Variable patterns in pteropod abundance between the shelf and slope from two decades of observations off Newport Oregon, USA

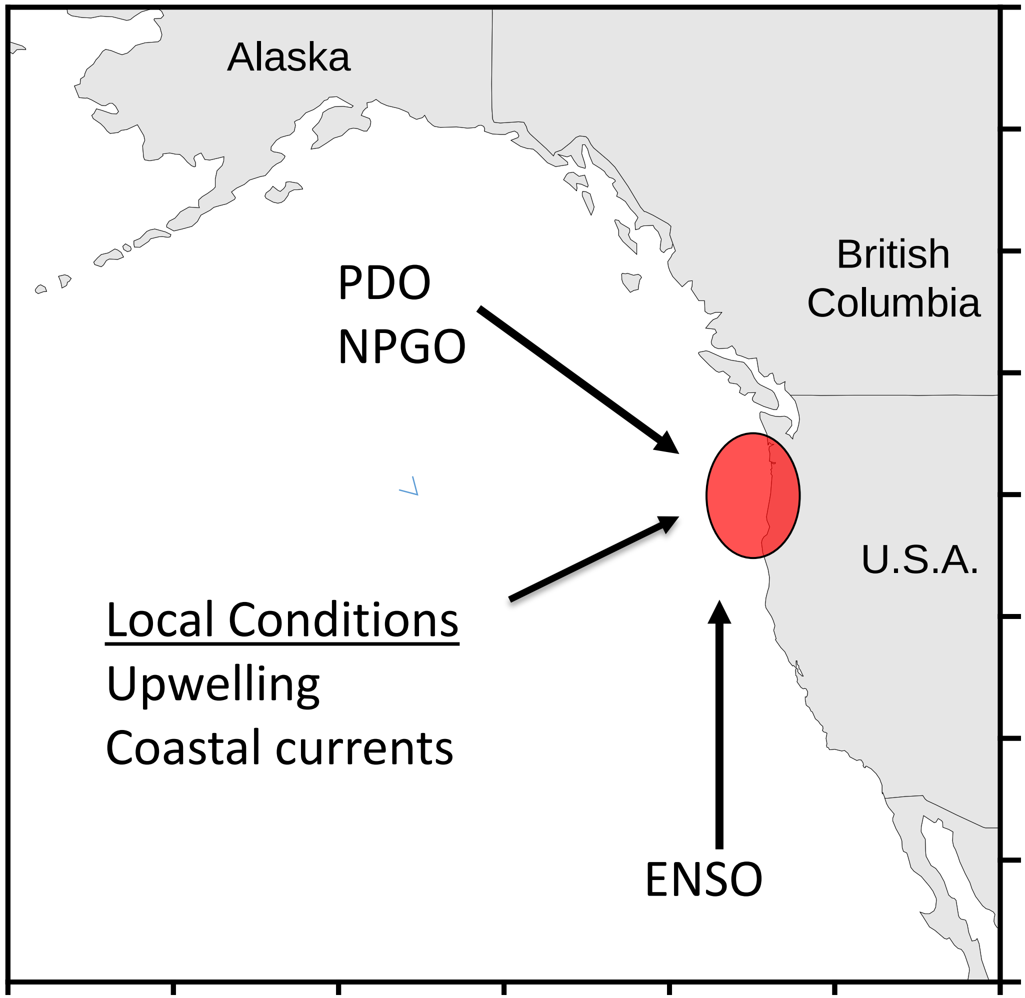
Jennifer L. Fisher[1], Bill Peterson[2], Hongsheng Bi[3], Brandon Chasco[2]

[1]Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR , USA

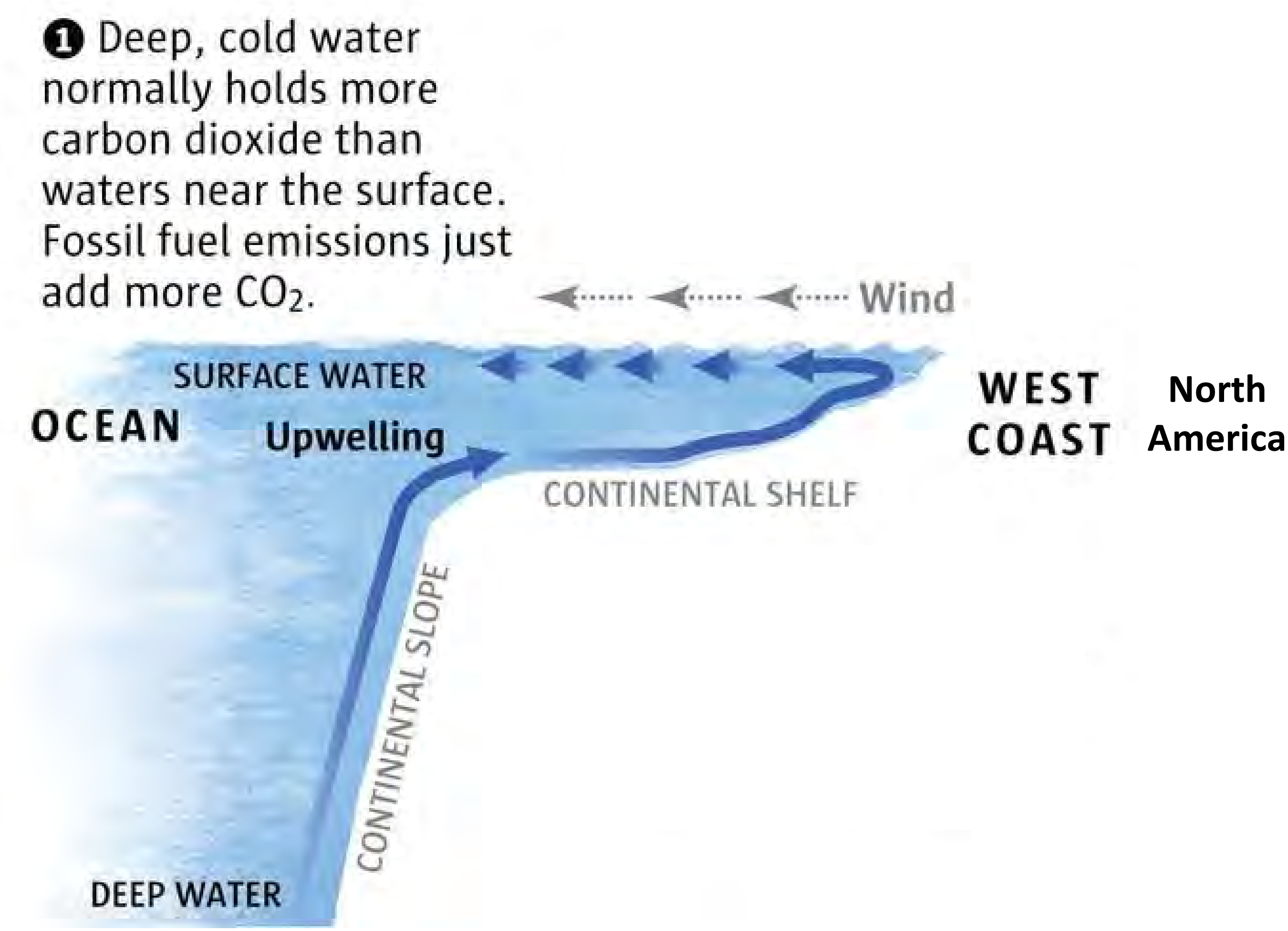
[2]NOAA, Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR, USA

[3]University of Maryland, Center for Environmental Science, USA

Our study region is influenced by large-scale and local physical forcing



Upwelling regions are particularly susceptible to ocean acidification as upwelling delivers CO_2-rich water onto the continental shelf

