

The influence of the Leeuwin Current on economically important fish and invertebrates off temperate Western Australia

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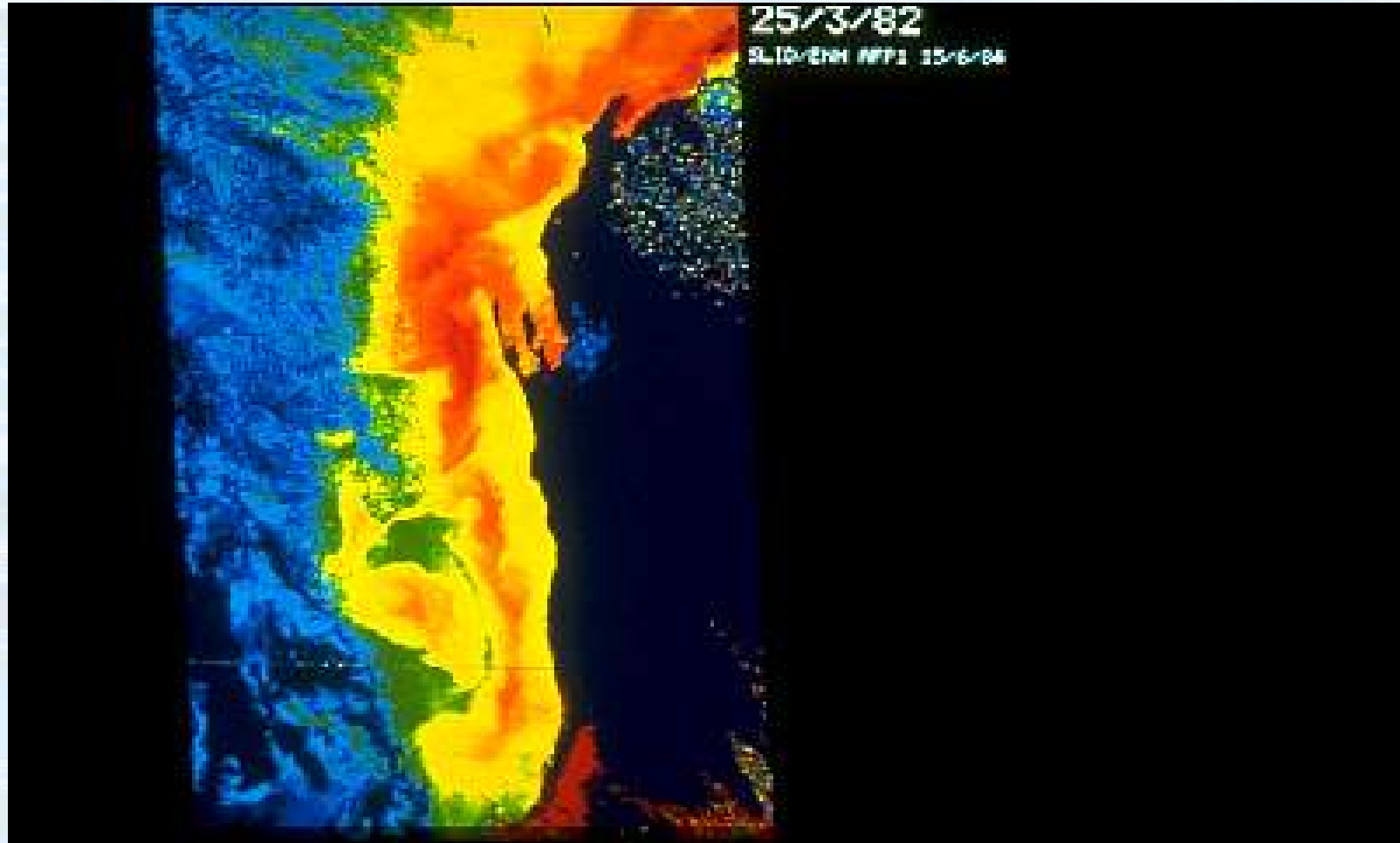
Outline

- Recap of major conclusions from earlier reviews.
- Report on some of the recent advances in our understanding of the influence of the LC on economically important fish and invertebrates.
- Discuss how this knowledge can contribute to better management of our fisheries.

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Leeuwin Current

(Warm low-nutrient waters flowing south)



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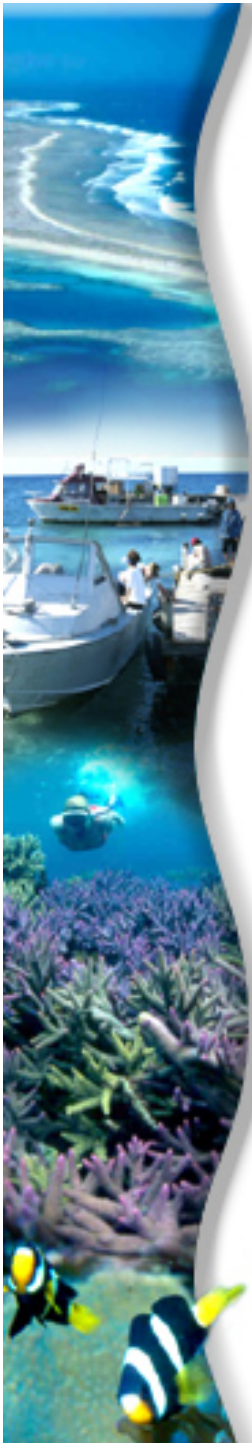


Earlier Reviews

Lenanton et al 1991.

- LC contributed to warmer/low nutrient water column environment off WA.
- As a consequence, fisheries production dependent on benthic-based food web.
- Species investigated for LC effects included WRL, SB prawns, SB scallops, A salmon, A herring & pilchard.
- Relationships invoked from statistical correlations.
- Mechanisms underlying observed relationships poorly understood.

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Earlier Reviews

Caputi et al 1996.

- Improved understanding of annual, seasonal, & regional behaviour of LC.
- Further exploration of mechanisms underlying observed effects of LC on
 - larval stages - recruitment.
 - later life history stages – growth and catchability.
- Updated investigations on WRL, SB prawns, SB scallops, A salmon, A herring pilchards.
- added whitebait.

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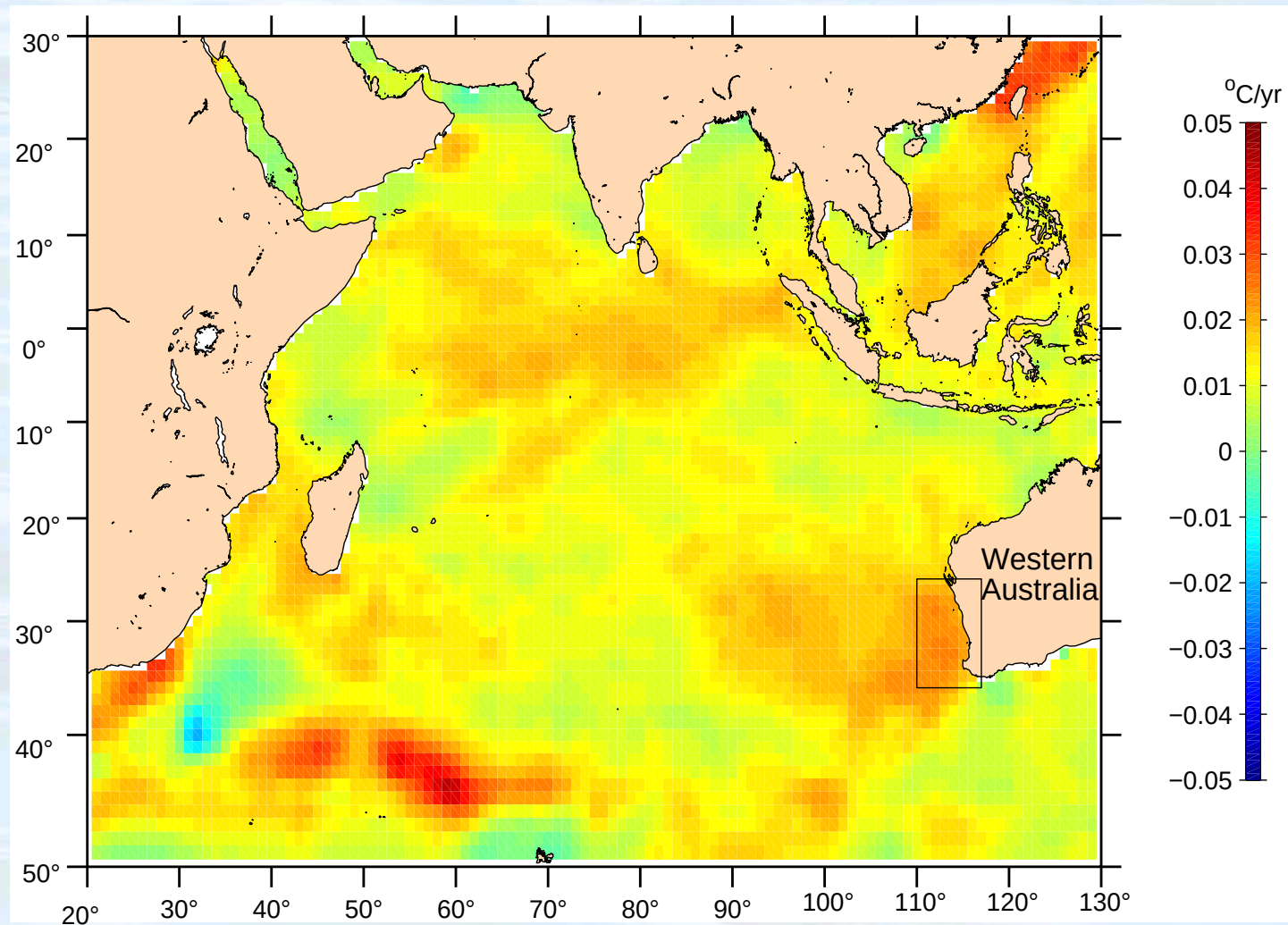
Recent Advances

- Leeuwin Current “system” i.e. Leeuwin Current, Leeuwin undercurrent, on-shelf Capes Current & Ningaloo Current.
- Range of interannual & seasonal variability in LC strength & behaviour, and it's effect on temperature, salinity, and productivity is related to ENSO cycle.
- Global atmospheric changes also contributing to observed physical oceanographic changes i.e. gradual warming of oceanic waters off lower west coast.

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Rate of warming ($^{\circ}\text{C}/\text{year}$) 1951 – 2004 (Pearce & Feng, in press.)



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Recent Advances

- Of the 7 species hitherto considered, investigations have continued with WRL, SB prawns, SB scallops, A. herring.
- Additional species studied include mudcrabs, WA dhufish, & tailor.
- A. salmon in WA - Changing nature of the fishery has prevented ongoing work.
- Albany pilchards - Stock abundance and distribution changes relative to LC has changed this relationship.
- Whitebait - Restructure of the fishery means whitebait relationship needs to be reviewed.

