REGIME SHIFTS AND RECRUITMENT IN WESTERN AND CENTRAL PACIFIC OCEAN TUNA FISHERIES

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PFRP Project started in 2005

Why bother?

Ecosystems exhibit natural variability at multiple scales – decadal scale variability may determine the frequency of interannual variability (e.g. ENSO) and of associated ecological processes (e.g. recruitment)

Transitions from one quasi-stable ecosystem state to another have been observed in the North Pacific, most notably in the late 1970s and 1990s; have they occurred in the WCPO? Are they relevant to tuna?

Can we derive objective measures of long-term variability in multiple ecological time series?

Can we use an improved understanding of long-term variability to improve recruitment estimation?

Project has 4 elements:

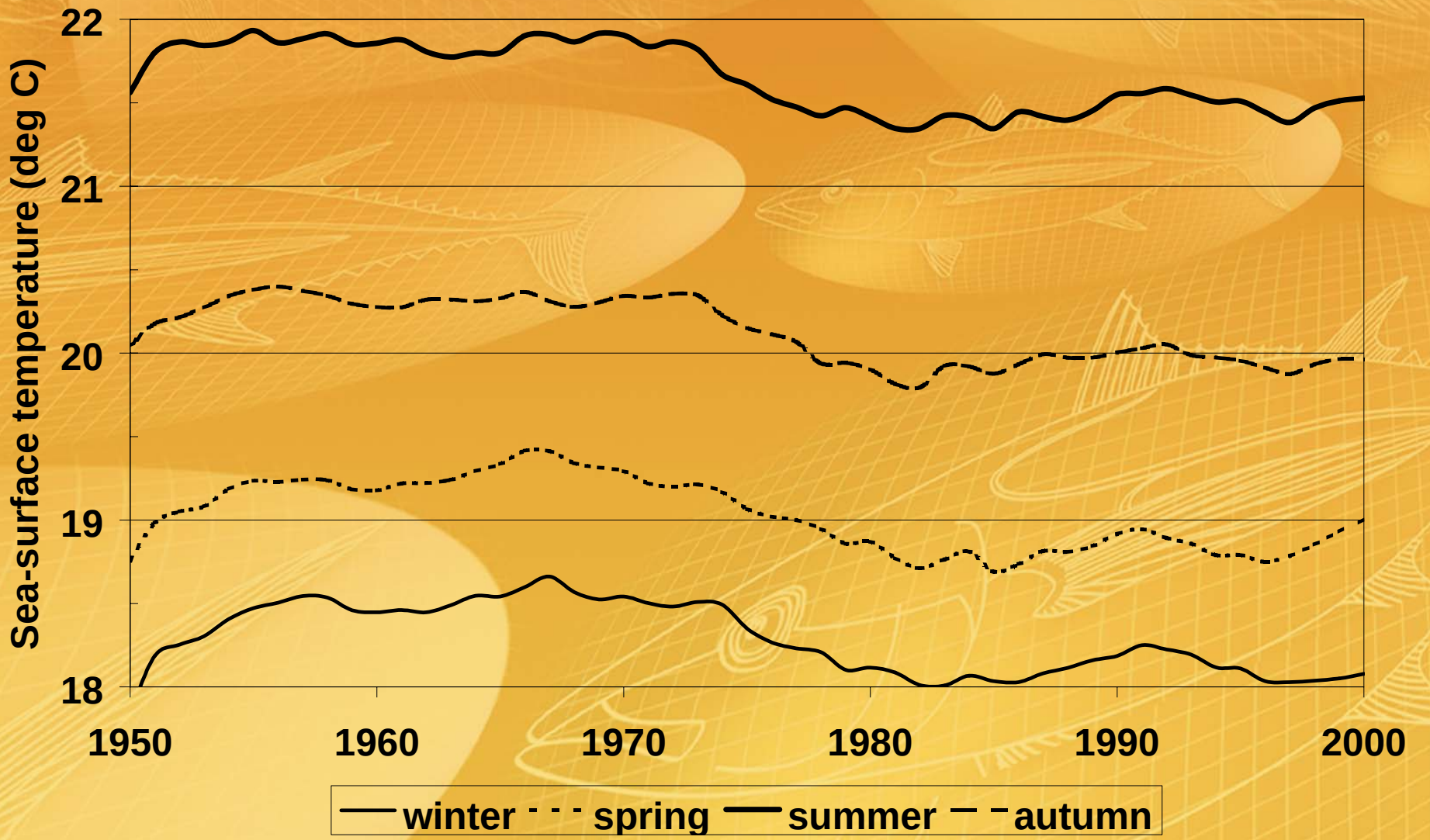
Objective characterisation of ecological time series