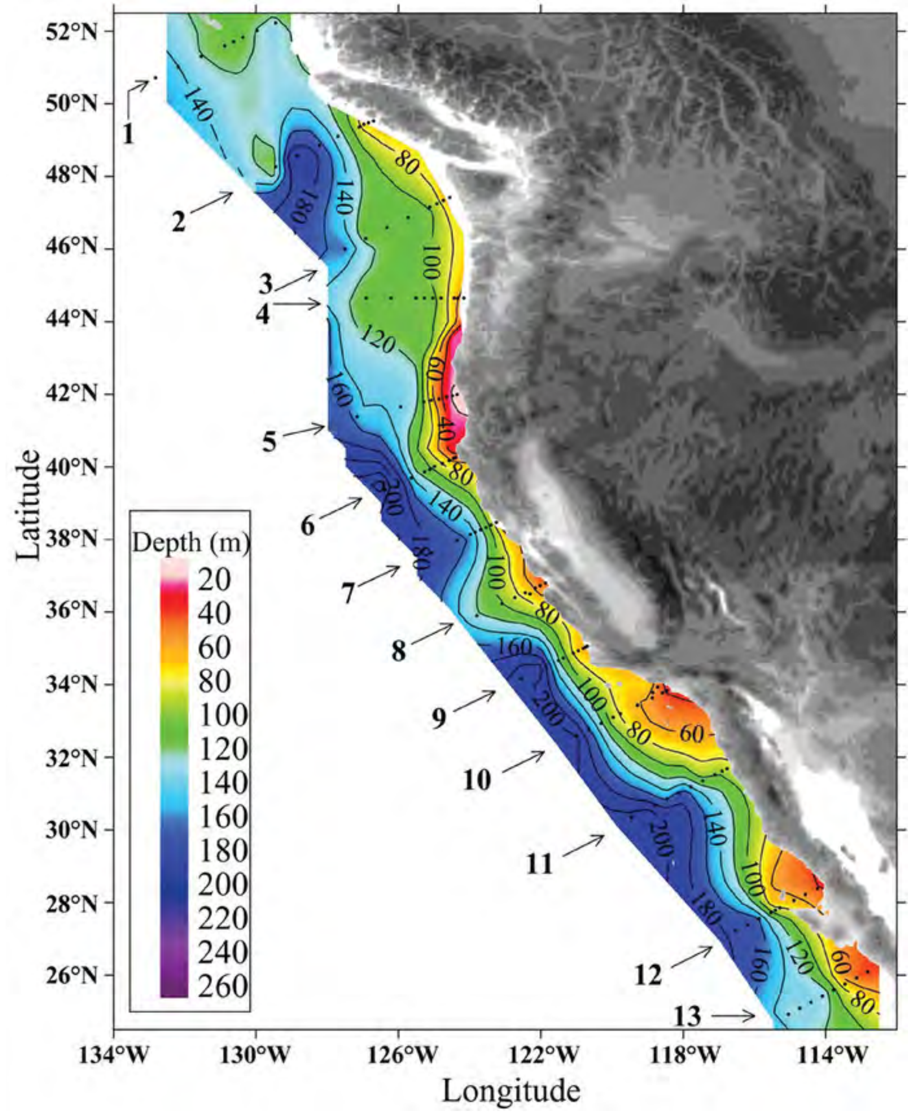


From the Seattle Times- Mark Nowlin

Upwelling regions have reduced habitat with respect to aragonite saturation

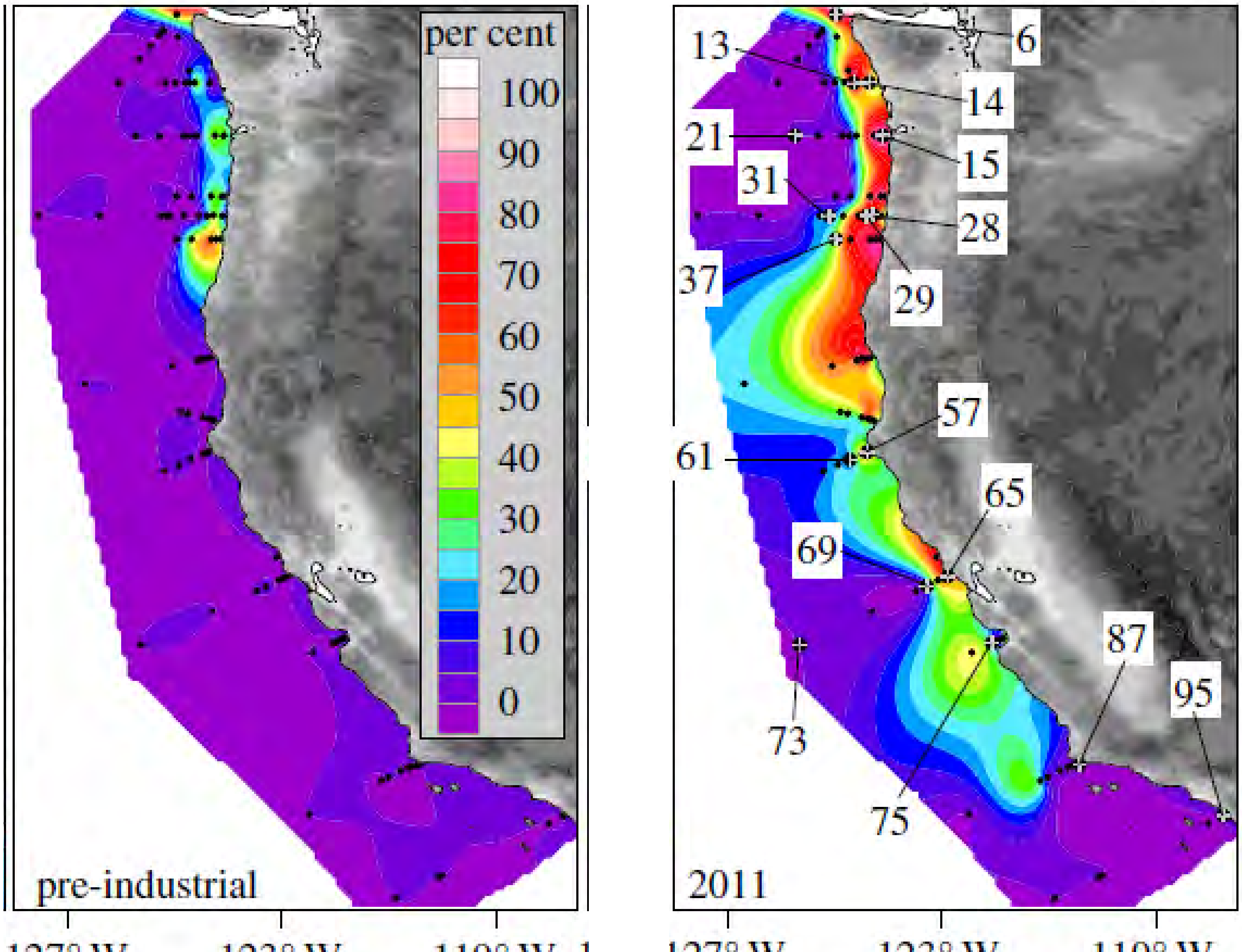
- High CO_2 water that upwells onto the shelf has a low saturation value with respect to aragonite (Ω_{ar})

- When Ω_{ar} <1 the water is undersaturated (or corrosive) and marine organisms with $CaCO_3$ shells are susceptible to dissolution



From Feely et al. 2008

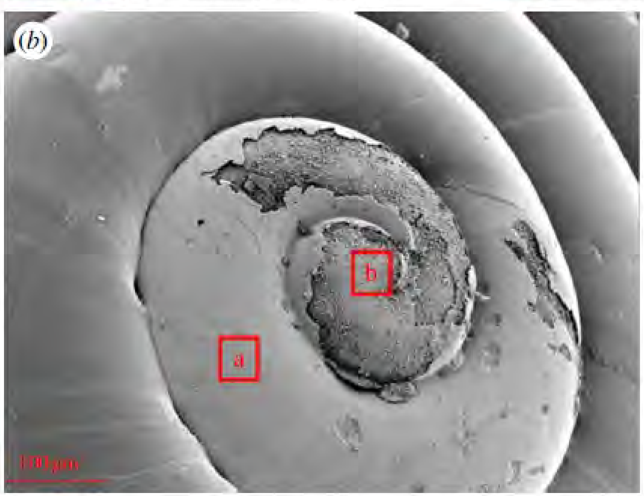
The fraction of water column that is corrosive has increased since the pre-industrial era