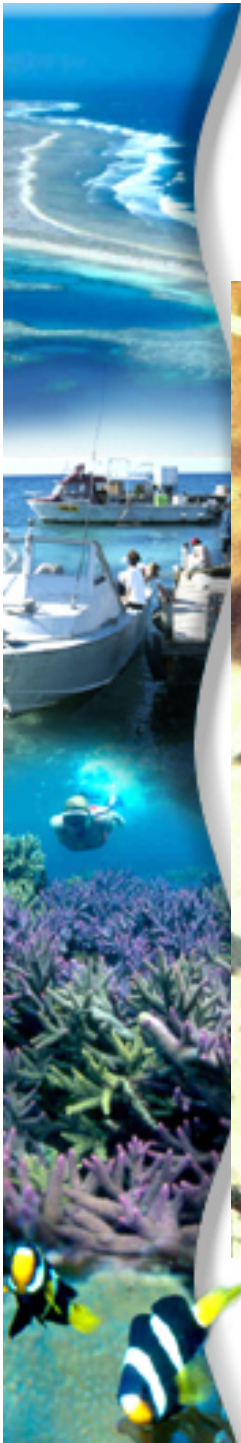
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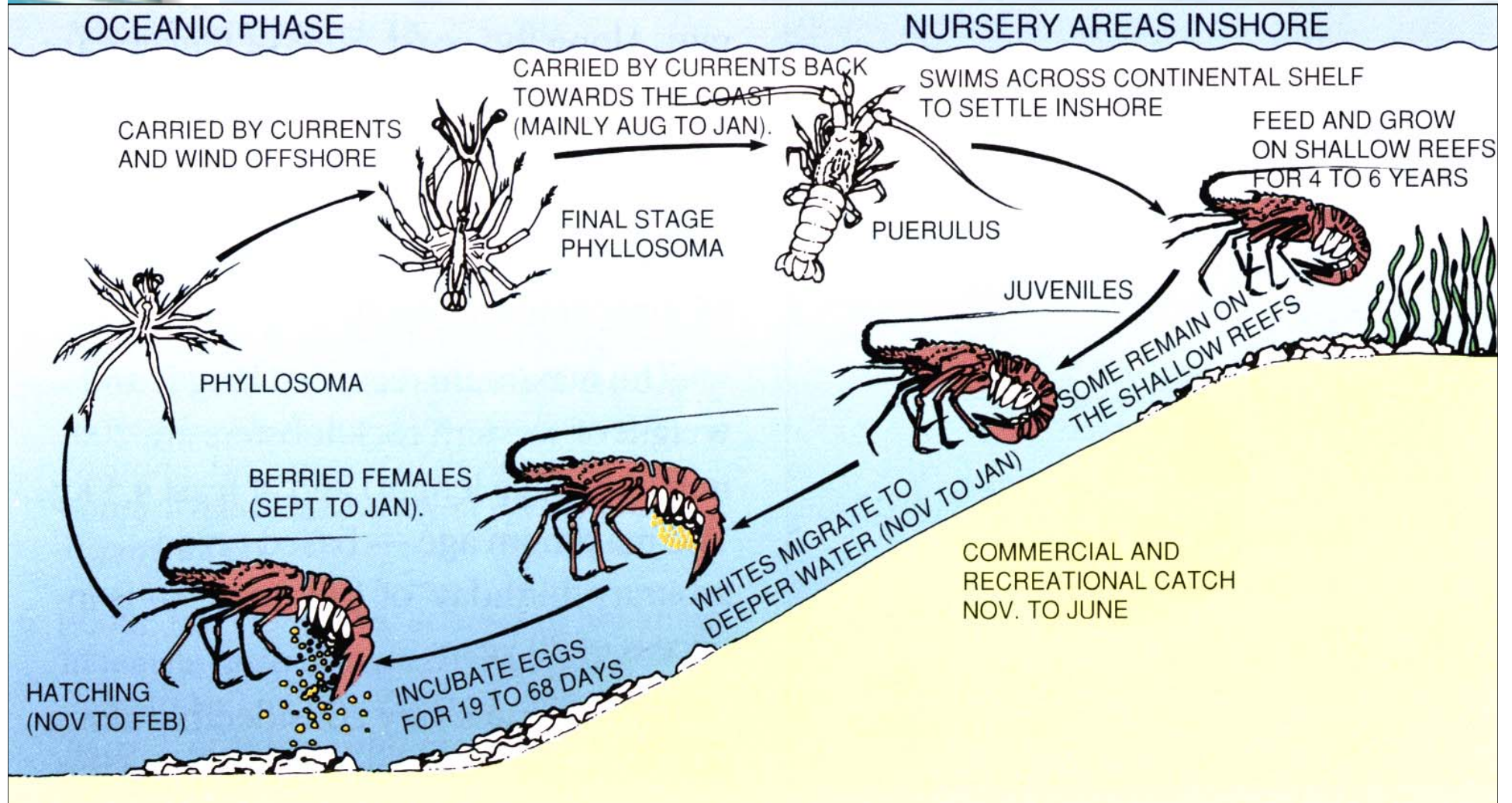
Western Rock Lobster (*Panulirus cygnus*)



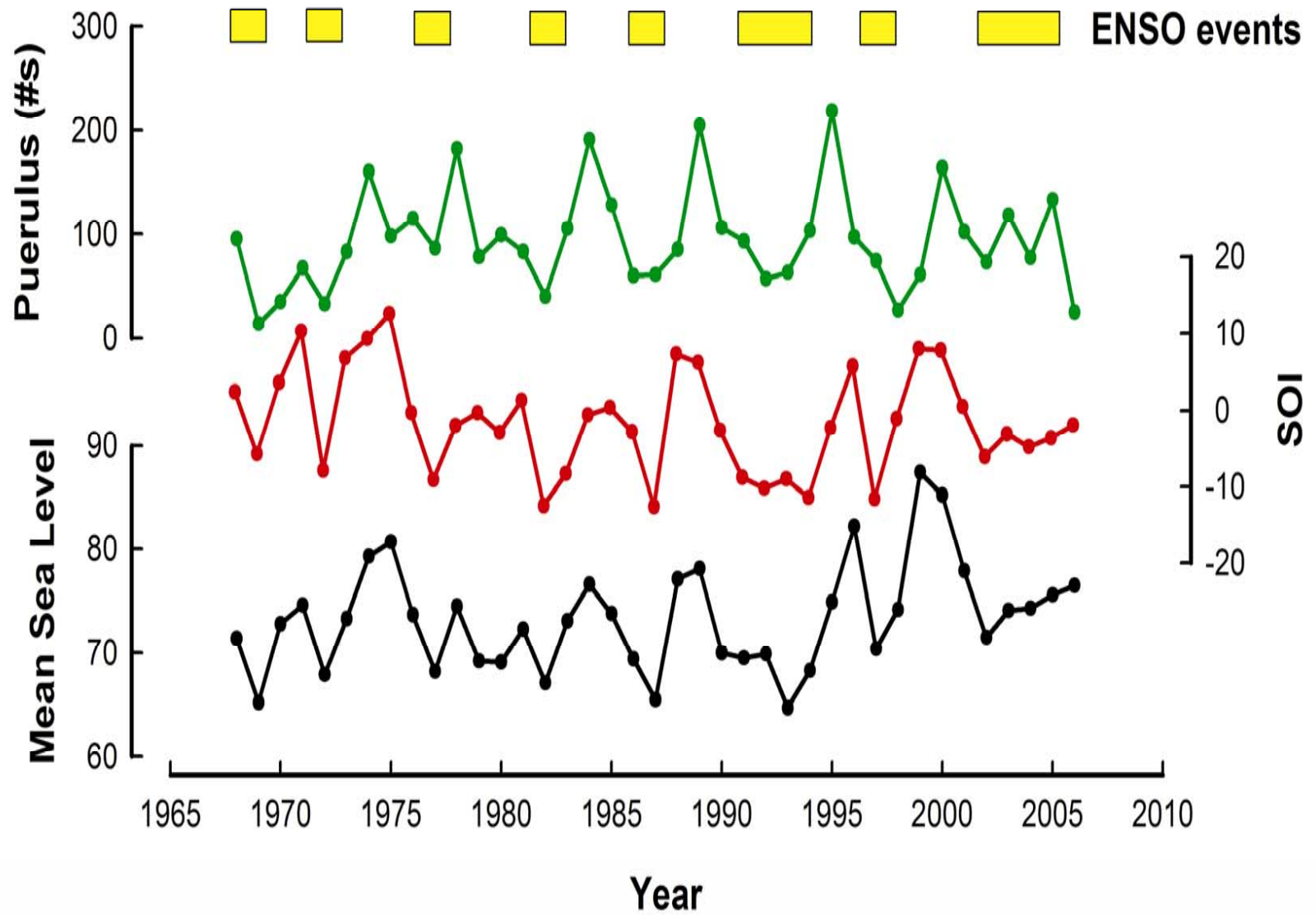
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Rock Lobster Life Cycle

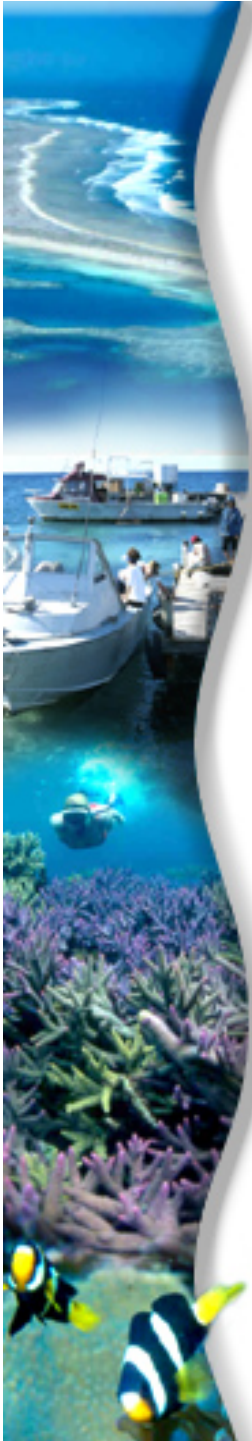


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Updated from Pearce & Phillips 1988

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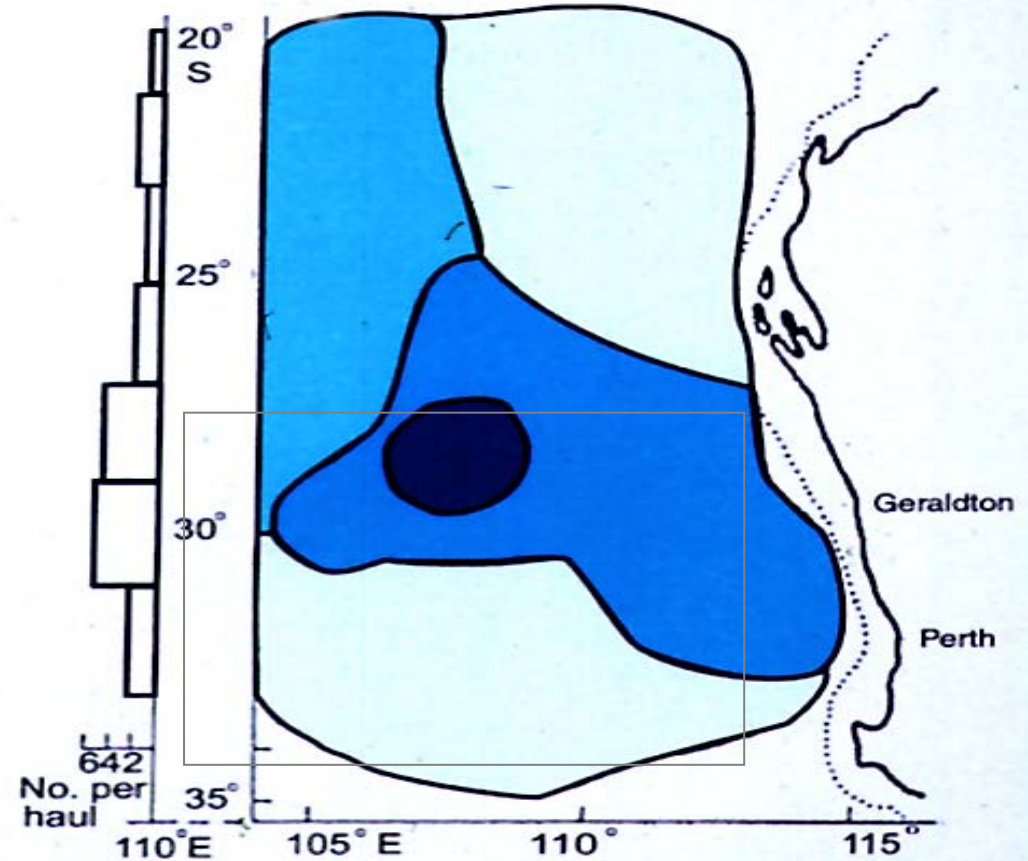
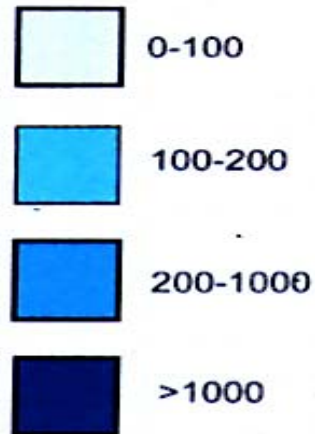
Strong Leeuwin Current effect on Puerulus abundance & distribution

