Oceanic and deep-sea fishery resources of the Pacific:
the potential impacts of Deep Sea Mining

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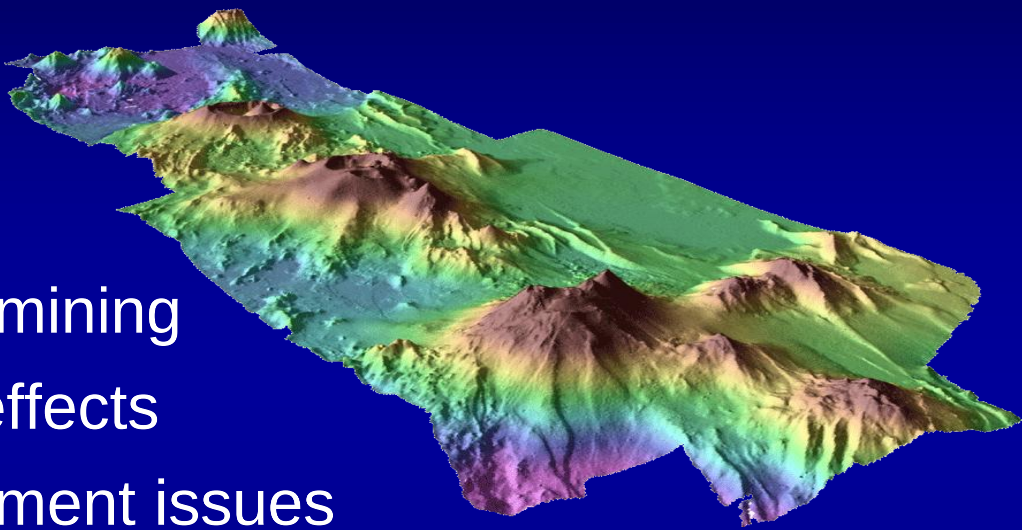
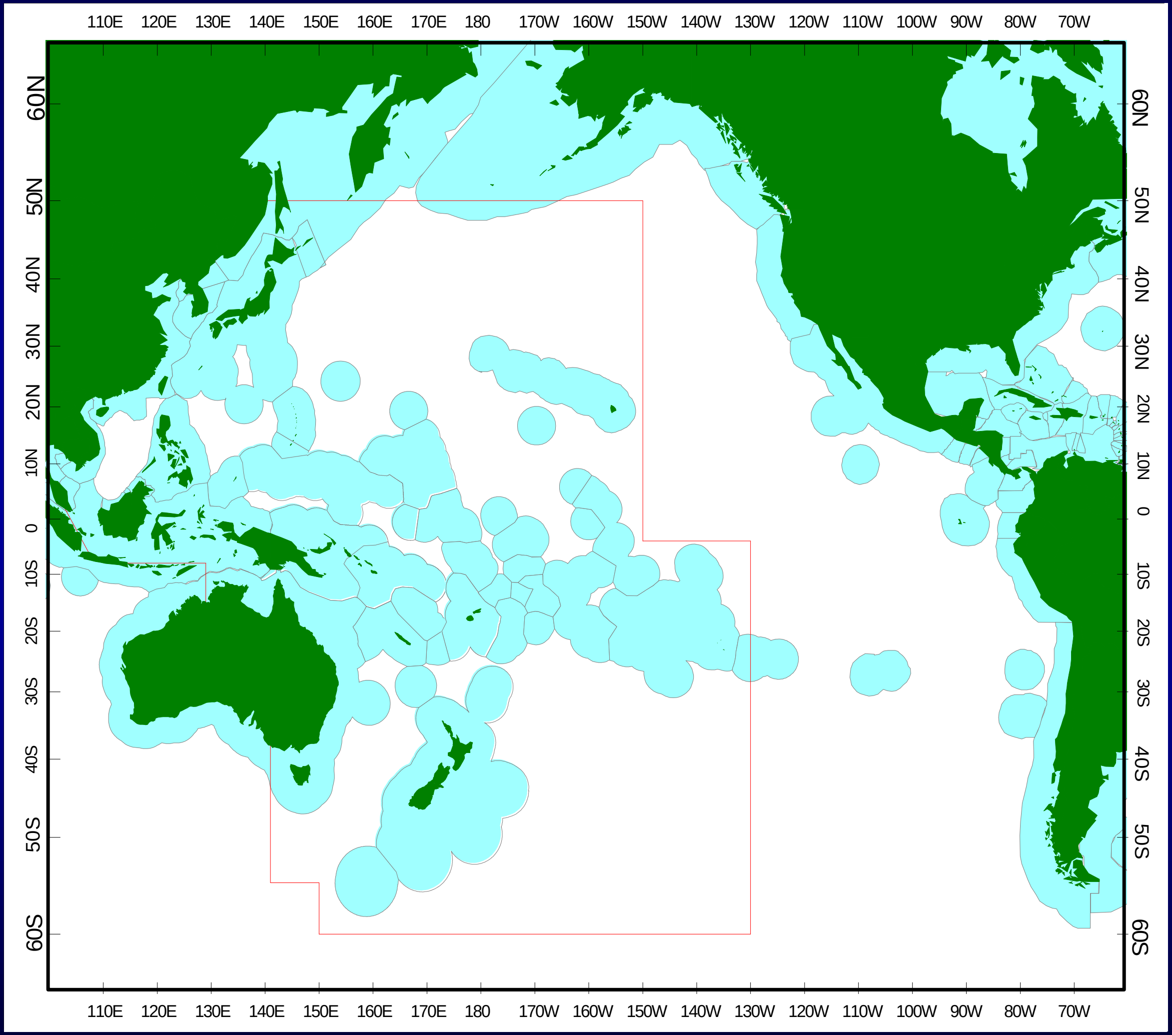
Presentation outline

- Pacific fisheries
  - Tunas
  - Deep snappers
  - Other fisheries
- Environmental impacts of mining
  - What are the relevant effects
- Fisheries-mining management issues
  - What needs particular attention



Pacific tuna fisheries



The Western and Central Pacific Fisheries Commission area

Fishery Overview – Target species

Skipjack (*Katsuwonis pelamis*)
A surface species that is short lived (2-3yr), mature young, highly fecund. Caught mainly by Purse-seine, Pole-and-line

Albacore (*Thunnus alalunga*)
Juvenile (surface; southern latitudes; troll caught); adults (deeper; subequatorial; LL). Mature ~ 5 yrs, lifespan ~ 20 years

Bigeye (*Thunnus obesus*)
Juvenile (surface; tropical latitudes; PS, LL and OTH caught); adults (deeper; mainly LL). Mature ~ 3-4 yrs, lifespan ~ 12 years

Yellowfin (*Thunnus albacares*)
Juvenile (surface; tropical latitudes; PS, LL and OTH caught); adults (deeper; mainly PS, LL, OTH). Mature ~ 2 yrs, lifespan ~ 7 years

Fishery Overview – Bycatch species

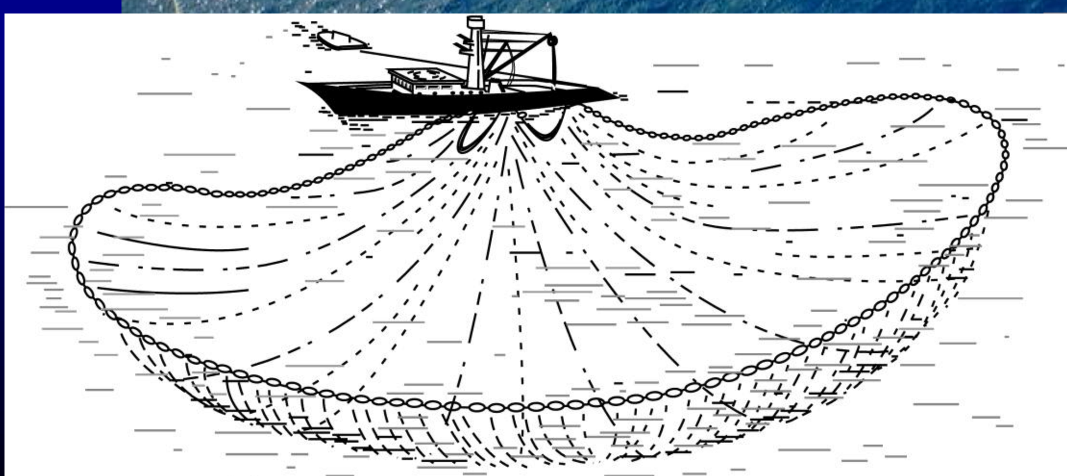
Billfish
Marlin, sailfish, spearfish and swordfish (targeted in some areas) mainly caught on LL, some PS, and in recreational fisheries.

Sharks and rays
Over 100 species observed. Slower growing, low fecundity, late age at maturity puts these species at higher relative risk

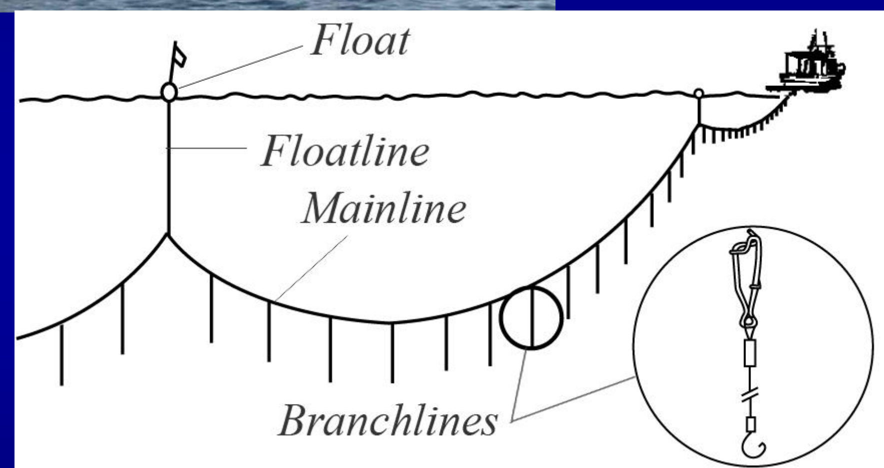
Other fish
Many other fish species (~150) have also been observed to interact with the fisheries targeting tuna in the WCPO.

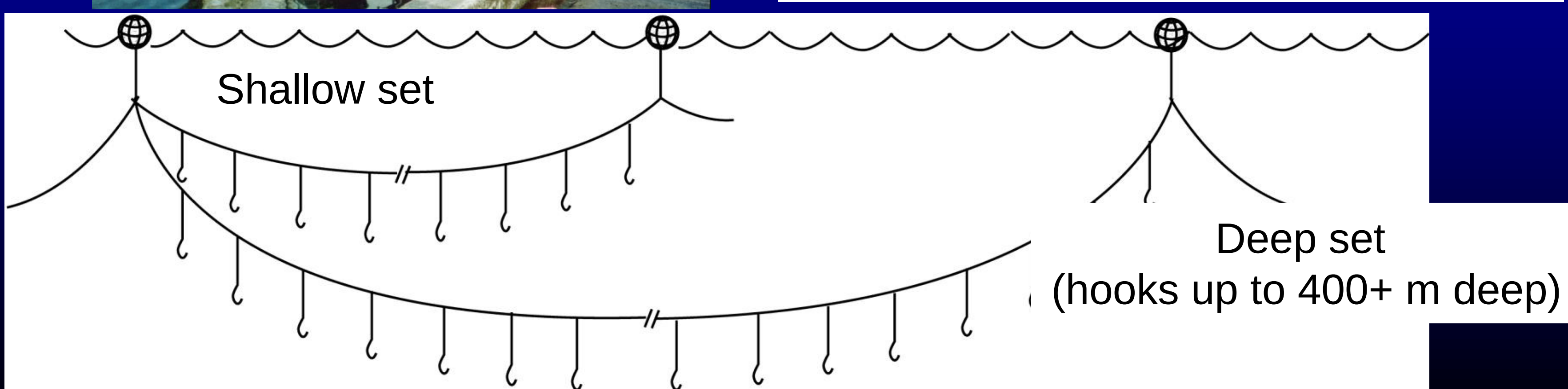
Non-fish species
Sea birds, marine mammals and turtles interact with the WCPO fishery. There is significant international focus on these interactions

