Comparison of chaetognath assemblages along the Pacific Coast and adjacent Inland Waters of the Philippines: biological indicator of water movement

Mary Mar P. Noblezada[1,2*] and Wilfredo L. Campos[2]

[1] Atmosphere and Ocean Research Institute, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba 277-8564 Japan, marymar@aori.u-tokyo.ac.jp/zoea21st@yahoo.com

[2] OceanBio Laboratory, Division of Biological Sciences, College of Arts and Sciences, University of the Philippines Visayas, 5023, Miagao, Iloilo, Philippines, oceanbio2002@yahoo.com

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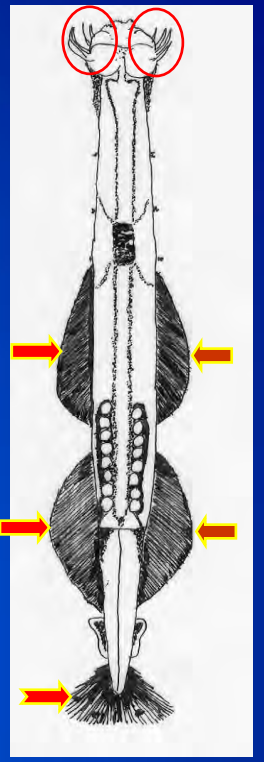
INTRODUCTION

Phylum Chaetognatha

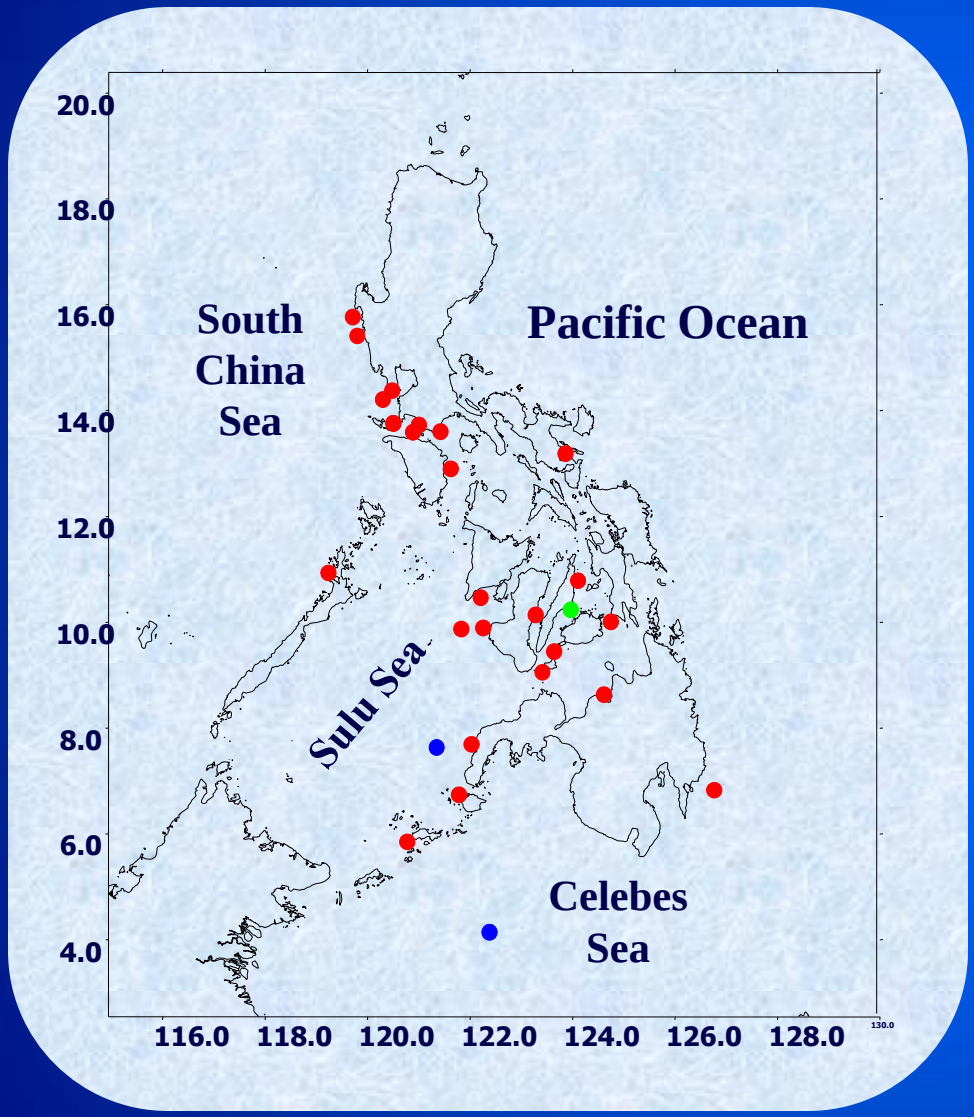
- Vermiform marine invertebrates
- " Arrow Worms or Glass Worms"
- colorless, transparent, and slightly opaque
- torpedo-shaped body