- Warmer temperature (lower salinity)
 - effect on larval survival & growth?
- Stronger eddy structure
 - retaining larvae close to the coast?
- Higher productivity with stronger eddies
 - Increased larval survival & growth?
- Strong southerly flow of water
 - Spatial distribution of puerulus



LARVAL DISTRIBUTION (PHILLIPS 1981)

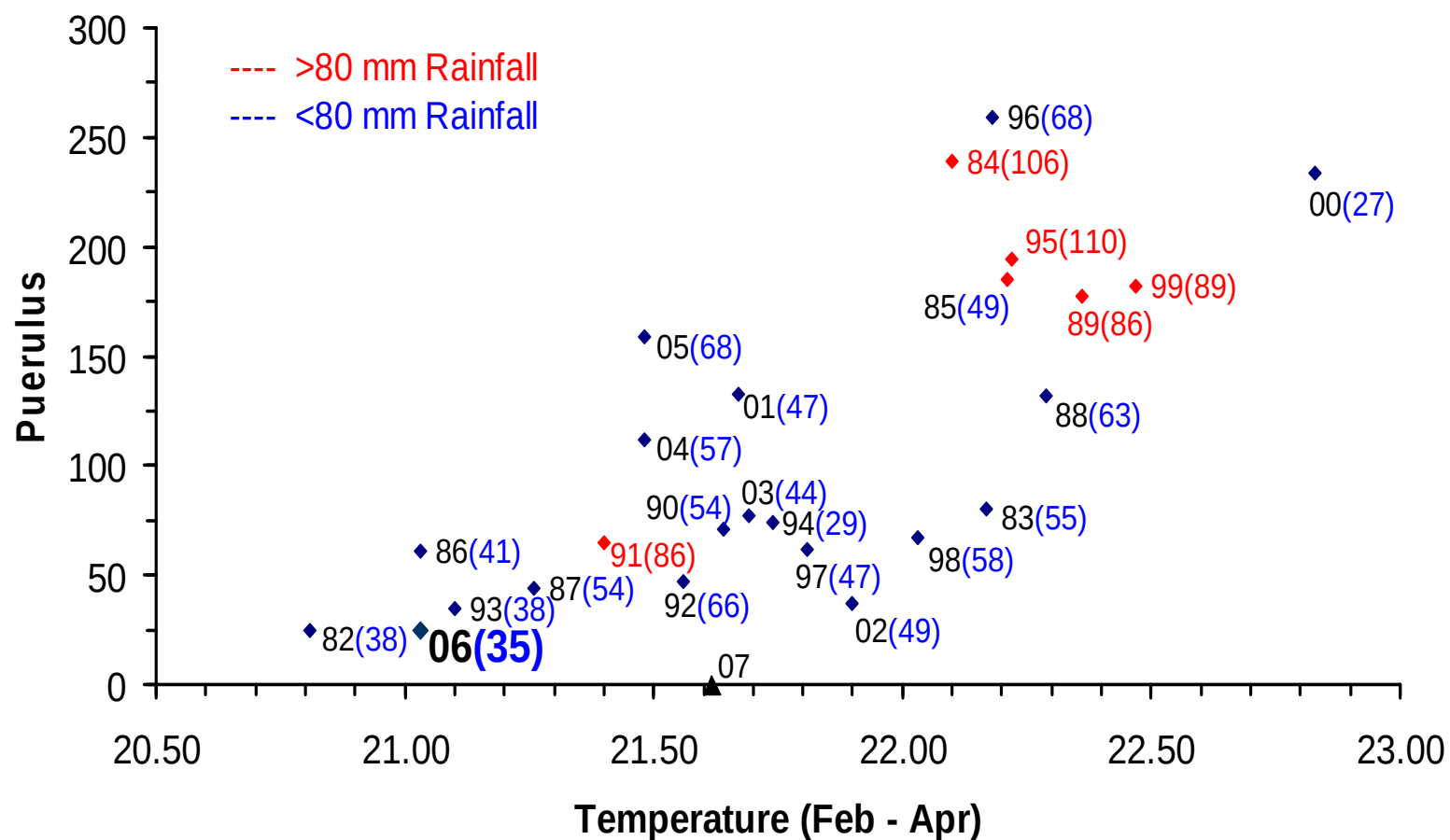
Nos. phyllosoma
per haul



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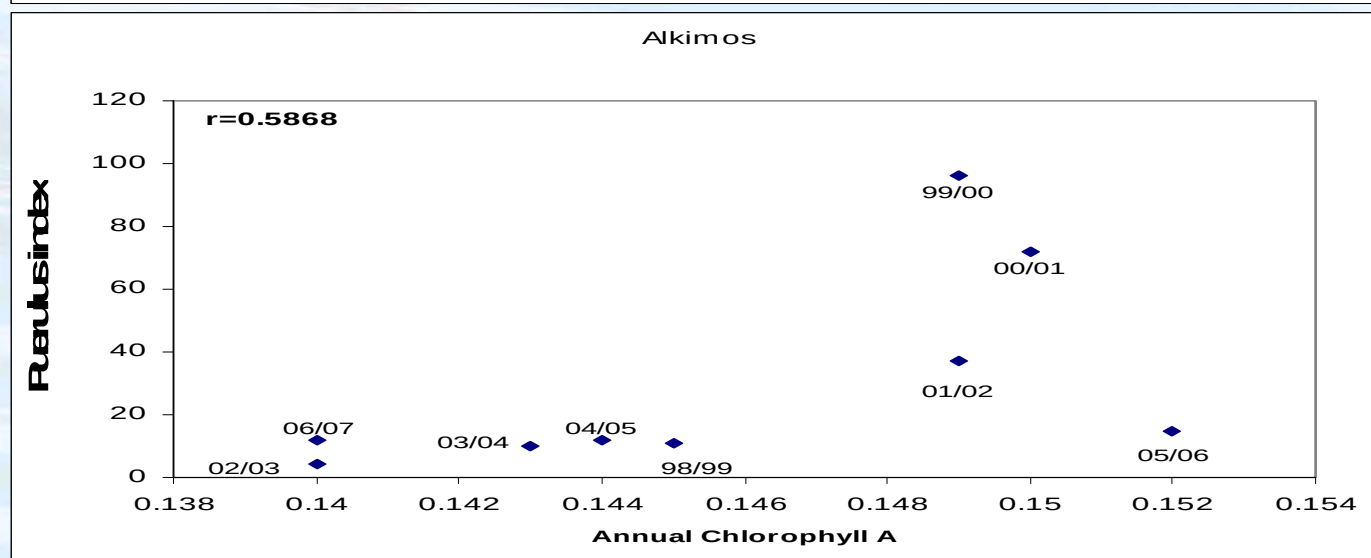
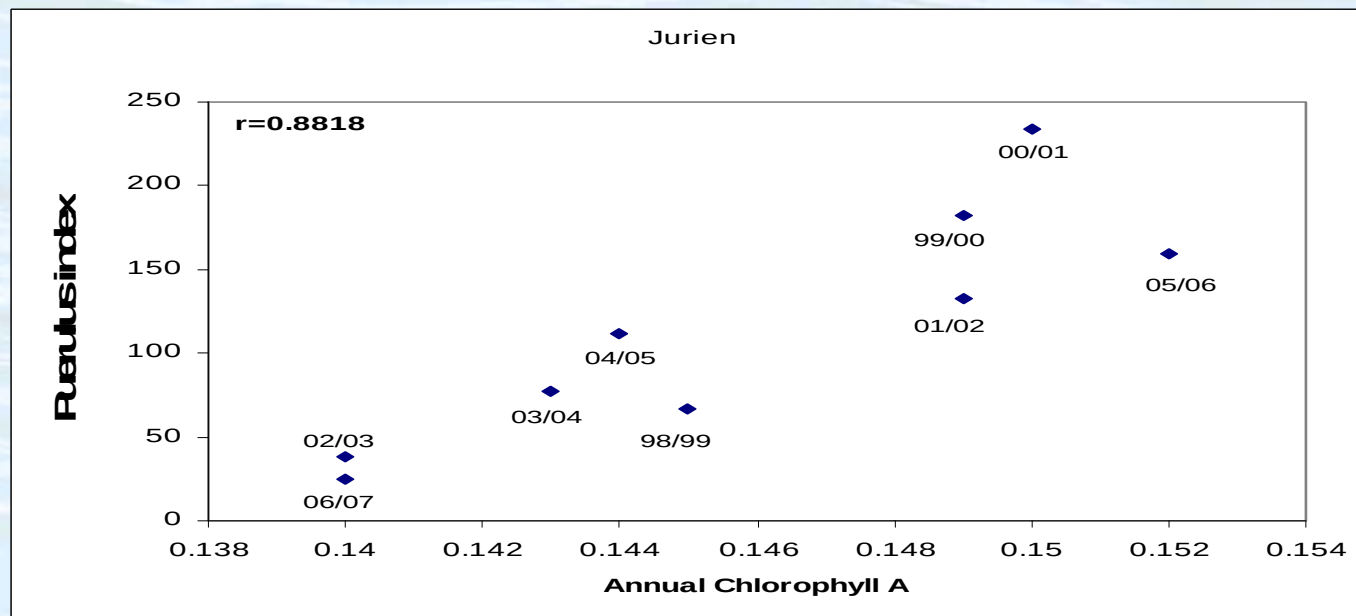
Puerulus abundance & temperature

Puerulus Jurien - Temperature (Feb - Apr)
(Rain South Oct - Nov)