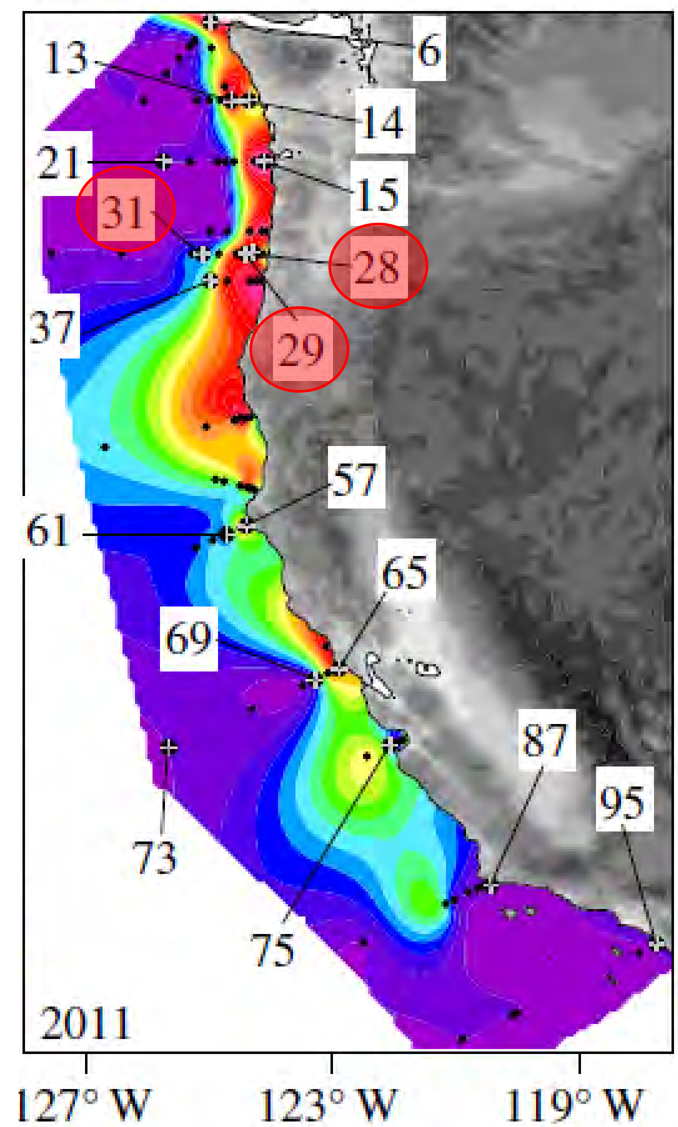


From Bednarsek at al. 2014

Severe shell dissolution was observed in regions with corrosive water

Slope





From Bednarsek at al. 2014

Objectives of this study

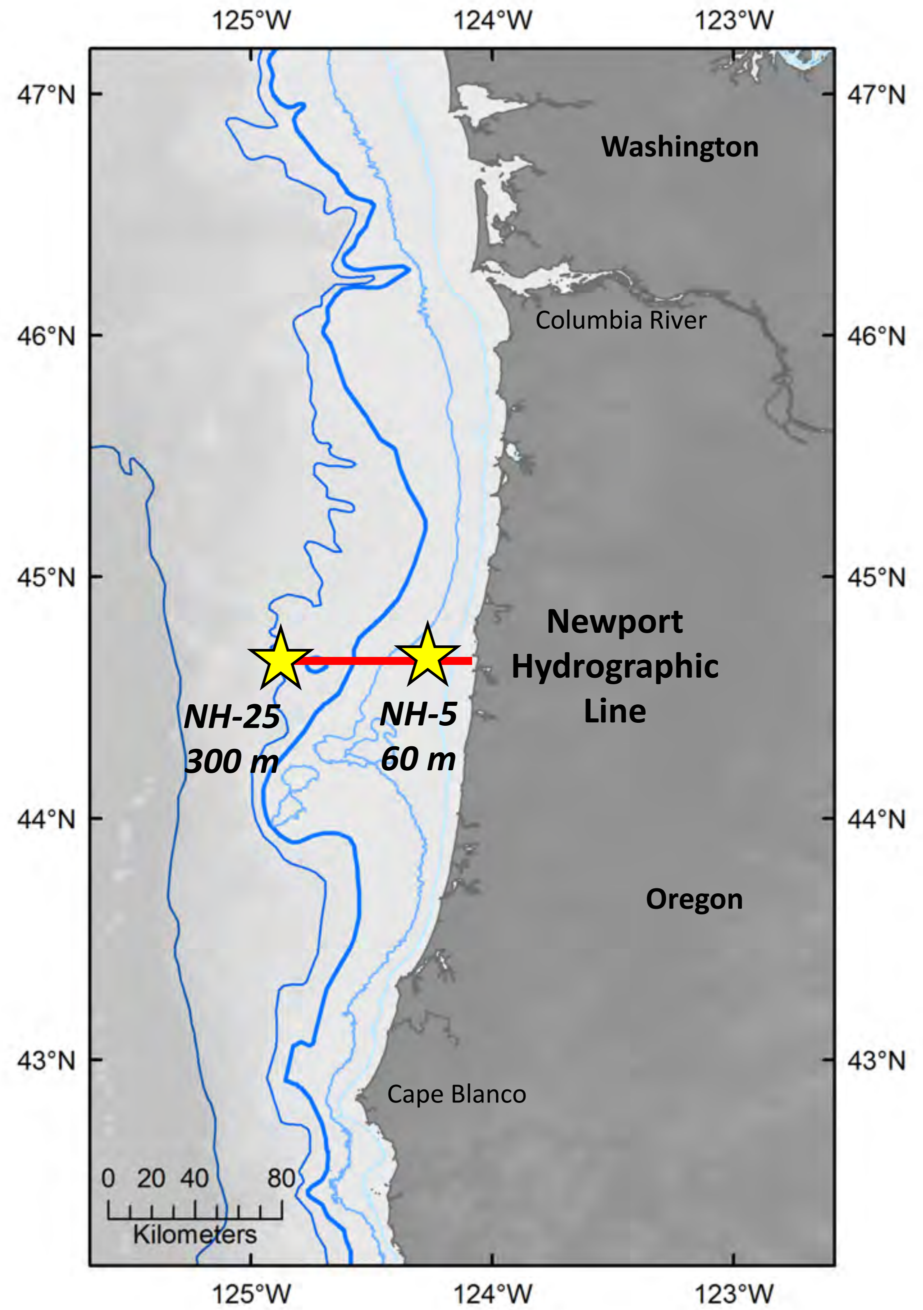
1. Determine the seasonal and inter-annual patterns of aragonite saturation and *Limacina* sp. on the shelf and slope

2. Investigate whether patterns in *Limacina* sp. abundance are correlated with aragonite saturation or other environmental parameters

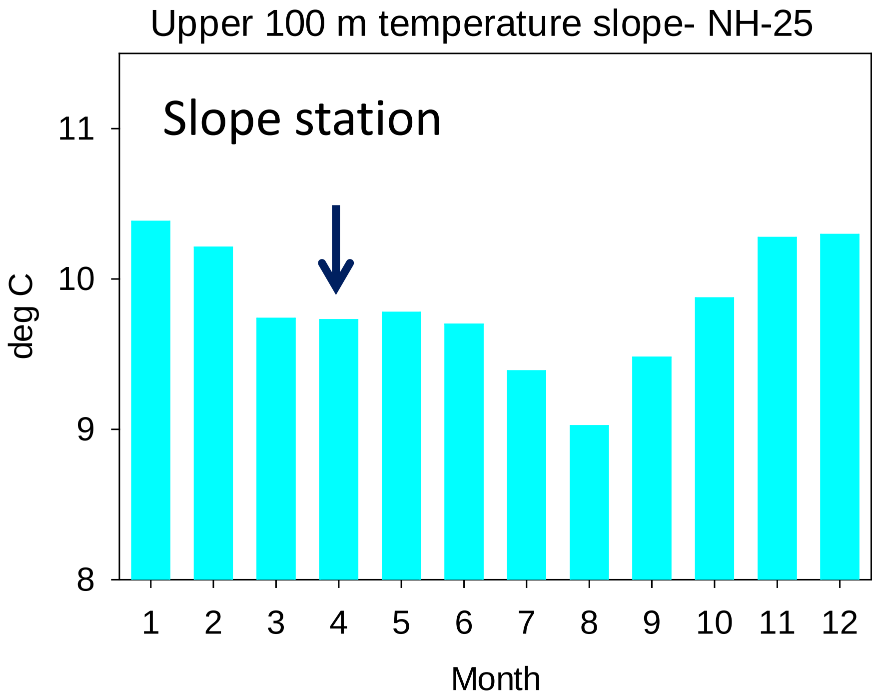
3. Develop a model with a suite of environmental parameters that best characterize changes in *Limacina* sp. abundance

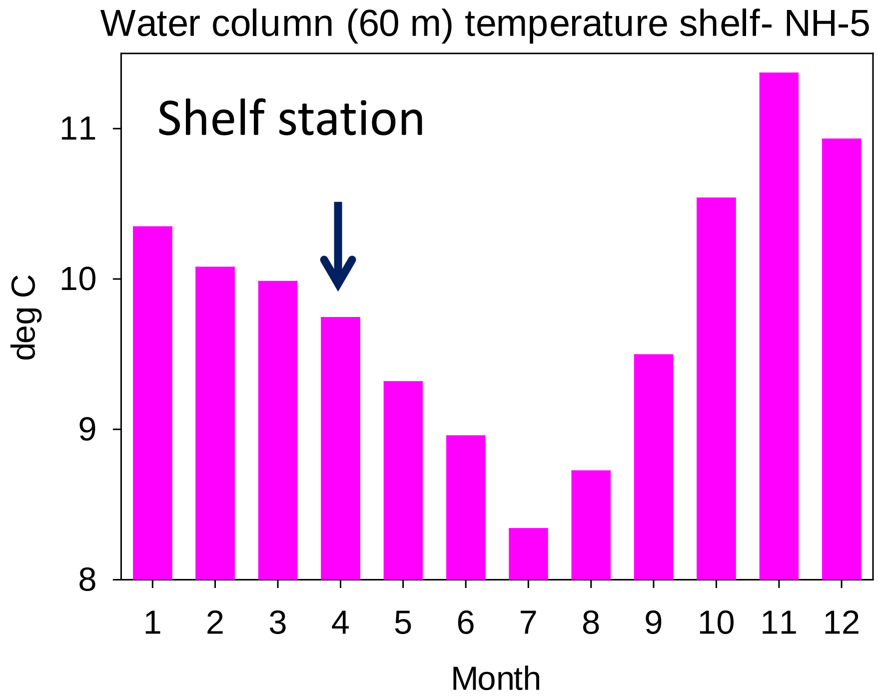
Methods

- Newport Hydrographic Line
- Sampled biweekly/monthly 1996-present
- 2 stations
  - Shelf- NH-5 (60 m)
  - Slope NH-25 (300 m)
- Pteropod collections
  - *Limacina helicina*
  - ½ m vertical net (202-um)
  - upper 100 m or 2 m off the bottom
- Aragonite saturation
  - Derived from CTD- temperature and oxygen (Juranek et al. 2009)
  - 2006 – present (most consistent)
- Time series analysis and GLM
  - Determine seasonal and long term trends (decompose in R)
  - Quantify effect of environmental variables on pteropod density



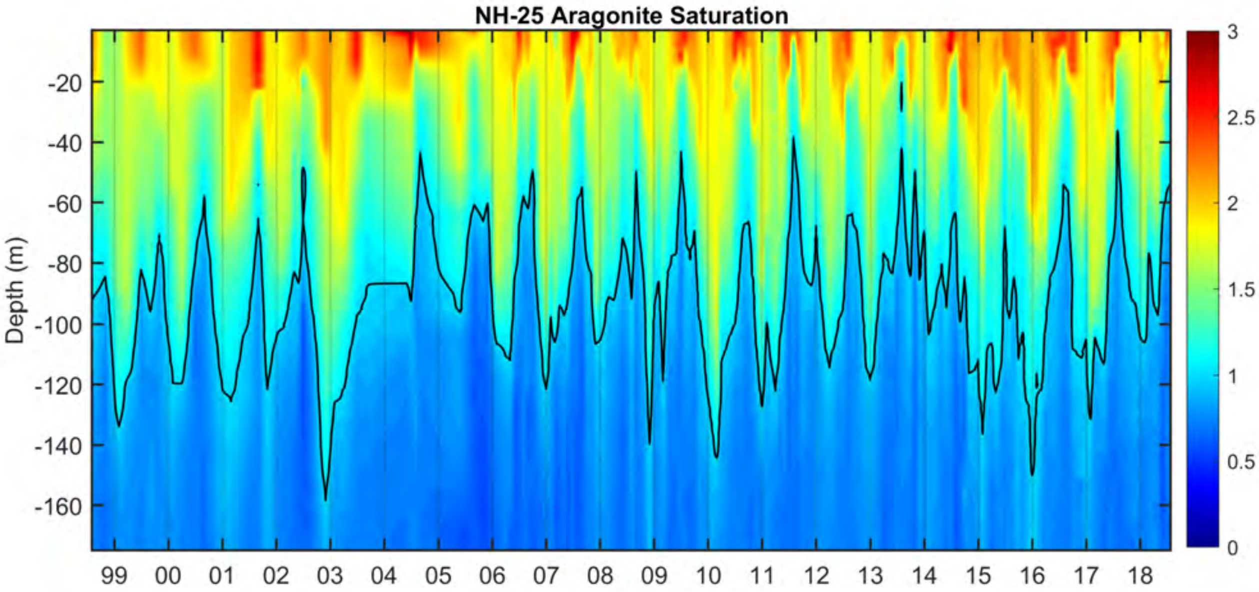
Summer upwelling stronger on the shelf compared to the slope