Comparative analysis of tuna diet 1960s vs. 2000s

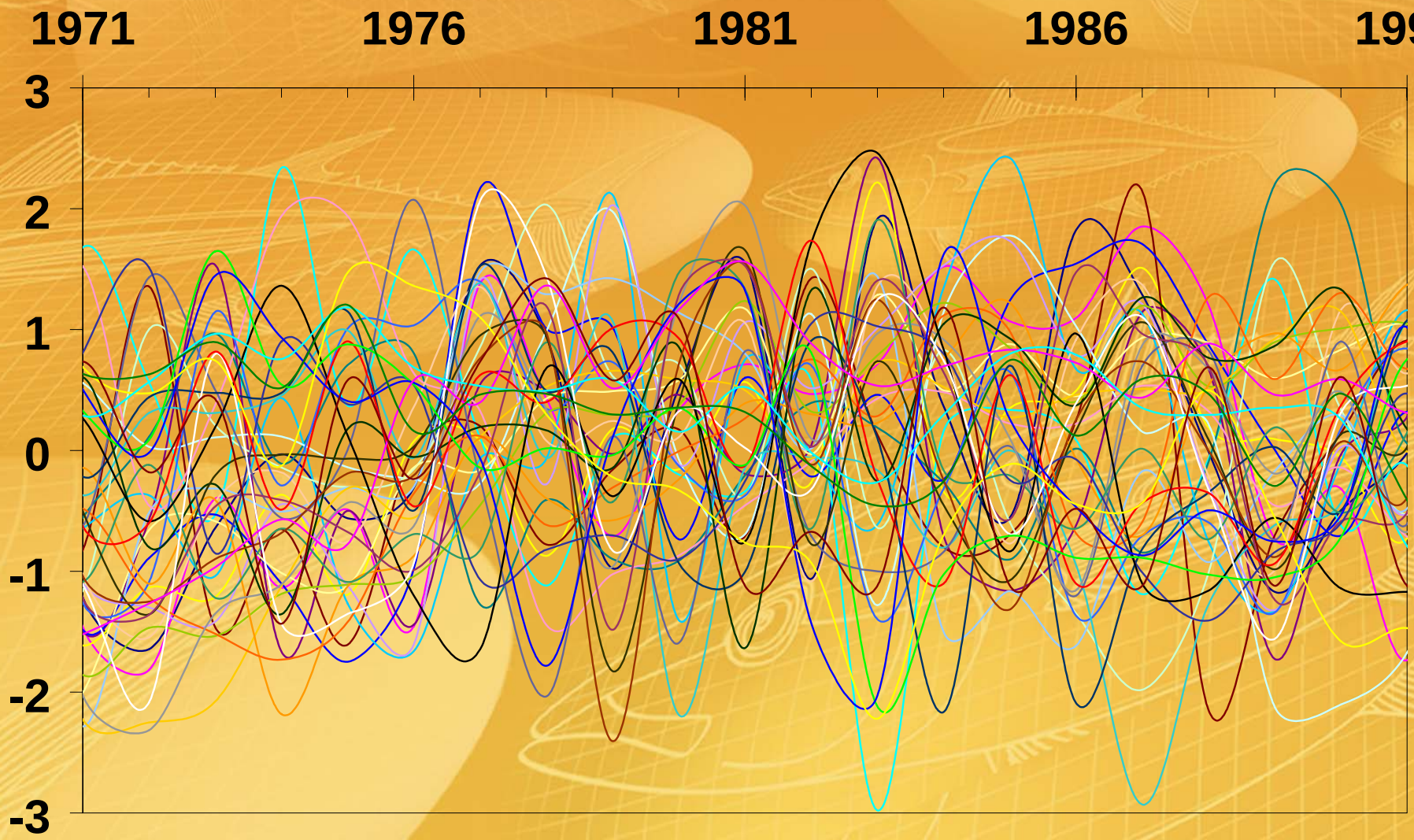
Data rescue of skipjack catch and effort data pre-1972 so series extends through 1970s regime shift

Incorporate indicators of ecosystem variability into a stock-environment-recruitment relationship, leading to improved recruitment estimation

Sea-surface temperature – North Pacific



Multiple ecosystem indicators can be presented ... but they are difficult to interpret like this



North Pacific data – Hare & Mantua 2000

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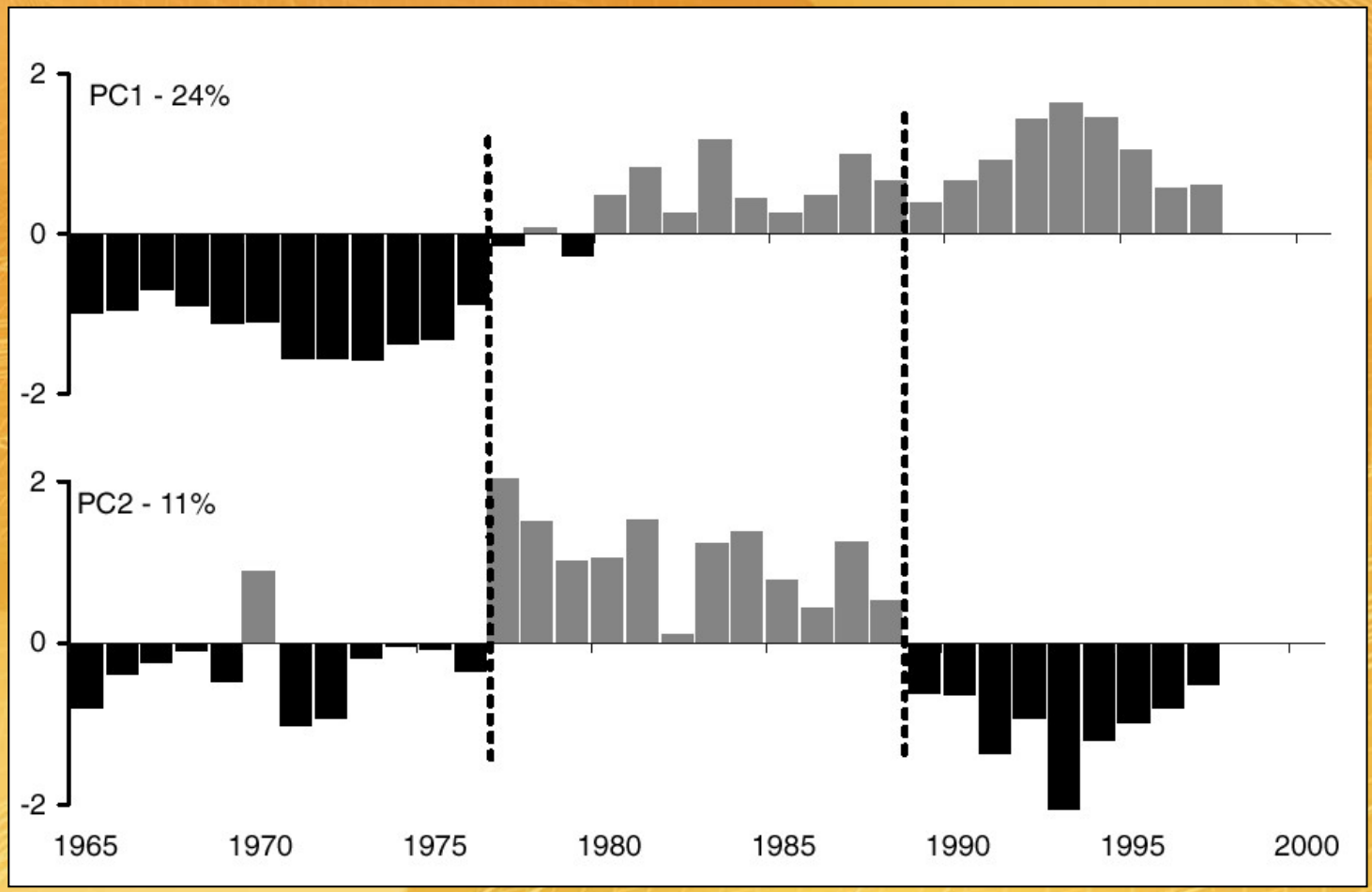
*Cycle periods:

50 yr

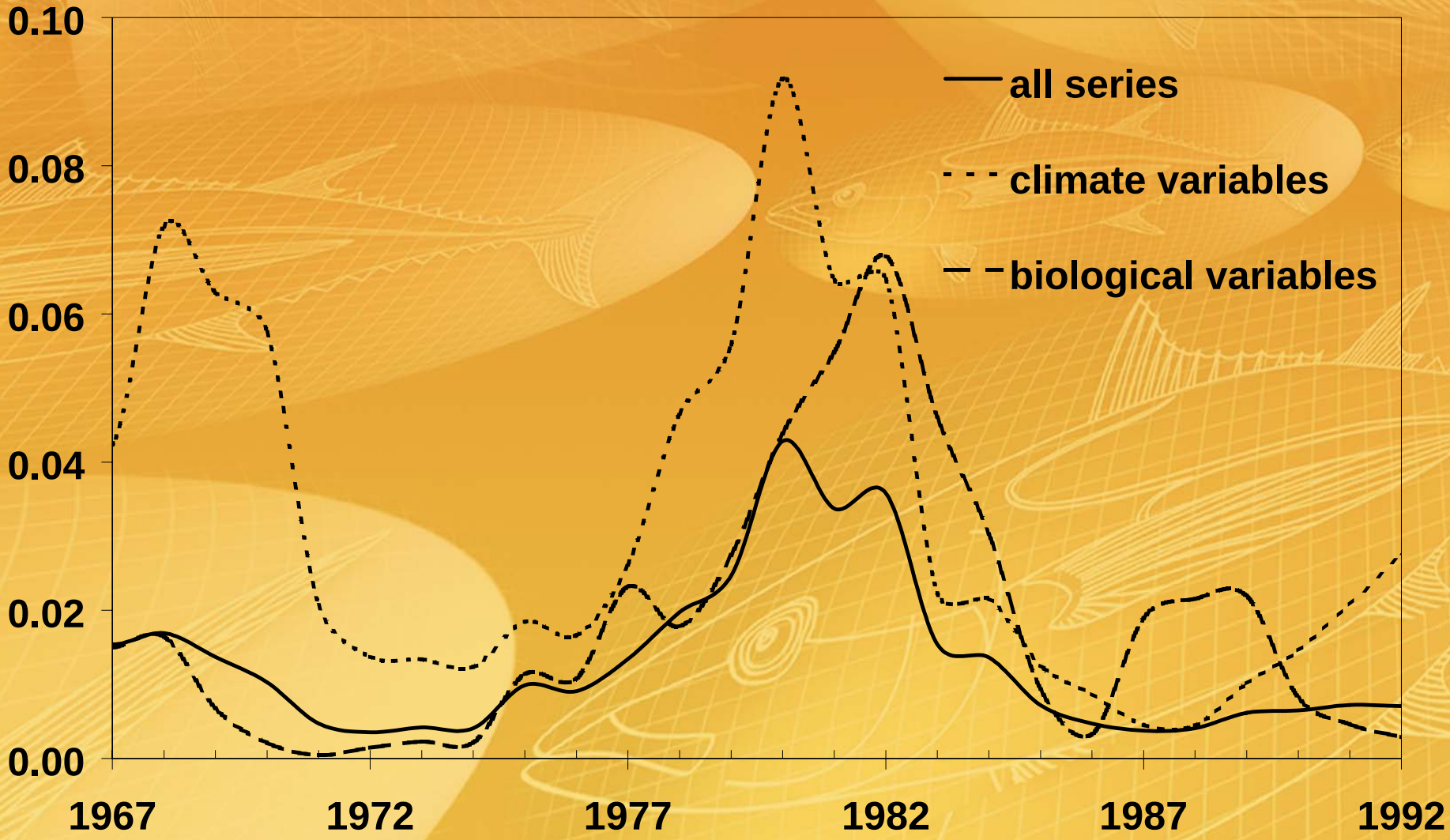
25 yr



First two principal component scores from an empirical orthogonal function analysis of the 100 environmental time series

*Consistent with Minobe (1999) wavelet analysis of NPI

Fisher Information – North Pacific



Fisher Information (Fath et al. 2003: J Theor Biol)