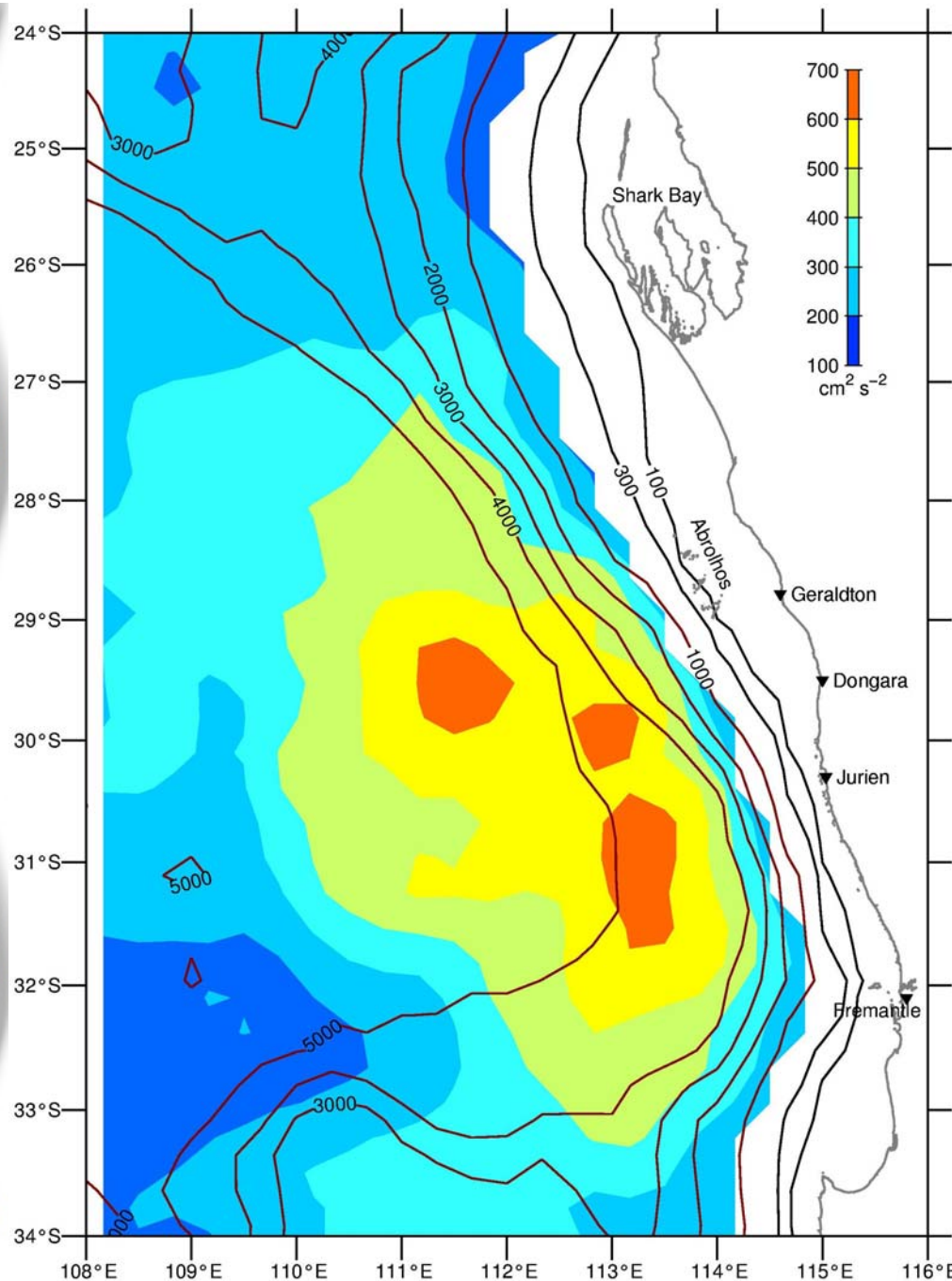
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Chl A v Puerulus Jurien & Alkimos



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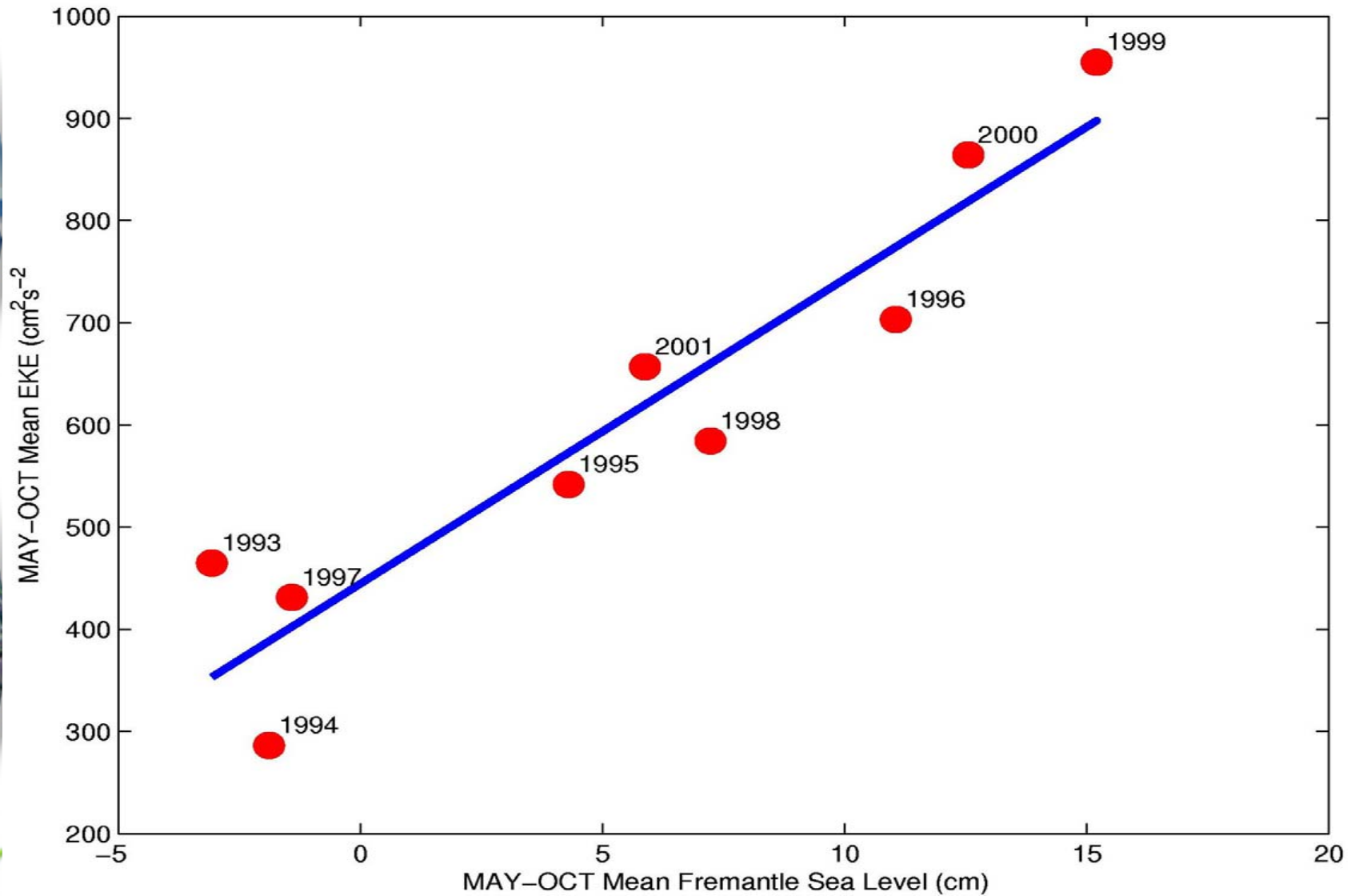
11-Year Mean Eddy Kinetic Energy (Ming Feng)



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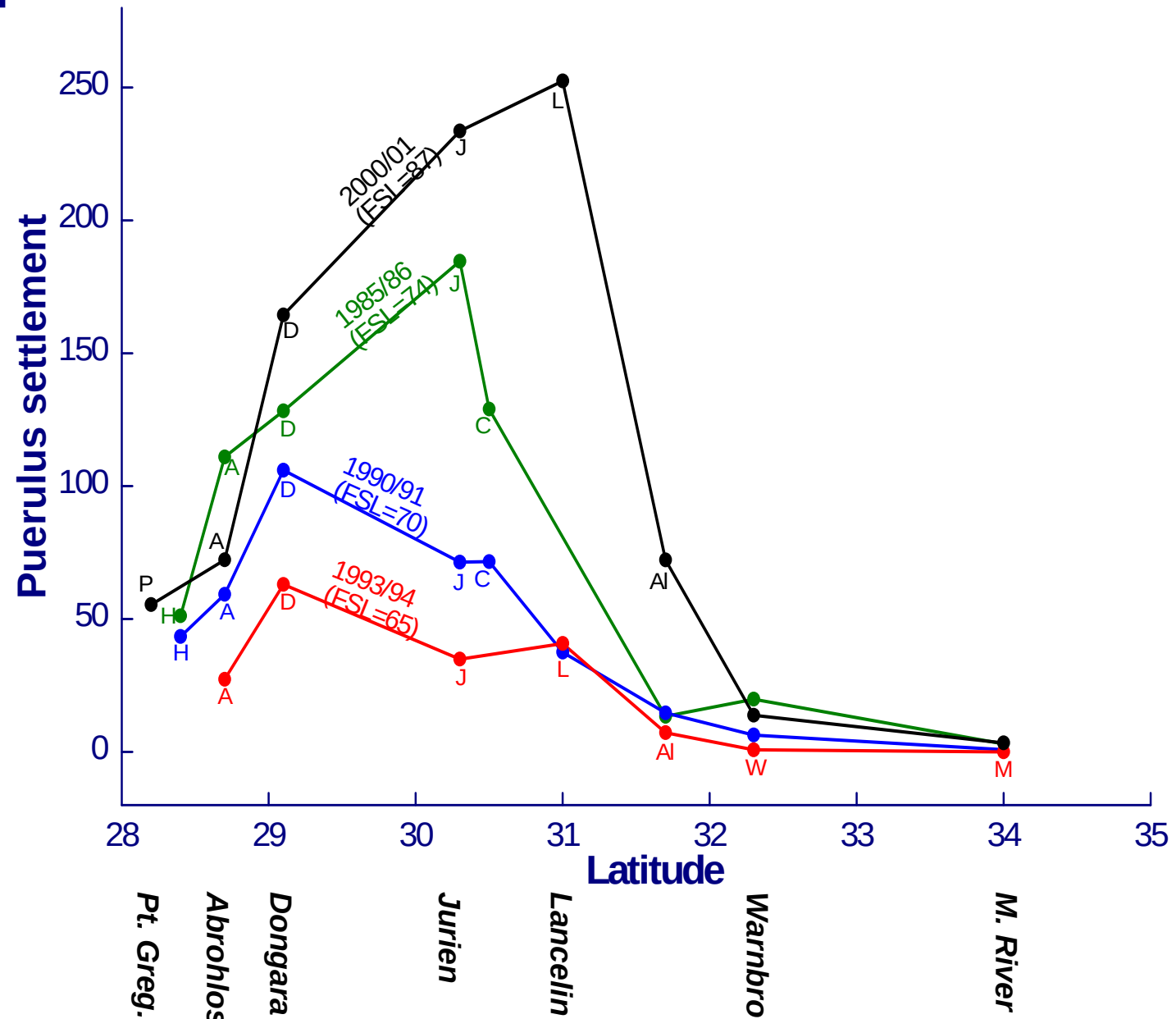
Fremantle sea level v. Eddy Energy

(M. Feng)



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Spatial Distribution of Puerulus Settlement versus Leeuwin Current

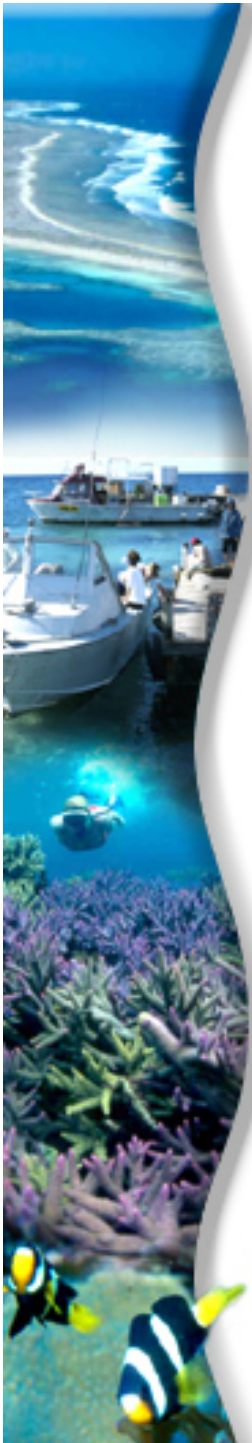


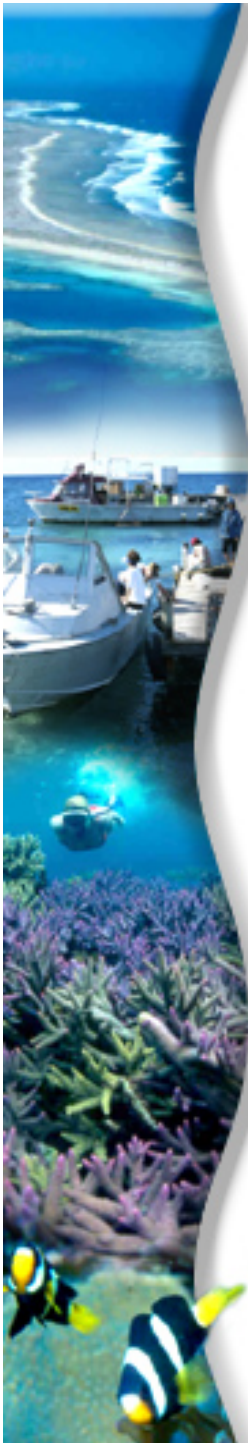
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Leeuwin Current – RL puerulus abundance

- Puerulus abundance, LC strength (Free sea level), temperature, chlorophyll A, eddy kinetic energy all positively correlated.
- More southerly distribution of higher puerulus abundance positively correlated with LC strength.