Fisheries –Purse-seine



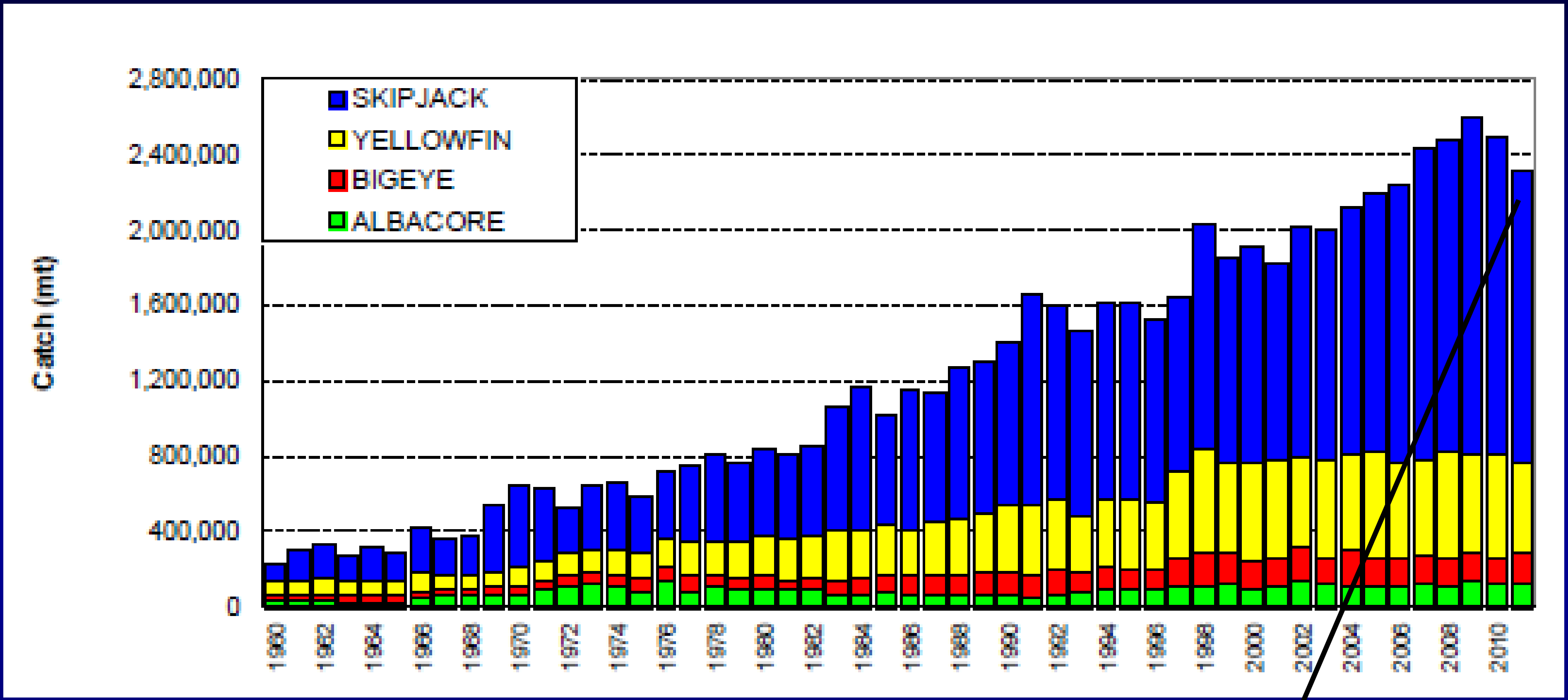
Fisheries Longline





Fisheries – Pole and Line

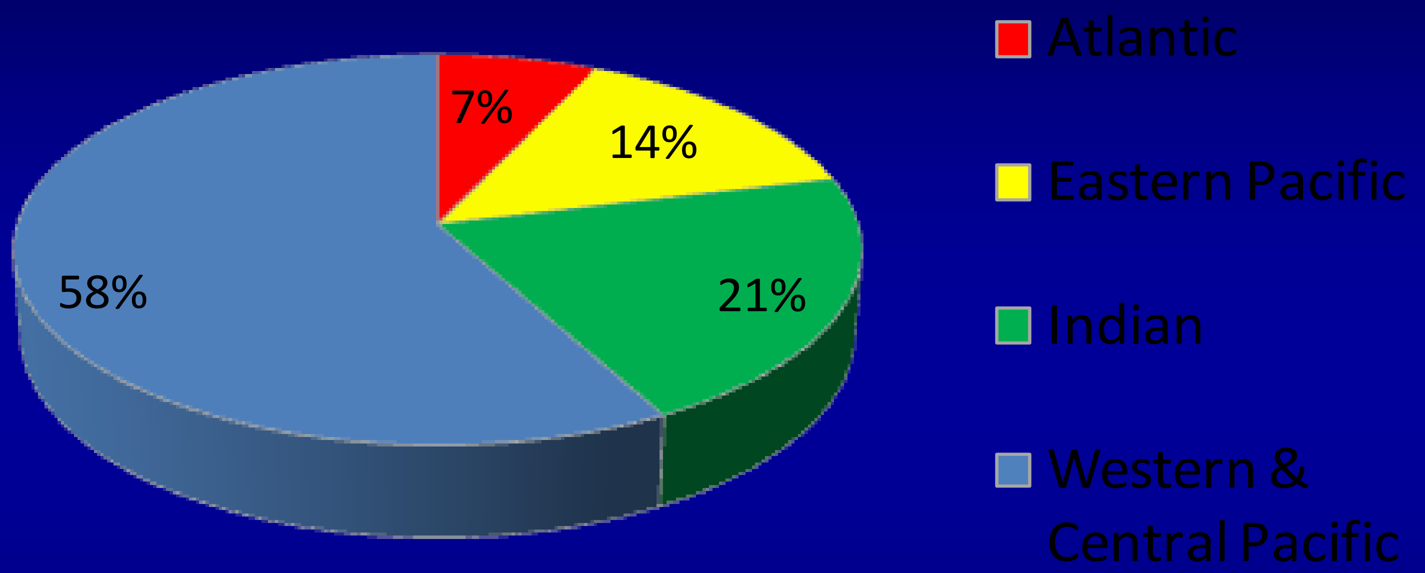
Tuna Catch by species



Total Catch 2011 – 2,310,600 mt

SKJ : 1,550,400 mt
YFT : 476,800 mt
BET : 153,500 mt
ALB : 72,700 mt

Significant tuna fishery…



- Fishery value (2010):
  - **Purse seine US $2.480 billion**
  - **Longline US $1.487 billion**
  - Not value to Pacific Island Countries and Territories

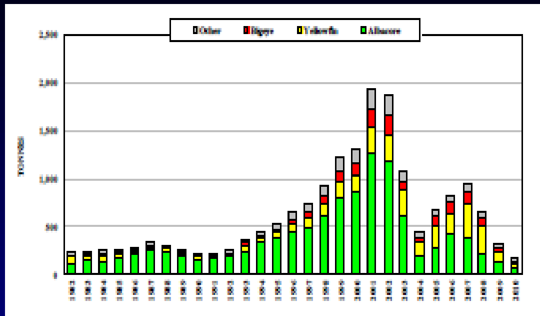
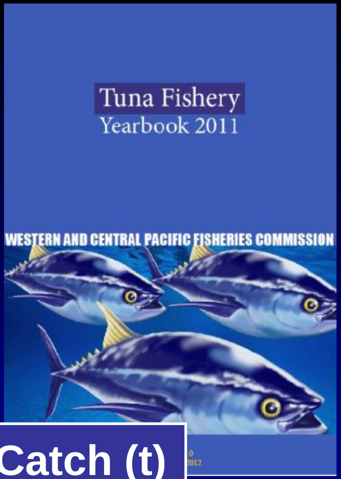


Figure 23. Catches by Tongan longliners

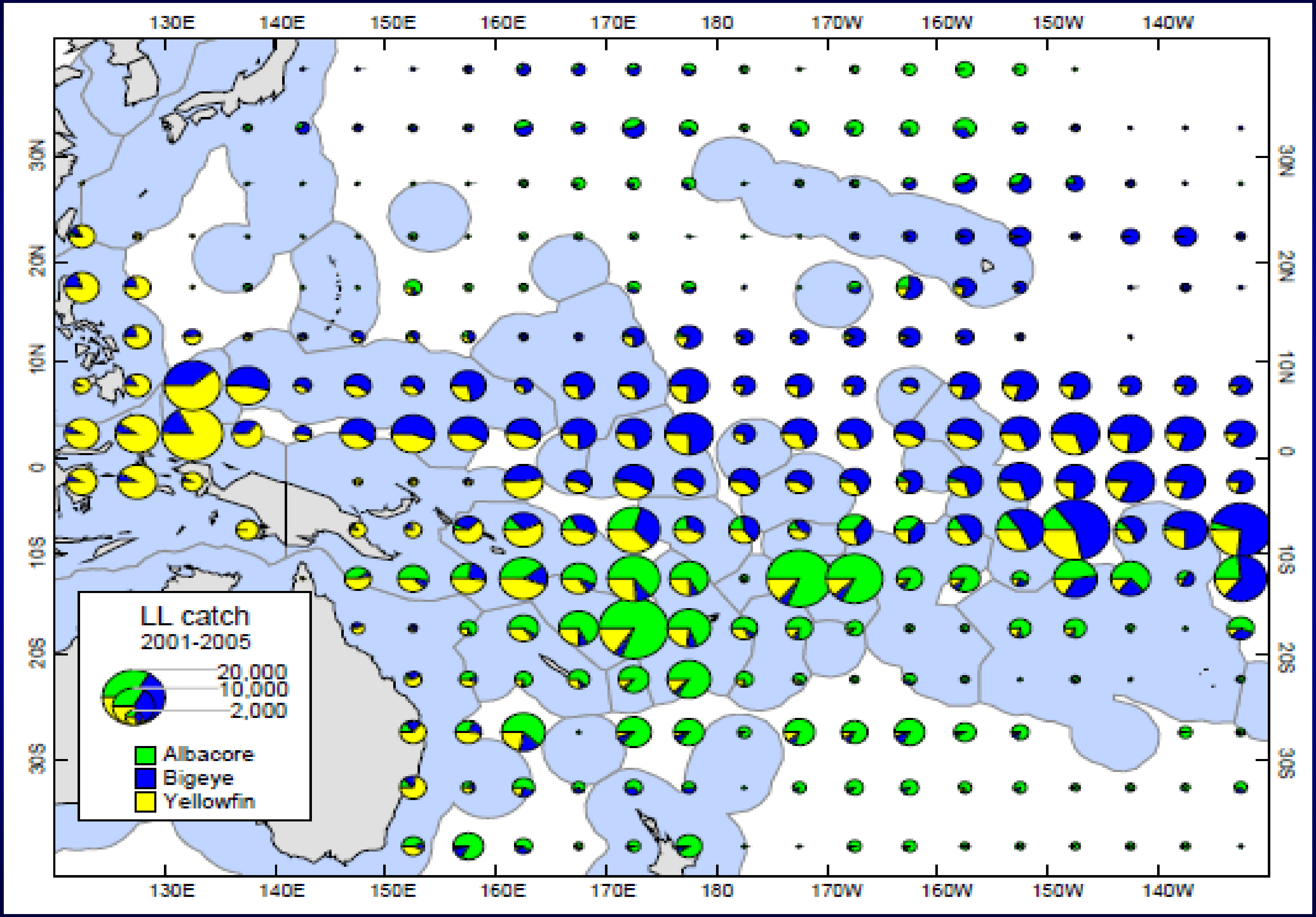
Catch by country fleet



2011 total tuna catch
SKJ, YFT, BET, ALB

Country	Catch (t)	Country	Catch (t)
Australia	2924	Marshall Is	90544
Belize	220	Nauru	4
China	105275	New Caledonia	2362
Cook Is	3636	New Zealand	23792
Ecuador	18045	Niue	0
El Salvador	12226	Papua New Guinea	164556
FSM	28432	Philippines	192956
Fiji	11286	Samoa	1932
French Polynesia	6028	Solomon Is	40374
Indonesia	390279	Spain	39468
Japan	363257	Chinese Taipei	226901
Kiribati	60003	Tonga	224
Korea	231558		