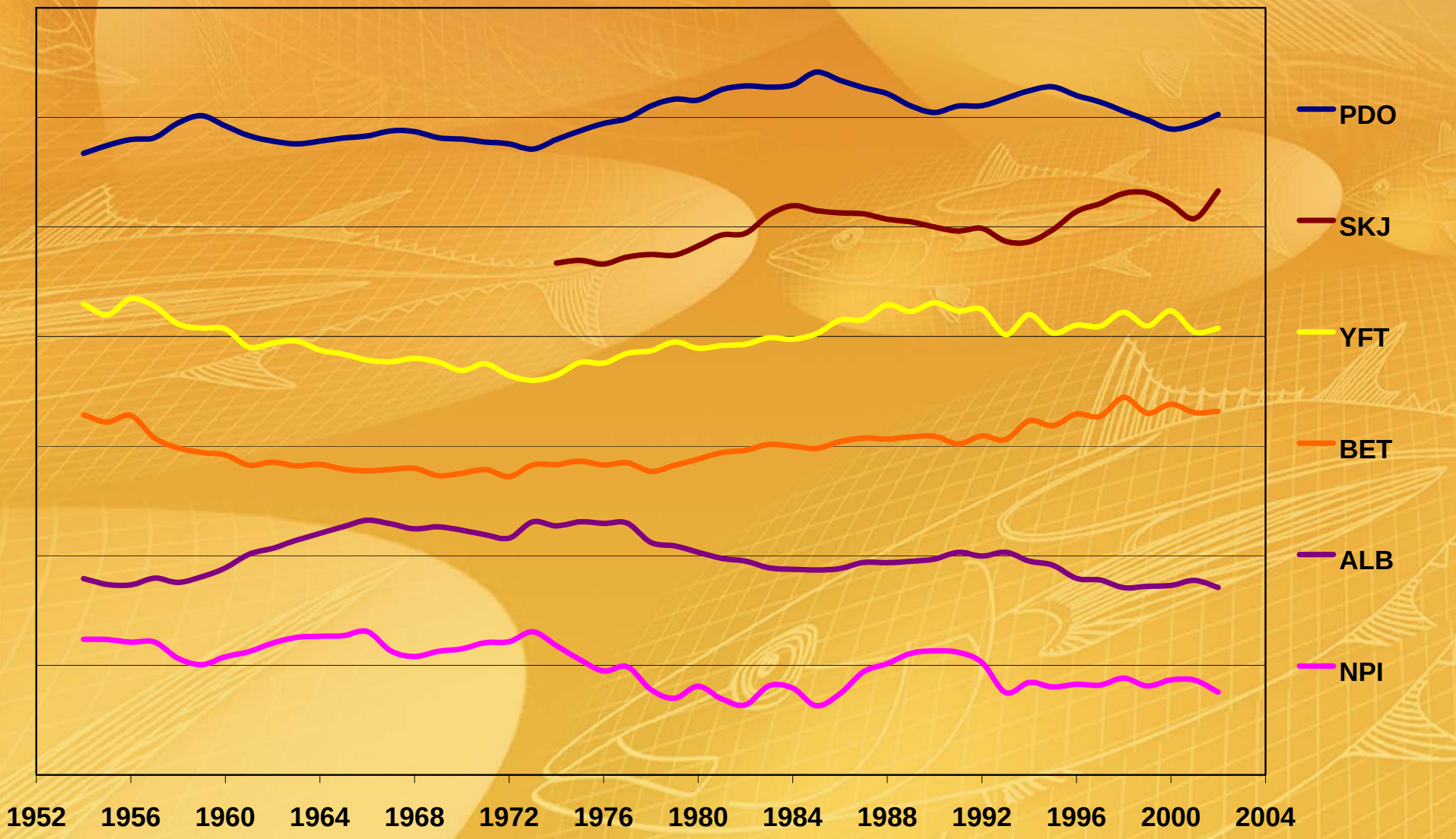
$$I = \frac{1}{T}\int_0^T \frac{\left(R''(t)\right)^2}{\left(R'(t)\right)^4}\mathrm{d}t$$

$$R'(t) = \sqrt{\sum_{i=1}^{n}\left(\frac{\mathrm{d}y_i}{\mathrm{d}t}\right)^2}$$

$$R''(t) = \frac{1}{R'(t)}\left[\sum_{i=1}^{n}\frac{\mathrm{d}y_i}{\mathrm{d}t}\frac{\mathrm{d}^2 y_i}{\mathrm{d}t^2}\right]$$

Fisher Information is a good indicator of coherent variability in multiple time series but does not tell you the 'direction' of any changes

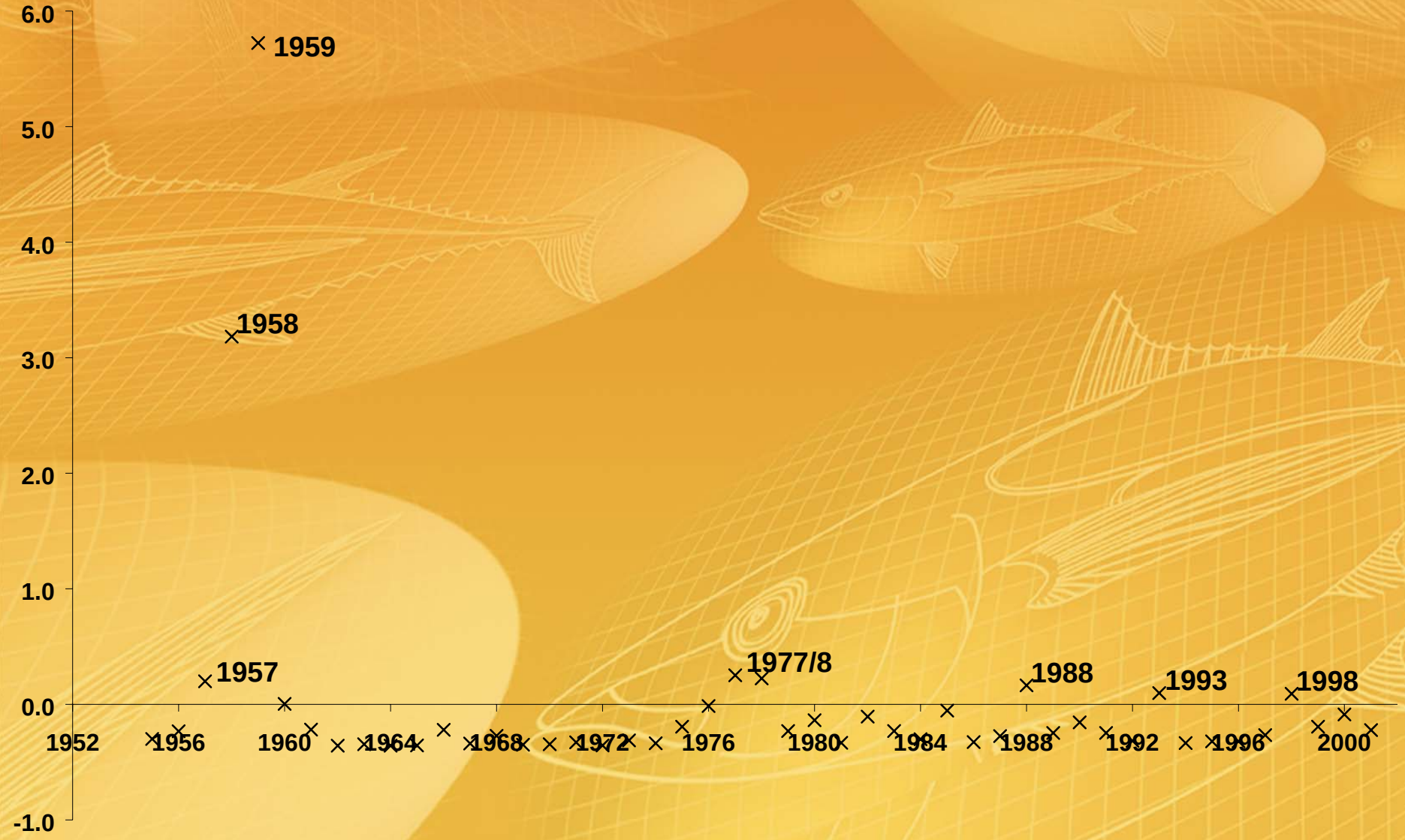
Climate indices and 2005 recruitment estimates for WCPO tunas