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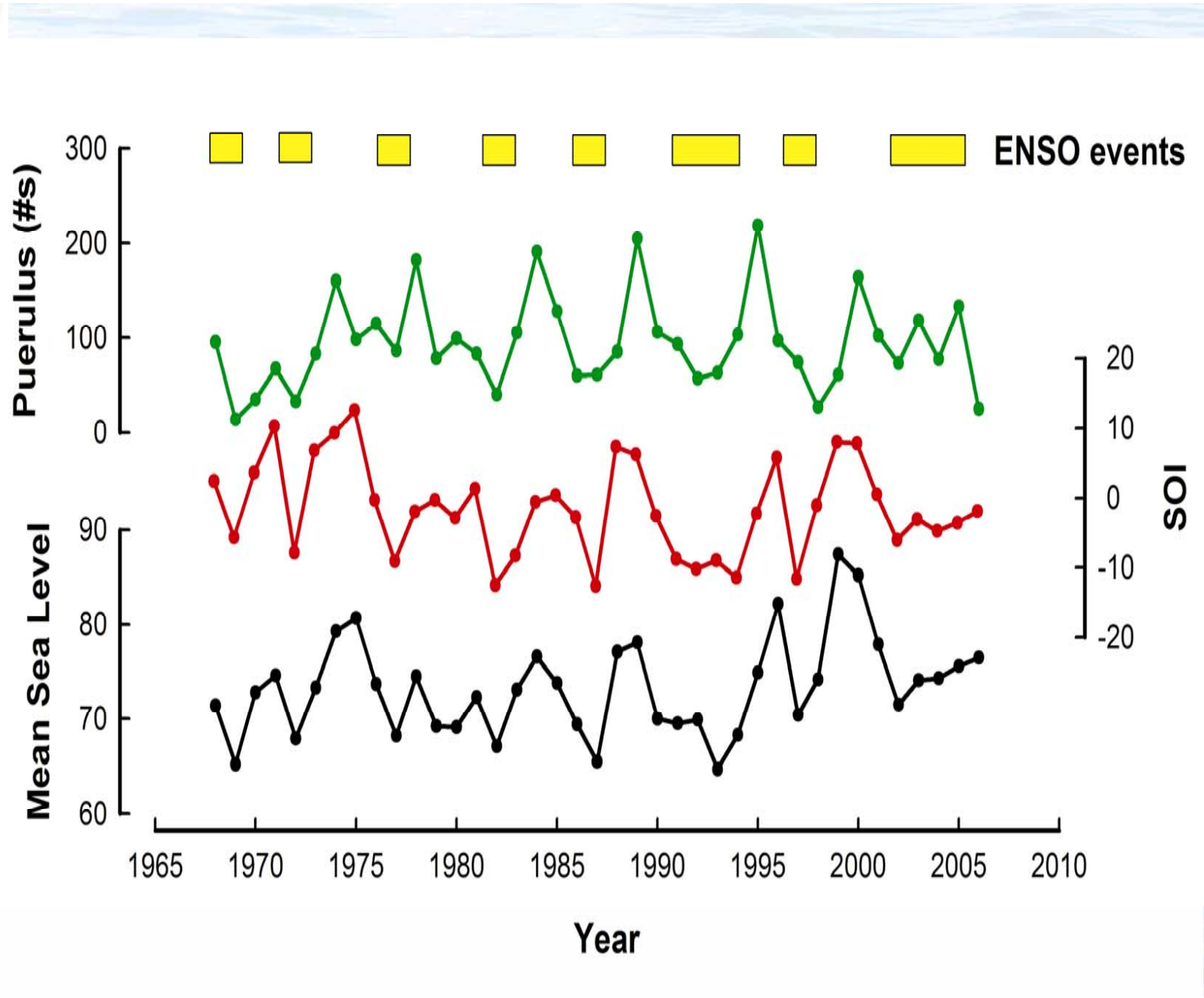




Frequency of ENSO events

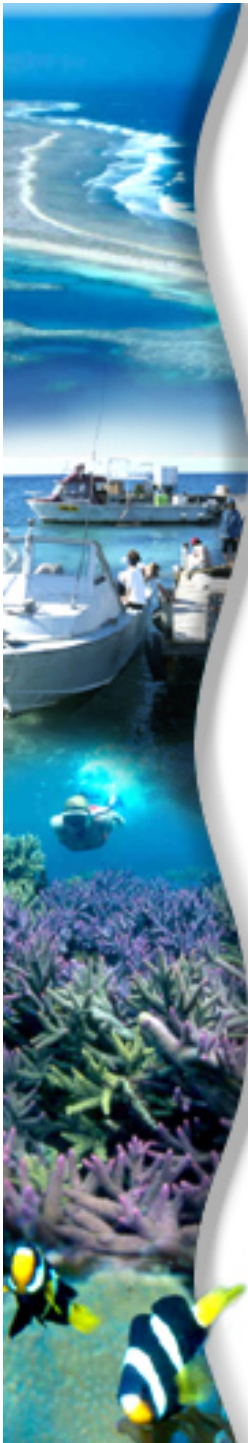
- 8 events in 16 years (1991-2006)
 - 1 in 2 years
- 5 events in 20 years (1971-1990)
 - 1 in 4 years

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Updated from Pearce & Phillips 1986

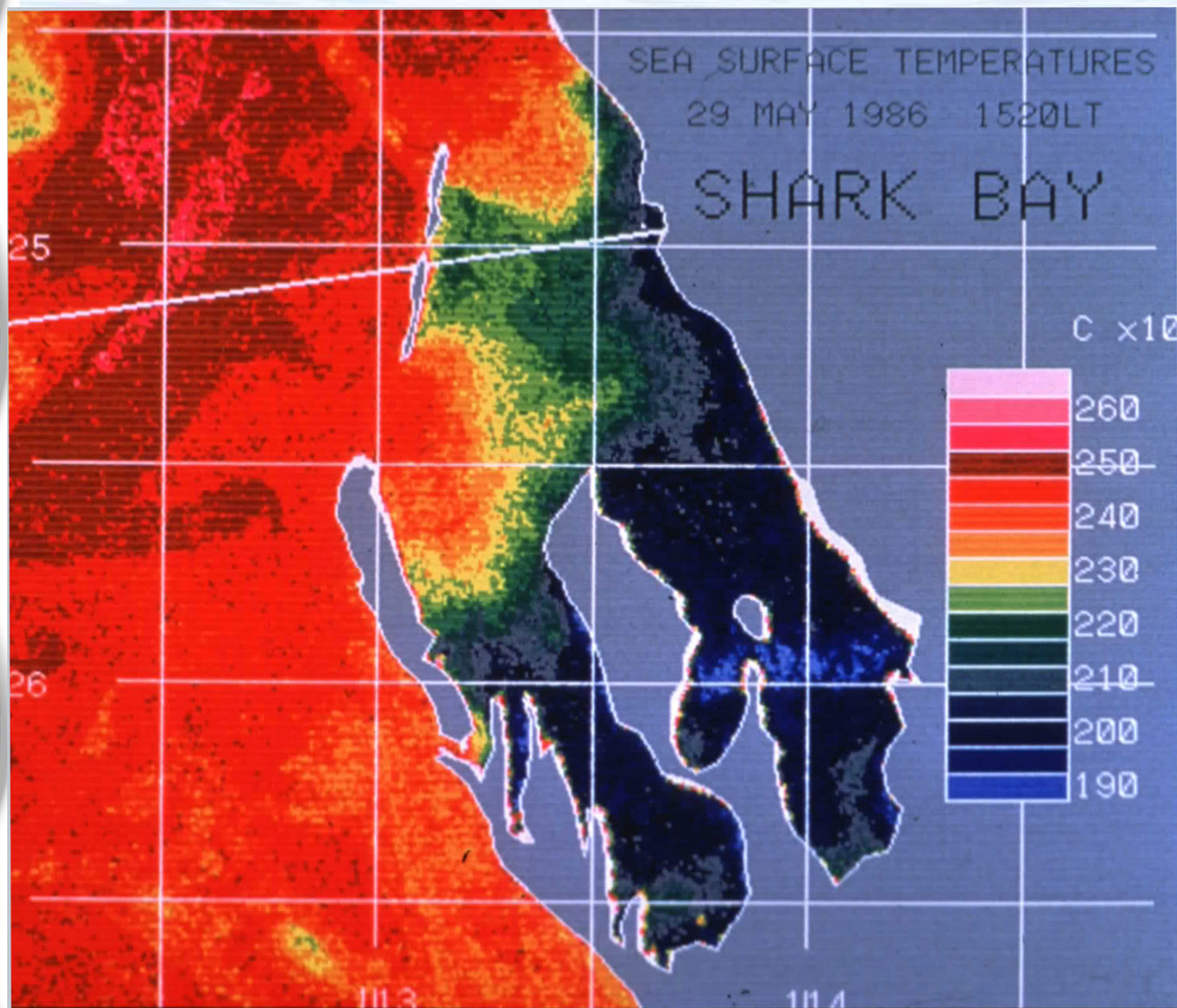
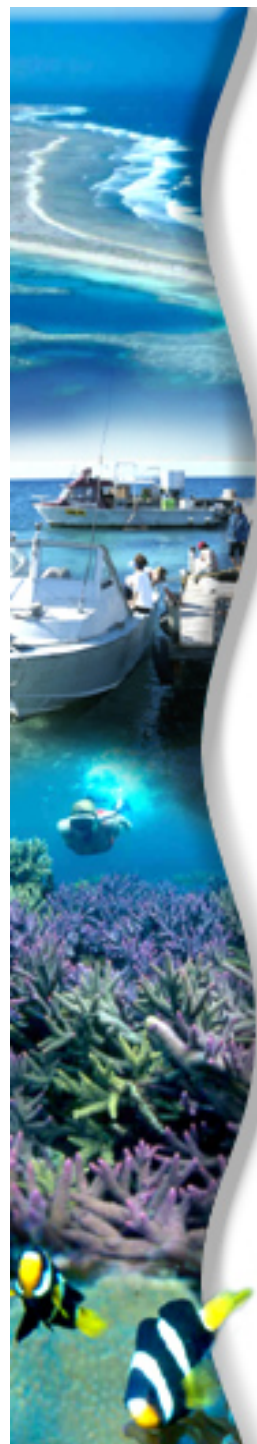
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The immediate future?