Importance of studying chaetognaths

- Important components in most marine planktonic communities
- Active predators/competitors of copepods, other crustaceans and fish larvae/eggs
- Valuation of the reduction of larval abundance of fish and other marine fauna
- Good indicator of water masses: biological indicator

Studies in the Philippines



Major Studies

- Michael 1919
- Jumao-as & Westernhagen 1978
- Johnson 2005

Others

- Bieri 1959
- Alvariño 1967
- Rottman 1978

Focused mainly on the western waters of the Philippines and some limited to specific water basins

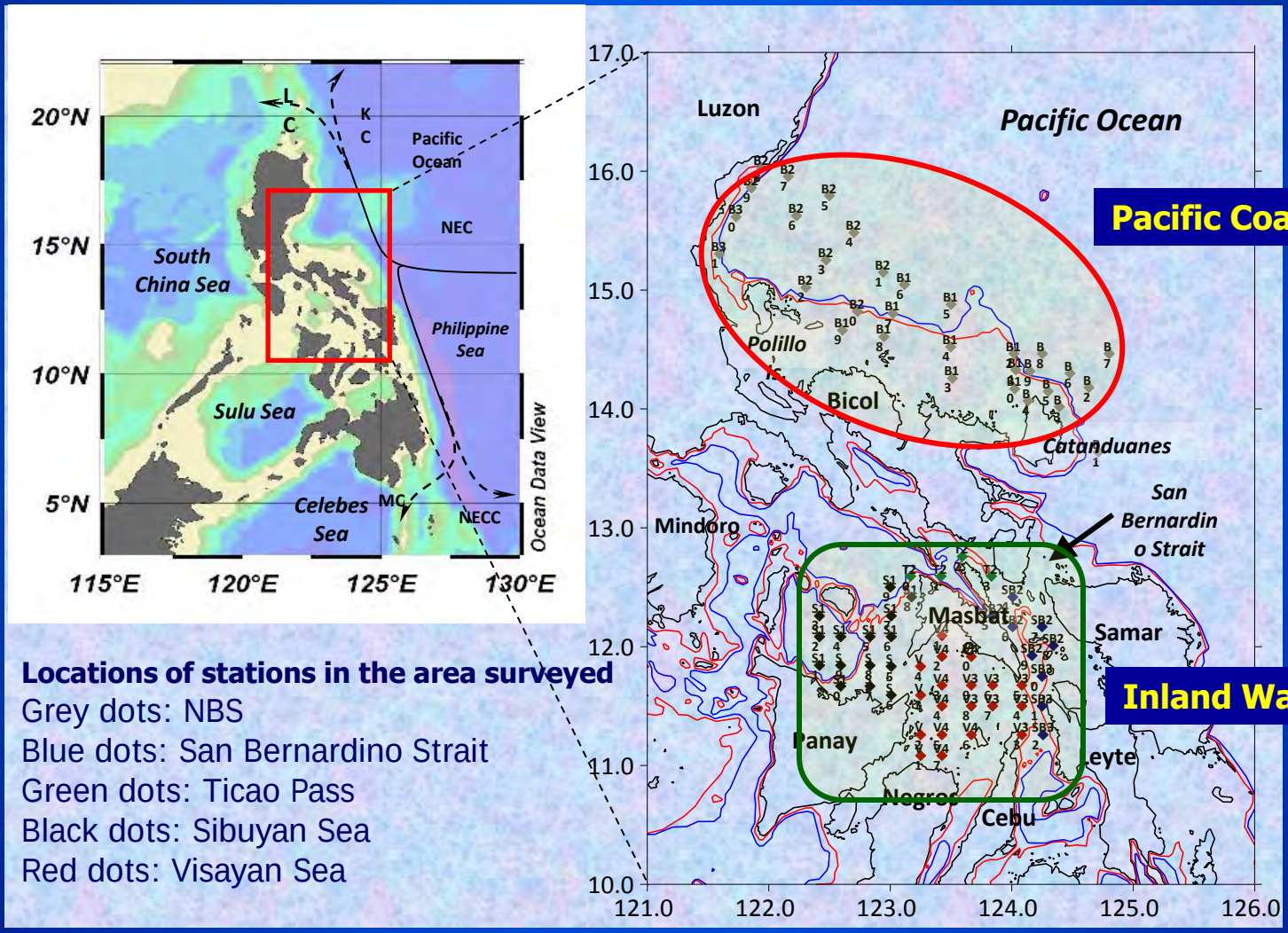
OBJECTIVES

- determine the species composition, abundance and distribution of chaetognaths;

- determine hydrographic conditions that possibly influence variation in their composition, abundance and distribution; and

MATERIALS AND METHODS

Study Area



Locations of stations in the area surveyed

Grey dots: NBS

Blue dots: San Bernardino Strait

Green dots: Ticao Pass

Black dots: Sibuyan Sea

Red dots: Visayan Sea

Note: 200m isobath is shown as a red line surrounding the major islands while the blue line represents the 500m isobath.