PDO: derived from SST; NPI derived from SLP

Note that PDO is the same as anomalies in Earth's rotation

Fisher Information for tuna recruitment & climate indicators (exc. skipjack)



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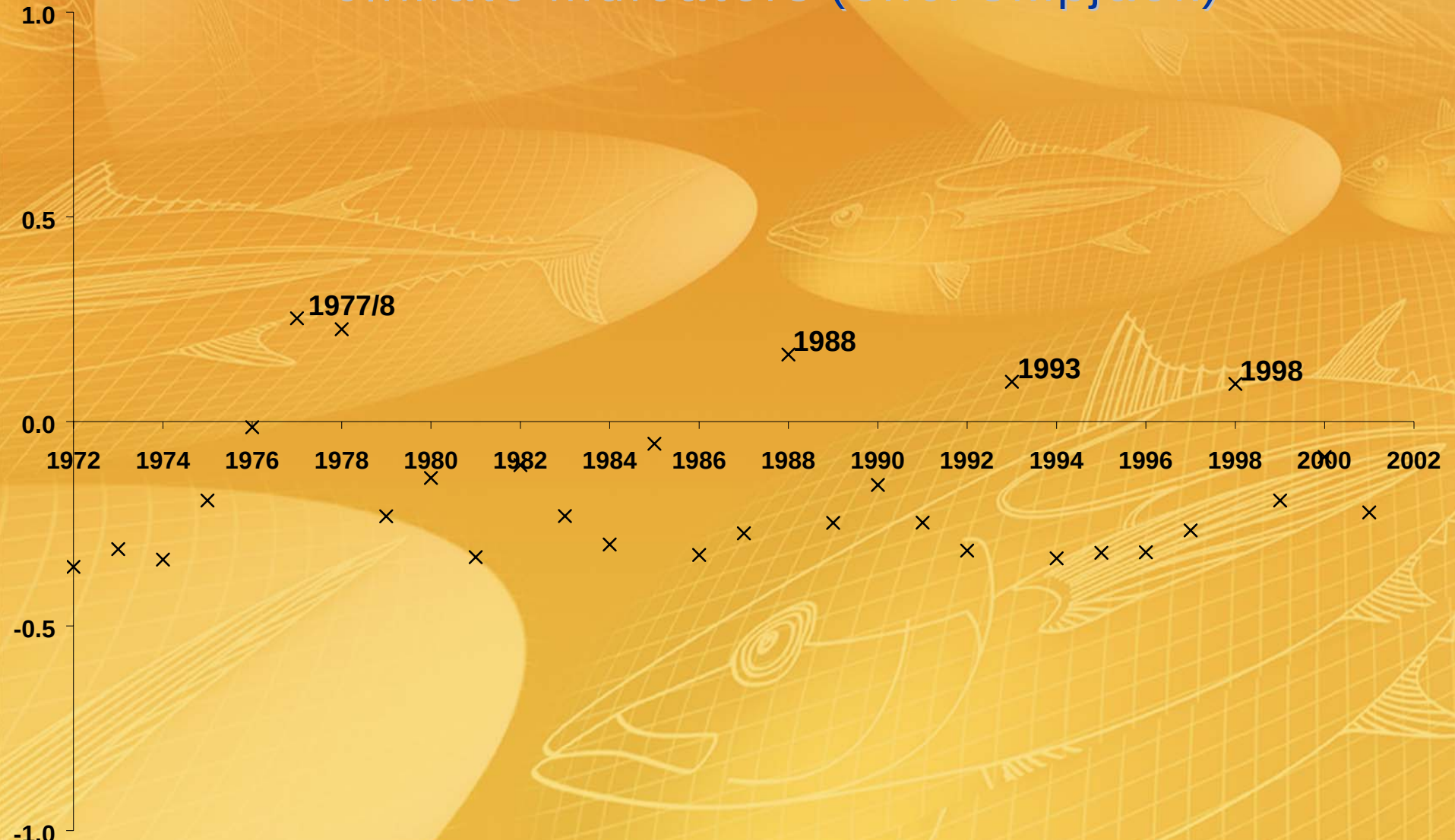