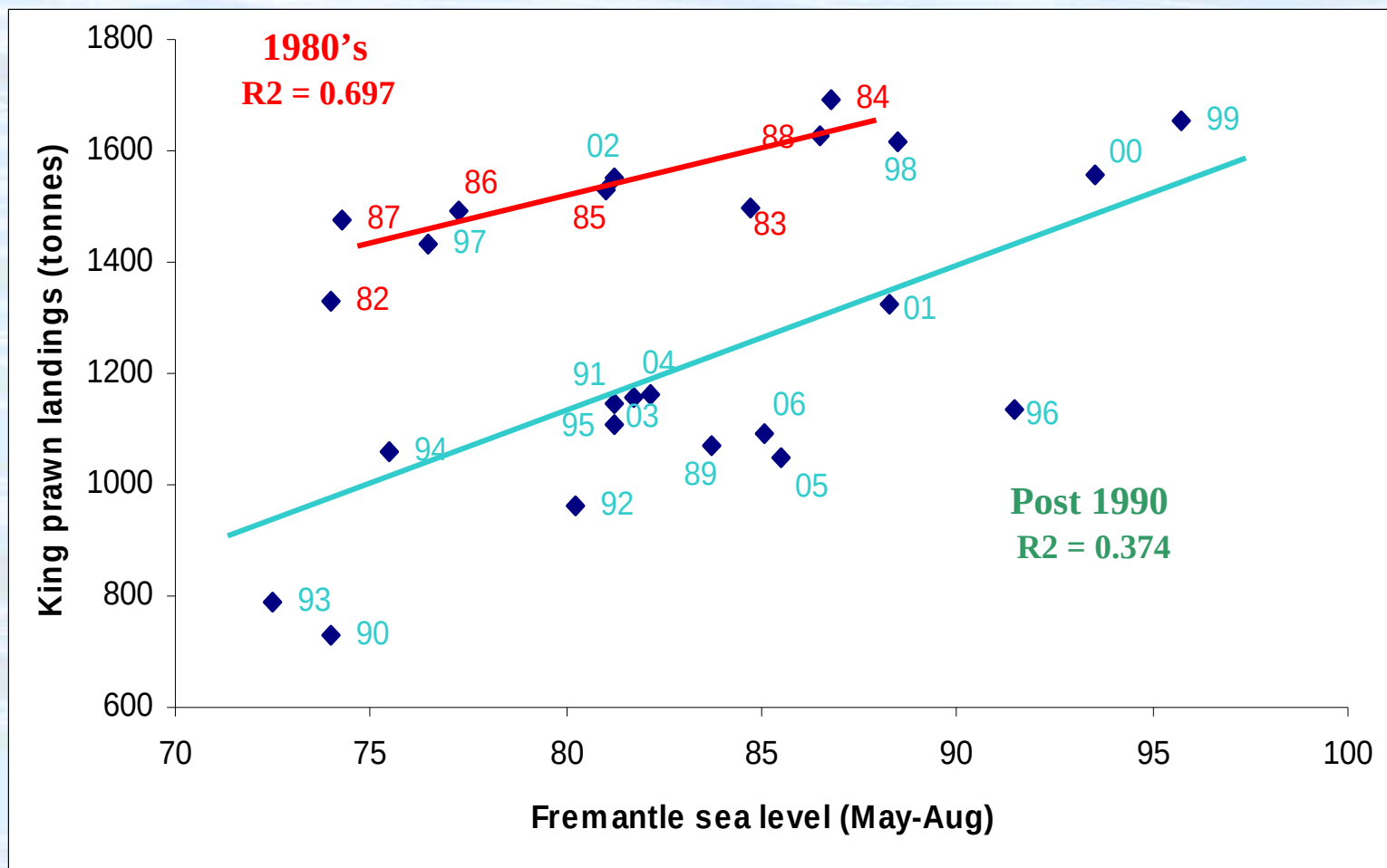
- More years of weaker currents?
- More years of poor recruitment centered around the northern regions of the fishery?

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Shark Bay Western King Prawns

(Kangas, unpublished)



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Shark Bay Scallops

- Earlier published reviews report a strong negative correlation between juvenile abundance and the strength of the Leeuwin current.
- The addition of more recent data has weakening the relationship considerably ($R^2=0.1221$).

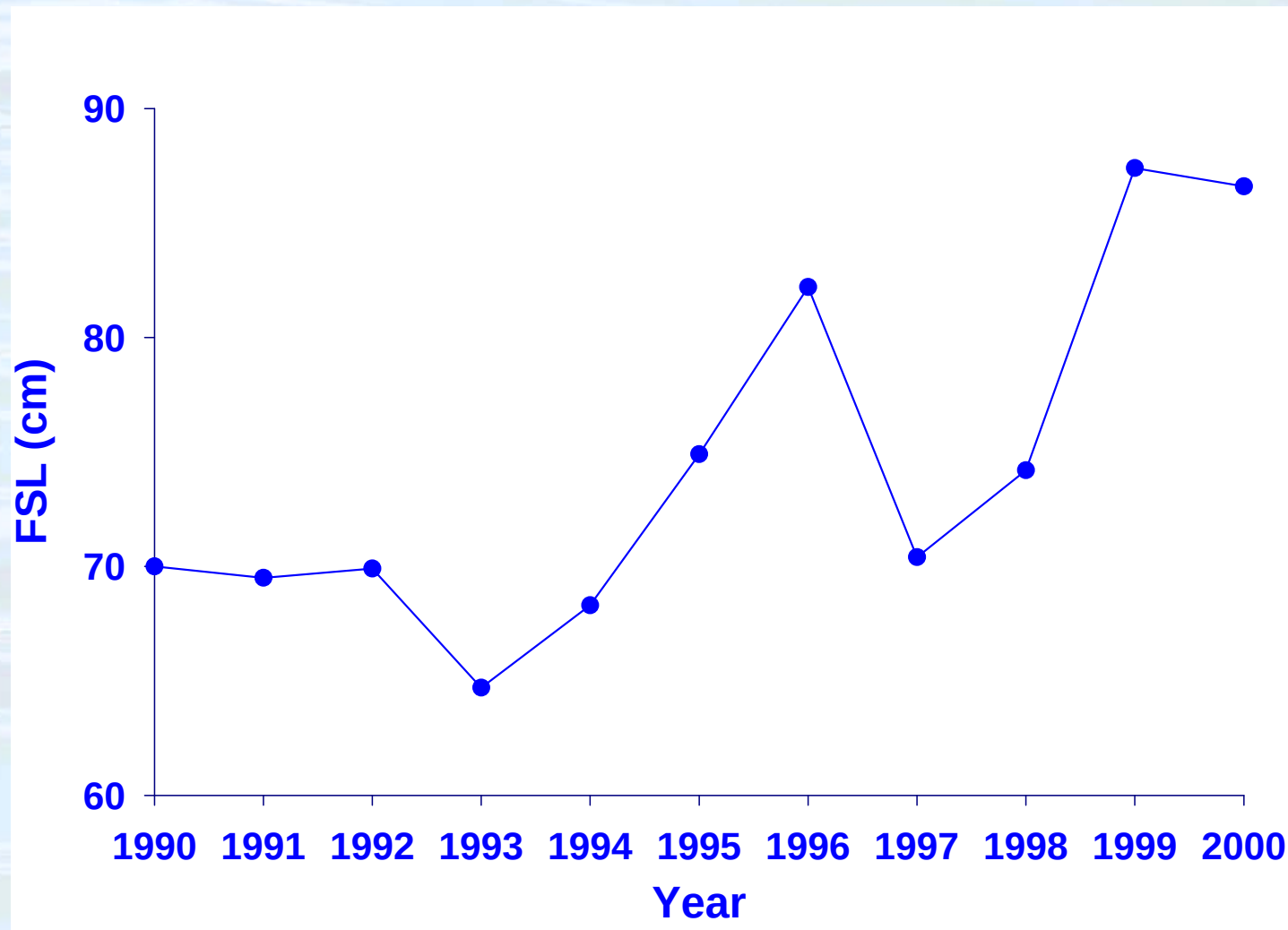
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Southerly Shift in Species Distribution Mud Crabs (Gopurenko, et al 2003)

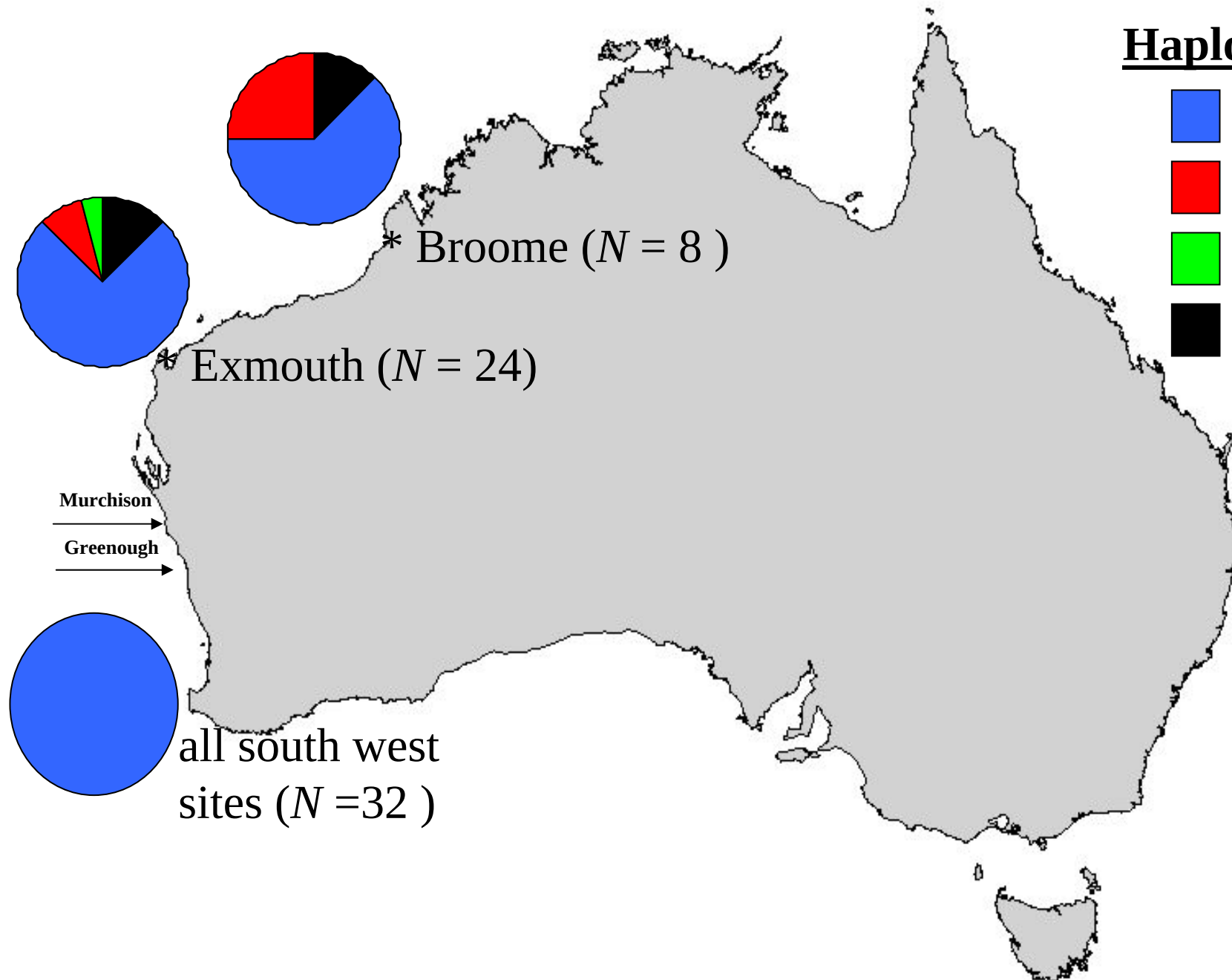
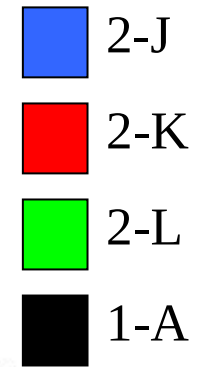