Oceanographic Sampling

PACIFIC Seaboard R&D Program

Bicol Shelf (Pacific Coast)

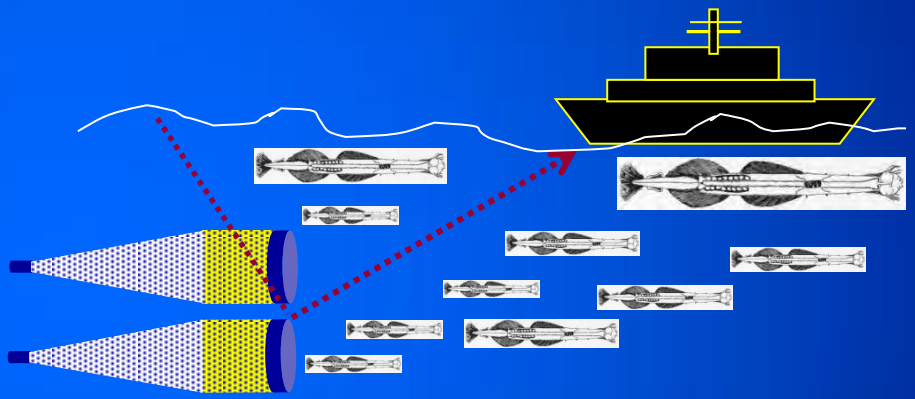
- 1-11 April 2001
- 31 stations
- R/V DA-BFAR

Internal Waters

- 26 April – 2 May 2001
- 47 stations
- TRV Sardinella

Double Oblique Tow (DOT)

- 60-cm diameter ring (bongo net)
- 335µm mesh
- fitted with flowmeter
- maximum depth 100m
- 5m above the bottom (shallow stations)



Hydrographic profiles

- SBE911 + CTD Rosette system
- CTD – SEACAT Profiler
- Nu – Shuttle Chelsea Instrument
- Van Dorn bottles
- oceanographic data: temperature, nutrients, c*hlorophyll a* & salinity

Sample Processing

- samples preserved in 10% buffered seawater-formalin solution
- chaetognaths were sorted out from the samples
- identified to species level
  - dissecting and compound microscopes

Biomass

- vol. displacement method ($ml.\cdot m^{-3}$)

Density

- $ind.\cdot 100m^{-3}$
- plotted on maps of the study area

Data Analysis

Diversity Indices

- Shannon diversity index (H′)
- Species Richness (S)
- Pielou species evenness (J′)

$H' = - \sum (P_i) \ln P_i$
Where: P_i is the proportional abundance of the ith species (n_i/N)

$J' = H'/\ln S$
Where: H′ – species diversity
S - species richness

Cluster Analyses (Q and R)

- Bray-curtis dissimilarity coefficient (data log10 (x+1)
- Program COMM (Piepenburg and Piatkovski 1992)

$$B = \frac{\sum /x_{ij} - x_{ik}/}{\sum (xij + xik)}$$

Q-mode cluster analysis

- examine station clusters

R-mode analysis

- assemblages of species showing similar relative abundances in the same stations

Stepwise multiple regression

- gain insight into the hydropgrahic factors that influence the distribution of various assemblages and chaetognath overall densities

- Hydrographic factors include: surface and bottom of salinity, temperature, chlorophyll *a*, nutrients and stratification index

RESULT

Species	Area					
	Bicol	Sibuyan	Ticao	San	Visayan Sea	All
	%	%	%	%	%	%
Aidanosagitta neglecta	12.3	37.2	18.8	14.9	79.7	54.7
Flaccisagitta enflata	43.0	32.4	34.6	39.4	12.9	23.8
Serratosagitta serratodentata	10.0	12.2	3.0	15.5	0.7	5.5
Sagitta bipunctata	7.2	2.3	9.1	4.1	0.5	2.3
Ferosagitta ferox	5.6	2.7	1.2	7.2	0.3	2.2
Mesosagitta minima	2.3	2.5	9.2	2.8	0.8	1.5
Pterosagitta draco	0.1	1.8	0.5	5.3	1.3	1.5
Zonosagitta bedoti	4.6	0.7	2.5	1.0	0.6	1.3
Ferosagitta robusta	3.1	0.5	0.4	1.0	0.6	1.0
Decipisagitta decipiens	1.6	1.5	3.4	2.5	0.2	0.9
Total no. of genera	14	15	13	15	16	17
Total no. of species	26	28	22	29	26	33
Density of all species	444.7	889.3	111.3	887.9	2428.8	1061.2
						95.2%