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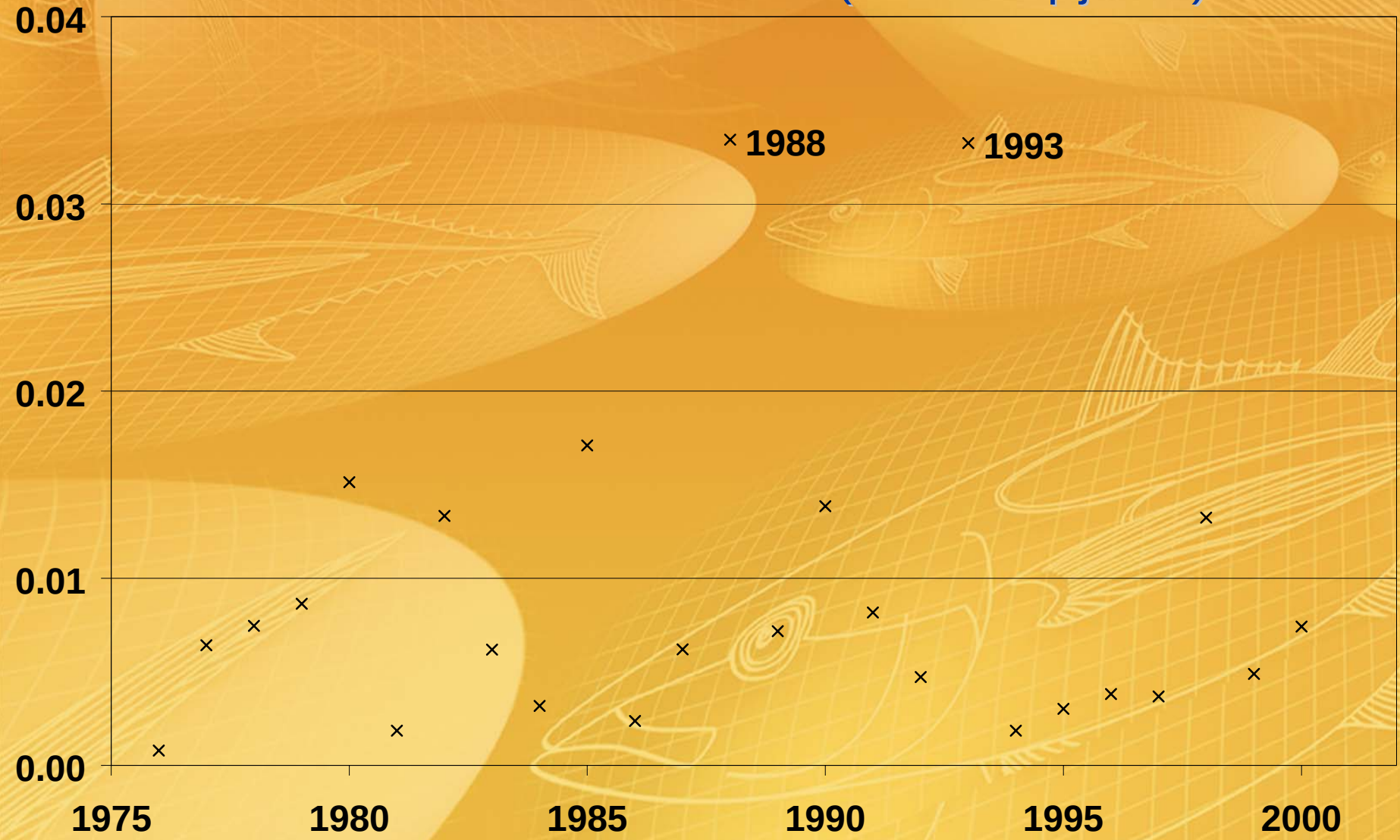
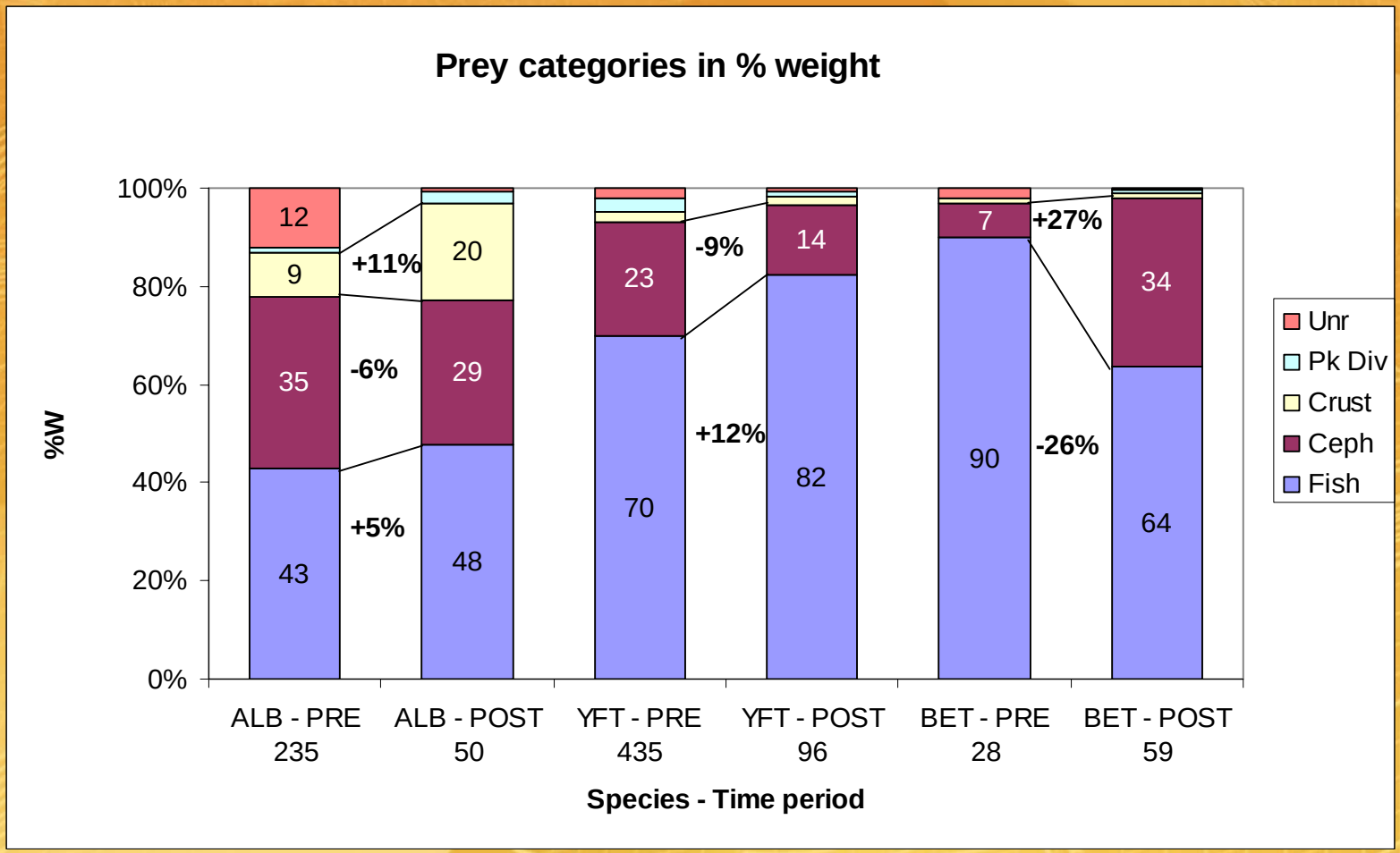