Fremantle Sea Level

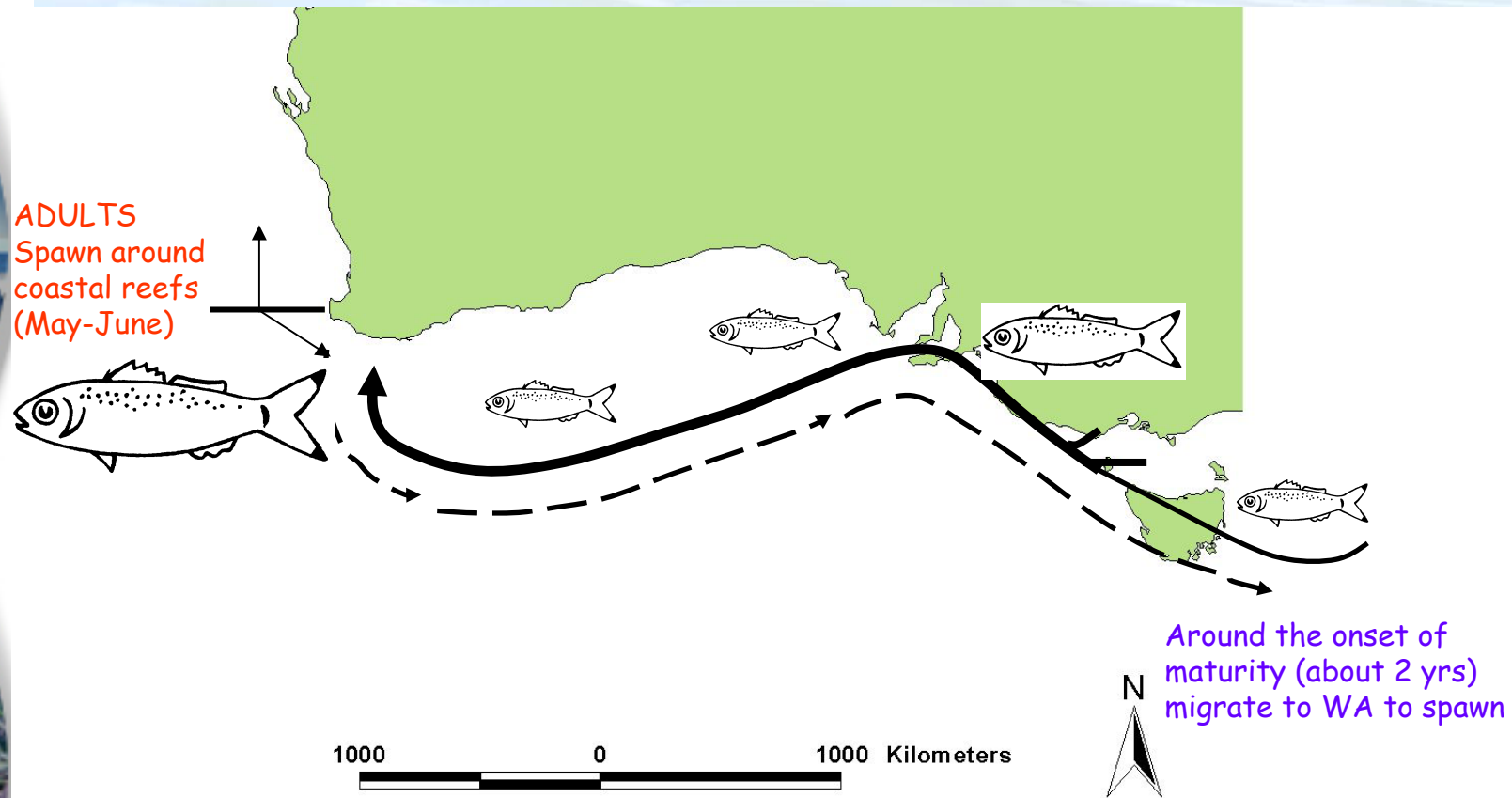


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Haplotypes



Life cycle of Australian herring



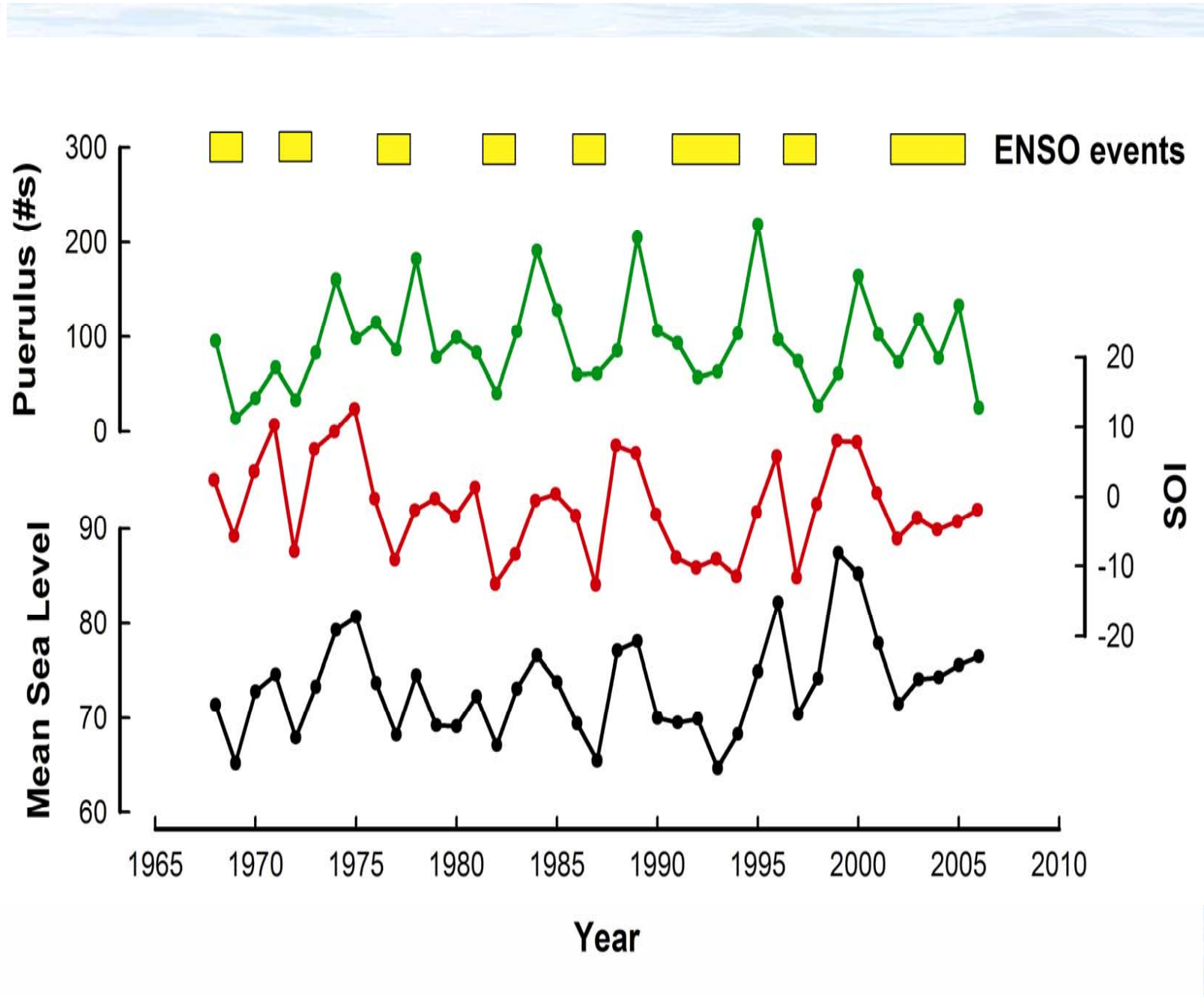
Distribution of larvae to south coast inshore nursery areas

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A herring – Larval Distribution throughout south coast nursery areas.(Dimmlich et al 2000)

- Biophysical transport model
 - inputs: Leeuwin Current velocities at various distances from spawning area, wind patterns (9 BoM stations), fish swimming velocities (literature).
 - outputs: predicted degree of recruitment success to various regions of the southern coastline.
- Recruitment indices across the south coast range of nursery areas between 1996 – 1998



Updated from Pearce & Phillips 1986

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A. Herring

(Dimmlich et al 2000)

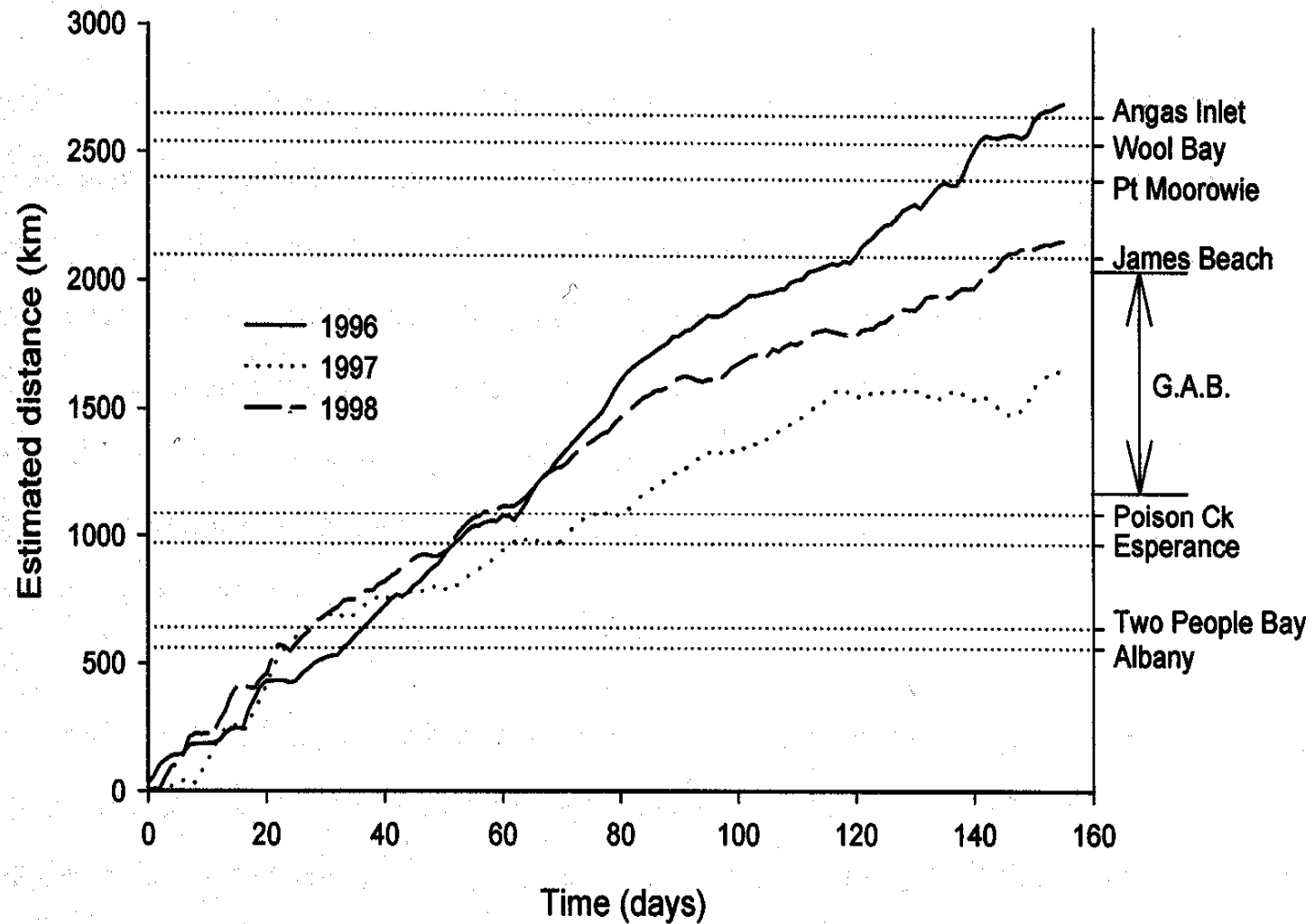


Figure 4.5 Results of model run for the years 1996-1998.

