


Biological Oceanography of Western Rock Lobster & the recent recruitment failure

Peter Thompson | Program Leader CSIRO Marine and Atmospheric Research

Co-authors and Project Team

Anya M. Waite, UWA

Lynnath Beckley, Murdoch Univ.

Christin Säwström, UWA

Megan Saunders, UWA

Ming Feng, CSIRO

Nick Caputi, Fisheries Dept. WA

Simon DeLestang, Fisheries Dept. of WA

Andrew Jeffs & Richard O'Rorke, Univ. of Auckland

Roger Barnard, Lobster Harvest

Nik Sachlikidis, Queensland DPI

R.V. Southern Surveyor, Australia's Marine National Facility

Major Funding:

Marine National Facility

Fisheries Research Development Corporation

The Western Rock Lobster Fishery

50 years of ‘good’ management, first fishery to be given Marine Stewardship endorsement

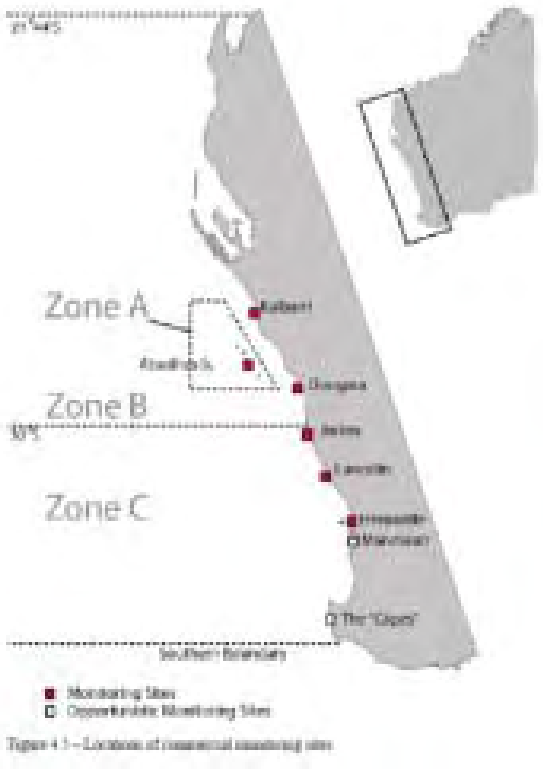
Australia’s most valuable fishery, $450 million

Larval stage
Phyllosoma
11 months at sea!

Catch could be accurately predicted from recruitment
Puerulus stage collected and counted, correlated with adult population

Collector, left on reef for ~ month

Collectors at red symbols

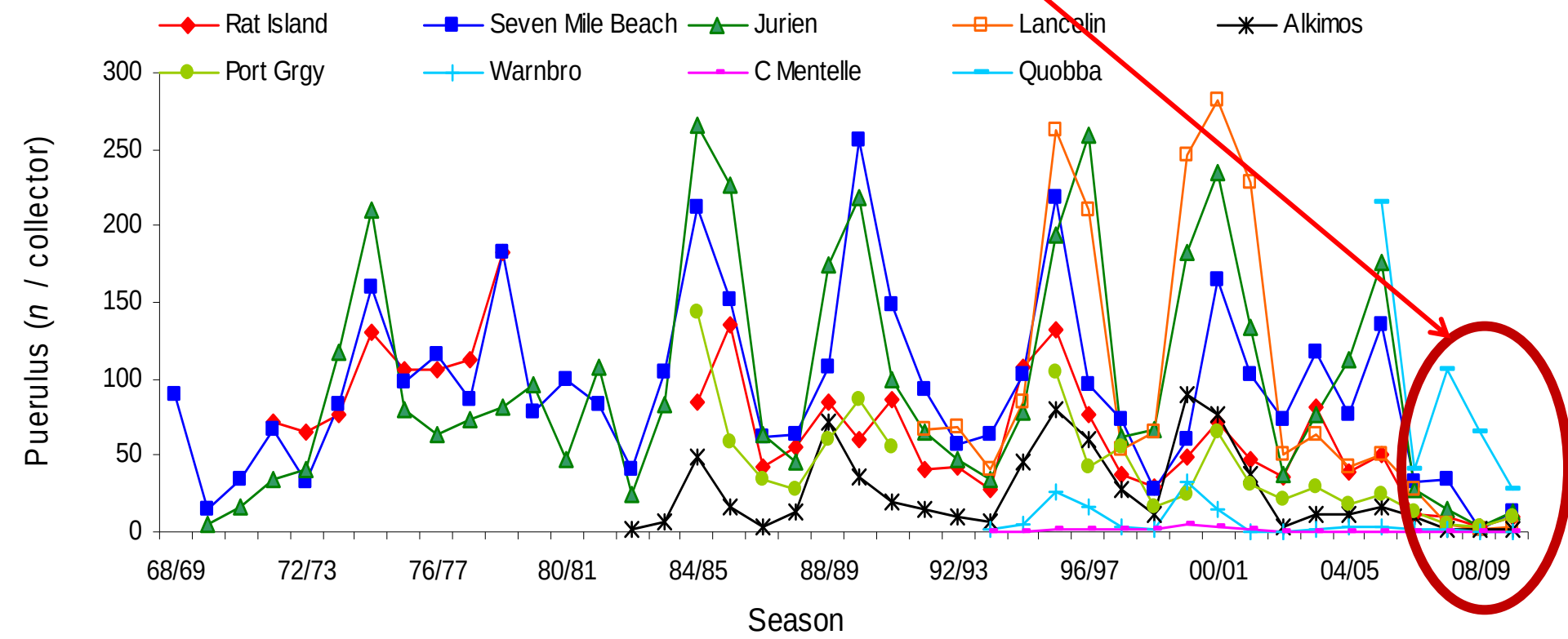


The Western Rock Lobster Fishery

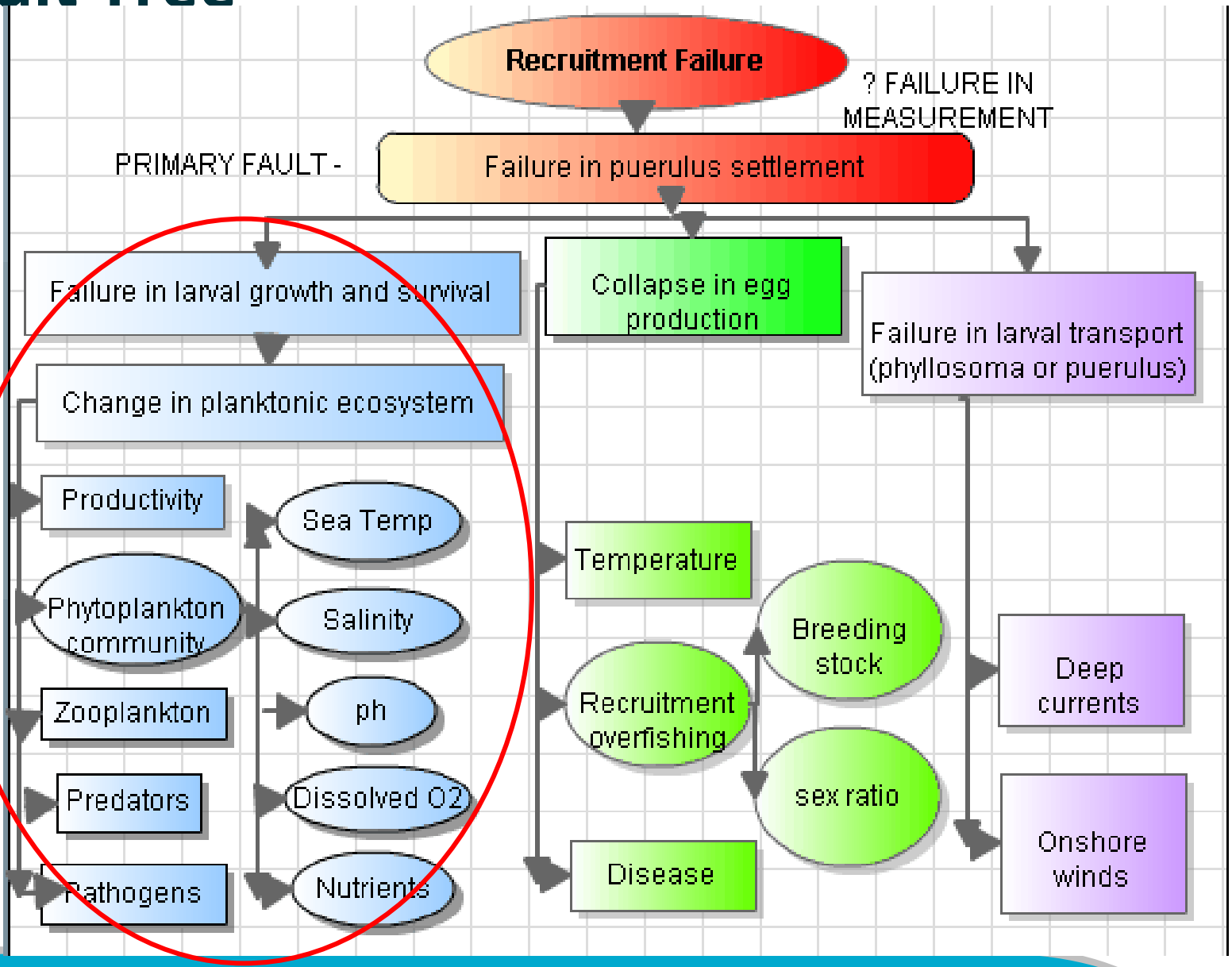
Australia's most valuable fishery, $450 million