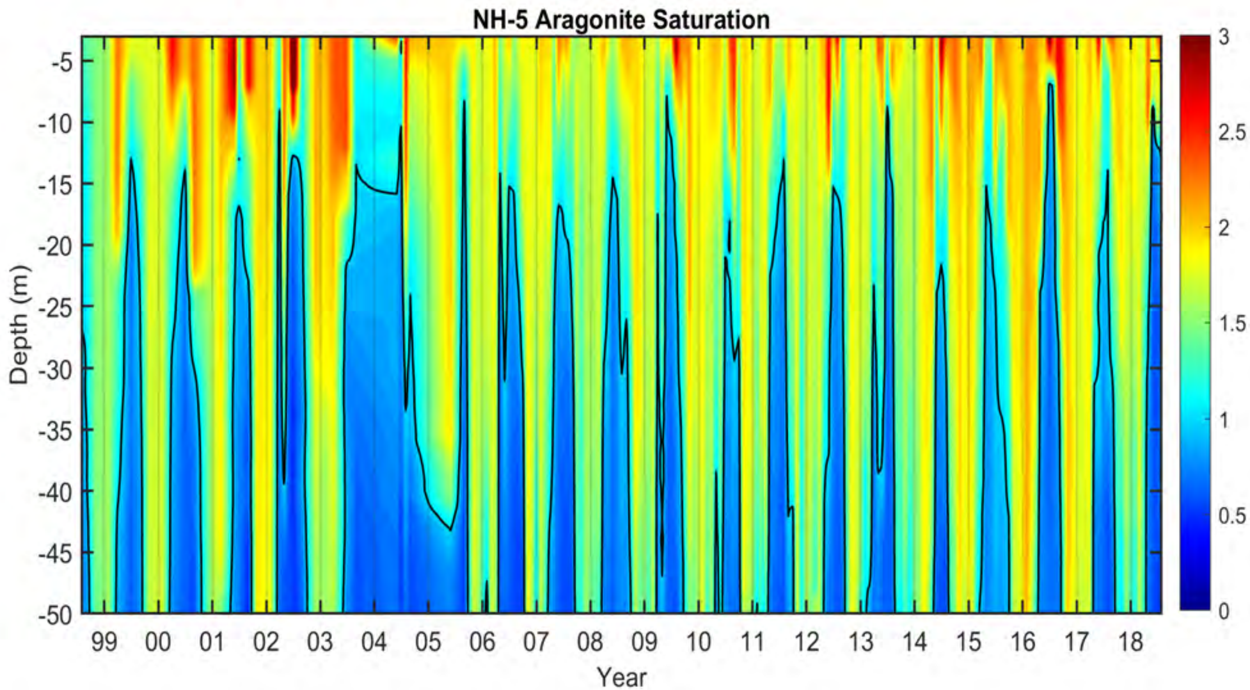


More suitable habitat on the slope compared to the shelf

Slope station

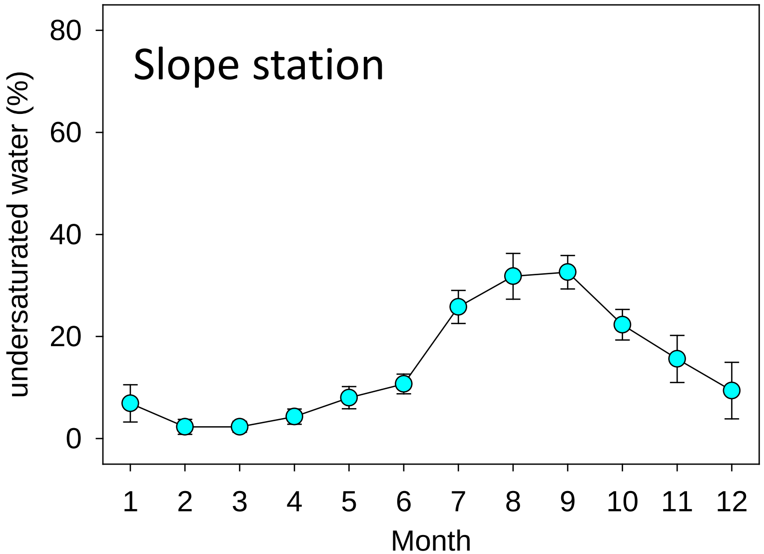


Shelf station

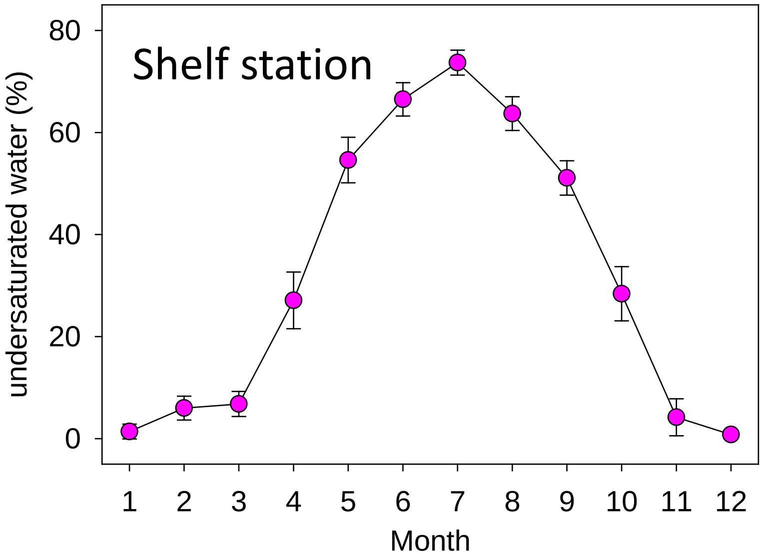


More suitable pteropod habitat on the slope compared to the shelf

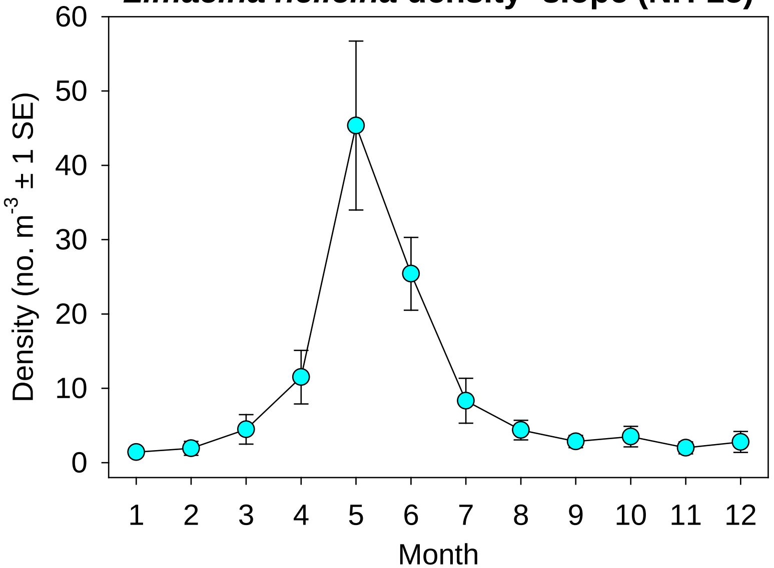
Percent of upper 100 m corrosive- slope (NH-25)



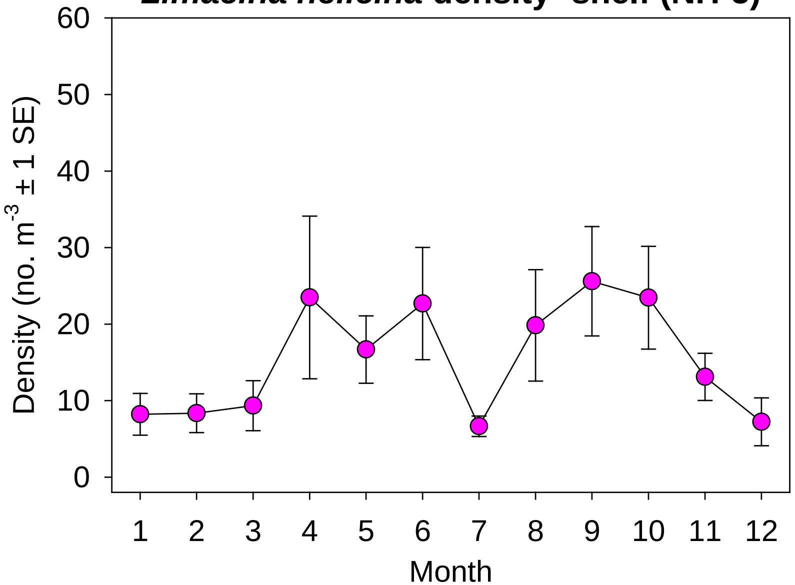
Percent of water column (60 m) corrosive- shelf (NH-5)



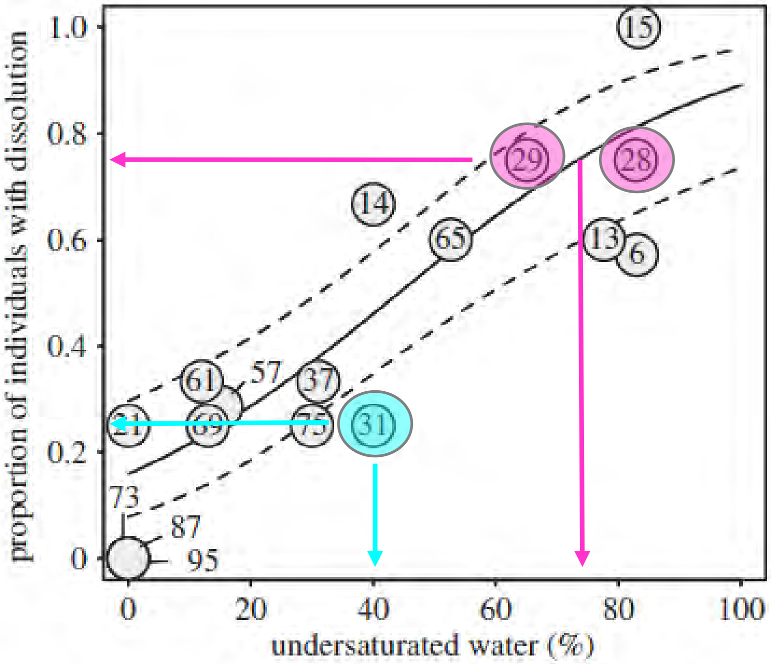
***Limacina helicina* density- slope (NH-25)**