So, we have unfinished business in the area of objective characterisation of ecosystem variability...

Now for the diet data!!

Diet data: pre- and post-1970s regime shift

Merci *to Valerie Allain for 'rescuing' the data in* Grandperrin (1975)

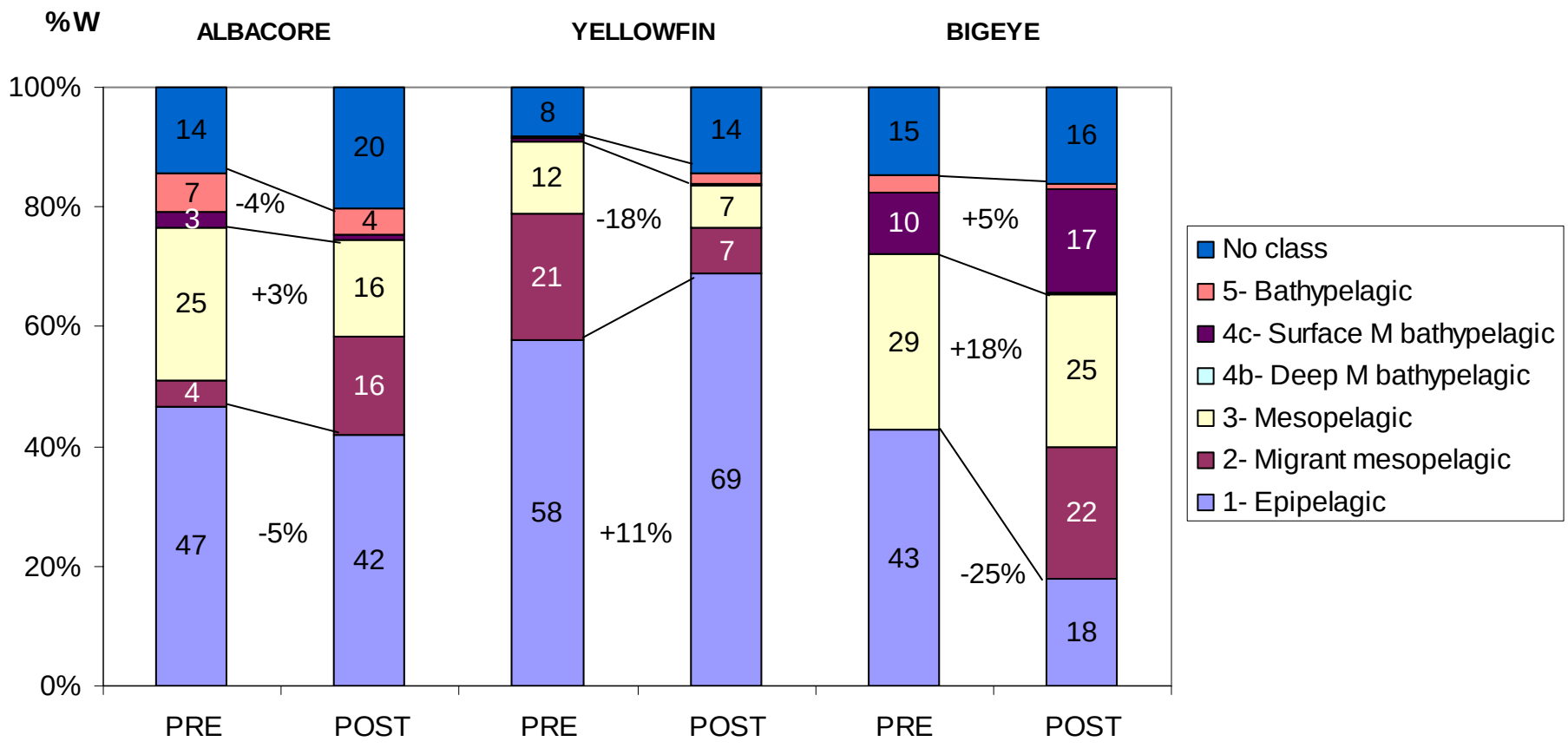


PREY DIVERSITY

		ALB		YFT		BET	
Number of stomachs examined	PRE	235	⇩	435	⇩	28	⇧
	POST	50		96		59	
Number of identified fish items	PRE	518	⇩	2364	⇩	40	⇧
	POST	187		179		206	
% of identified fish (N)	PRE	90	⇩	78	⇩	74.07	⇧
	POST	70		43		76.01	
Number of fish items	**PRE**	**72**	⇩	**145**	⇩	**13**	⇧
	POST	**26**		**36**		**19**	
Number of fish families	**PRE**	**39**	⇩	**64**	⇩	**12**	⇩
	POST	**18**		**25**		**10**	

Tuna now appear to eat a narrower range of fish prey than in the pre-regime shift environment, possibly due to a lower diversity of prey available

Prey categories by functional group:



ALB and BET eat less epipelagic and less mesopelagic, but more migrant mesopelagic; ALB eats less bathypelagic and BET eats more surface-migrating bathypelagic. By contrast, YFT eats more epipelagic but less mesopelagic and less migrant-mesopelagic

