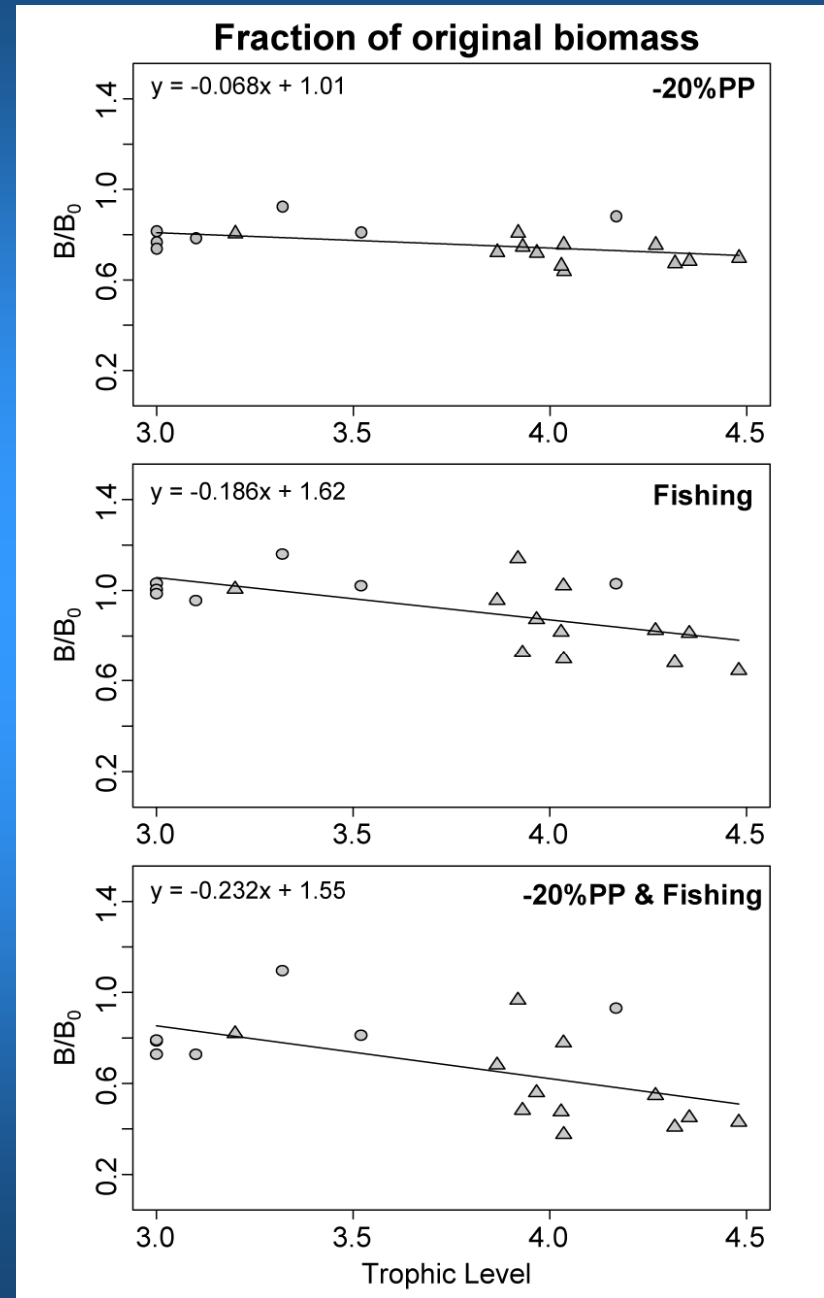


Ecosim Model Results (CNP8, Kitchell et al. 2002)

TL	<i>p</i>
FF	0.04
FF Fish	0.01
Fish No FF	0.005

	<i>r</i> ²
FF	0.17
FF Fish	0.28
Fish No FF	0.34

- TL > 4
- Blue Marlin (4.48)
 - Str. Marlin (4.32)
 - Swordfish (4.32)
 - Large Sharks (4.27)
 - Cetaceans (4.17)
 - Bigeye (4.04)
 - Blue Sharks (4.03)
 - Yellowfin (4.03)



Ecosim Model Results (CNP8, Kitchell et al. 2002)