Tuna catch distribution



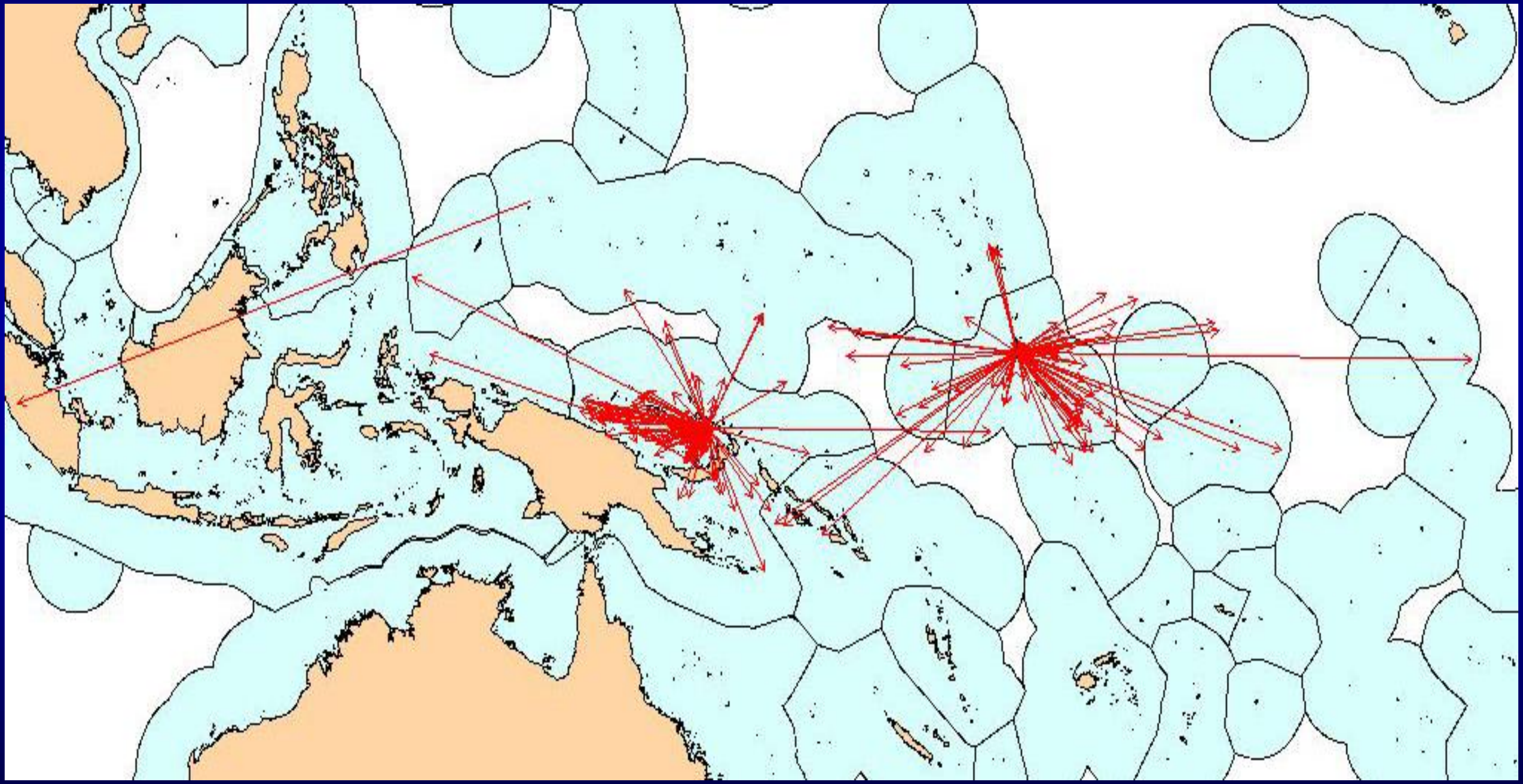
Catches in the longline fisheries in the WCPFC area (ALB,YFT,BET)

Stock distribution characteristics

- Bigeye
  - Widespread spawning, most months of year
  - 15 N to 15 S, 105 W to 175 W
  - Surface temperatures >24 deg C
  - Relatively mobile, up to 1000 n.mi
- Yellowfin
  - Widespread spawning, throughout year, although sometimes 2 main events (temp)
  - Surface temperatures >24 deg C
  - Relatively mobile, up to 1000 n.mi
- Skipjack
  - Spawning Central Pacific throughout the year
  - 10 N to 10 S, 110 W to 150 W
  - Not very mobile, generally <200 n.mi

SPC tagging programme

- Under a GEF project, tuna tagging



An example of some initial tagging results for Bigeye tuna in the central Western Pacific (SPC, unpublished. From Nicols & Allain 2010**)**

Global status of tuna stocks

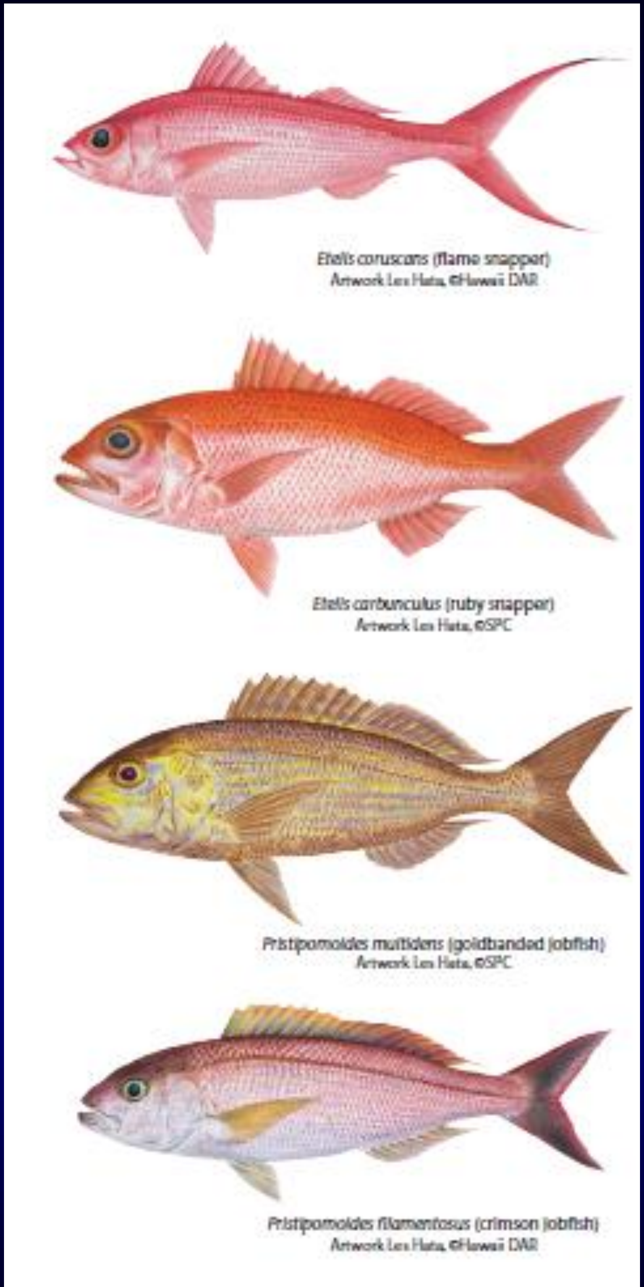
	W. Atlantic	E. Atlantic	Indian	E. Pacific	W. Pacific
Skipjack					
Yellowfin					
Bigeye					
	N. Atlantic	**S. Atlantic**	**Indian**	**N. Pacific**	**S. Pacific**
Albacore					

	Key
	Overfished and overfishing – rebuilding plan in place
	Overfished OR overfishing. CMMs needed
	Not overfished, nor is overfishing occurring

From International Seafood Sustainability Foundation

Deepwater snapper fisheries

- 1970s increasing pressure on reef resources, encouraged to look deeper
- Dropline survey fishing in 19 SPC PIC through the 1980s, found good catches to 250 m
- Commercial fisheries developed in Samoa, Tonga, Fiji, Vanuatu, Papua New Guinea, American Samoa
- Over 200 species of fish were caught
- Current (2008-) SPC Deepwater snapper research programme



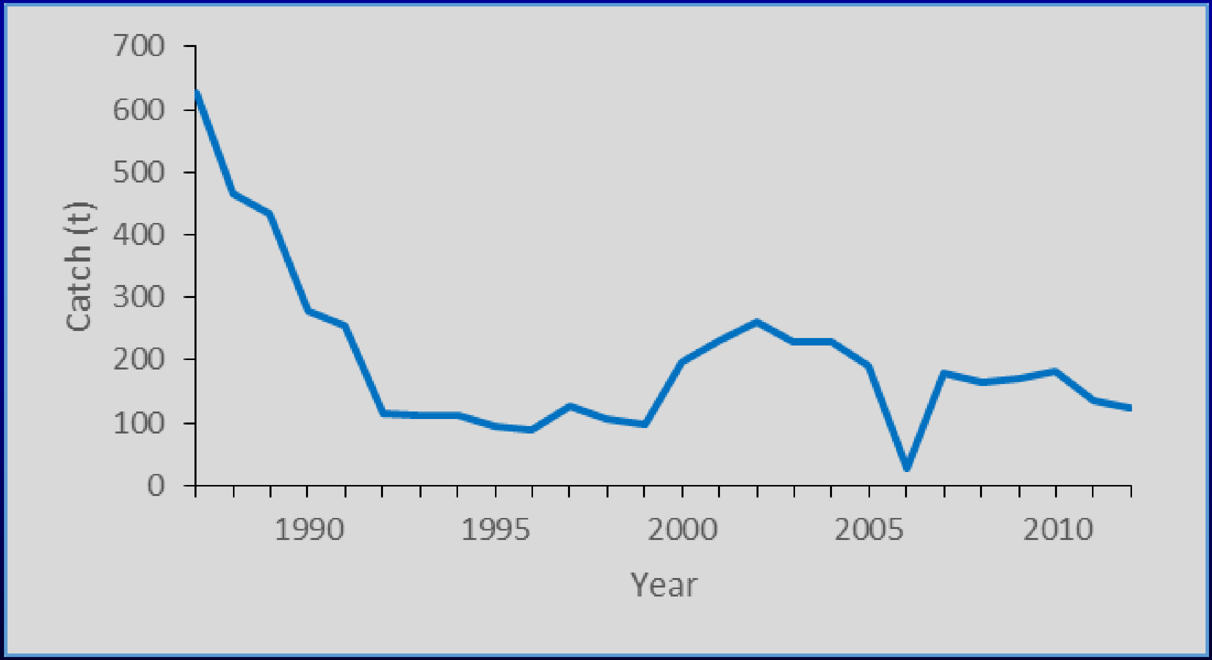
Scientific Name	Common Name (from Preston et al. 1999)
SNAPPERS	
Etelis carbunculus	Ruby snapper
Etelis coruscans	Long tailed red snapper
Aphareus rutilans	Small-tooth jobfish
Pristipomoides filamentosus	Rosy jobfish
Pristipomoides flavipinnis	Yellow-finned jobfish
Pristipomoides multidens	Purple-cheeked jobfish
Pristipomoides amoenus	Flower snapper
Pristipomoides auricilla	Gold-tailed jobfish
Pristipomoides zonatus	Banded flower snapper
GROUPERS	
Epinephelus septemfasciatus	Giant grouper
Epinephelus morrhua	Curve-banded grouper
Epinephelus cometae	Snakeskin grouper
SOME INCIDENTALLY-CAUGHT SPECIES	
Seriola rivoliana	amberjack
Promethichthys prometheus	Snake mackerel
Ruvettus pretiosus	Oilfish