Relative abundance (%) of top 10 chaetognath species recorded in the various basins surveyed in April – May 2001

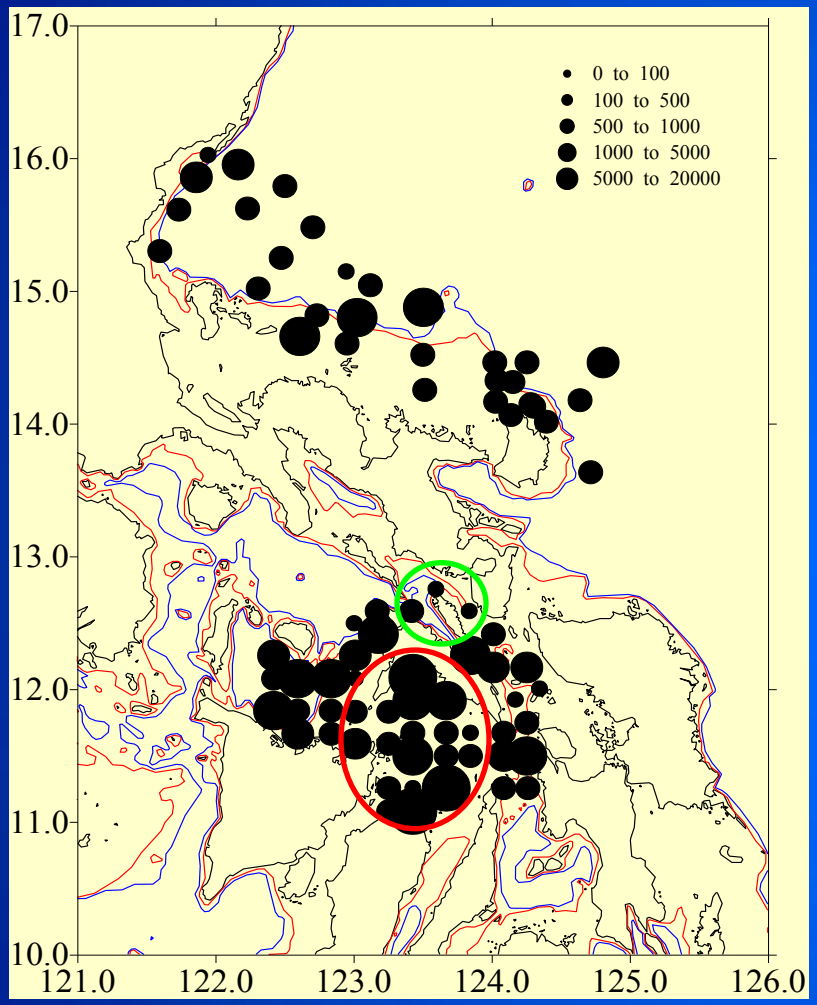
Total specimens examined = 28, 284

- ⇒ 33 species
- ⇒ 17 genera
- ⇒ 5 families

Top 10 comprised 95.2 %

- ⇒ *A. neglecta* (54.7 %)
- ⇒ *F. enflata* (23.9%)

Density Distribution



Spatial distribution of chaetognath densities (no. ind.100^{-3}) in the area surveyed in April – May 2001.

Overall Mean Density

➢1,061.2 ind.100m^{-3}

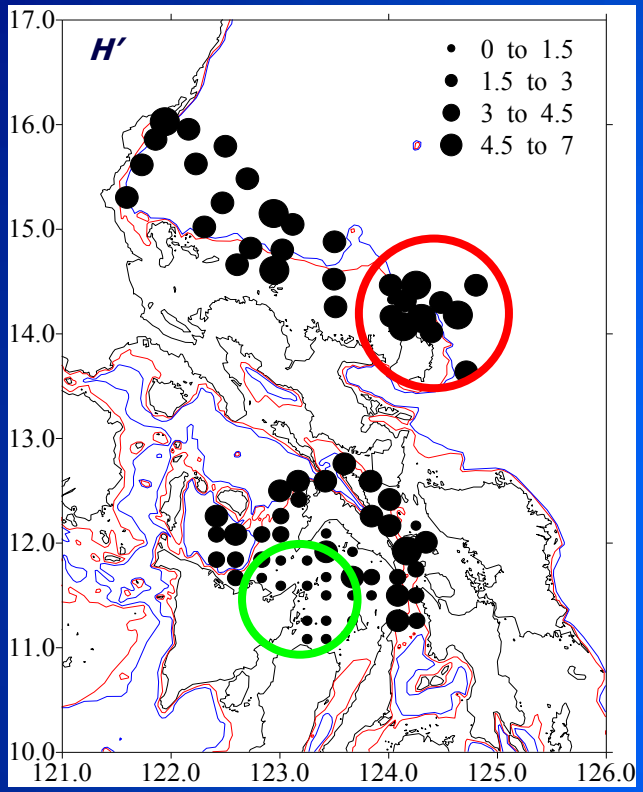
Highest density (no. ind.100^{-3})