Recruitment failure in 2007

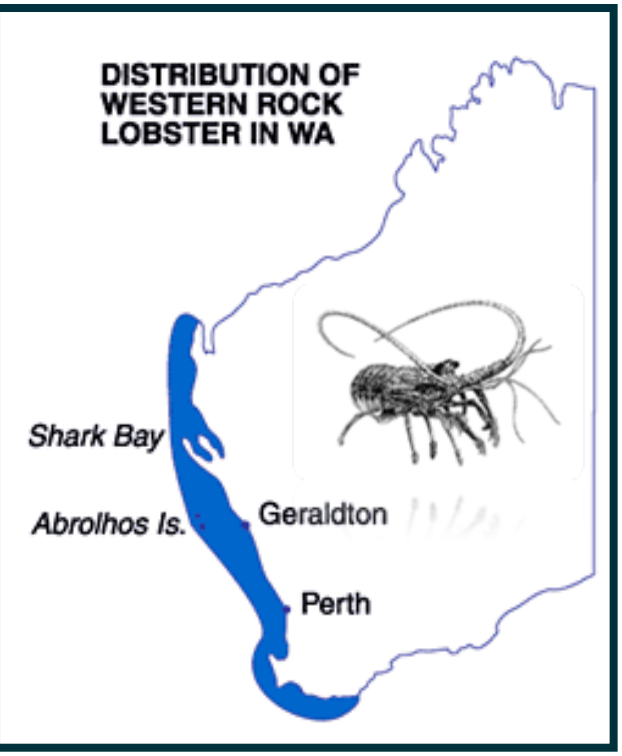
Allowable catch halved in 2011 to 5,000 tonnes