Deepwater snapper catches

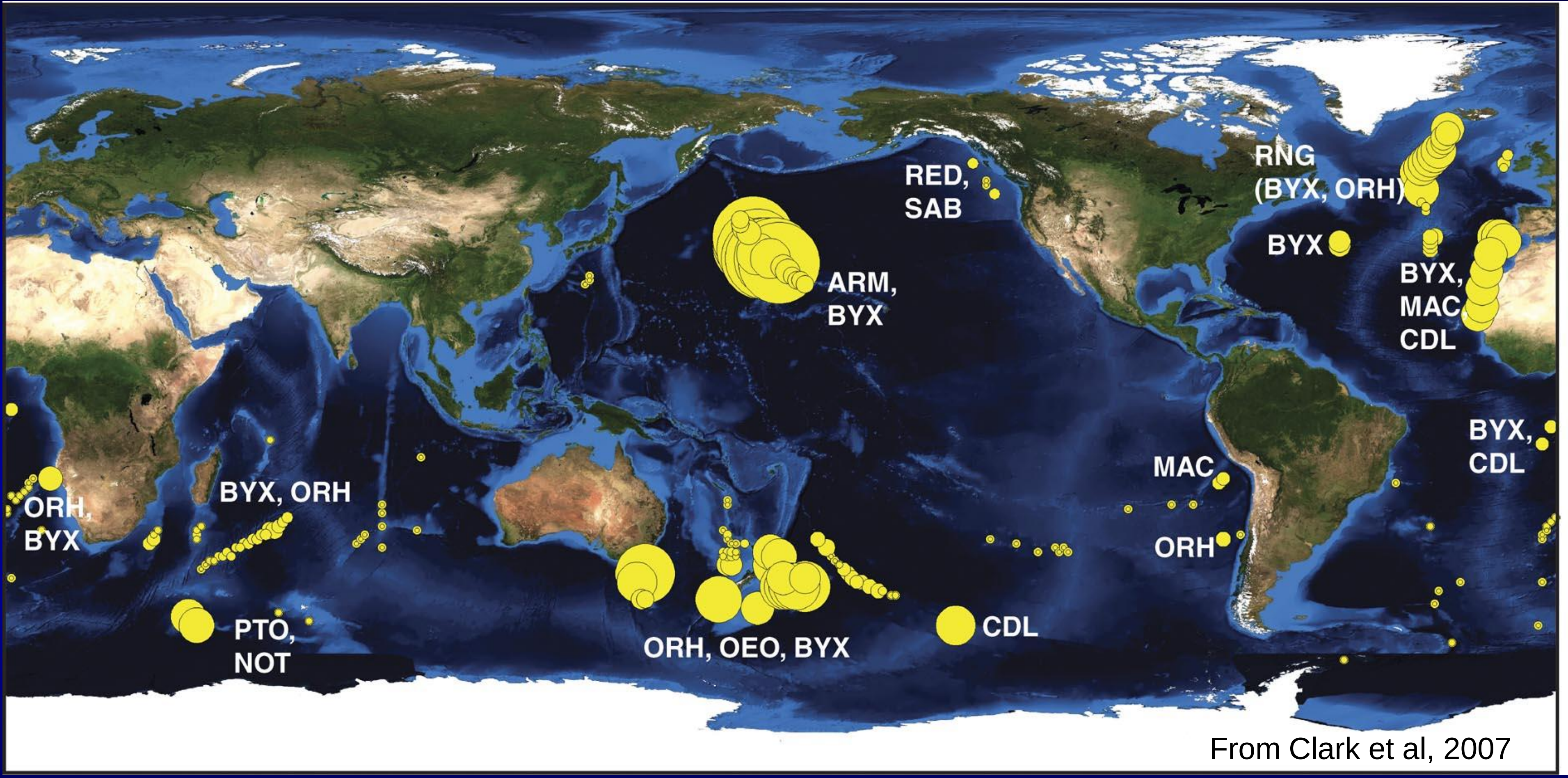
- Variable between countries:
  - American Samoa, 8 part-time vessels, 4 t
  - Palau, 4 vessels part-time, 3 t
  - Fiji, 7 licensed vessels, low catches
  - French Polynesia, 60 vessels part-time, 200 t
  - New Caledonia, 18 vessels target snappers
  - Tonga, 12 vessels commercially fishing, 200 t
  - Most other countries have no current fishery or very small and sporadic catches

Bottom longline catches

- Typically high initial catches and CPUE
- Decline rapidly after only several years to lower levels, possibly as resident fish are reduced
- Example of Tongan fishery for deepwater snappers



Deep-sea seamount trawl fisheries



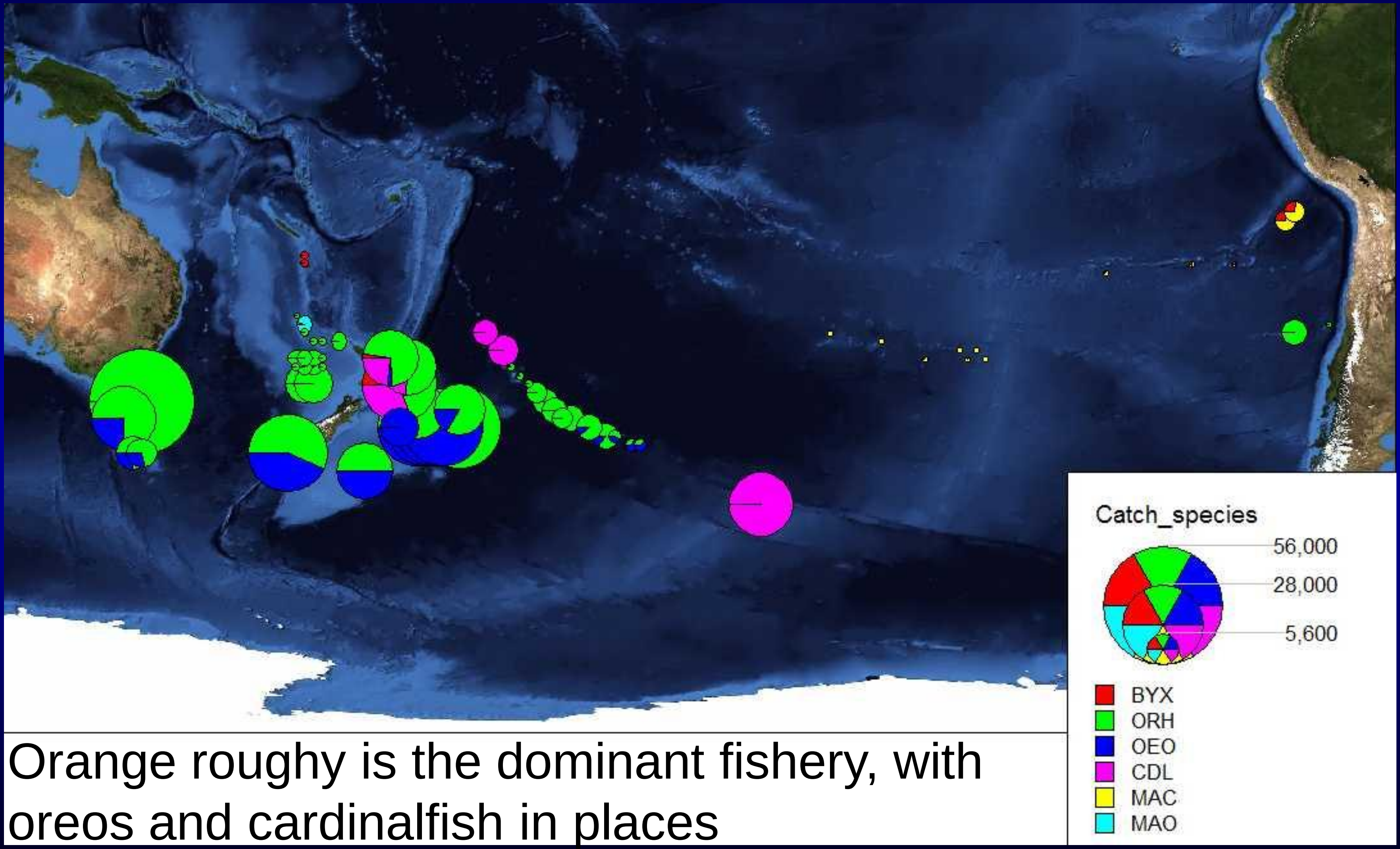
Extensive bottom trawl fisheries developed from 1970s

Catch per 1 degree square, largest circle area = 85,000 t

Total estimated catch 2-2.5 million tonnes

Deep-sea species

Distribution of seamount fisheries

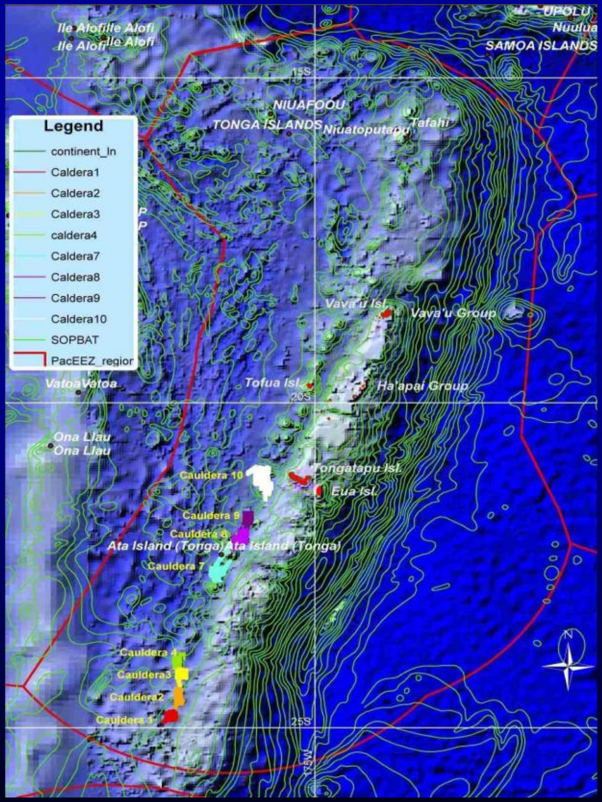


Orange roughy is the dominant fishery, with oreos and cardinalfish in places

Data from Clark et al 2007 [1970 to 2006]

Potential deep bottom longline fisheries

- Exploratory fishing in 2009-2010 in southern Tongan EEZ
- Bluenose catches relatively high (3t/set)
- Up to 28 suitable seamounts, 500-800m depth



Coastal fisheries

- Very wide range of reef fish and shellfish species
- Depth typically less than 20 m
- Combination of subsistence fishing, and local market commercial operations
- Subsistence fishing provides up to 90% of protein intake of some coastal communities
- Very important for local incomes
- Catches normally lumped rather than individual species
- Many coastal fisheries are overexploited

Coastal fisheries statistics

PICT	Subsistence catch (tonnes)	Commercial catch (tonnes)	Fish eaten per person (kg per year)*	Animal protein in diet (%)	Households earning 1st/2nd income (%)a
Melanesia					
Fiji	17,400	9500	113		93.3
New Caledonia	3500	1350	43		46.2
PNG	30,000	5700	53		85.8
Solomon Islands	15,000	3250	118	94	61.0
Vanuatu	2830	538	30	60	61.1
Micronesia					
FSM	9800	2800	96	80	52.5
Guam	70	44			
Kiribati	13,700	7000	115	89	58.1
Marshall Islands	2800	950			53.6
Nauru	450	200	62	71	22.0
CNMI	220	231			
Palau	1250	865	79	59	25.9
Polynesia					
American Samoa	120	35			
Cook Islands	267	133	79	51	20.1
French Polynesia	2880	4002	61	71	26.7
Niue	140	10	50		10.1
Pitcairn Islands	7	5			
Samoa	4495	4129	94		50.8
Tokelau	375	0			
Tonga	2800	3700	85		46.2
Tuvalu	989	226	146	77	48.4
Wallis and Futuna	840	121	56		44.3
Total	109,933*	44,789*			(47.4)

*Includes 25–30% nearshore pelagic fish, including tuna; a = based on estimates from at least four sites in each PICT; blank spaces indicate that no estimate is available

Many coastal fisheries are overexploited, and together with climate change (warmer water temperatures, changes in currents, nutrient supply, habitat loss, productivity of coastal fisheries is expected to decrease (SPC Policy Brief 16/2012)

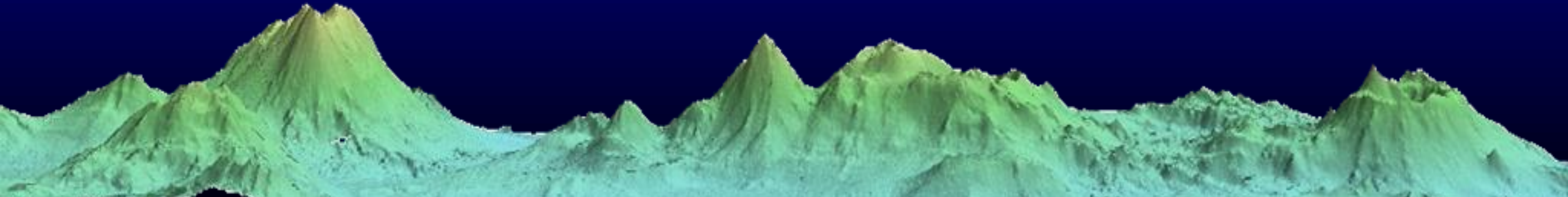
Important biological differences

- Tunas
  - Widespread distribution
  - Spawning often widespread over much of year
  - Typically highly migratory, up to 1000 n.mile
  - Some favour seamounts, but general oceanic
  - Live around 10 years.
- Deepwater snappers
  - Often localised stocks
  - Seasonal spawning (as well as locality)
  - Seamount habitat very important
  - Limited migrations
  - Longevity of 20 years
- Deep-sea species
  - Localised stocks (although alfonsinos widespread ?gyre)
  - Seasonal spawning, localised
  - Seamount habitat very important (spawning and feeding)
  - High longevity (30-40 years)