✓ Visayan Sea (2,428.8)

Lowest density

✓ Ticao Pass (111.3)

Diversity



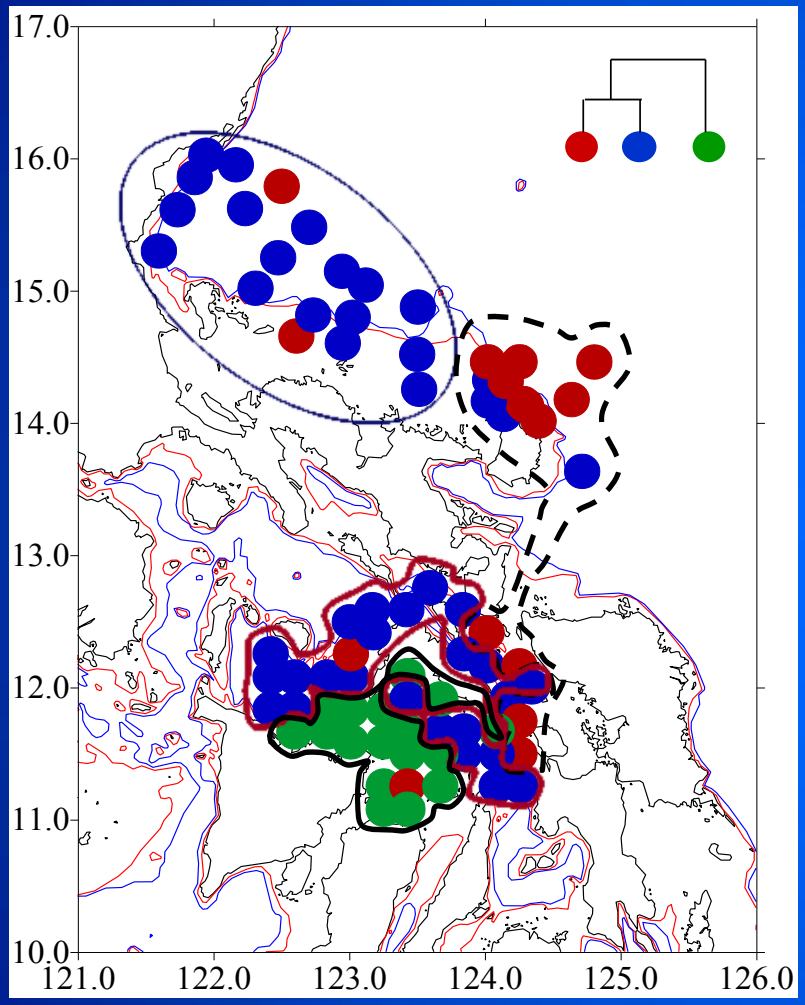
Spatial distribution of Shannon Diversity Index

- Diversity overall mean:
  - Inland waters (2.2)
  - NBS (4.0)
- Highest: southeastern portion of NBS
- Lowest: Visayan Sea
  - low diversity attributed to the numerical dominance of *A. neglecta*
- Overall: diversity decreased from Pacific coast towards internal waters

Comparison of Overall Mean Shannon diversity index (*H'*) with previous studies

Location	*H'* values	Reference	No. of stations	Gear Type
Sulu sea	2.11	Johnson (2005)	1 (16 depths)	MOCNESS
Sulu Sea	2.07 – 3.17	Cordero (2006)	9	HT
Celebes Sea	1.87	Johnson (2005)	1 (16 depths)	MOCNESS
Bicol Shelf	4.0	Present study	31	DOT
Inland Basins	2.2	Present study	47	DOT

Spatial Distribution



Map of the geographical location of station clusters

3 MAJOR STATION CLUSTERS

Pacific Inflow : Red circles

- comprised of San Bernardino and north Catanduanes stations
- correspond with Pacific water entering Internal Seas via San Bernardino Strait

Bicol Shelf and Visayan Shelf Margin : Blue circles

- consists of stations in Ticao Pass and deep stations in the Visayan and Sibuyan Seas