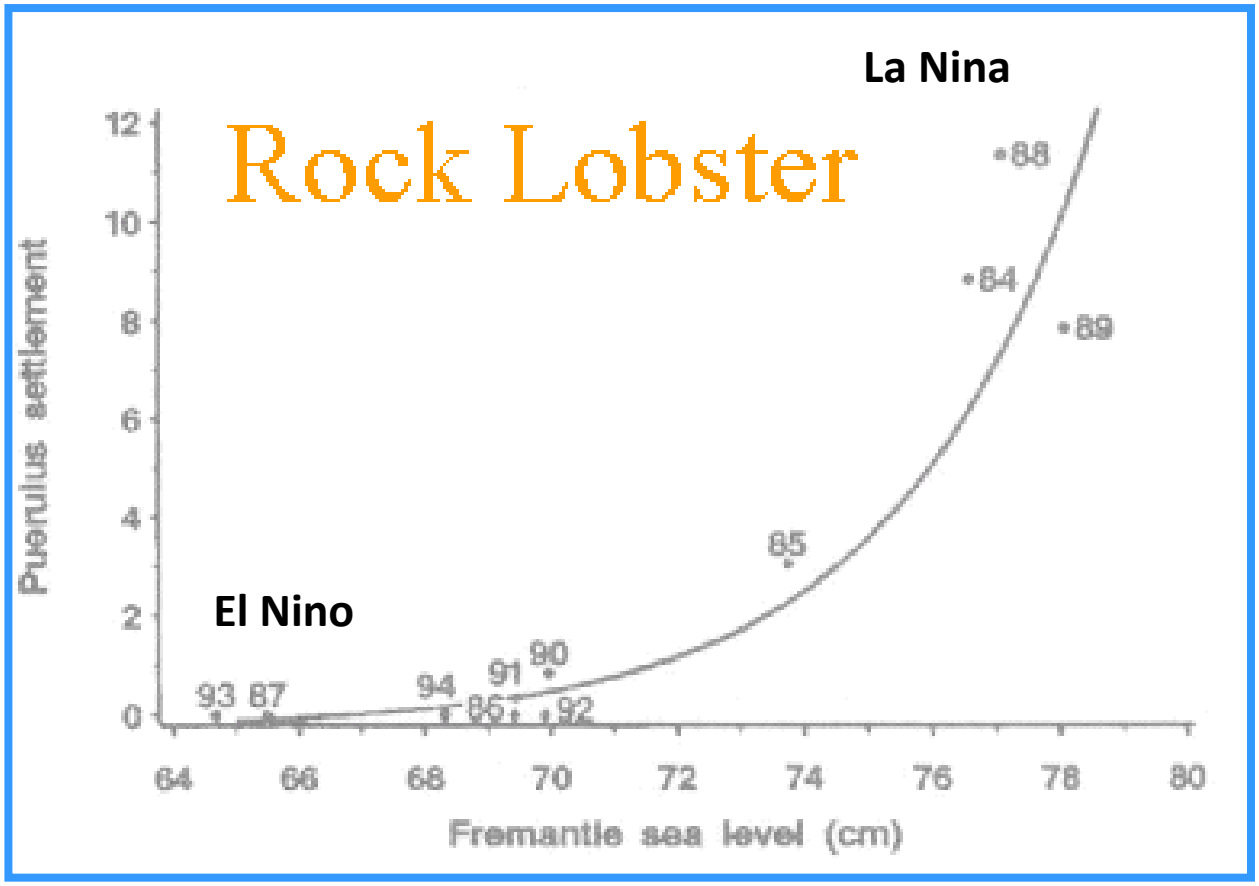


Fault Tree

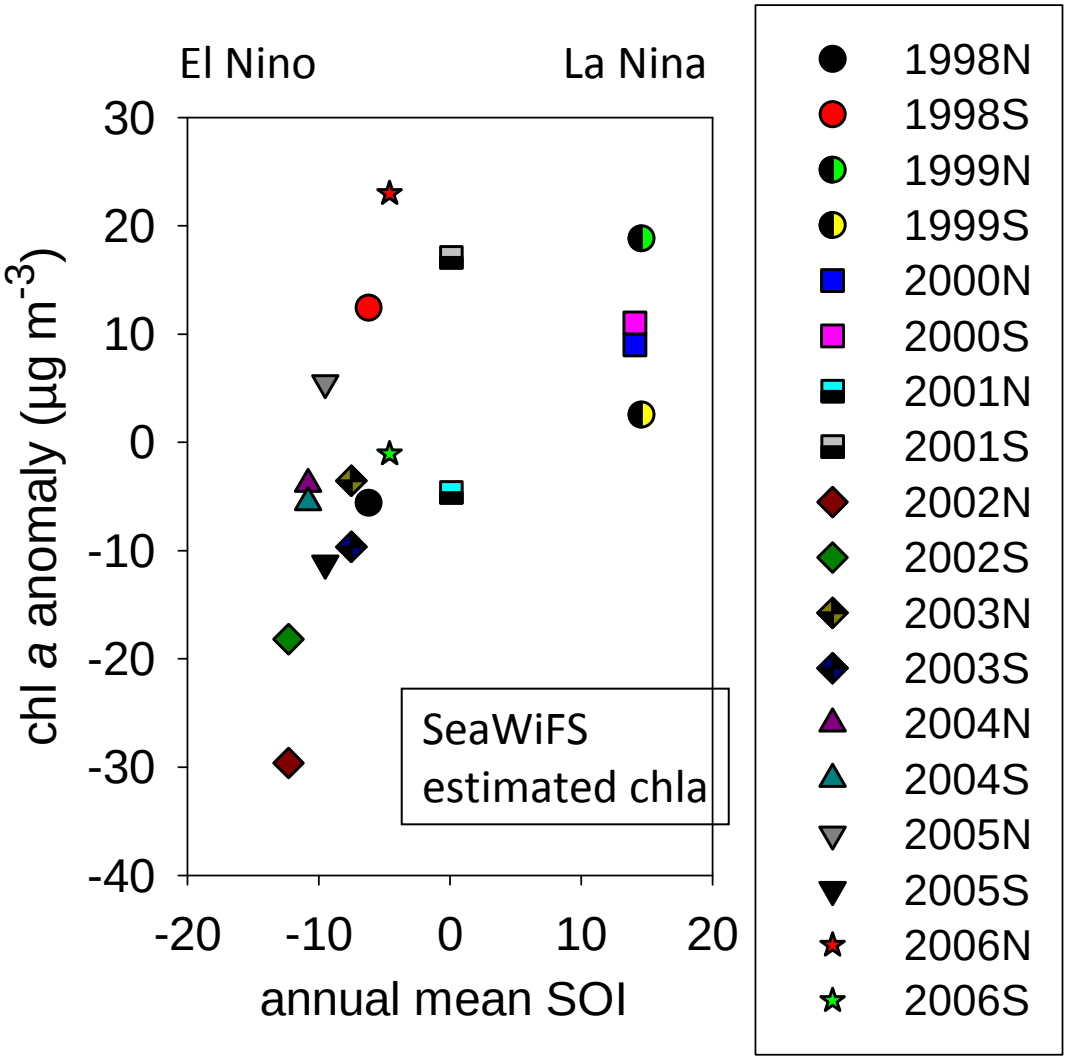

Recruitment Failure
? FAILURE IN MEASUREMENT
PRIMARY FAULT -
Failure in puerulus settlement
Failure in larval growth and survival
Collapse in egg production
Failure in larval transport (phyllosoma or puerulus)
Change in planktonic ecosystem
Productivity
Phytoplankton community
Zooplankton
Predators
Pathogens
Sea Temp
Salinity
ph
Dissolved O2
Nutrients
Temperature
Recruitment overfishing
Disease
Breeding stock
sex ratio
Deep currents
Onshore winds

MOTIVATION


DISTRIBUTION OF
WESTERN ROCK
LOBSTER IN WA
Shark Bay
Abrolhos Is.
Geraldton
Perth

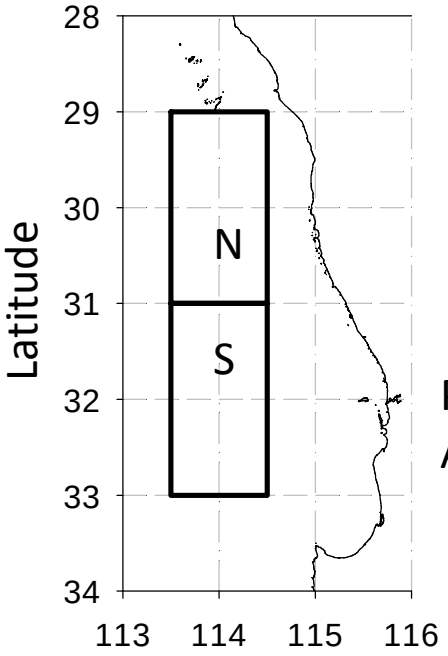

La Nina
Rock Lobster
El Nino
Puerulus settlement
Fremantle sea level (cm)
0
2
4
6
8
10
12
64
66
68
70
72
74
76
78
80
93
87
94
91
86
80
92
85
88
84
89

Trends in chlorophyll on West Australian shelf



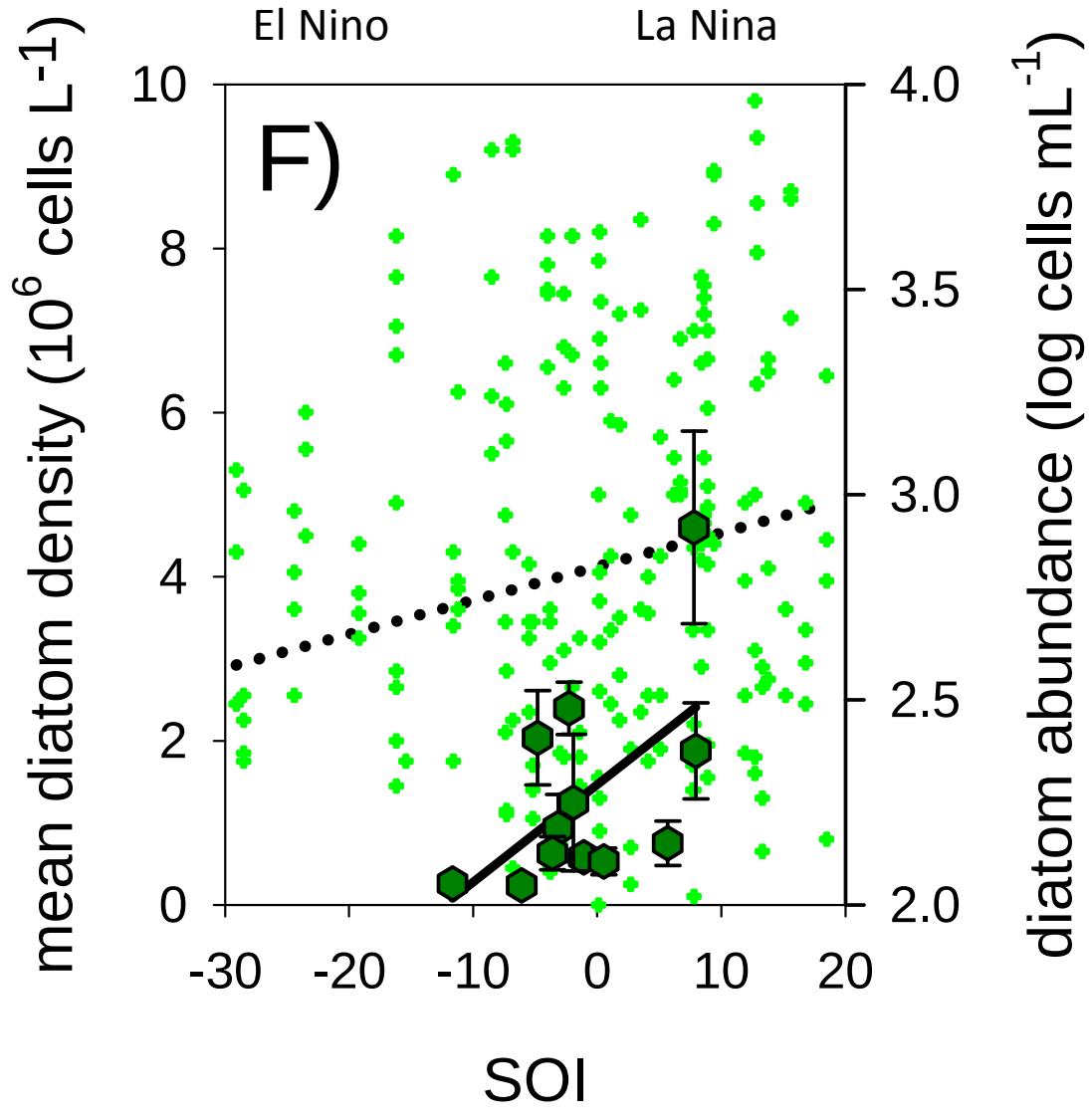
- 29 and 31°S = North
- 31 to 33°S = South

- High SOI (La Niña) years have greater annual mean chl*a*



**Adapted from Thompson, PA , Baird, ME, Ingleton, T, Doblin, MA. 2009 Long-term changes in temperate Australian coastal waters and implications for phytoplankton.*