Potential explanations:

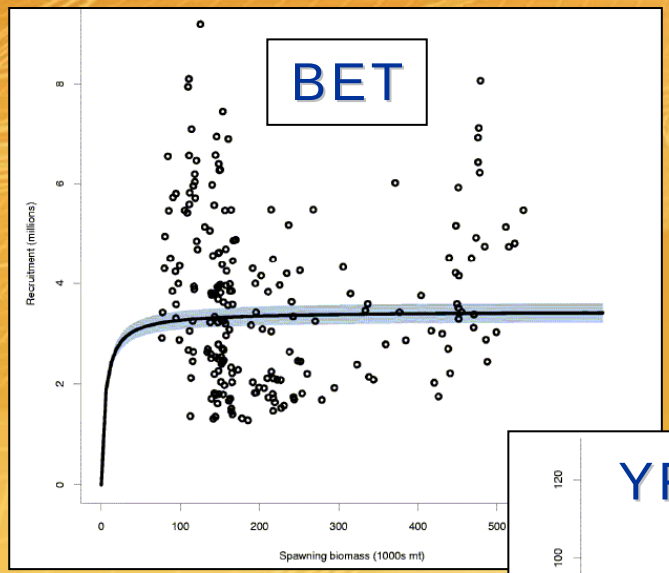
Changes in biomass of the different prey classes

Changes in behaviour of the predators: YFT stay longer in surface waters while ALB and BET stay more at deeper depth (changes in thermocline??)

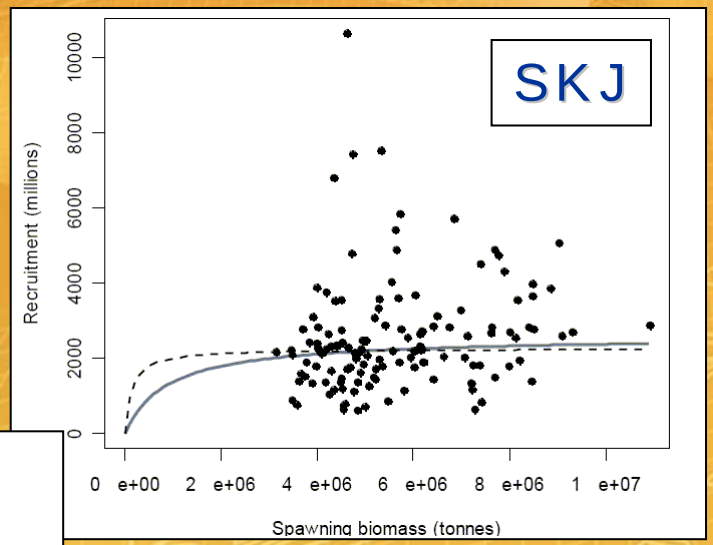
Both are testable using the SEAPODYM model

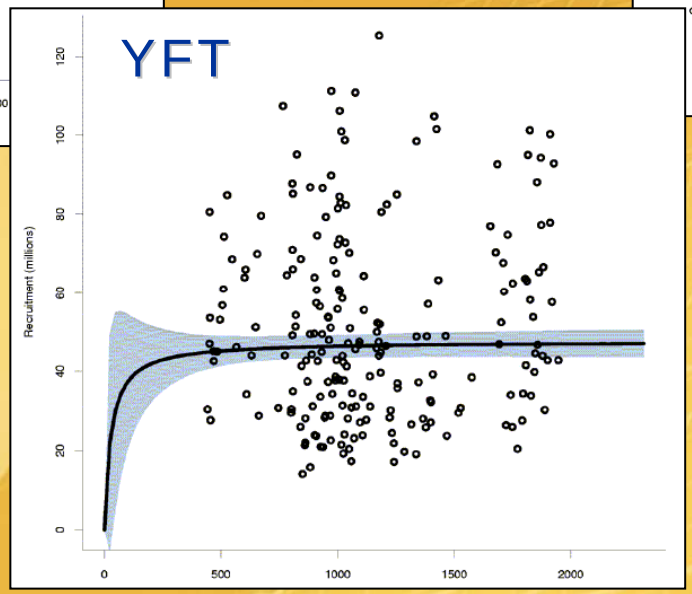
Stock-(Environment)-Recruitment relationships:

Stock assessments for tunas in the WCPO estimate recruitment around a fairly uninformative Spawning-Stock Recruitment (SSR) curve

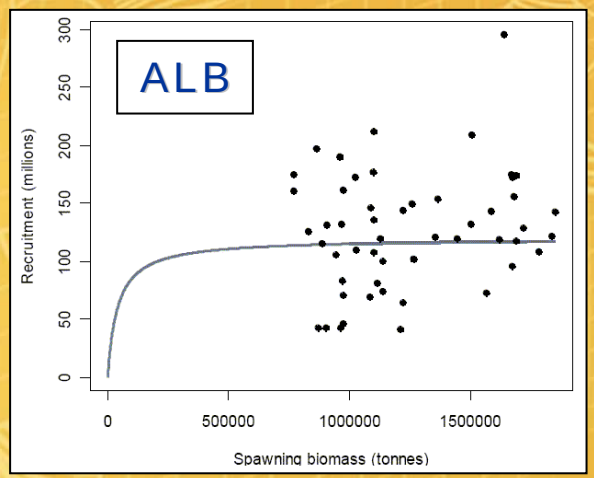


SSR curves from 2005 assessments





We will develop regime-specific SER curves using metrics for ecosystem state



Conclusions:

Diet data shows some interesting results but old data is poorly documented and highly aggregated – it would be interesting to do further work on data from French Polynesia (ECOTAP data), which is cleaner and more comparable to Valerie's data, to investigate changes pre- and post 1998 regime shift

There are long-term signals in tuna recruitment estimates but need to identify proximate physical correlates for these, i.e. objective evidence that 'regime shifts' also occur in the tropics

Indicators from this analysis may then be incorporated into SER relationships