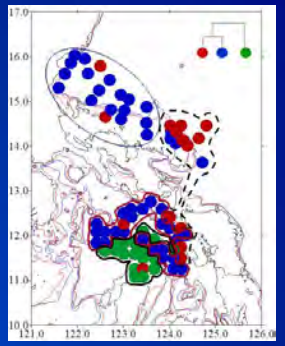
Visayan Sea Shelf : Green circles

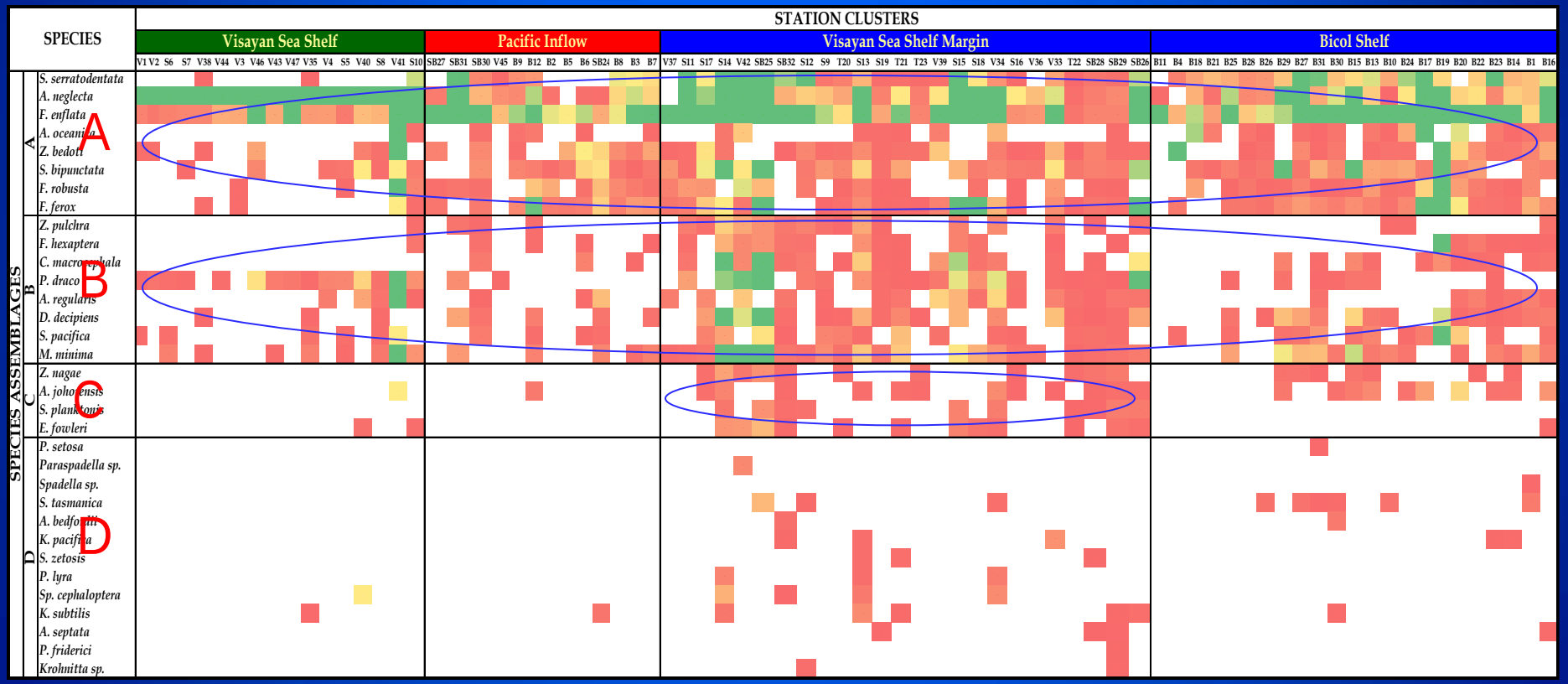
- includes station located at the inner and shallow portion of the Visayan Sea and southeastern Sibuyan Sea

Community structure & pattern of distribution

R-mode cluster analysis: 4 species assemblages

- A: High densities & frequency of occurrence
- B: widely distributed species with moderate densities
- C: frequencies of occurrence in the Visayan Sea Margin
- D: no distinct distribution pattern, rare, occurring in patches of low densities,