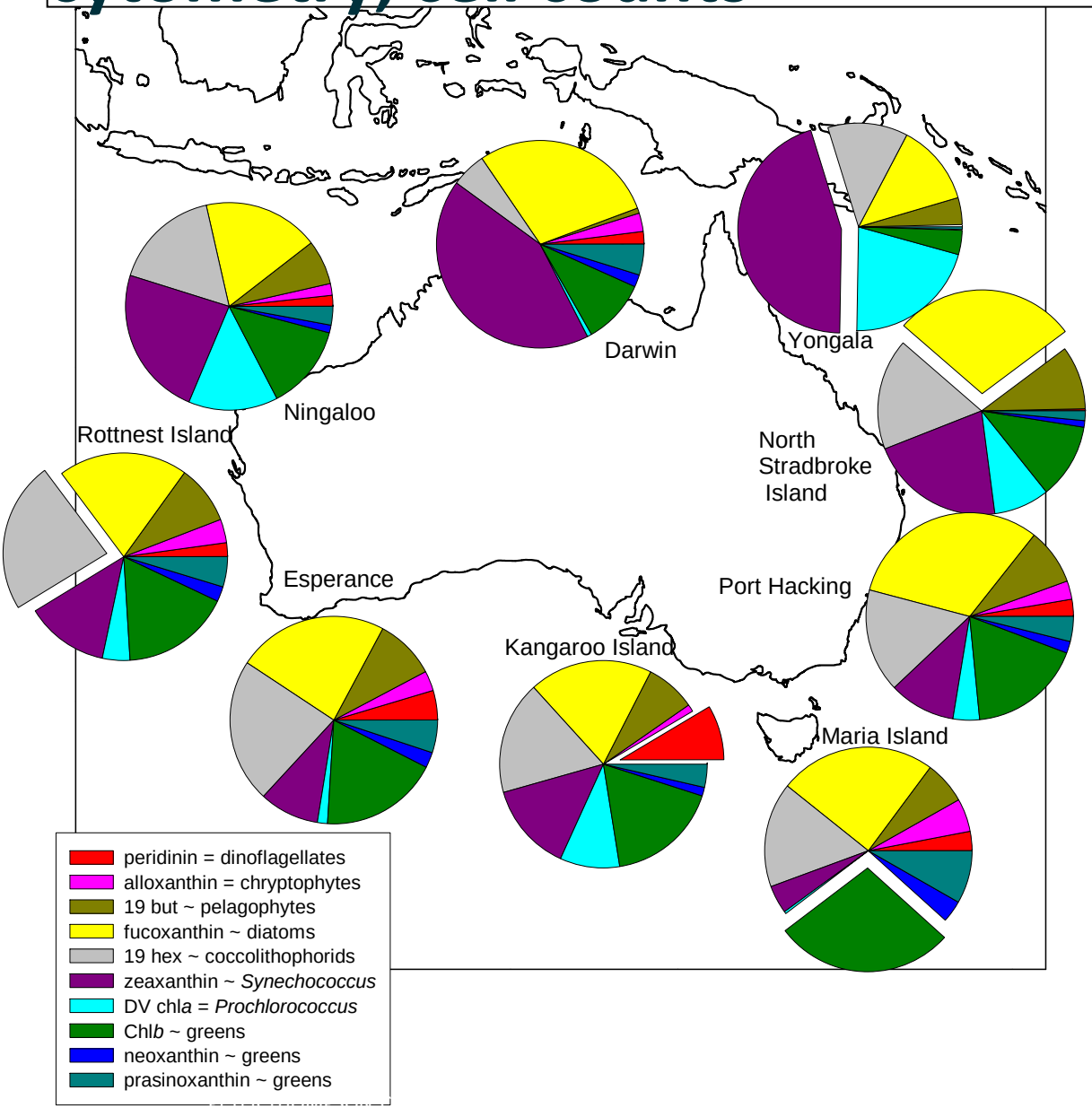
Phytoplankton community composition



- 1993 to 2011 phytoplankton data
- High SOI = more diatoms
  - Annual or m

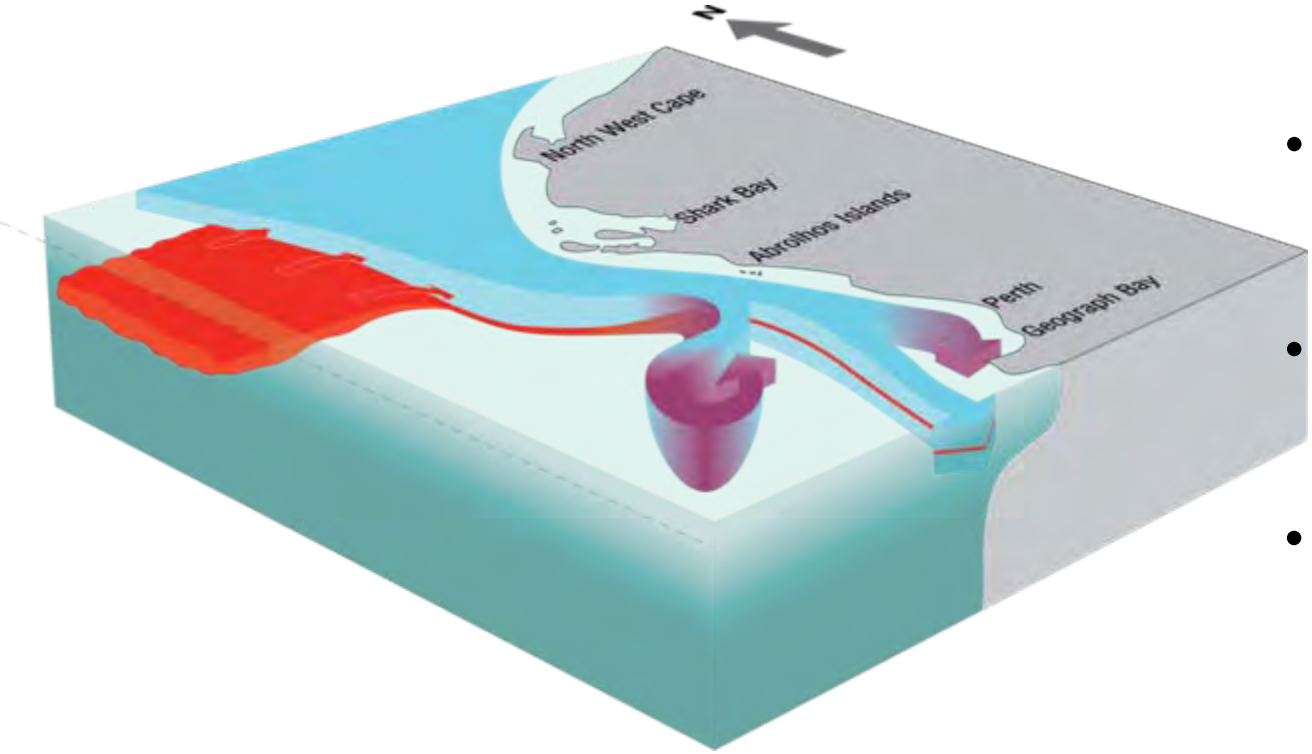
**Adapted from Thompson, PA , Baird, ME, Ingleton, T, Doblin, MA. 2009 Long-term changes in temperate Australian coastal waters and implications for phytoplankton.*

Phytoplankton taxonomy by pigments, flow cytometry, cell counts



- West coast La Nina events increase:
  - Prochlorococcus 50%
  - Synechococcus 50%
  - Coccolithophores 30%

Conceptual model for nitrogen supply to the west coast of Australia



- Thin layer of high nitrate, low DO, colder, fresher water at ~ 24 and 25°S
- Captured by LC, dragged south at base of LC
- Where LC cools it intrudes into this layer and mixes to surface
- 3 modes south of 28°S
  - Eddy
  - Vertically mixed LC
  - Stratified LC

Adapted from Thompson, P.A., Wild-Allen, K., Lourey, M., Rousseaux, C., Waite A.M., Feng, M., Beckley L.E. 2011. Nutrients in an oligotrophic boundary current: Evidence of a new role for the Leeuwin Current. Progress in Oceanography. 91: 345-359.