P/B

p

FF 0.02

FF Fish 0.03

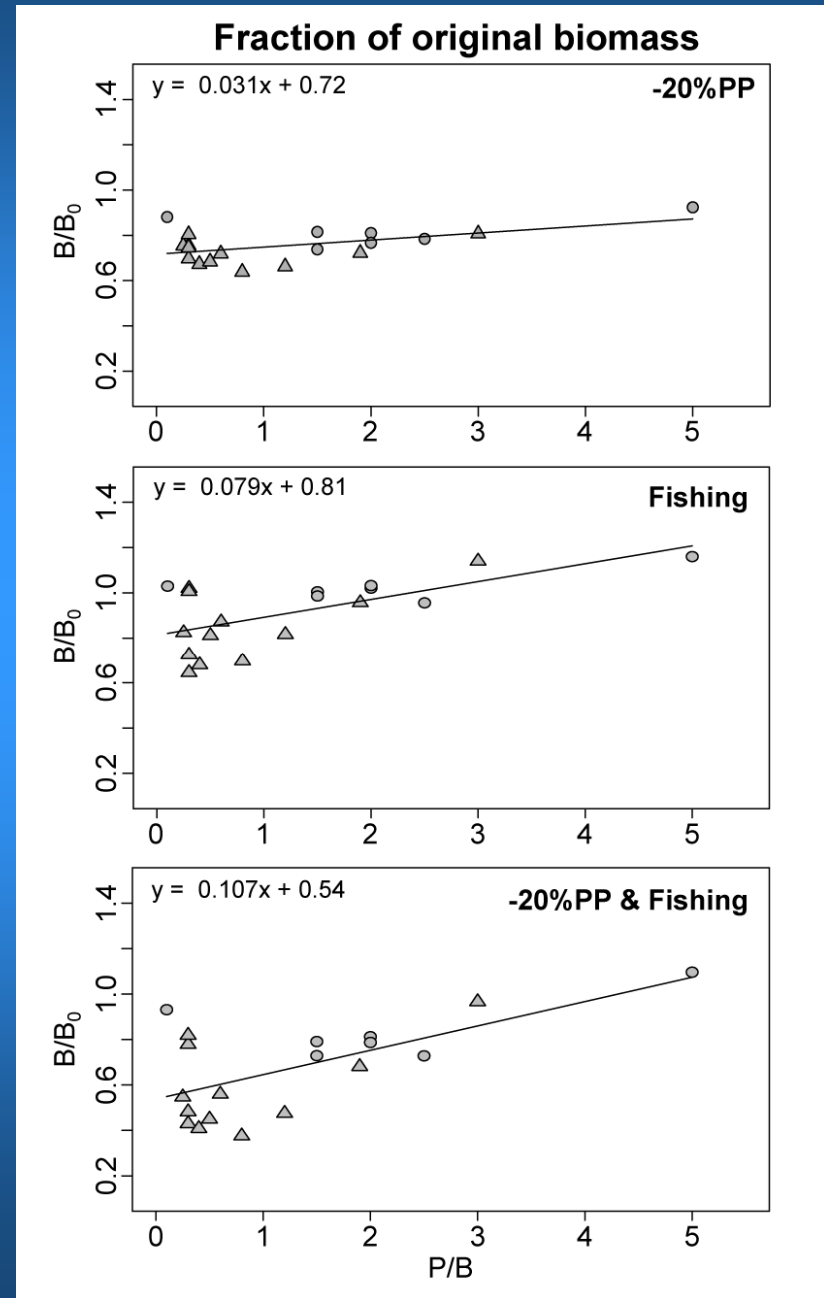
Fish No FF 0.003

*r*²

FF 0.24

FF Fish 0.38

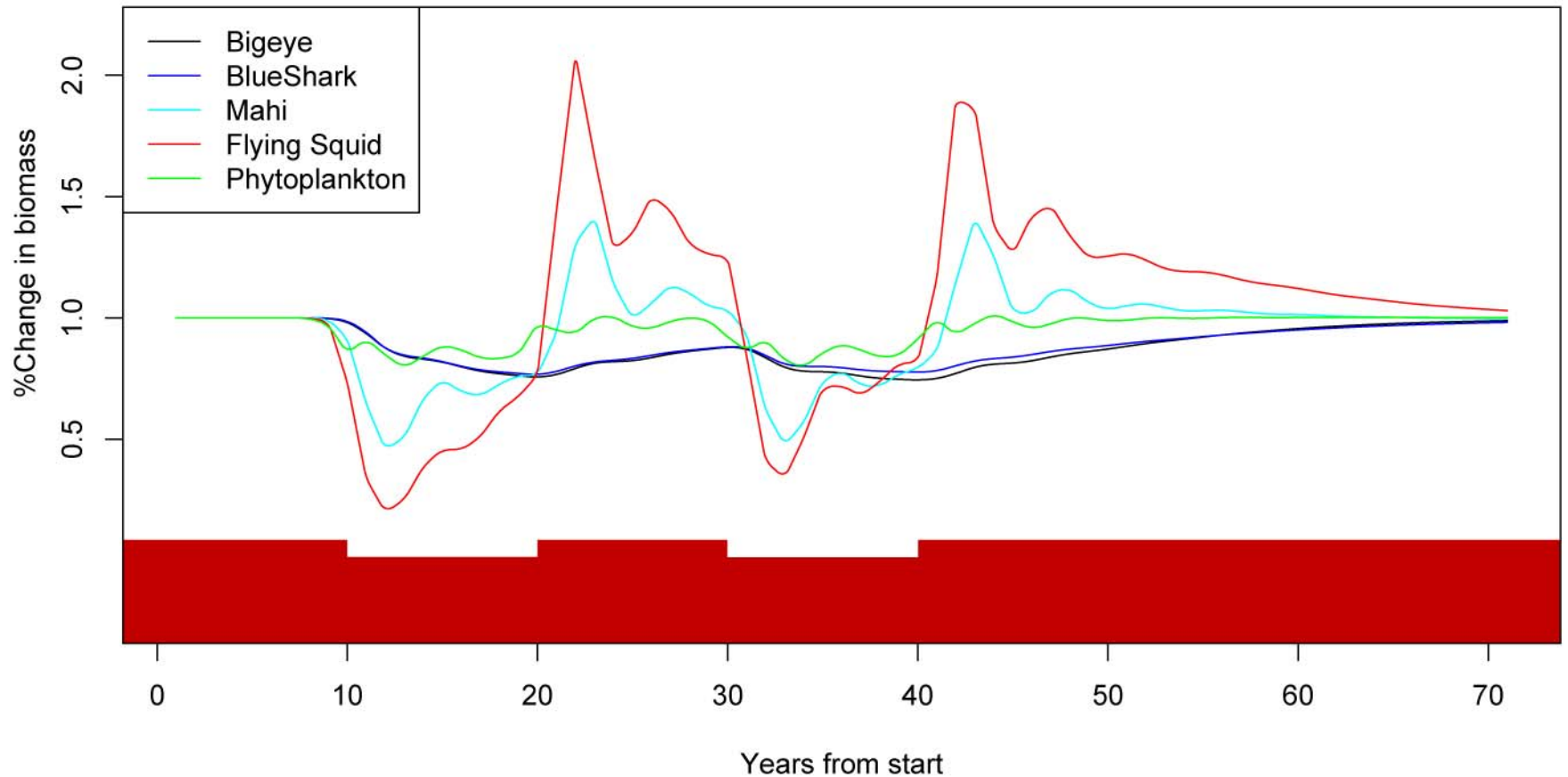
Fish No FF 0.37



Comparisons between CPUE trends and Ecosim

- Both model and CPUE data suggests that fishing and lower productivity results in a increase in high P/B species and a decline in high TL species.
- Both model and CPUE exhibit declines at top trophic level (bill fishes, sharks, tunas) and an increase in mahi mahi.
- Model doesn't show collapse of albacore or increase in monchong as seen in CPUE trends.
- Species that do best in model simulation are flying squids (TL=3.3, P/B=5.0) that increase in biomass and mahi (TL=3.9 and P/B= 3.0) and cetaceans (TL=4.1, P/B=0.1) both which maintain initial biomass.

Changes in biomass of species with various P/B ratios in response to decadal changes of 10% in phytoplankton biomass



Summary

SeaWiFS data suggests that there has been an expansion of the least productive areas in the ocean's subtropical gyres over past decade.

Fishery data and model simulations suggest that in response to climate change lowering productivity and continued fishing, the subtropical gyre will see:

- i) a continued decline in fished species with low P/B and high trophic levels (billfishes, sharks, large tunas)
- ii) an increase in mid-trophic level species especially those with high P/B ratios (mahi, squids, monchong(?))
- iii) an increase in high trophic level species not caught in fisheries (sperm whales, beaked whales, pilot whales)
- iv) due to the increase in high P/B species, the ecosystem will be more sensitive to climate forcing – making mean P/B of the catch a useful indicator

Seasonal pattern in recruitment to the fishery for those species with substantial seasonality