Decreasing productivity and resilience

Fisheries habitat: Seamounts

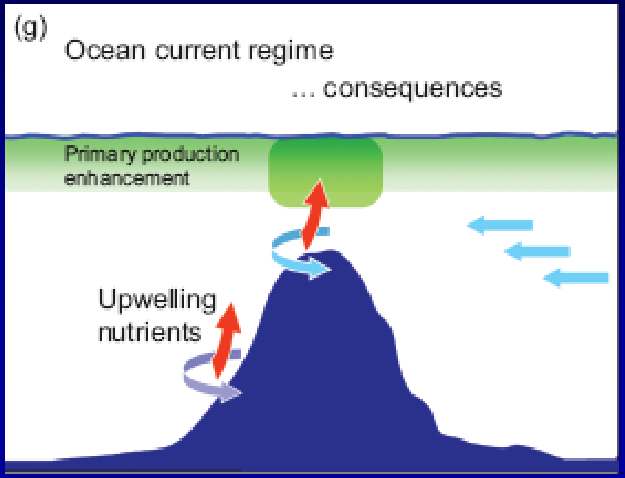
- Elevated seafloor topography, distinct feature
- Usually volcanic, commonly formed as “hotspots” in the mantle, and along plate boundaries
- Sites of hydrothermal activity, and seabed minerals
- Definition important
  - >1000 m “seamount” (IHO “geological” term)
  - 500 - 1000 m “knolls”
  - <500 m “pinnacles” or “hills”
  - Recent more general use of “seamount” >100 m (scientific “ecological” term)

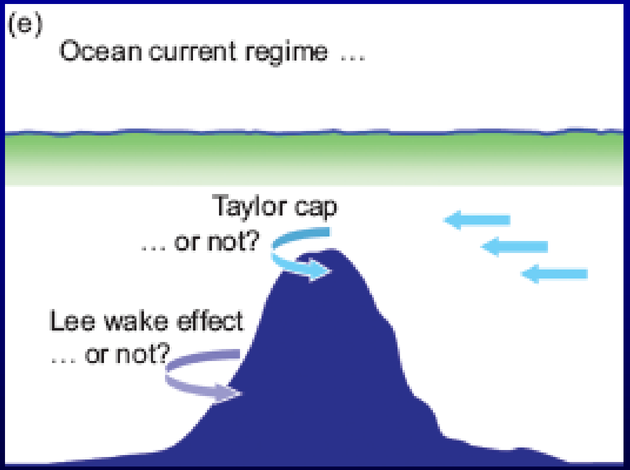


Seamount oceanography

Physical structure of some seamounts enables the formation of hydrographic features and current flows that:

- can accelerate water flow over the seamount, reducing sedimentation and exposing hard rock substrate
- can enhance local production through upwelling (but generally minor)
- restrict the dispersal of larvae and plankton
- keep species and production processes concentrated over the seamount

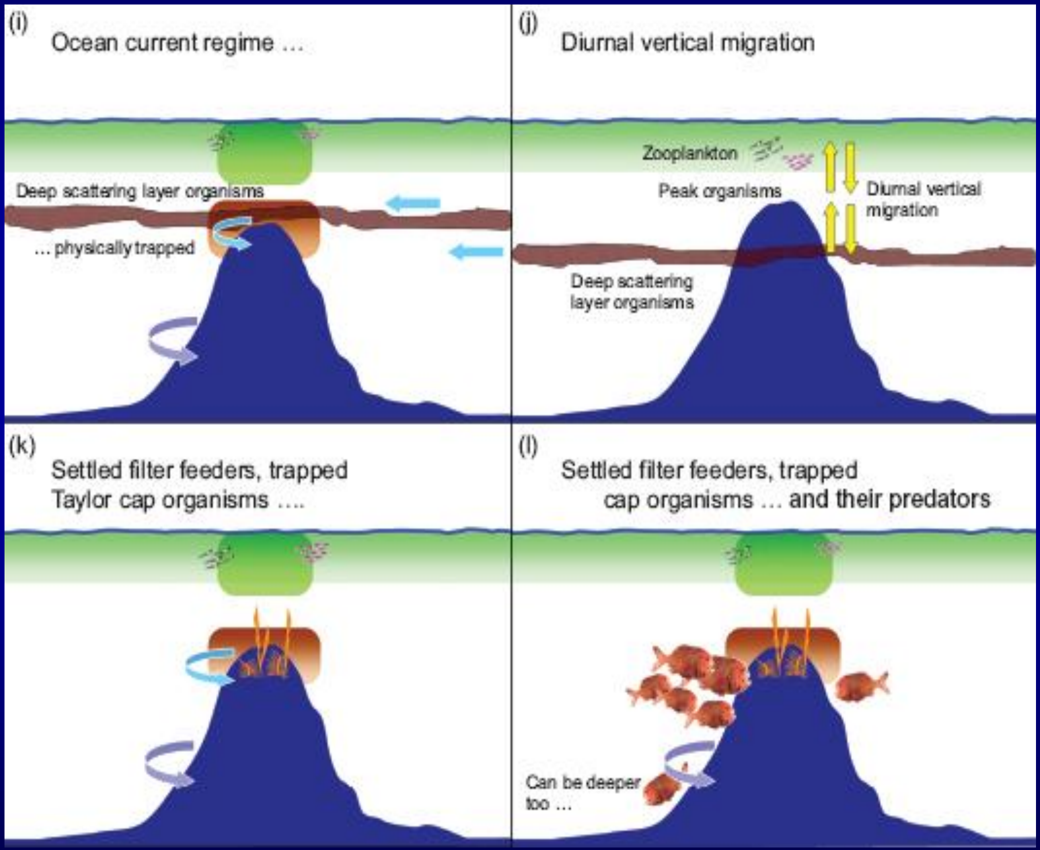




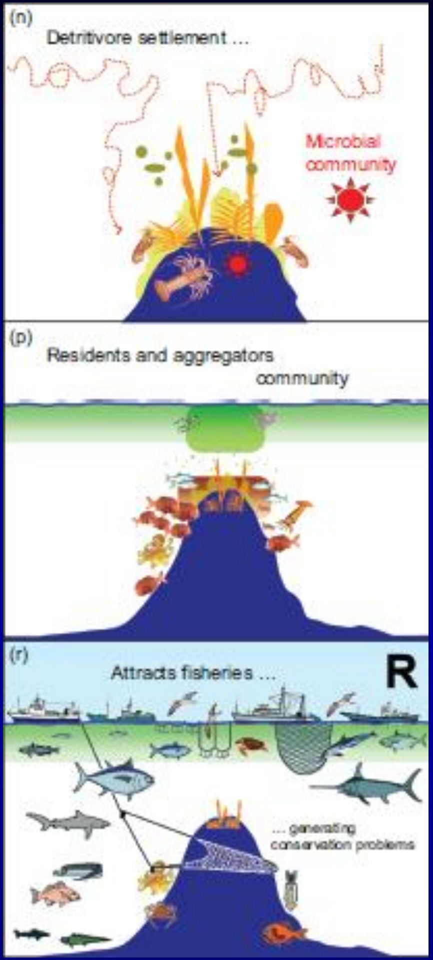
"Cartoons" from Pitcher & Bulman 2007

Seamount productivity

- Depth important as seamount extends well above the abyssal seafloor-can reach photic zone, or range of plankton migration
- There can be a plankton trapping effect at the summit
- Continuous "supply" of planktonic production from wider area is important for seamount aggregation processes.

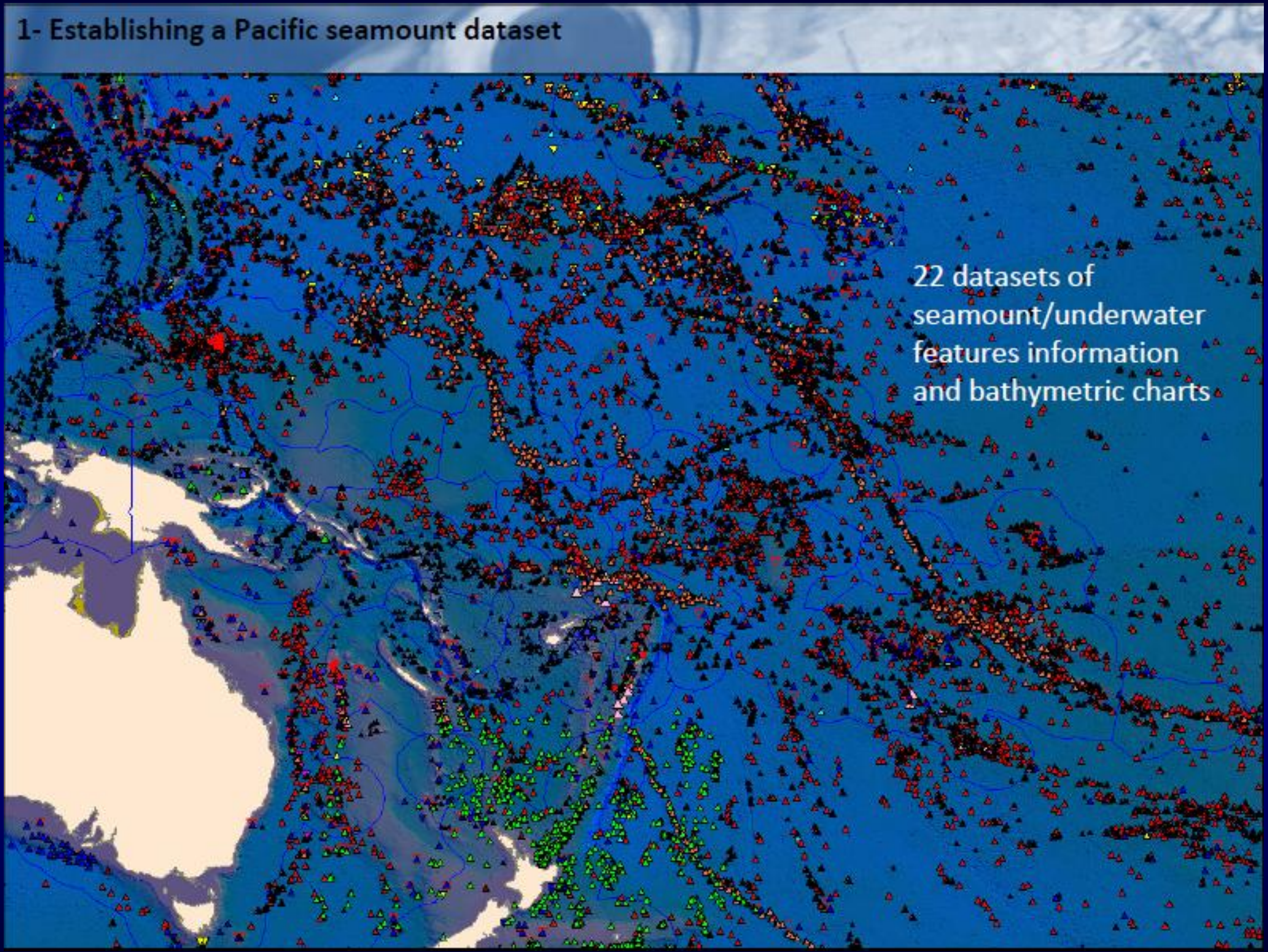


Seamount Biodiversity



- Physical characteristics (geographical location, depths, substrate type etc) mean communities can be rich and diverse
- Can be hotspots of biodiversity. Biogenic fauna (corals and sponges) provide habitat for hundreds of other species.
- Concentration of zooplankton and mesopelagic fish mean rich feeding grounds and spawning areas for fish and higher predators, and hence fisheries.