Western Rock Lobsters *Panulirus cygnus*

Phyllosoma
11 months at sea

Puerulus
Non feeding stage
Transitions to bottom and shore

Adults
4 years to reach maturity and legal size

Initial goals for new research on Phyllosoma

- Environmental changes are occurring in Indian Ocean but mechanisms whereby these affect puerulus settlement are unknown.

- Need to examine:
  - Biological / physical oceanographic mechanisms associated with *phyllosoma* growth in an oligotrophic ocean
  - Key prey / feeding of larvae – unknown in wild
  - Turn field measurements of phyllosoma into model parameters

Objectives of the proposed research

1. Regional Survey – Concentrations of phyllosoma and prey between 28 and 32°S
2. Food web analysis in key water masses using biomarkers (isotopes, fatty acids)
3. Phyllosoma feeding experiments
    1. Lipid / FA content feeding on different prey
    2. Sensitivity of Lipid/ FA content to starvation
    3. Prey preference

Ship board experiments with pseudo kreisel tanks

What do Western Rock Lobster phyllosoma eat?

- Scarce data suggest phyllosoma are “opportunistic carnivores” (Suzuki et al., 2007)
- Lipid increases during larval development (Jeffs et al., 2004)

- Phyllosoma nutritional status important for metamorphosis – this depends on ocean food sources

Neuston tows from 2200 to 0300 every night

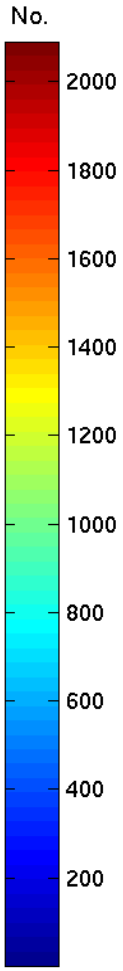
Bongos for prey

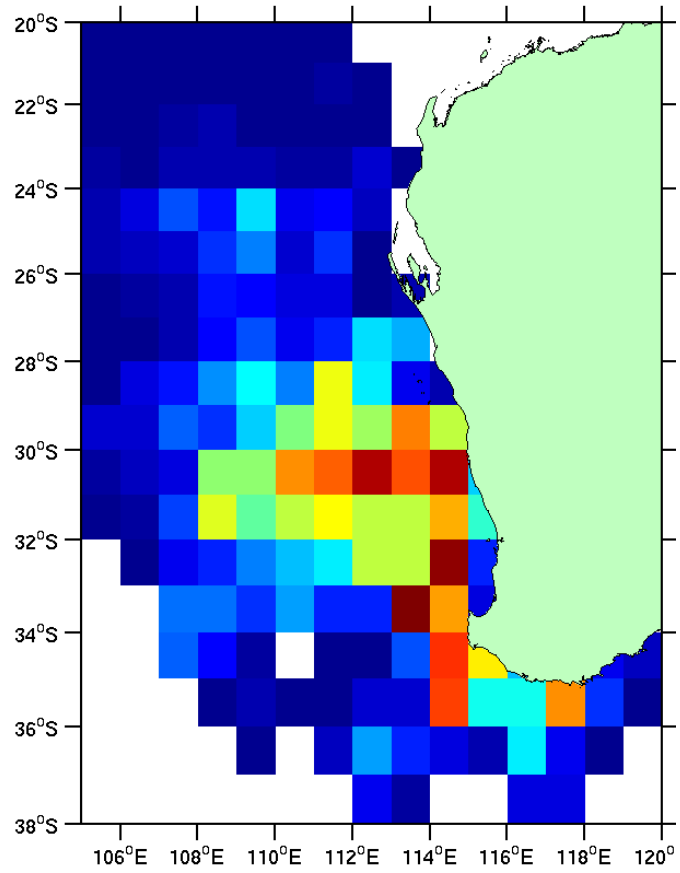
EZ depth stratified sampling

Photos: Megan Saunders

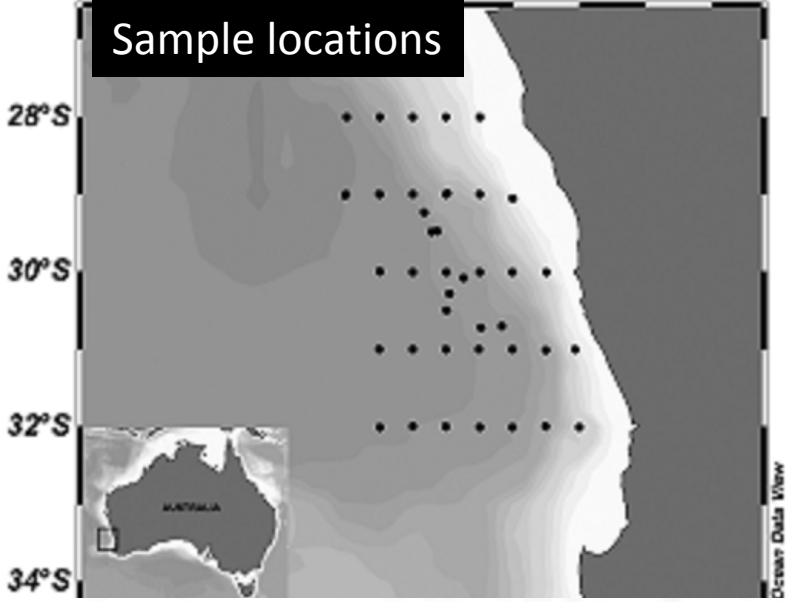
Sort out *phyllosoma*, stage and transfer to tanks or preserve for later