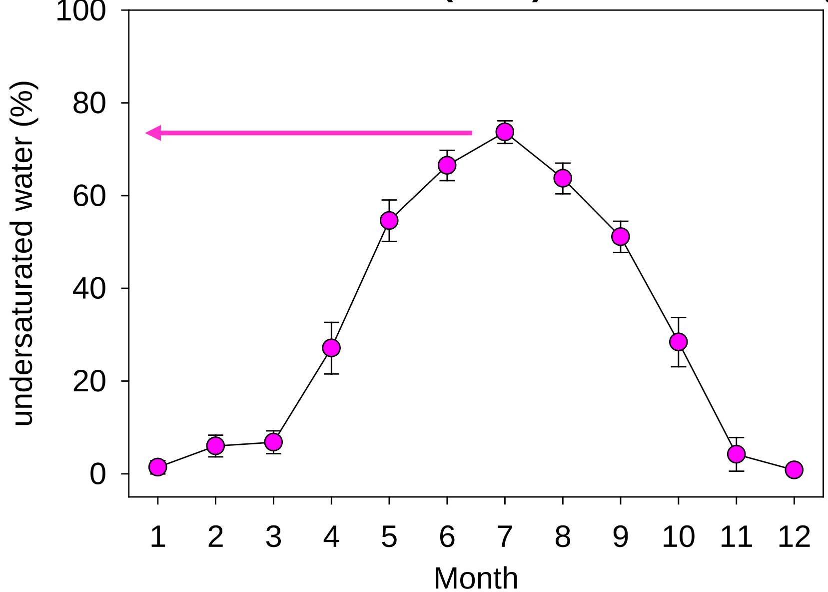


***Limacina helicina* density- shelf (NH-5)**



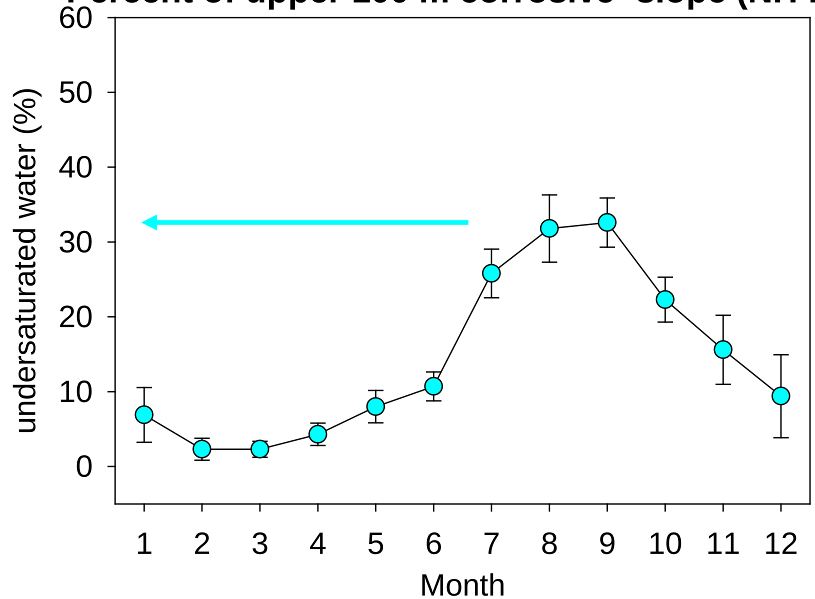
Patterns of undersaturated water consistent between 2011 (Bednarsek et al. 2014) and present study





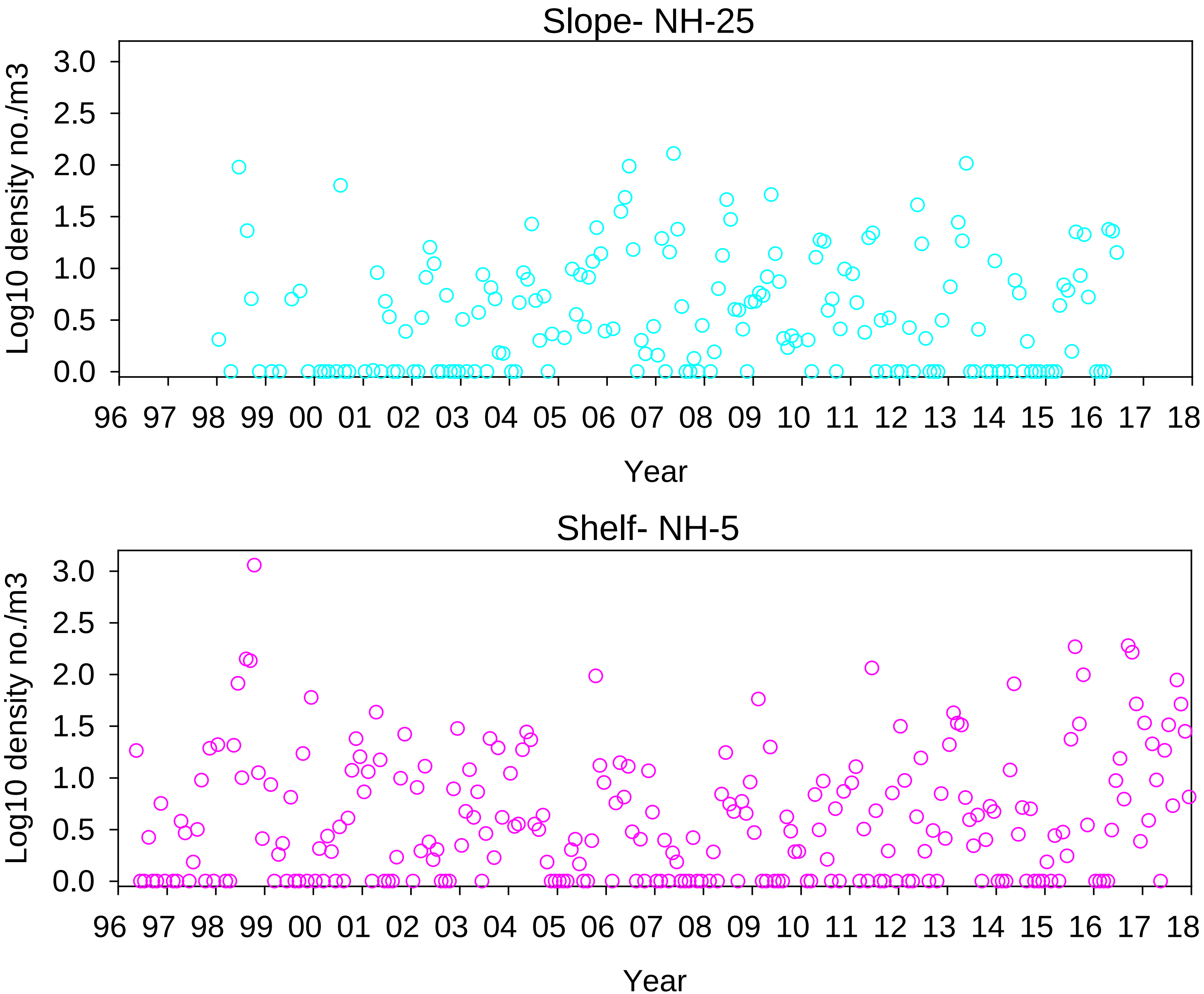
During peak period of undersaturation
% individuals encountering sever dissolution:

Shelf = 75%



From Bednarsek at al. 2014

Long term trends in *Limacina helicina*



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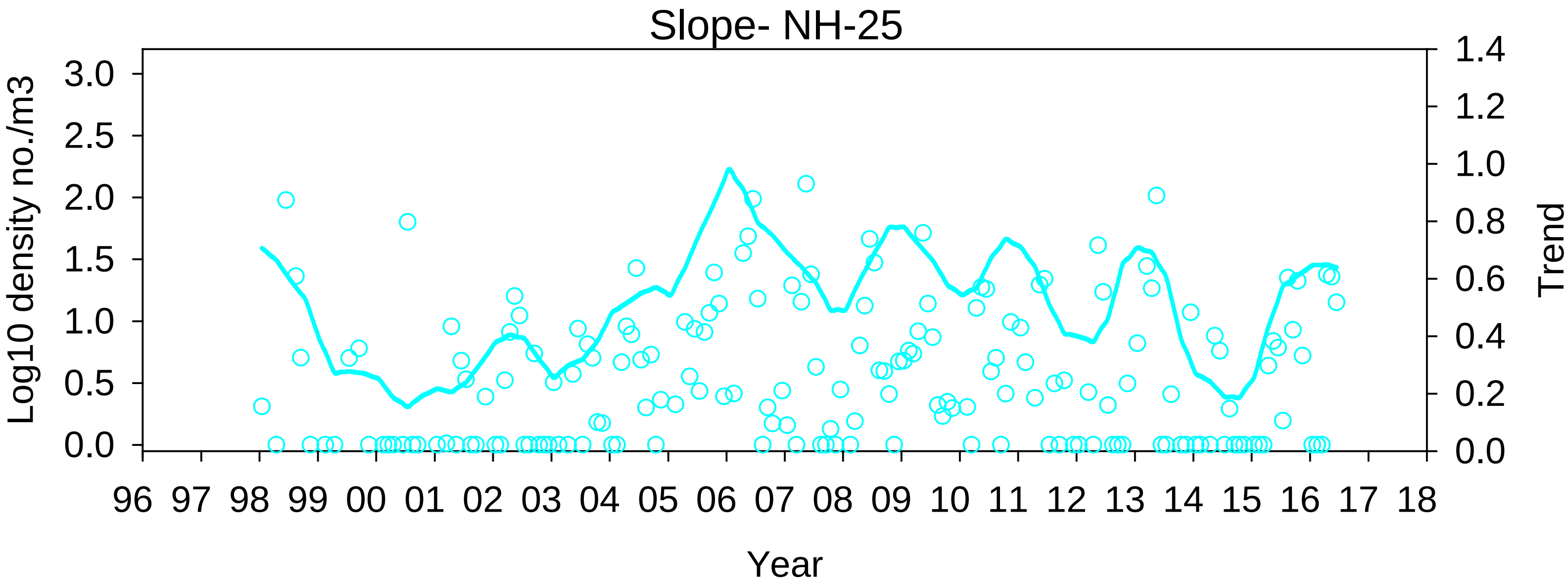