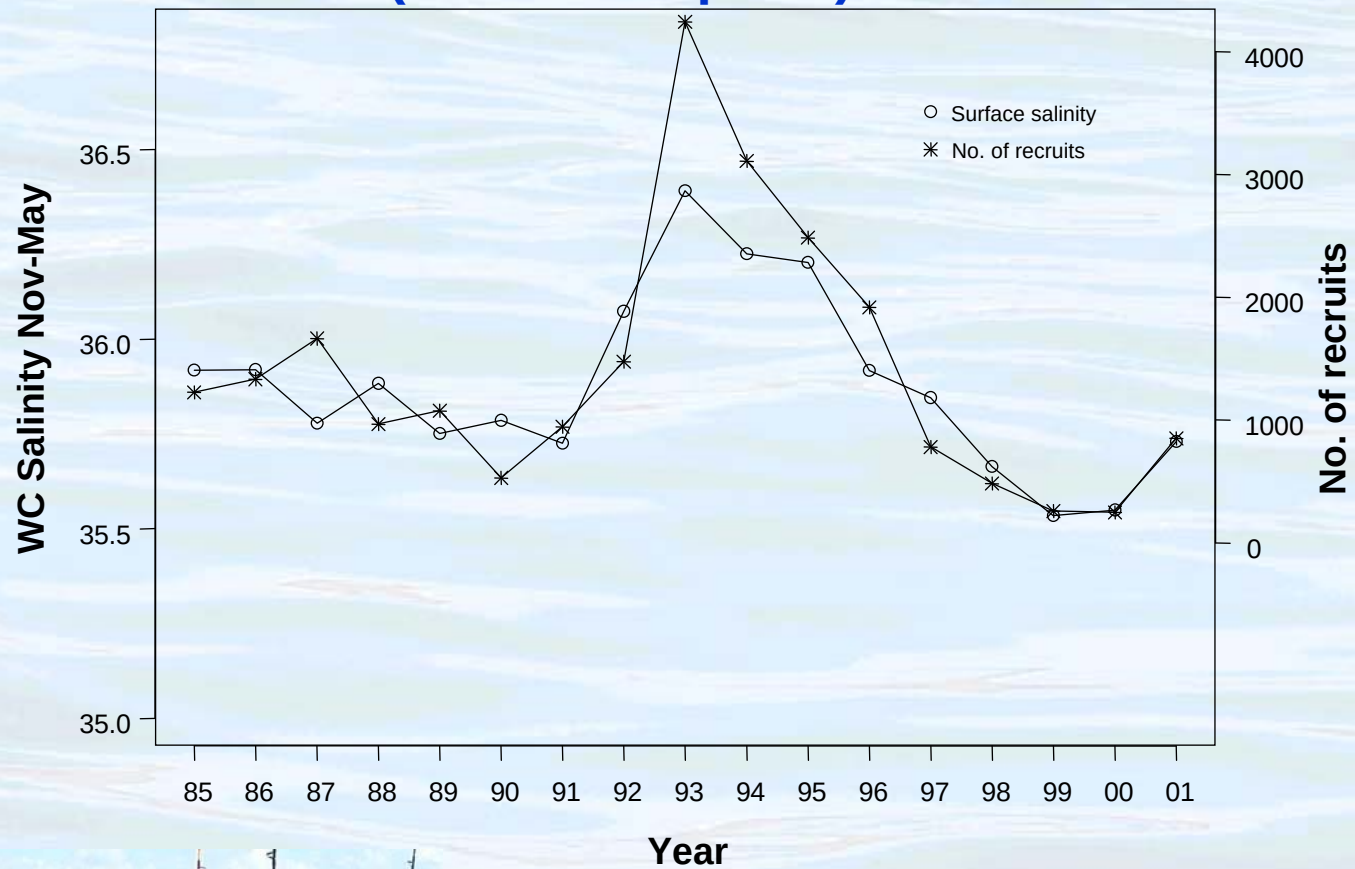
Work in Progress

Species	Adults	Spawning Period	Larvae	Juveniles
Dhufish	Temperate West Coast Mid to Outer Shelf	Summer	Water column	Inner to Mid Shelf
Tailor	Temperate West Coast Inner Shelf	Spring through Autumn	Neustonic	Nearshore/E stuarine

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Work in progress – Dhufish

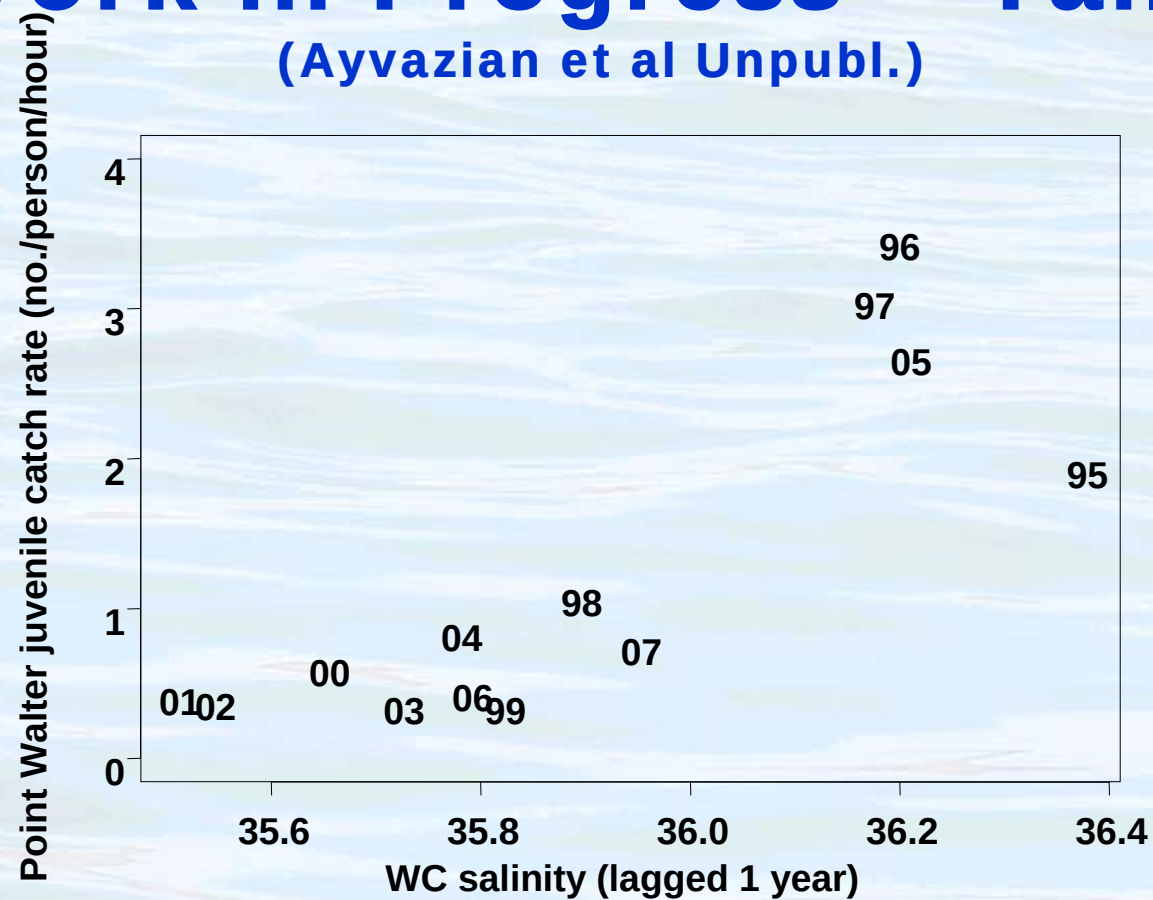
(St John unpubl.)



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Work in Progress – Tailor

(Ayvazian et al Unpubl.)



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Management

- Knowledge of LC effects
 - better understanding of spatial & temporal distribution of recruits (recruitment variability)
 - more rigorous recruitment sampling methodology, and
 - more robust recruitment index for use as a predictive tool (RL & A. herring).
 - helps interpret changes in catchability (RL, SB prawns, A salmon)
- Also assists with modeling the “on-shelf marine community” level response to environmental change and fishing (EBFM).

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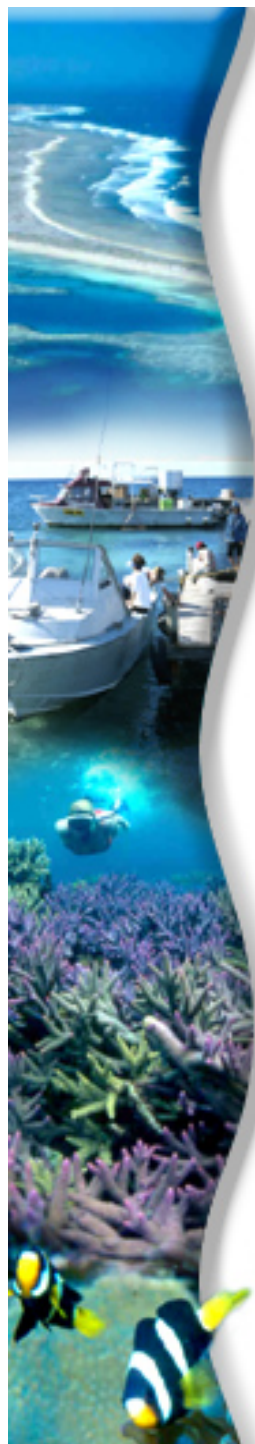


Conclusions

Species	Leeuwin Current Relationships		
	0+ recruits abundance	Adults abundance	Underlying Mechanisms
Rock lobster	+ve robust	+ve robust	good
SB Scallops	-ve weak	-ve weak	poor
SB prawns	?	+ve weak	fair
A herring	-ve(WA) +ve(SA)	?	good
Dhufish	"-ve"	?	poor
Tailor	"-ve"	?	poor

While important, many factors other than Leeuwin Current contribute to recruitment variability.

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Conclusions (cont.)

- **Future research:**
- Elucidate finer-scale detail of Leeuwin current “on-shelf” behaviour off West Coast (WC).
- Explore “on-shelf” interactions between LC (Capes Current?) and spawning behaviour, and the effect on recruitment variability for key WC scalefish (WC A. herring, dhufish, tailor) .
- Quantify the origin of spawning A. herring (exploitable biomass) for both WC and SC fisheries.
- Further study underlying mechanisms for SB scallops and prawns.
- Update the LC whitebait relationships

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Acknowledgements

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