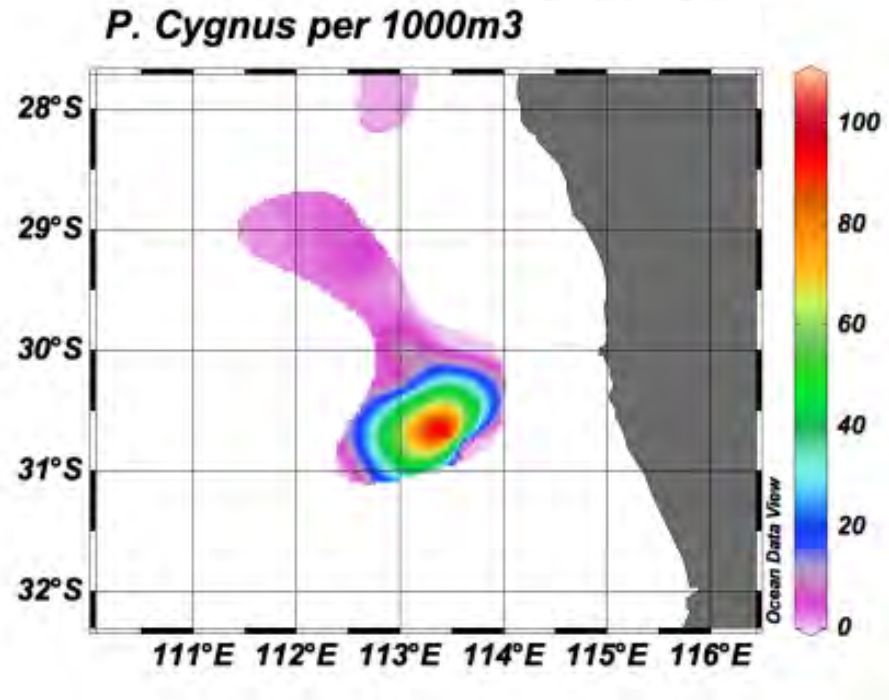
Spatial distribution of phyllosoma



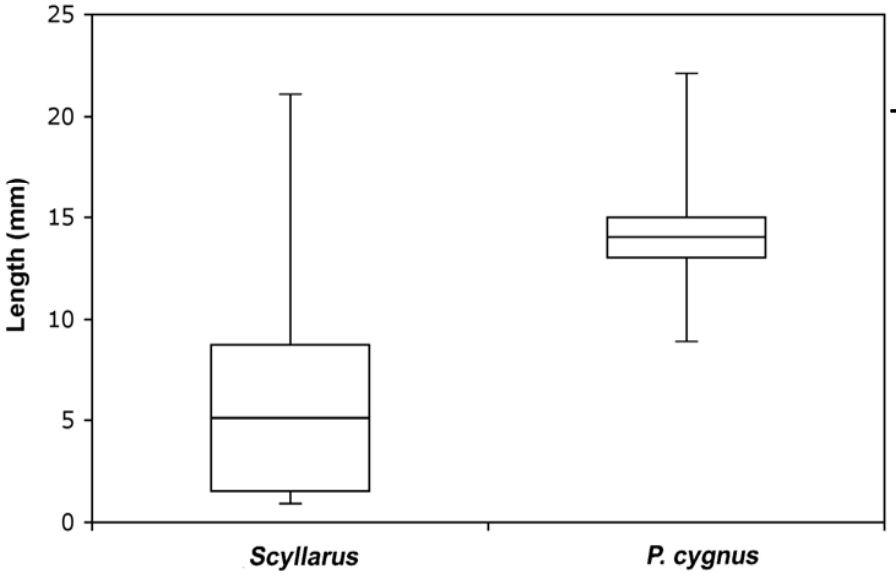


Predicted by model
Feng et al., unpublished data

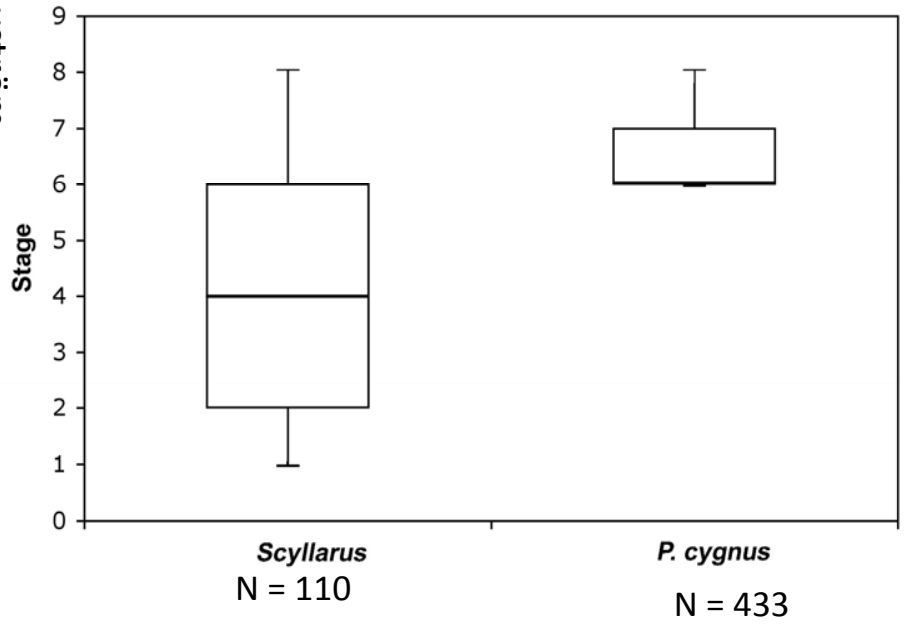




Observed by our cruises
Säwström et al., unpublished data



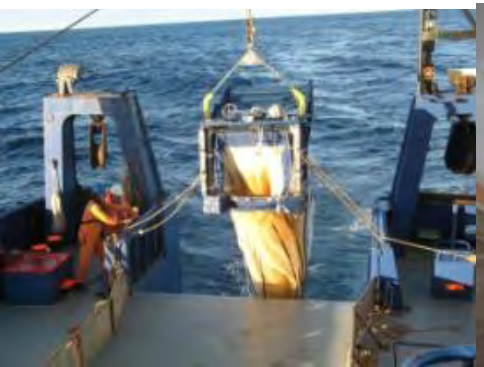
Graphs: Christin Säwström

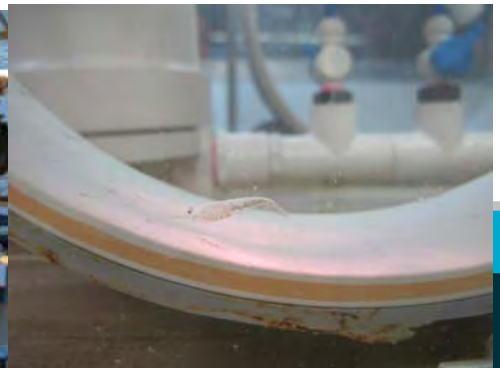


Average ~14mm length

Mainly stage 7 (of 11)