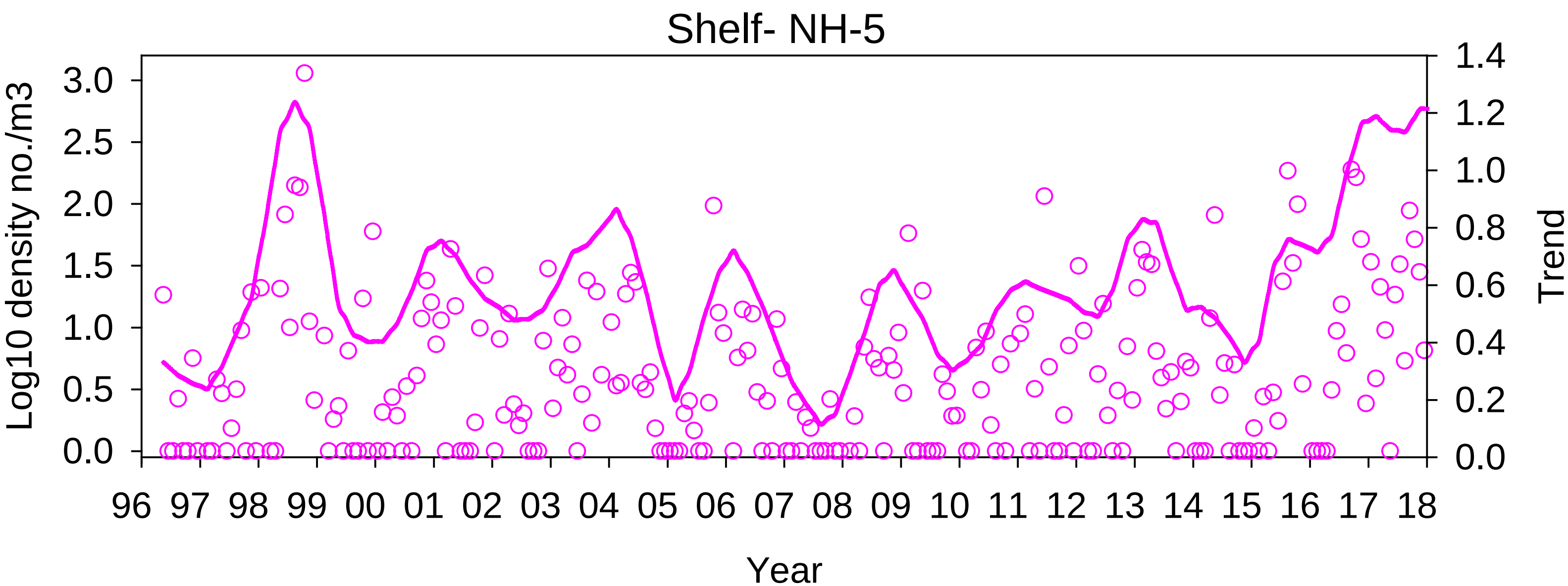

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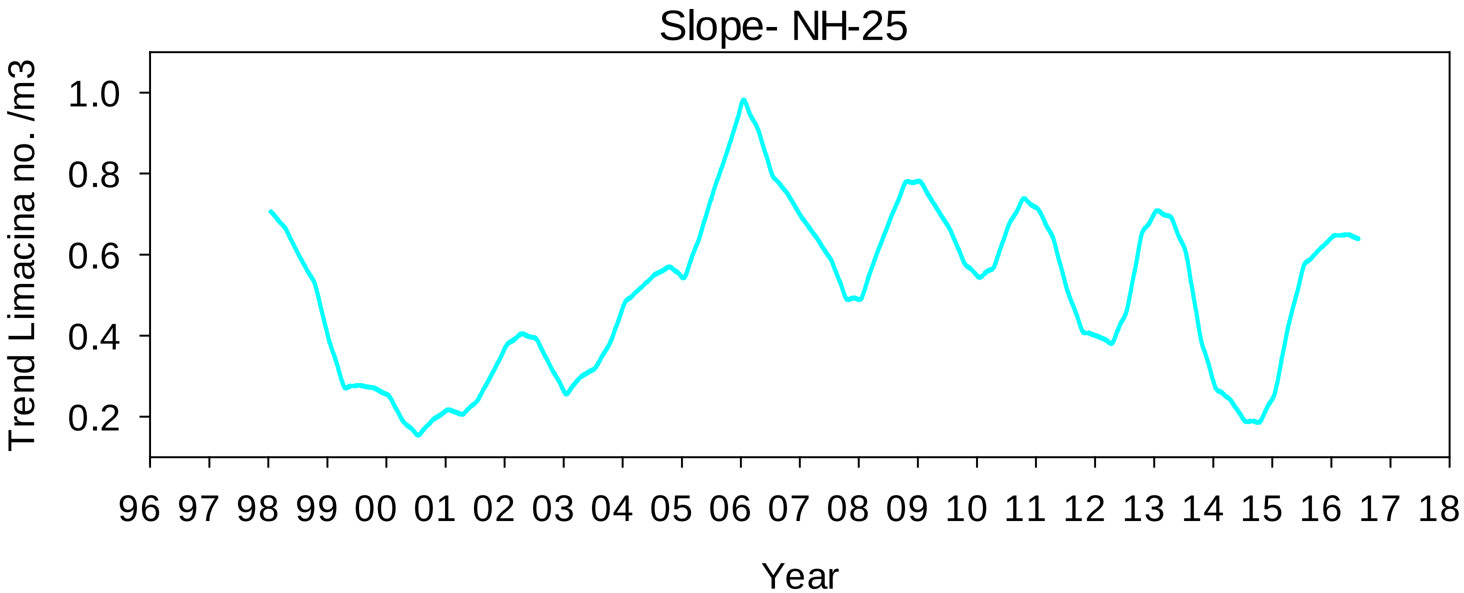
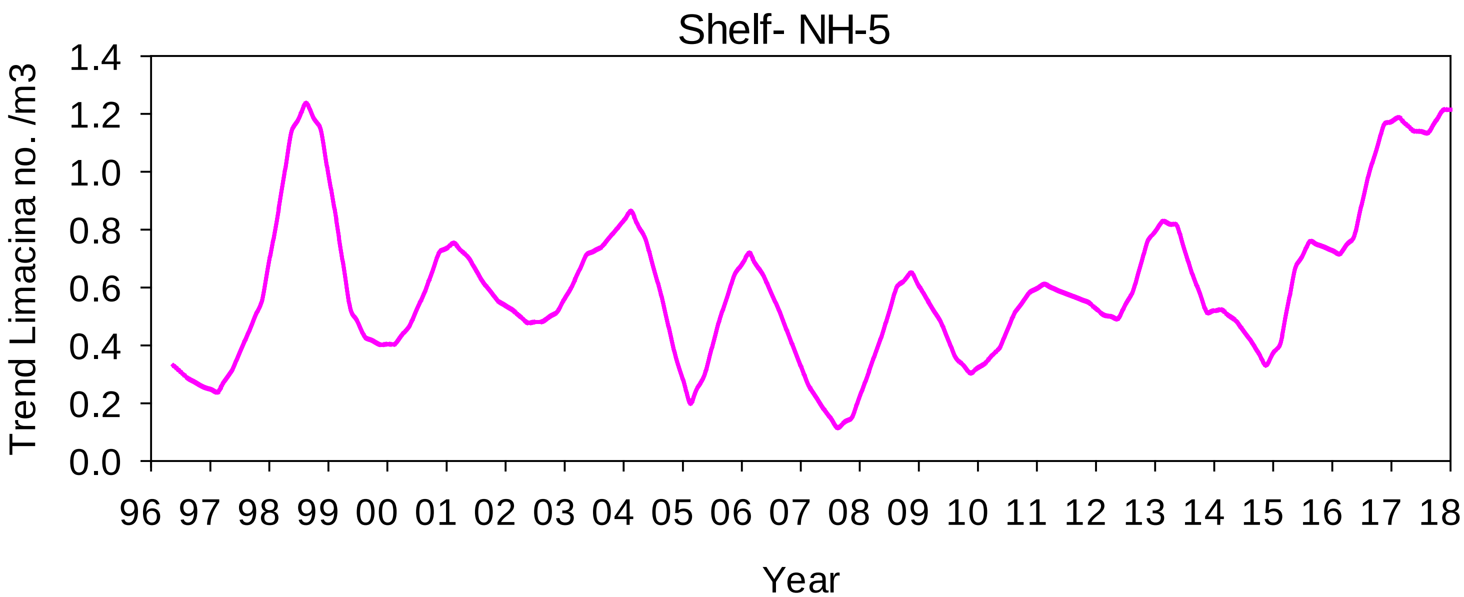
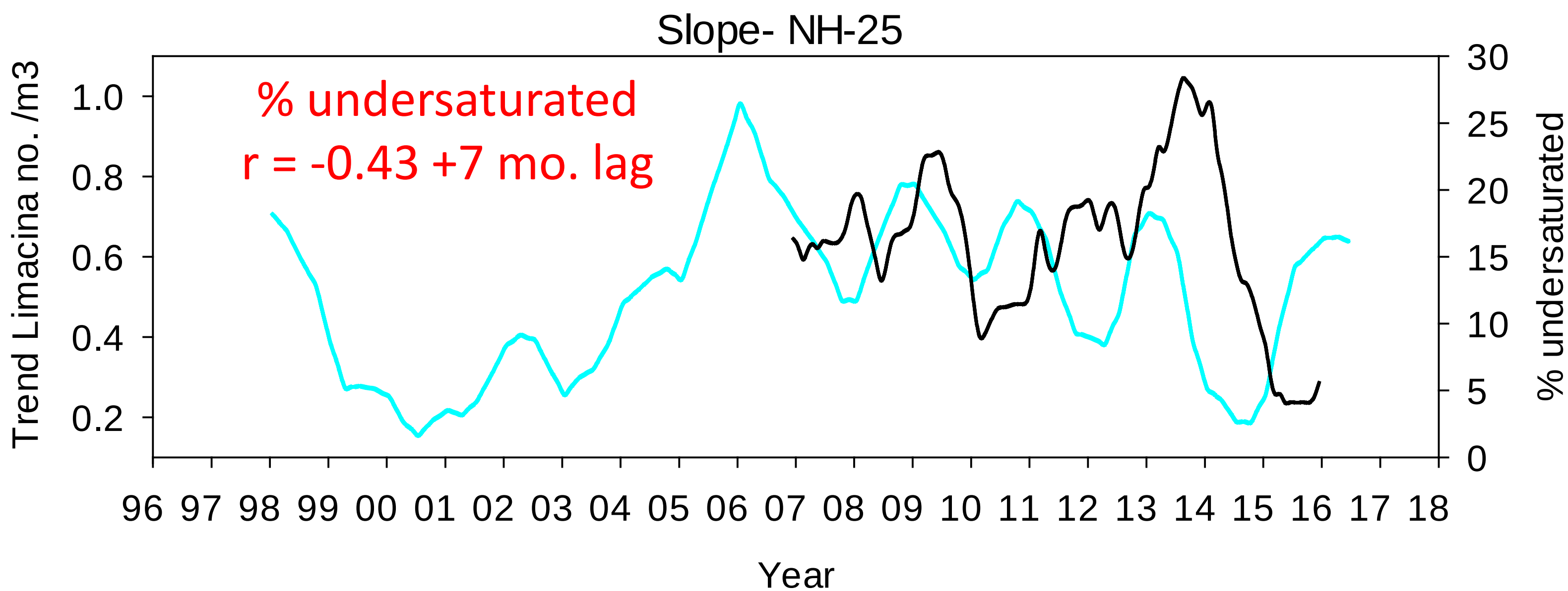
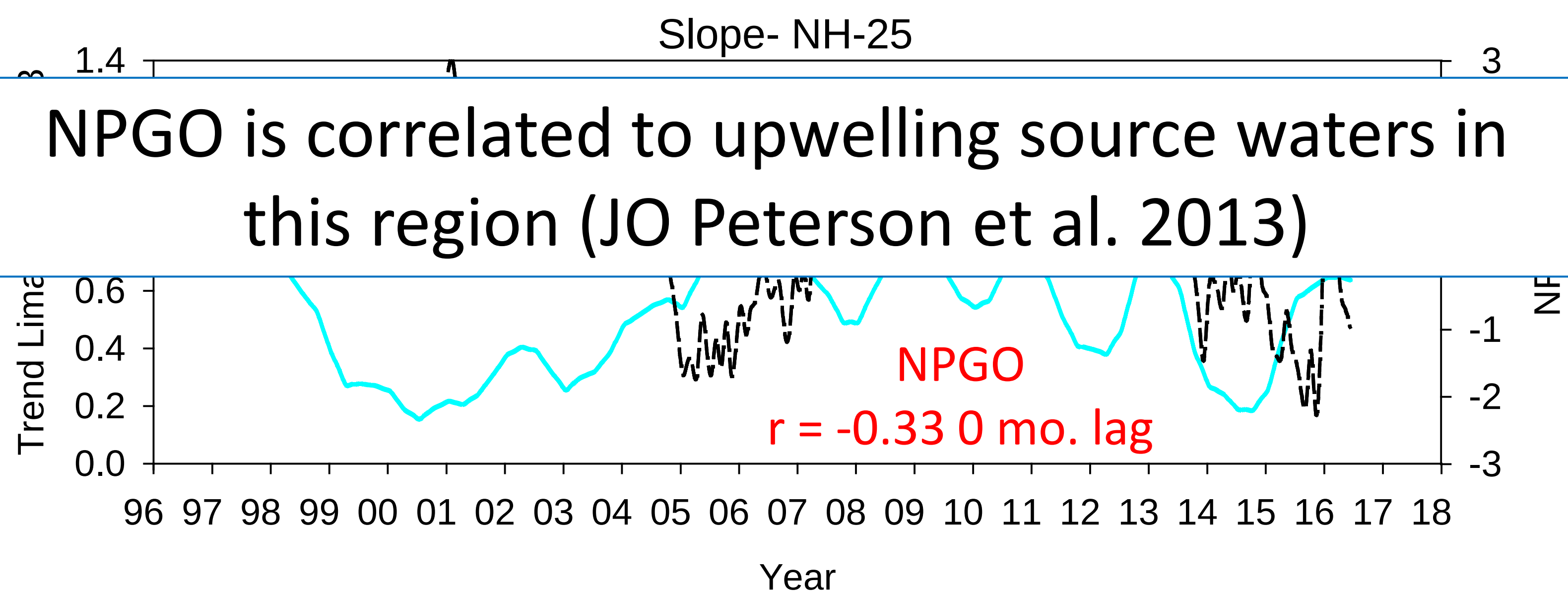