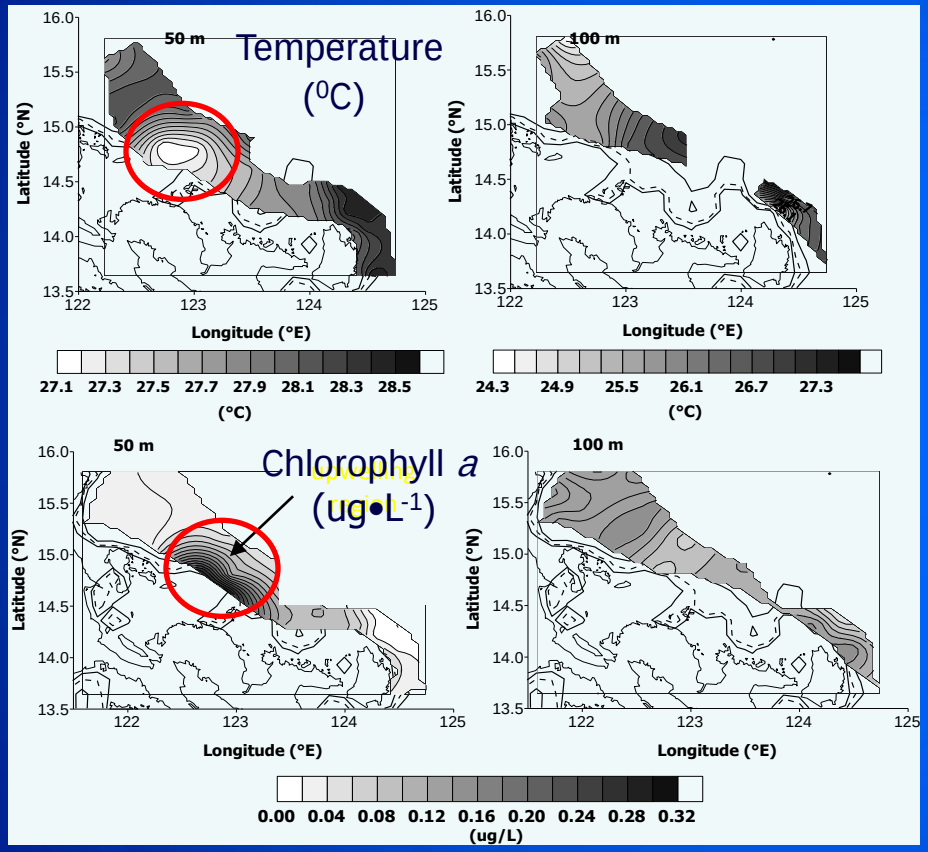


Two-way coincidence table showing station clusters and species assemblages in the survey area. Colors denote degree of relative abundance: ≥ green (20%) ≥ yellow (10%) ≥ red (0.01%) and white absent.

- **Assemblages changing gradually from Bicol Shelf to the Pacific Inflow and Visayan Sea Shelf margin and then into the Visayan Sea Shelf**

Relation to hydrography

Northern Bicol Shelf



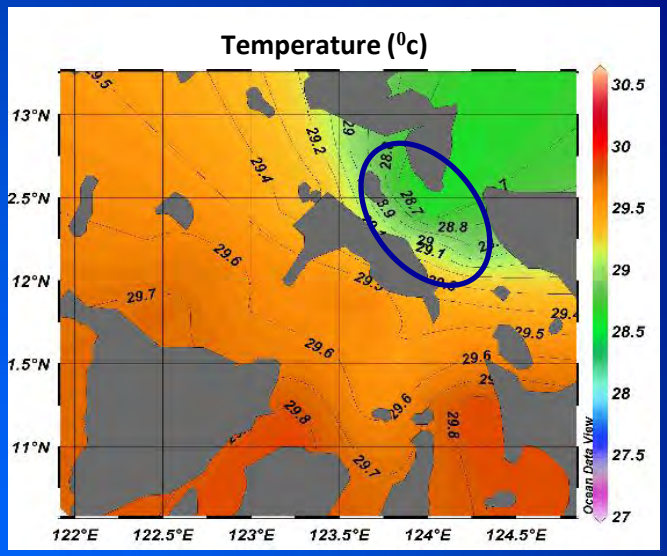
UPWELLING

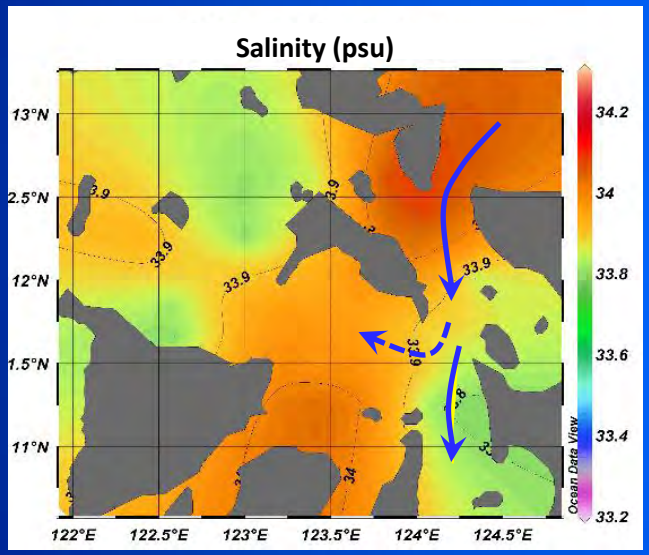
✓also where ***Spadella sp.*** recorded (benthic species)