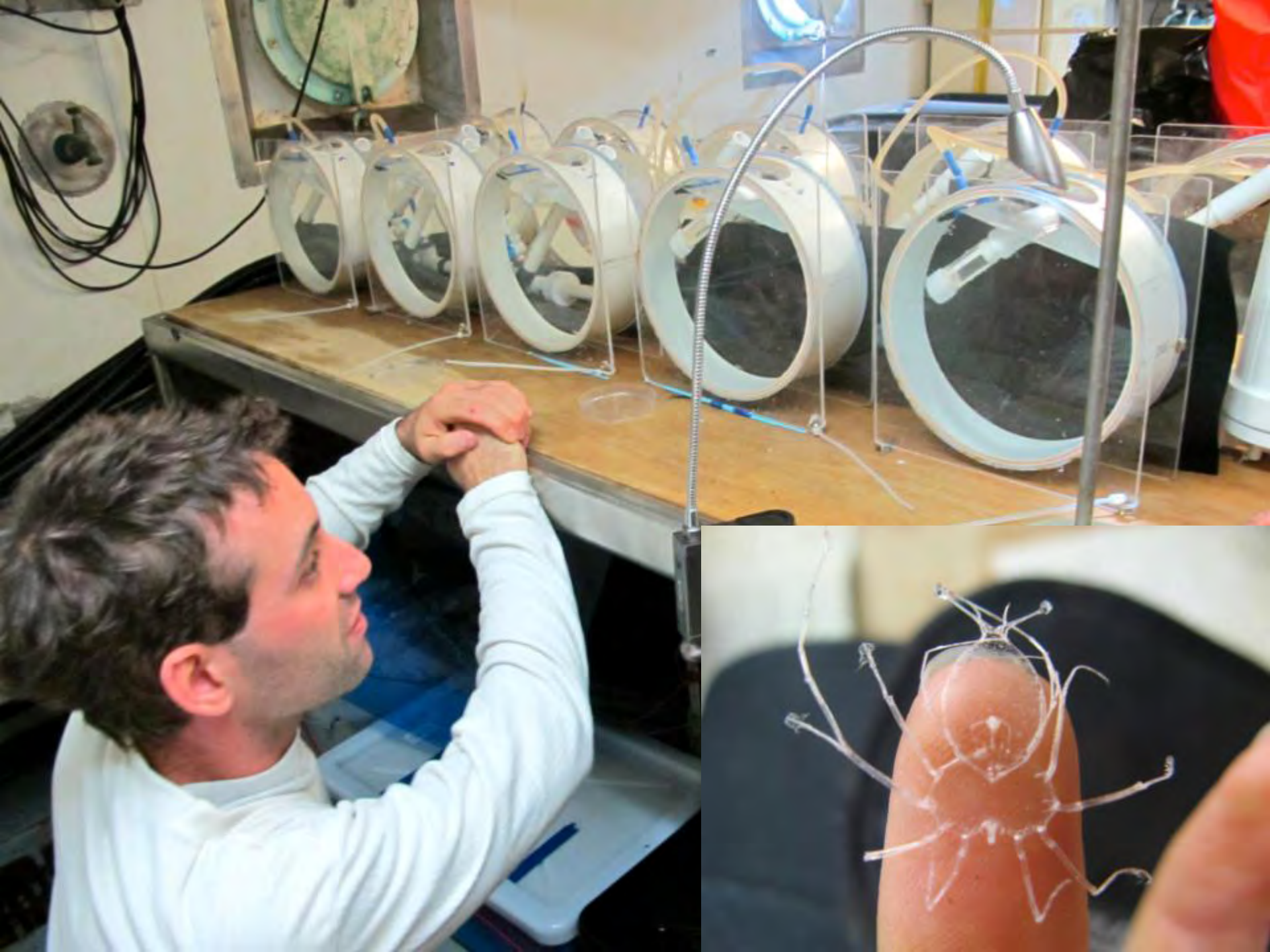
P. cygnus phyllosoma caught





Feeding experiments: 5 to 7 days long

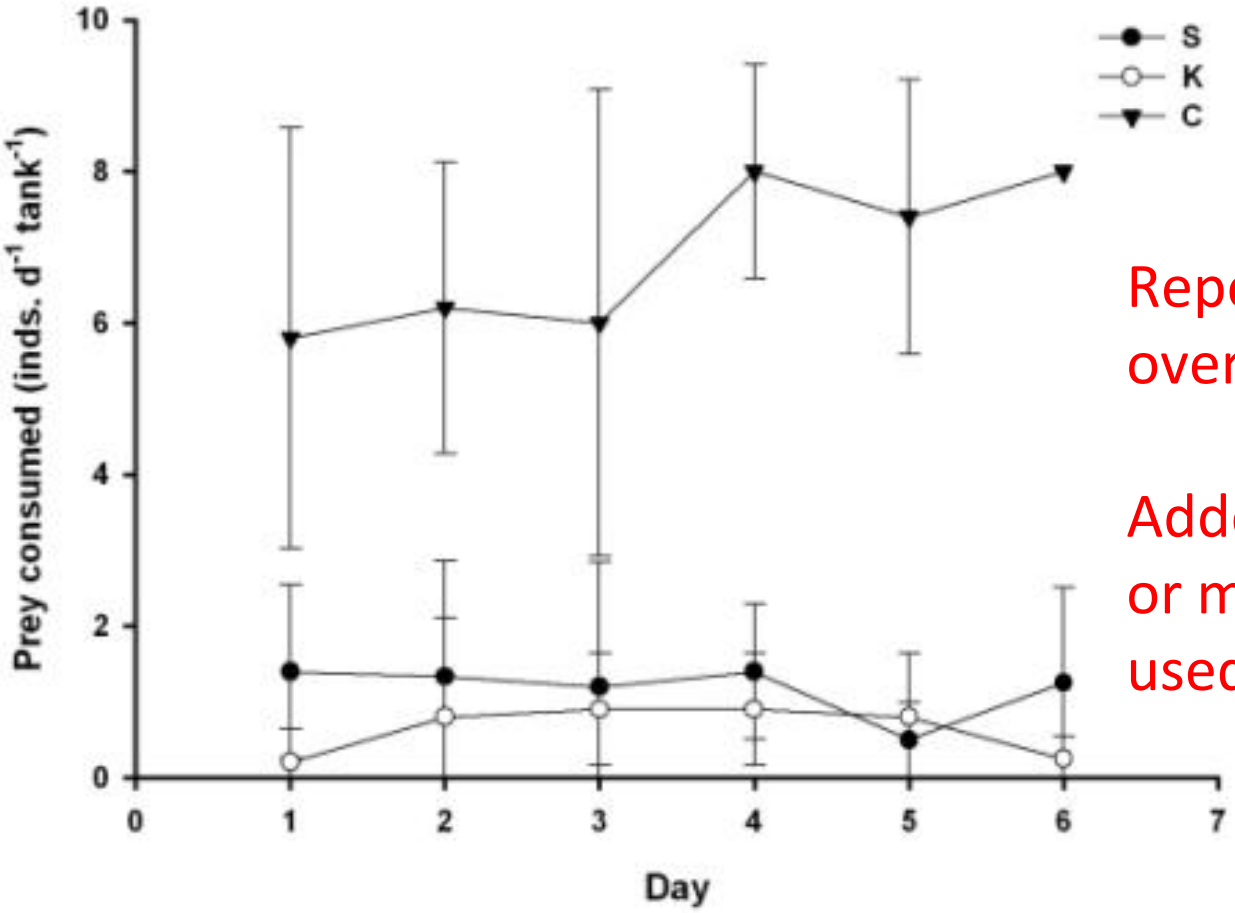
- Feeding preference studies with range of prey items
- Fatty acid/lipid analyses of dietary items and body composition
- Isotope analyses of dietary items and body composition
- Genetic analyses of dietary items and gut contents (Jeffs, U. Auckland)



Phyllosoma Feeding Experiments

Selected a range of prey items and presented those in single prey type or multiple prey types to 3 phyllosoma/tank with 3 tanks per experiment.

Experimental Design : Megan Saunders, Nick Sachlikidis



S = salp
K = krill
C = chaetognath

Repeated this 4 times over 2 years

Added as single prey type or multiple prey types, used a range or prey

Saunders MI, Thompson PA, Jeffs AG, Sawstrom C, Sachlikidis N, et al. (2012) Fussy Feeders: Phyllosoma Larvae of the Western Rocklobster (*Panulirus cygnus*) Demonstrate Prey Preference. PLoS ONE 7(5): e36580. doi:10.1371/journal.pone.0036580

Feeding experiment results

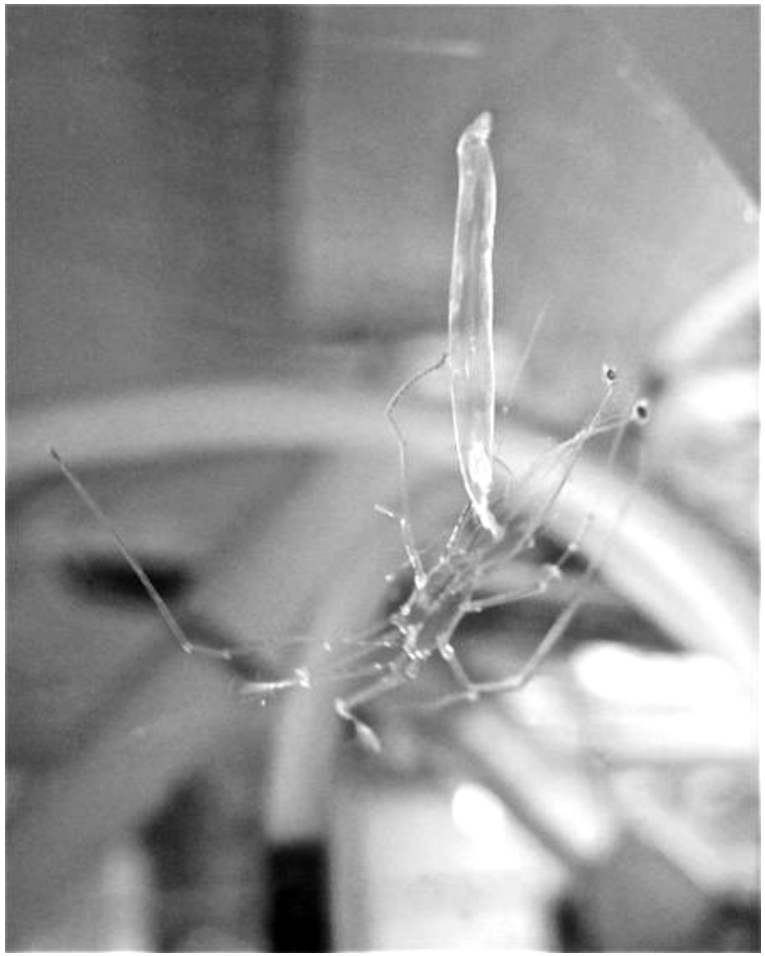
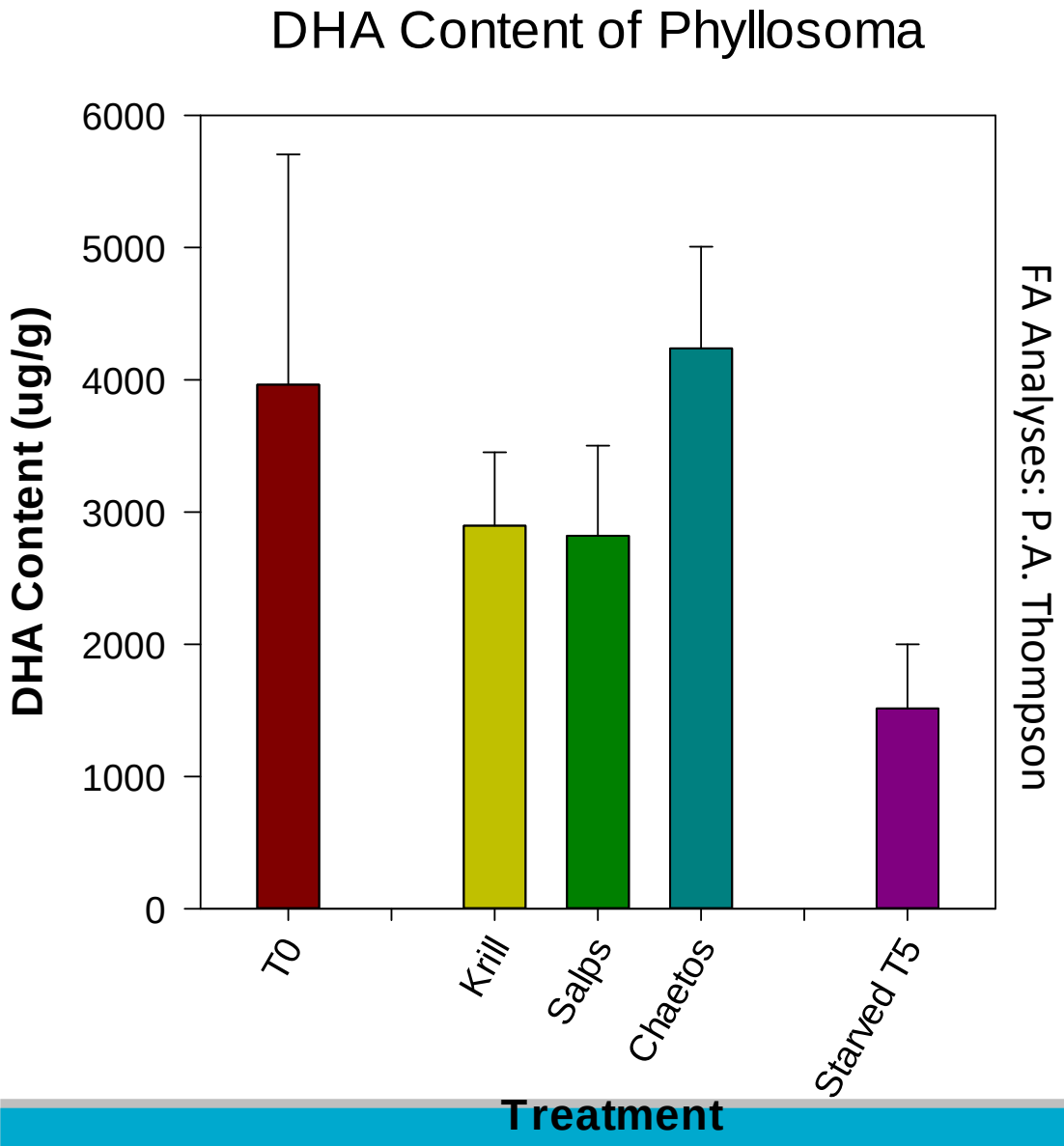