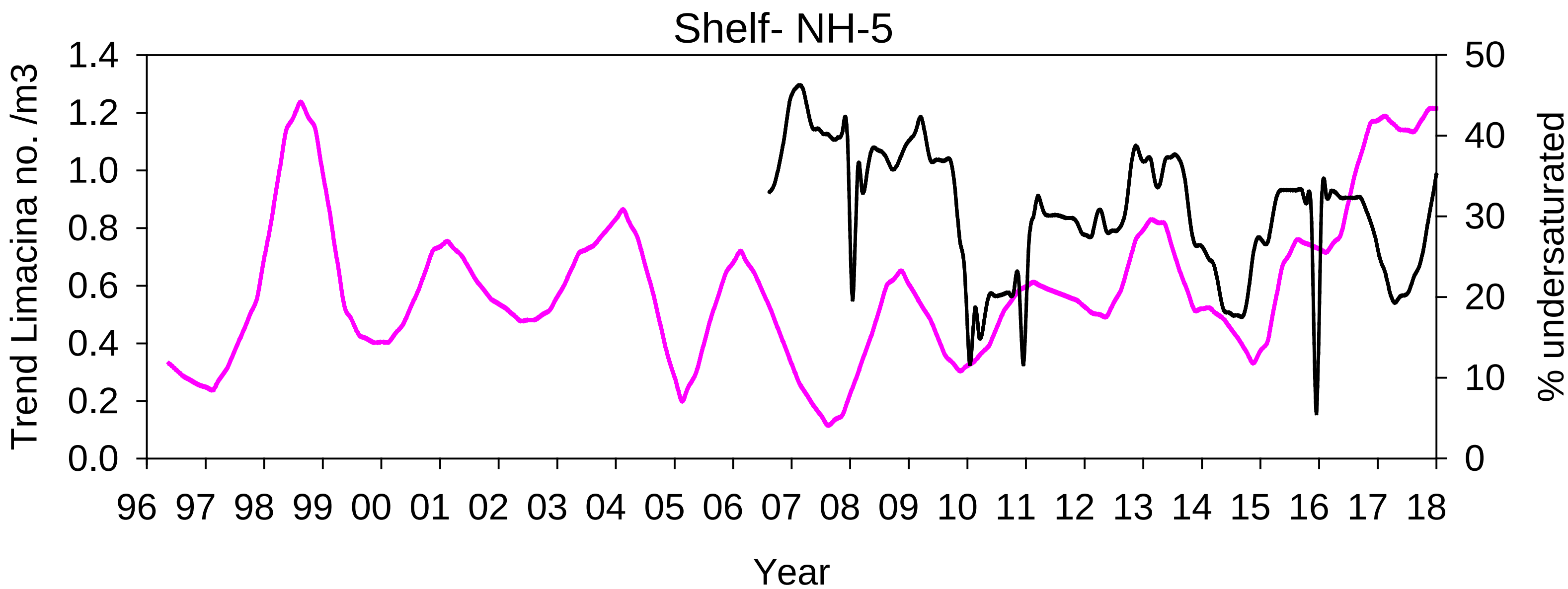
Long term trends in *Limacina* sp. on the slope correlated with % of water column undersaturated

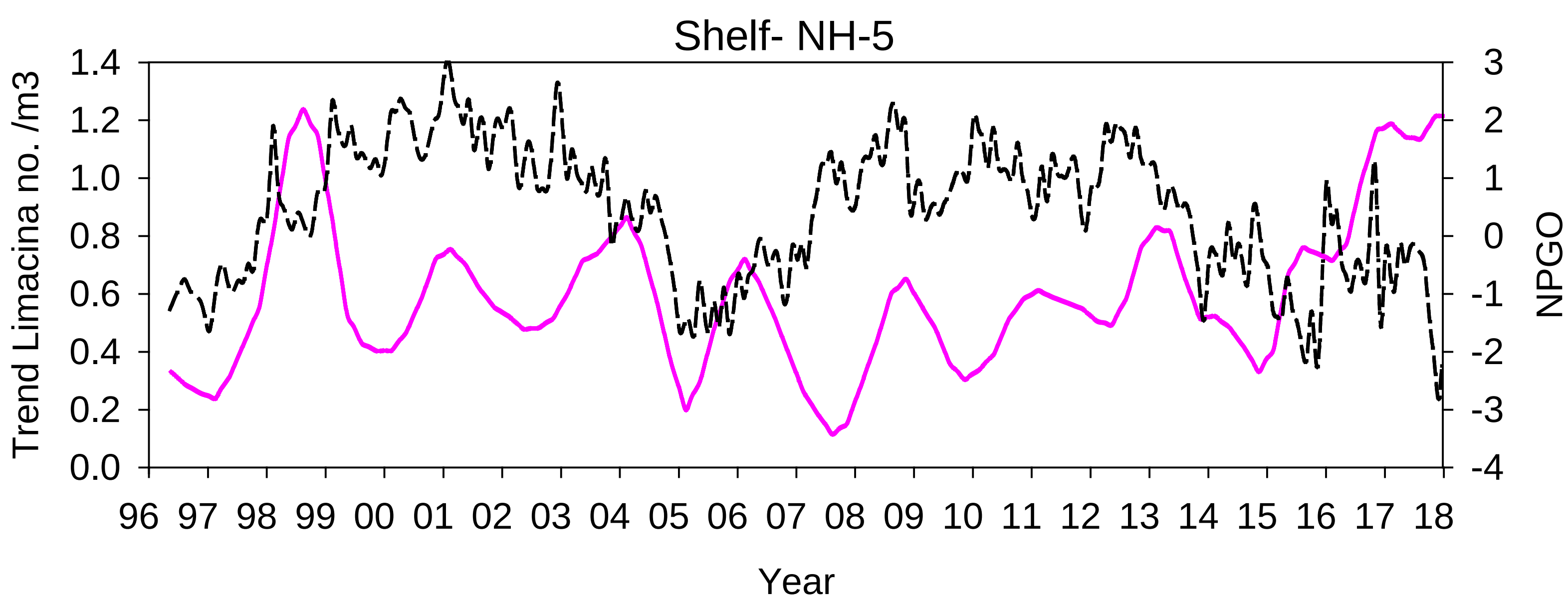




NPGO is correlated to upwelling source waters in this region (JO Peterson et al. 2013)