Pacific Seamounts



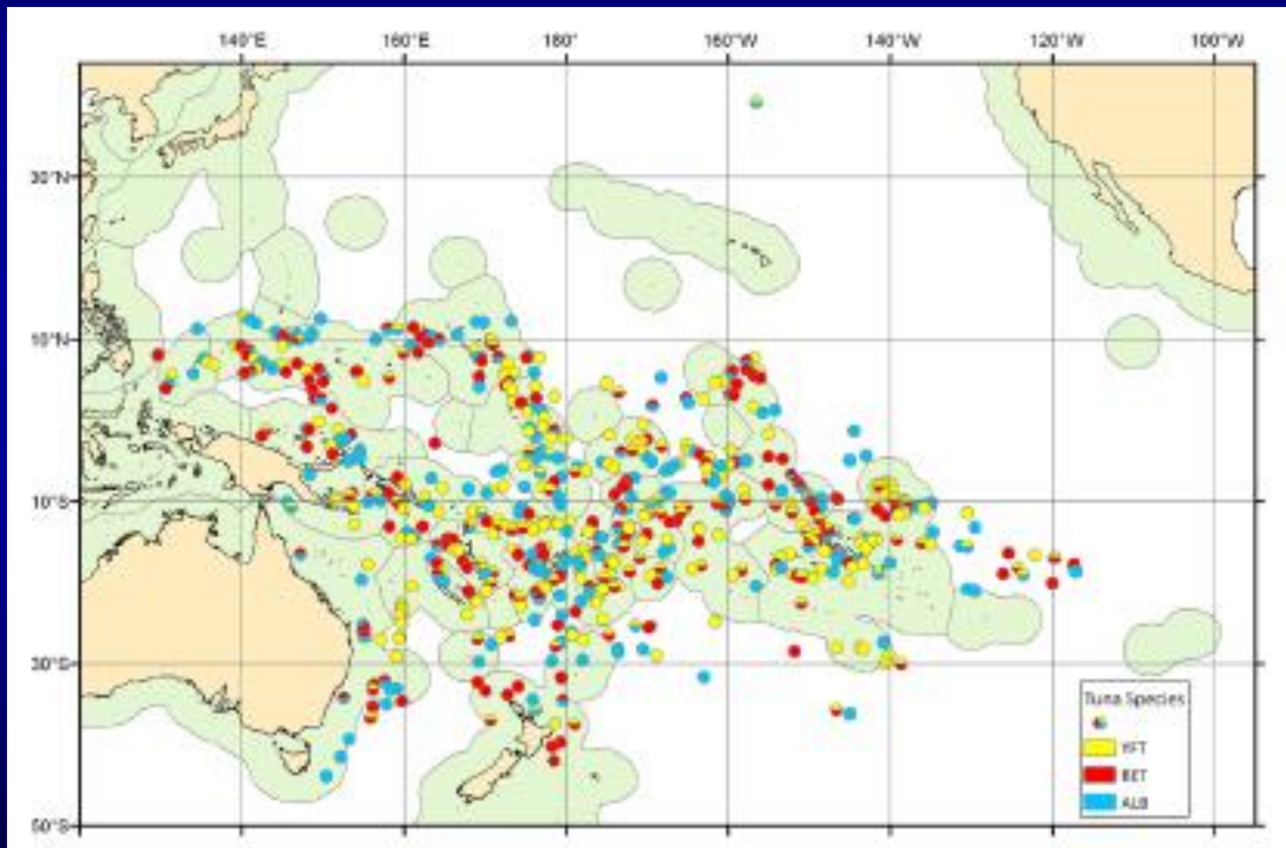
About 7000 known or likely seamounts in the general SW Pacific region (Allain et al. 2008)

Number of underwater features per EEZ

EEZ	Number	EEZ	Number
American Samoa	34	Nauru	6
Chile	12	New Caledonia	63
Cook Islands	108	New Zealand	571
Australia (East)	50	Niue	14
Easter Island	85	Norfolk Island	26
Federated States of Micronesia	236	Northern Mariana Islands	147
Fiji	112	Palau	110
French Polynesia	341	Papua New Guinea	91
Guam	45	Pitcairn	34
Hawaii	219	Samoa	15
Indonesia (East)	26	Solomon Islands	157
Japan	259	Tokelau	32
Kiribati (Gilbert)	54	Tonga	73
Kiribati (Line)	152	Tuvalu	60
Kiribati (Phoenix)	49	USA small territories	207
Marshall Islands	153	Vanuatu	27
Matthew Hunter	23	Wallis & Futuna	30
		High Seas	2713

Seamounts and tuna catch rates

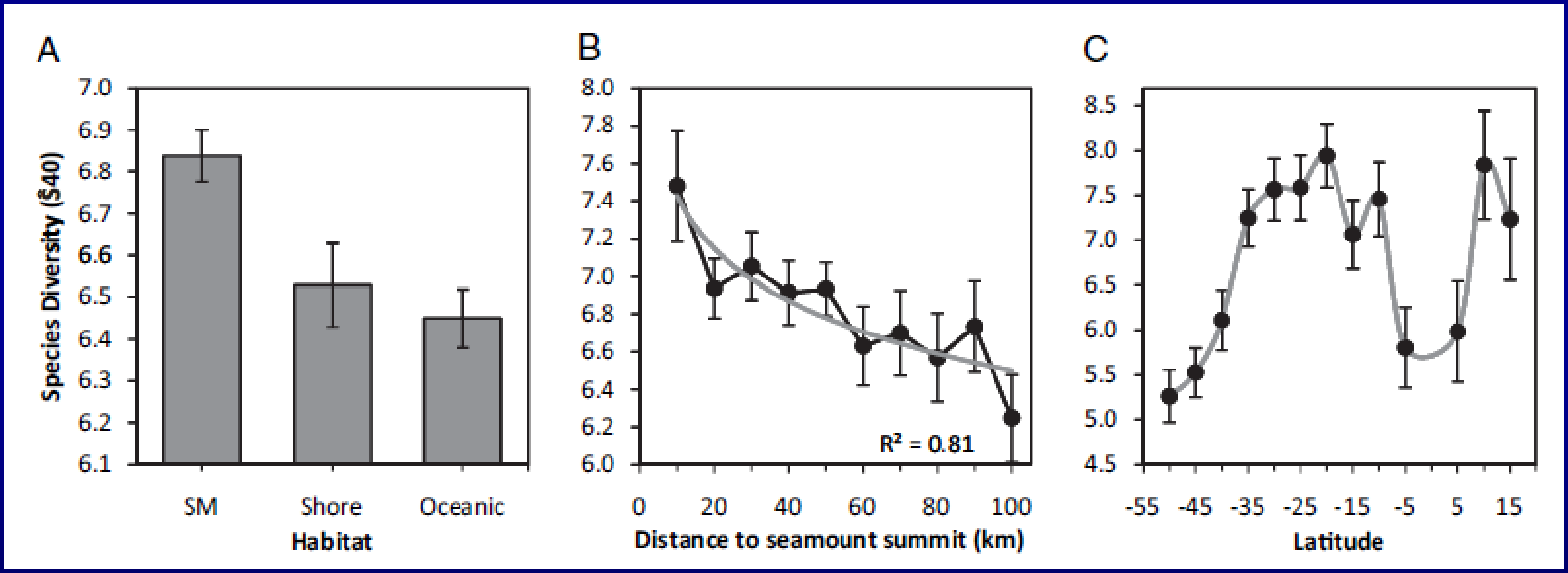
Used SPC tuna catch-effort database to examine association of high catch rates with seamount proximity



Seamounts with higher catch rates of tuna (yellowfin, bigeye, albacore). About 600 in total. From Morato et al. (2011).

Pelagic biodiversity on seamounts

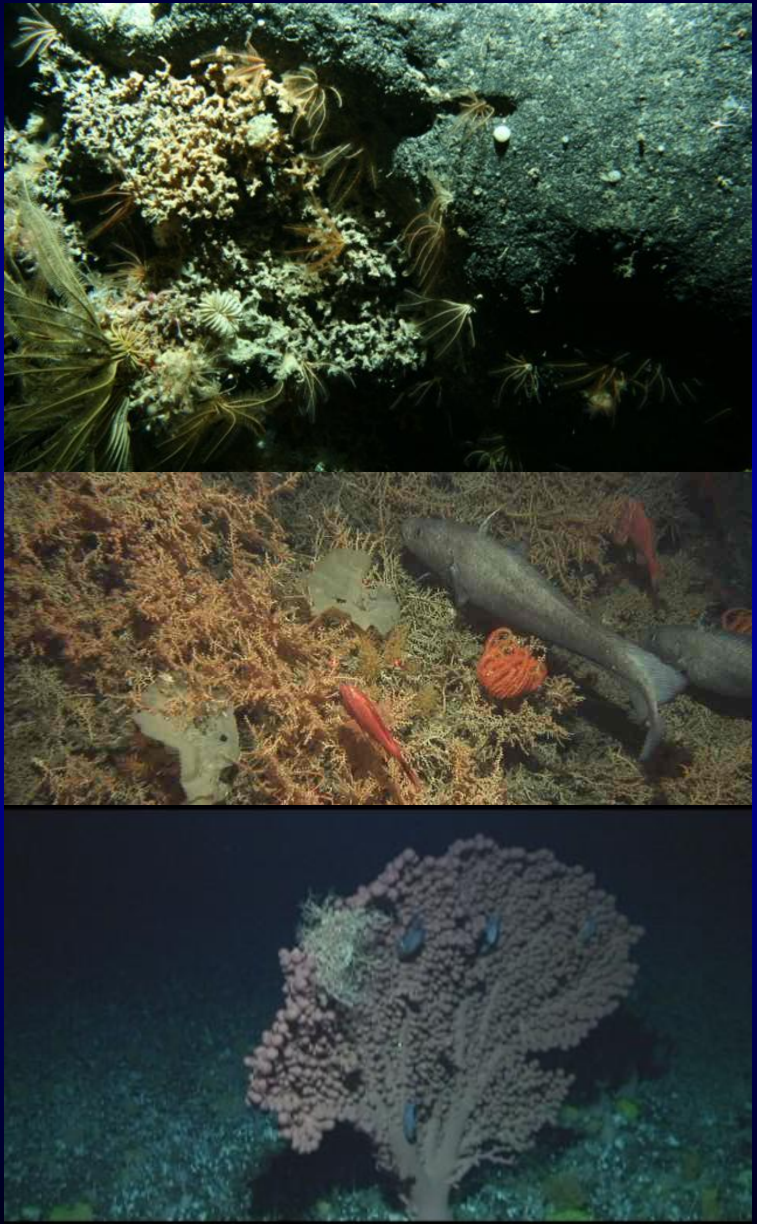
- SPC Observer catch data show clear “seamount effect”, with more species on seamounts than other habitats, and a decrease with distance from the seamounts.



- So there is a very strong take-home message that seamounts are really important habitat for fisheries in the PIC region

Seamount habitat

- Vulnerable to impact
- Small size relative to slope areas
- Concentrated fishing (or mining) effort
- Abundant structural species (e.g. cold-water corals) which are easily damaged
- Potential for high % endemic species (?)
- Low productivity of many deep species