Photo: Megan Saunders

- Phyllosoma strongly preferred *chaetognaths* over all other prey types

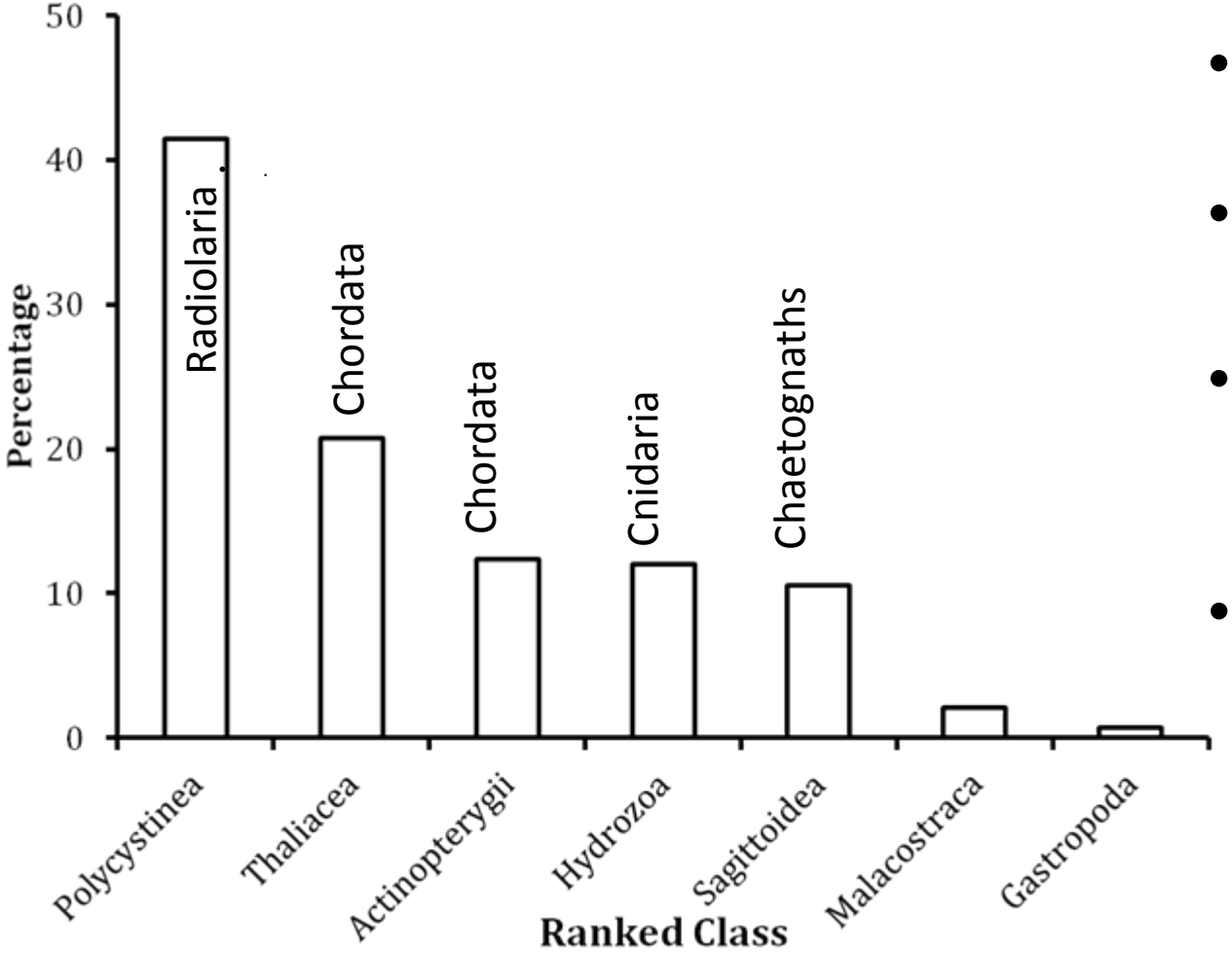
- Field samples showed a positive correlation between # of chaetognaths and phyllosoma ($r = 0.36$, $P < 0.05$)

Essential fatty acids in phyllosoma



- Initial phyllosoma are highly variable in DHA
  - suggests variable condition
- Starved animals show a strong decrease over 5 days
- Those fed Krill and (small) salps declined relative to those fed chaetognaths ($P < 0.05$)

Diet by DNA sequencing



- Extract stomach contents
- Sequence & match
- Most guts had no signal = empty
- Some evidence of chaetognaths but more frequently colonial radiolarians

O'Rorke R, Lavery S, Chow S, Takeyama H, Tsai P, et al. (2012) Determining the Diet of larvae of Western Rock Lobster (Panulirus cygnus) Using High-Throughput DNA Sequencing Techniques. PLoS ONE 7(8): e42757. doi:10.1371/journal.pone.0042757

Summary

- Confirm general model predictions of *phyllosoma* location
- Analysis of *phyllosoma* concentrations, abundance and stages suggest similar to previous survey in 1970s

- WRL *phyllosoma* strongly prefer chaetognaths
- Lipid analysis suggests *phyllosoma* are highly variable in their physiological state in the wild
- Genetic analysis of gut contents suggest most have not eaten recently. Radiolarian DNA was more common than other prey
- Still waiting on amino acid specific 15N data……

Acknowledgements

- Australian Marine National Facility
- University of Western Australia, Murdoch, CSIRO
- Department of Fisheries WA
- Fisheries Research and Development Corporation
- Queensland Department of Primary Industries
- Lobster Harvest (Pty Ltd)

Thank you

Marine and Atmospheric Research

Peter Thompson

Program Leader

picture by frank olsen

picture by megan saunders