Long term trends in *Limacina* sp. on the shelf variable and not correlated with aragonite or NPGO



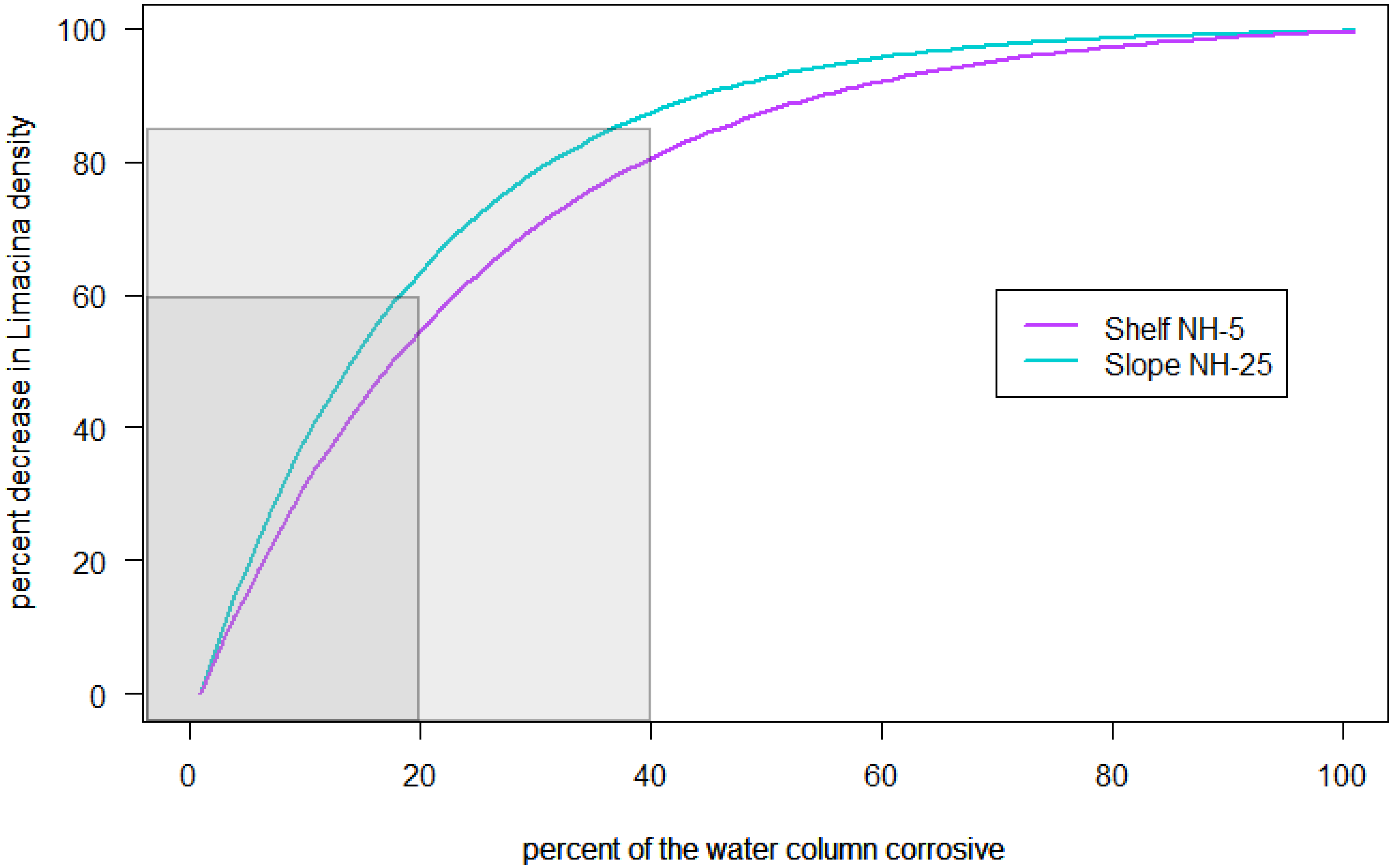


Generalized Linear Model preliminary results

working towards zero-inflated model

	Slope- NH-25		Shelf- NH-5
Effect			
Year	*		*
Month	*		*
% water Ω<1	*		*
NPGO	*		*
PDO	--		--
ONI	--		--

Limacina sp. decreases rapidly in response to the fraction of the water column that is corrosive



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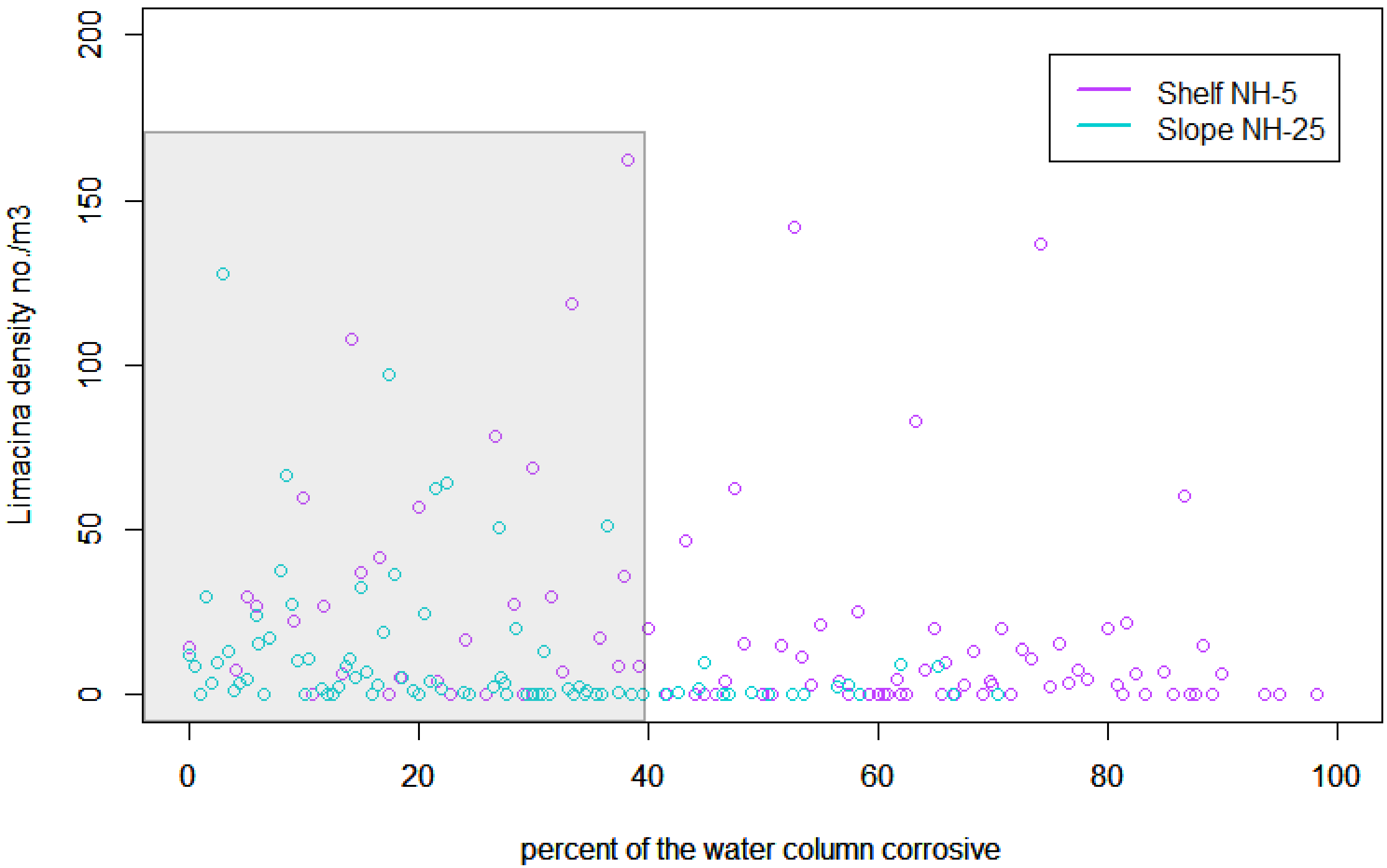

Summary- nearshore

- Shelf dominated (80%) by corrosive water seasonally creating habitat unsuitable for *Limacina* sp.
- *Limacina* sp. abundance drops dramatically when the shelf waters are most corrosive
- Long term trends in *Limacina* sp. abundance not correlated with other variables

Summary- offshore

- Suitable habitat available during most of the year, with corrosive water occupying 30% of the upper 100 m during July - Oct
- *Limacina* sp. abundance peaks in May when the water is not corrosive
- Long term trends in pteropod abundance are correlated with the % of the water column undersaturated and with the NPGO

Conclusions

- *Limacina* sp. do not appear to be declining over the 20-year time series
- However, *Limacina* sp. abundance appears to be strongly influenced by the fraction of the water column that is corrosive
- Future ocean conditions with increased corrosivity will reduce pteropod habitat and likely lead to declines

Acknowledgements

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