✓ mesopelagic species

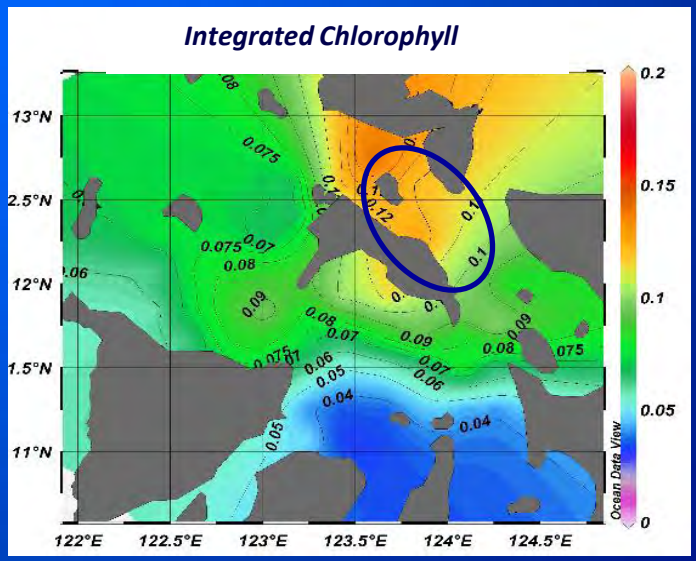
Internal Waters

- increase in temperature from Pacific to internal waters
- mixing in San Bernardino Strait & Ticao Pass
- in agreement with previously reported frontal formation (*Amedo et al.*, 2003)





- salinity decreased from the Pacific to the internal waters
  - decreased oceanic species particularly *F. enflata*
  - increase neritic species *A. neglecta*



- highest concentrations in Ticao Pass
  - (particularly in the surface)
  - consistent with front formation in the area

Multiple regression

- Temperature, salinity, NO_2 and stratification index were among the hydrographic factors influencing the distribution and abundance of chaetognaths

Dependent Variables			r2	Independent Variables						
				Temperature surface (ºC)	Temperature bottom (ºC)	Salinity surface (psu)	Salinity bottom (psu)	NO_2 surface (ug.ml^{-1})	NO_2 bottom (ug.ml^{-1})	Stratification Index
Stages		*Stage 1*	0.18		-0.29					
		Stage 2	0.17		-0.41					
		Stage 3	0.33				0.47			
		Stage 4	0.33				0.41			
Assemblages	A	*S. serratodentata*	0.22		-0.35			0.24		
		A. neglecta	0.31	0.3	0.29					
		A. oceanica	0.19			-0.34				
		Z. bedoti	0.32	-0.39						0.58
		F.robusta	0.29	-0.36		-0.26	-0.29			
	B	*Z. pulchra*	0.34	0.24	-0.44		-0.33			
		F. hexaptera	0.26		-0.27		-0.44	0.29		
		C. macrocephala	0.14		-0.33		-0.35			
		P. draco	0.27	0.25		0.24	-0.35			
		A. regularis	0.13							0.37
		D. decipiens	0.18		-0.33		-0.33	0.35		
		S. pacifica	0.18				-0.36			
	C	*A. johorensis*	0.13			-0.35				
		S. planktonis	0.13		-0.29					
	D	*Paraspadella sp.*	0.22		0.32					0.34
		S. tasmanica	0.18					0.29		
		A. bedfordii	0.7	0.16					0.79	
		K. pacifica	0.07	0.24						
		S. cephaloptera	0.07	0.26						
		K.subtilis	0.19		-0.35		0.25		0.25	

Summary of stepwise multiple regression results: Only those with significant regressions are included. The values presented are the standardized beta coefficients.

CONCLUSION

- Overall distribution of chaetognaths closely related to hydrography

- Chaetognaths are good indicators of (consistent)
  - ✓ Upwelling events
    - ➢ *Spadella sp. & mesopelagic species*
  - ✓ Intrusion of oceanic water into the internal waters
    - ➢ Pattern of distribution of oceanic species (limited to basins bordering the Visayan Sea)

RECOMMENDATION

Further investigations

- ✓ Seasonality (patterns between months & years)
- ✓ Vertical distribution (vertical migration)
  - ❖ Address trophic relationships between chaetognaths, fish larvae and eggs and other zooplankton groups (closer examination of potential as predator)
- ✓ Incorporation of biological and physical modeling synthesis and detailed analyses of hydrographical data (finer scale & long-term observations)
  - ❖ Better understanding of the hydrographic effects in the area, in the zooplankton communities and other marine fauna

ACKNOWLEDGEMENTS

Oceanbio & Marine Bio Labs People

5th International Zooplankton Production Symposium Organizers

AORI Plankton Group

DOST-PCMARD

MARAMING SALAMAT!