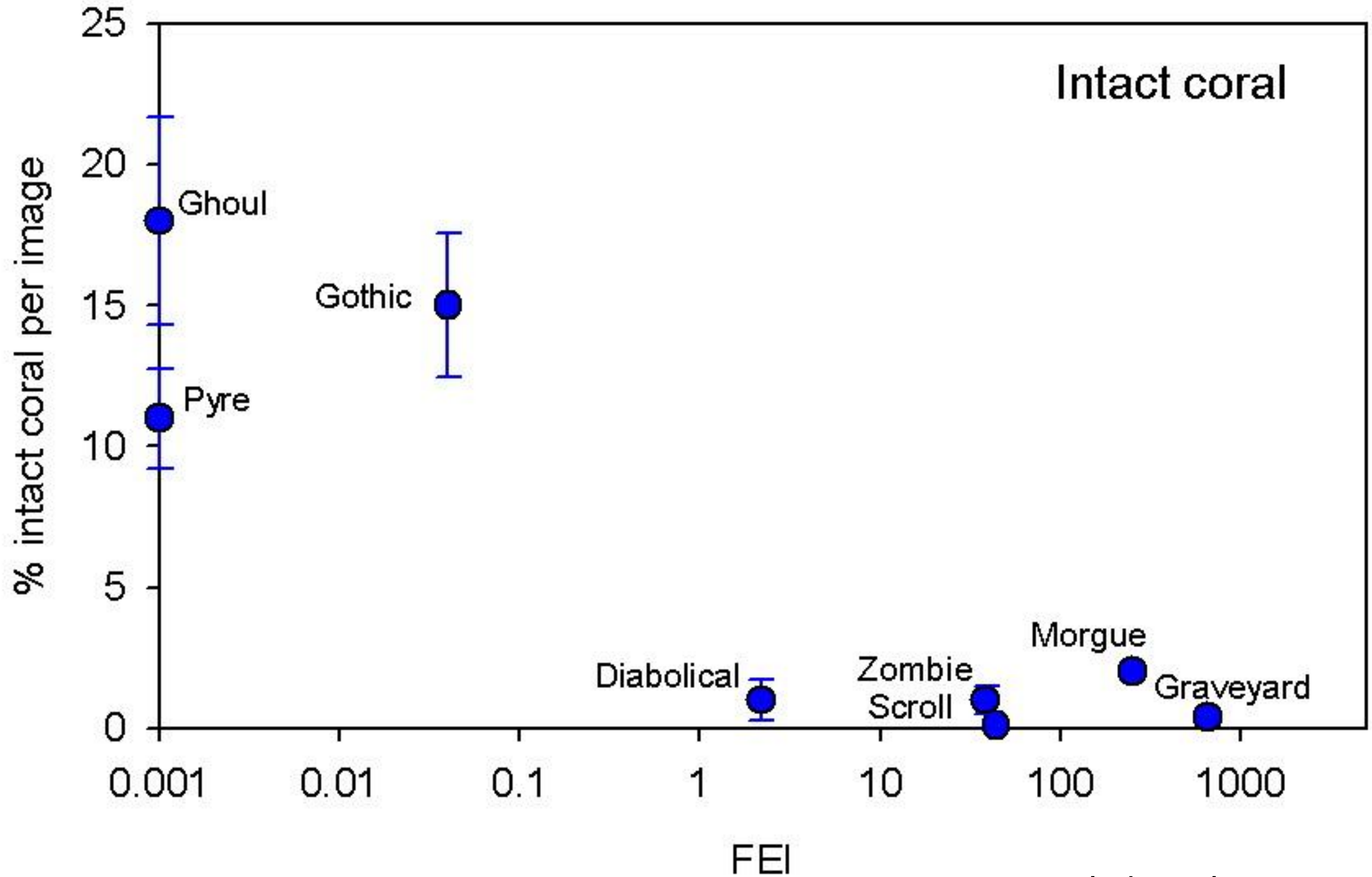


Deep-sea coral communities



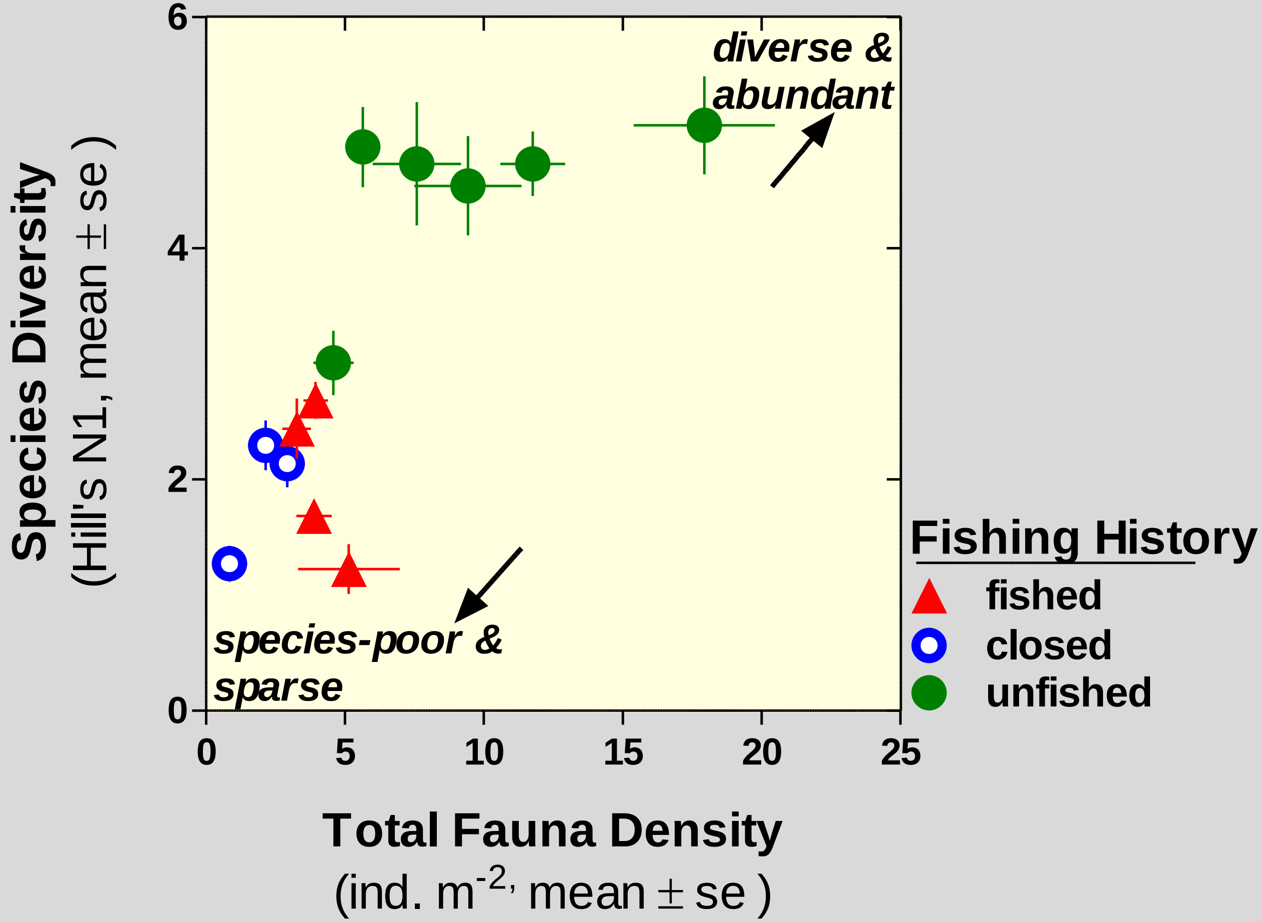

Corals and fishing don't mix

Neither will corals and mining…



Clark et al. 2009

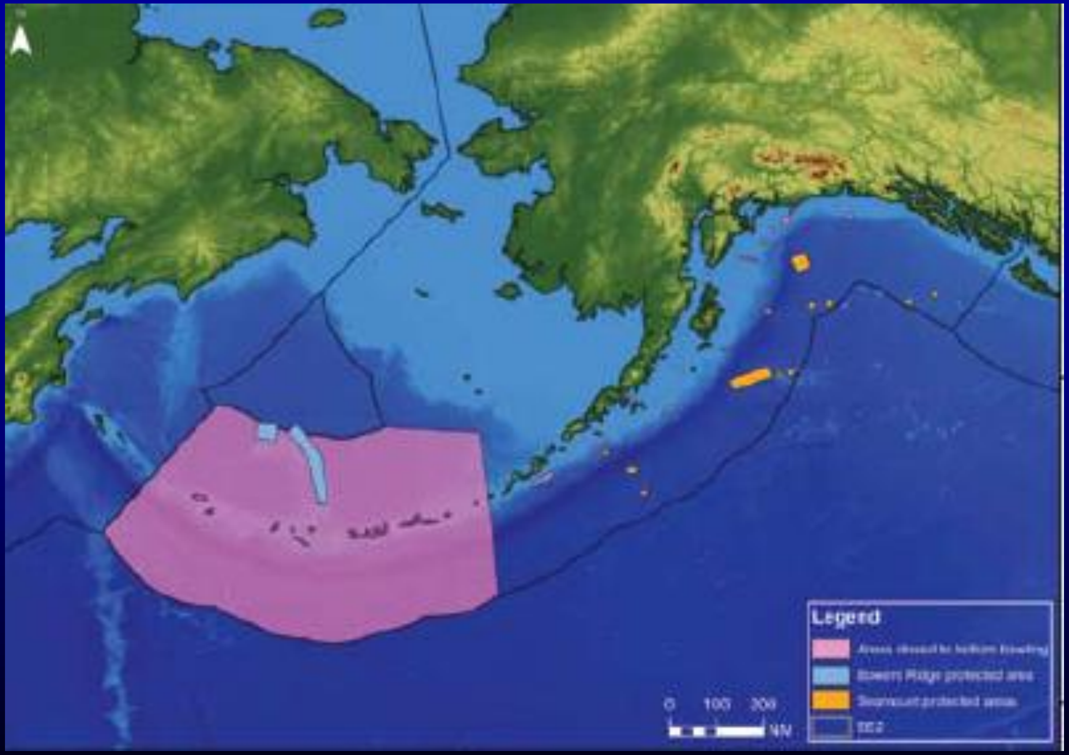
Density & Diversity effects

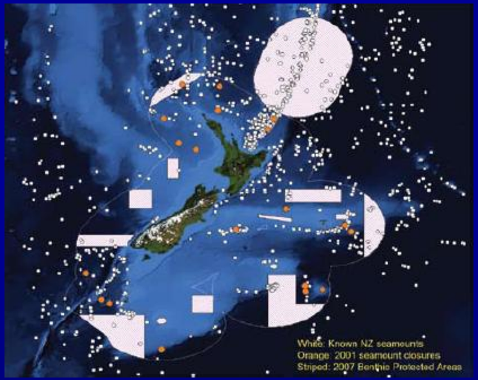


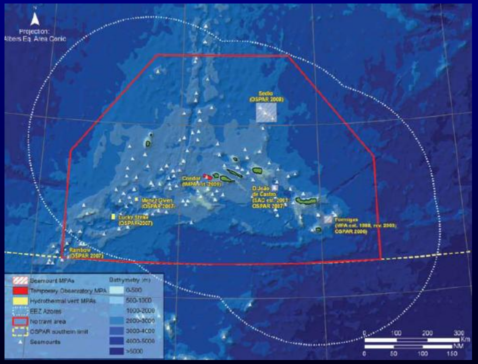
Althaus et al. 2009

Management implications

- Seamount benthos is severely affected by fishing (mining)
- Recovery is very slow (if at all...)
- The solution is to protecting undamaged habitat before exploitation expands



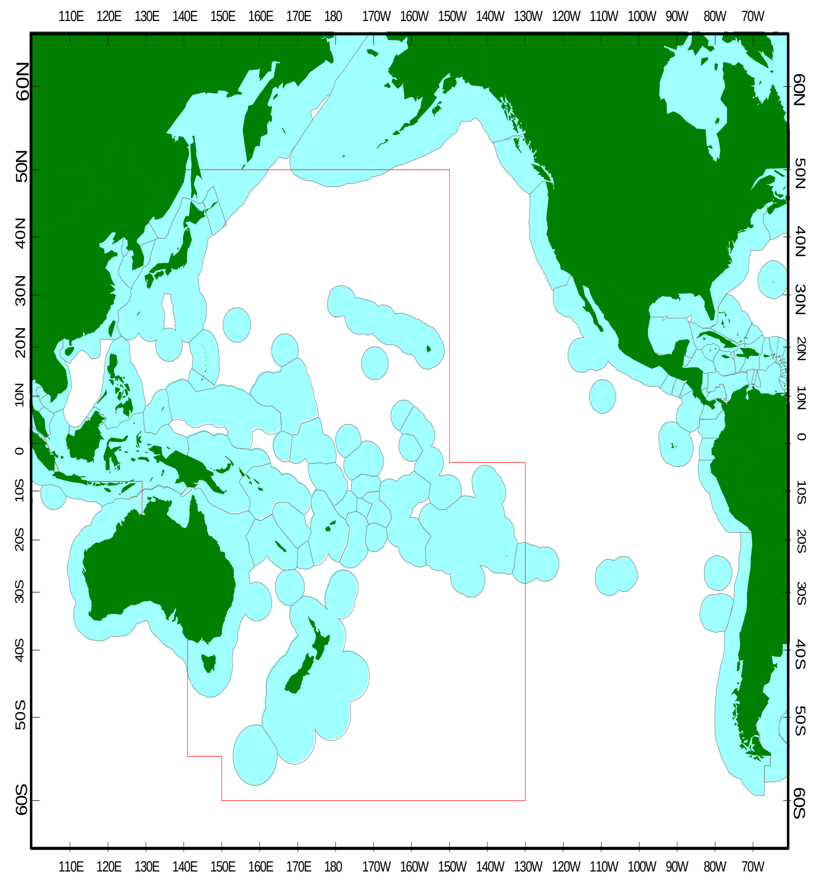




Existing fisheries management

- WCPFC manages tuna
- All nations, PICTs (FFA+) and DWFNs (e.g. JP, TW, CN)
- Regional management aims agreed by ALL parties
- SPC, FFA roles
- Individual EEZ management

- FAO guidelines and agreements
- Non tuna management plans
  - E.g., Tonga for snappers



So development and management of DSM needs to be integrated with a well developed, and complex, fisheries regime

Precautionary principle

- Authorities take preventive action when there is a risk of severe and irreversible damage;
- Action required even in the absence of certainty about damage and without having to wait for full scientific proof of the cause-effect relationship; and
- When there is disagreement on the need to take action, the burden of providing proof is reversed and placed on those who contend that the activity has or will have no impact.

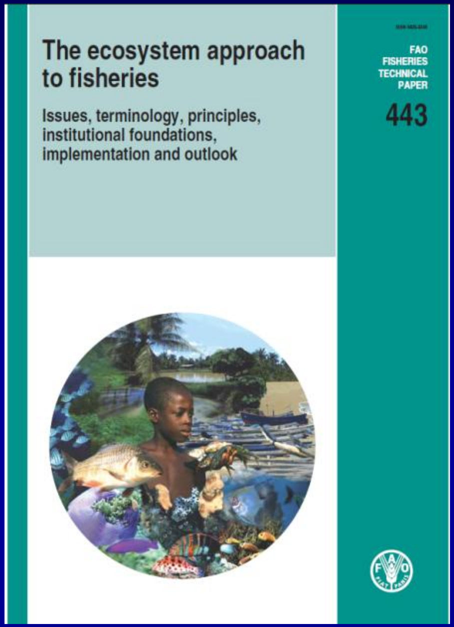
- **i.e. uncertainty or a lack of information means action should still be taken, and that action should be ‘precautionary’**

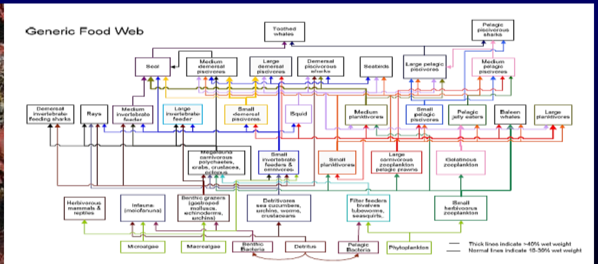
Ecosystem approach

- There is increasing recognition of the importance of an Ecosystem Approach to Management,
- "*Ecosystem and natural habitats management….to meet human requirements to use natural resources, whilst maintaining the biological richness and ecological processes necessary to sustain the composition, structure and function of the habitats or ecosystems concerned*".
- The approach requires integration of information from:
  - a range of disciplines (geology, oceanography, biology)
  - across different levels of ecological and socio-economic organization
  - on a range of temporal and spatial scales

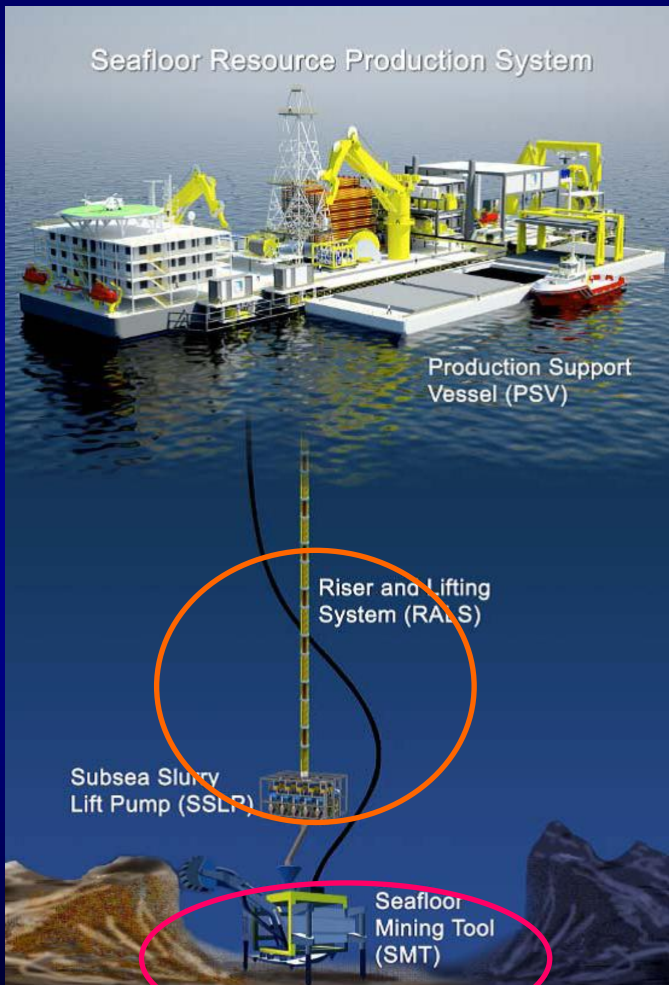
The Ecosystem Approach (2)

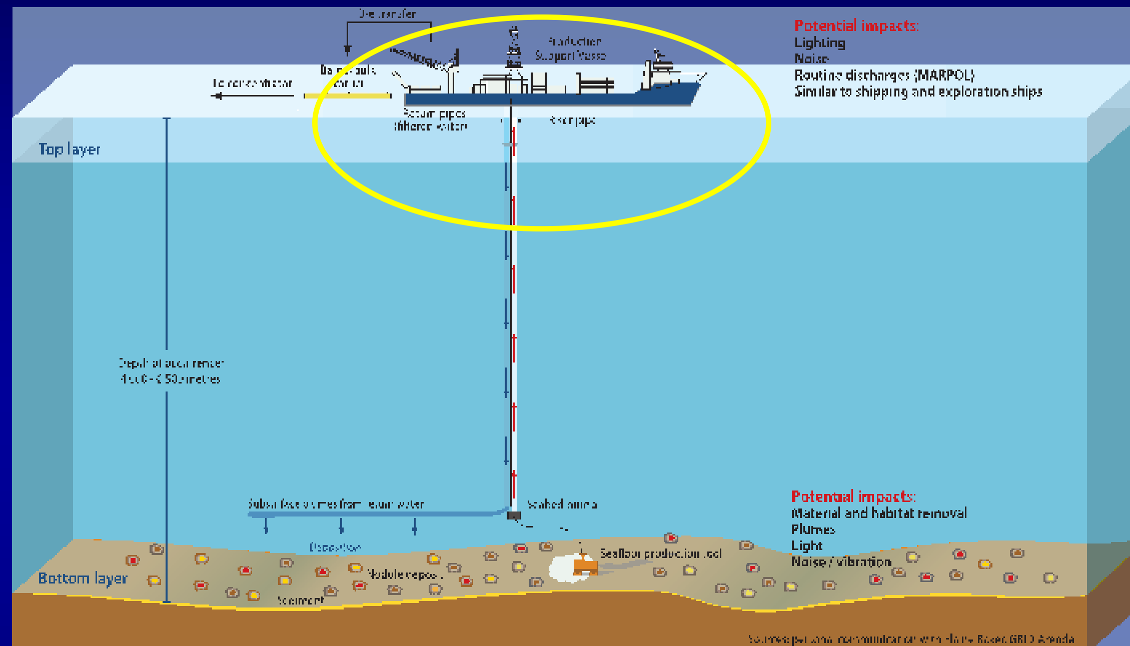
- Reasonably well developed in fisheries literature, but no-one really knows how to carry it out….
- In practice we consider as many important parts of the system as one can
  - -so for tunas the oceanography is critical, consider zooplankton production (prey), effects of taking out big predators on smaller fish and trophic cascades, and linkages between benthic and pelagic components of the ecosystem
- Still measure individual things, but combine them in an holistic assessment





Back to the key issues for mining impacts on fisheries…





Surface
Midwater
Seafloor

The impacts of DSM are 3 dimensional

- Surface: physical presence of ships/platforms, noise, light, surface discharges
- Midwater: physical presence of riser pipes, discharges of processing water/waste, rovs/tools going up and down
- Seafloor: physical disruption by seafloor production tools, sediment plume generation, tailing disposals etc

Key effects to consider

- **Potential surface impacts**
  - reduction in primary production through sediment plume shading
  - effects on behaviour of surface/deep-diving mammals and birds through changes in water clarity
- **Potential water column impacts**
  - plankton/mesopelagic fish mortality
  - bioaccumulation of toxic metals though food chain
  - sediment plume through water column
  - potential oxygen depletion
  - effects on deep-diving marine mammals
- **Potential benthic impacts**
  - direct physical impact of mining/sampling gear
  - smothering/burying of animals by sediment
  - clogging of suspension feeders
  - toxic effects with metal release
  - loss of essential habitat (spawn/nursery areas)

Critical issue 1: Depth

- Coastal inshore fisheries-typically <20 m
- Tuna fisheries-typically shallow, surface waters, but can extend to 300-400 m. Offshore, wide area
- Deepwater snappers-down to 250 m, seamounts
- Deep-sea (alfonsinos and bluenose) down to 600 m on seamounts, but not commercial at this time
- A diverse deep-sea fauna > 1000 m is likely, even though not commercial (remember the Ecosystem Approach). New Zealand, >100 fish species
- Most can move, but not so easy if they live on seamounts
- Deep-diving marine mammals to 1000 m.

Depth: continued

- Limited direct overlap of deep-sea mining and fishery distributions **at the seafloor** (nodules, >3000m, SMS >1000m, CRC >800m)
- Surface and midwater effects are the important issues, to ensure mitigation against
  - increased ship-presence (accidental spills etc), FAD…
  - discharge products (water chemistry, particle loading, toxins),
  - leakages from riser pipes
- Downstream effects where impacts may be upwelled
- Generally poor knowledge of vertical structuring of ecosystems and the role of deep productivity

Critical issue 2: Location

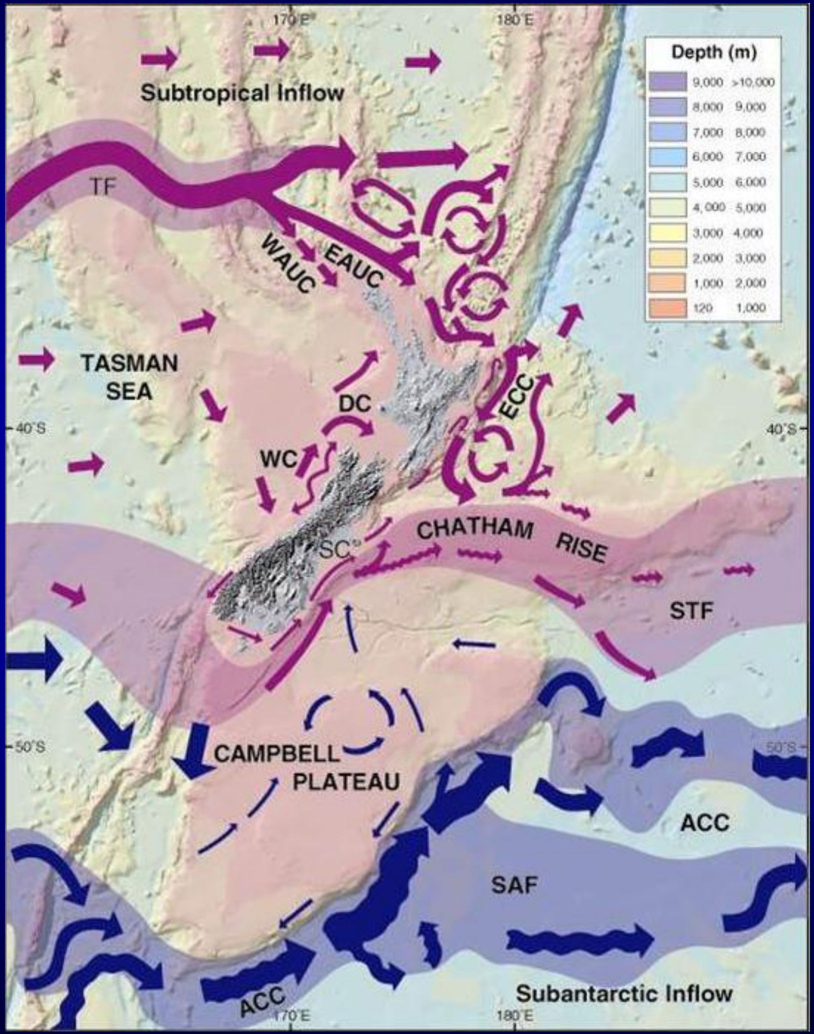
- This depends on the proximity of mining operations to fishing grounds
- If not “near” the islands (100 km) then impacts may not be an issue for coastal fisheries
- Seamount operations are the main concern for tunas and DW snappers
- Spawning and nursery grounds are especially important
- Need more information on “Essential fish habitat” for commercial species, as well as fish species associated with seamounts/biogenic habitat on them.
- Spatial separation of mining and fishing is likely the easiest, most effective (and precautionary) management approach

Critical issue 3: Sediment

- Sediment plumes will be generated by all operations, especially nodules.
- Will affect a larger area than the physical footprint
- Will extend into midwater from the seafloor, and also from discharge if at surface or midwater
- DISCOL, plumes visible for up to 6 hours from a single disturbance, CCZ modelling indicates dispersal up to 100 km. Video yesterday showing “avalanche” effect.
- Gradient of impact as particle density drops, but smothering and clogging of feeding mechanisms are issues, especially larval and juvenile fishes
- Also reduced visibility for visual predators (e.g, tunas, marine mammals)

Critical issue 4: Oceanography

- Direct current measurements very important at depth
- Regional oceanographic models (NZ and Australia)
- Plume modelling by contractors and research institutes
- The “downstream” dispersal of product is a key aspect of adaptive management in the early stages
- Plus understanding connectivity of populations



Critical issue 5: Time

- This is deep-sea stuff, and like the formation of the minerals, good things take time-so too the biology
- Pelagic fisheries are productive, deep-sea snappers much less so
- Recovery of the benthos will be slow, if at all
  - No recovery of corals evident on Aus-NZ seamounts after 10 yrs

Conclusions

- Fisheries are a very significant SUSTAINABLE industry the South Pacific, and tuna stocks are economically very important for many countries
- Most fisheries are either inshore, or offshore in surface waters, which reduces potential conflict through depth separation.
- However, biological information for many fish species, or life history stages, is lacking
- Environmental effects of mining on fisheries could be detrimental, depending primarily upon surface and midwater impacts of water chemistry and sedimentation from processing operations or waste
- There is a need to integrate environmental assessment and management of fisheries and mining together.

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