MONSOONAL INFLUENCE ON THE SPATIO-TEMPORAL PATTERNS OF ZOOPLANKTON ABUNDANCE AND ASSEMBLAGE STRUCTURE IN ILIGAN BAY, NORTHERN MINDANAO, PHILIPPINES

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GENERAL QUESTION:

Are zooplankton distribution and abundance patterns useful in environmental management in our region?

Issues: GROWTH OVERFISHING; POLLUTION from 10 major industries (cement, chemicals, cooking oil, steel-making plant, flour, etc); agricultural runoff; and agricultural and urban runoff; CLIMATE CHANGE

SPECIFIC QUESTION:

Do change in monsoonal wind patterns and hydrometeorological and hydrodynamic processes influence distribution and abundance patterns of zooplankton in Iligan Bay?

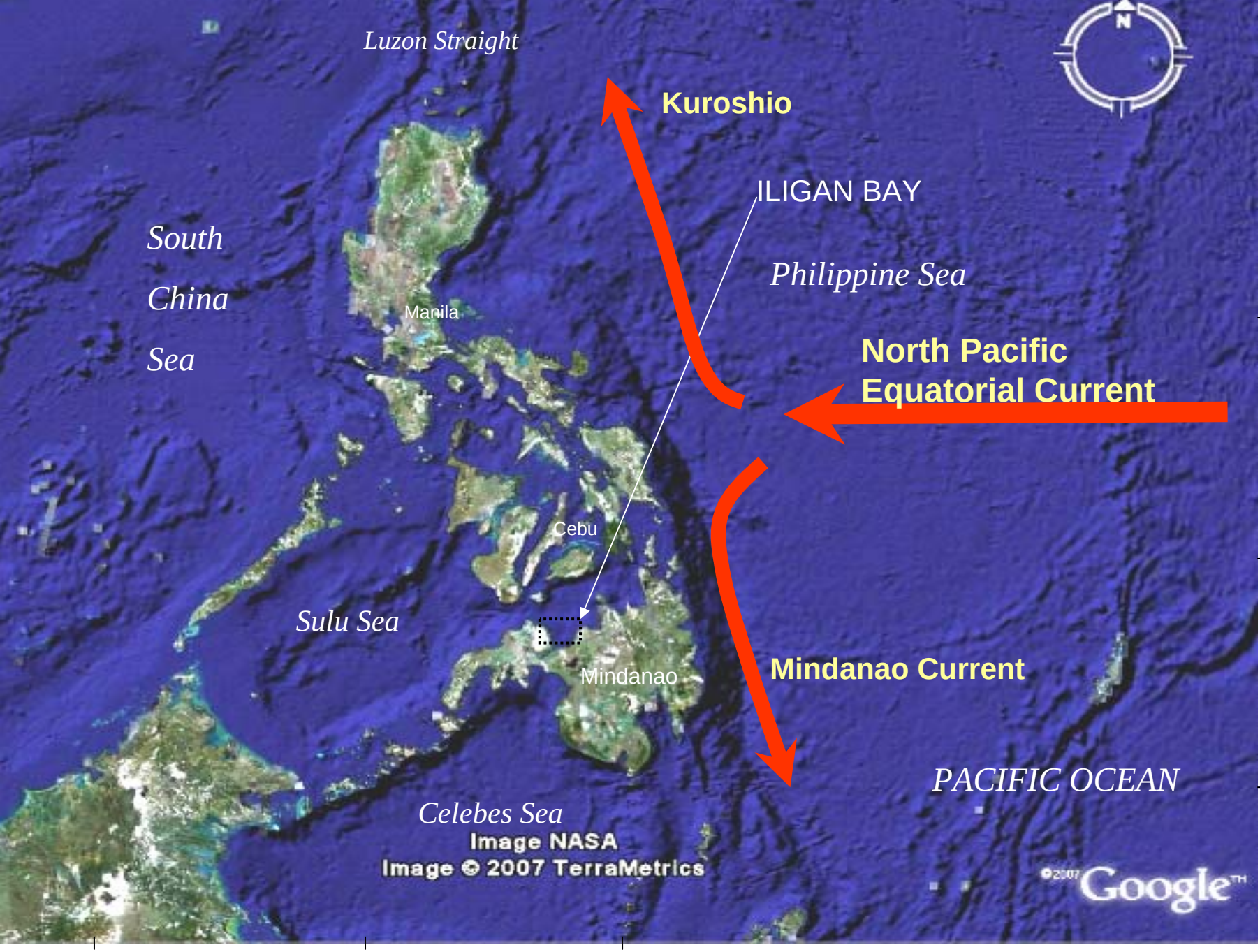
OBJECTIVES

- Determine the abundance of zooplankton during peak periods of the northeast (November-December) and southwest (July-August) monsoon winds throughout Iligan Bay,

- Determine the abundance of zooplankton in two nearshore sampling stations for one year,

- Determine the community properties of zooplankton assemblages during the baywide and one year sampling

- Use multivariate statistical analysis techniques to understand the nature and possible causes of spatio-temporal distribution patterns of zooplankton assemblages in Iligan Bay


Luzon Straight
Kuroshio
ILIGAN BAY
South
China
Sea
Philippine Sea
Manila
North Pacific
Equatorial Current
Cebu
Sulu Sea
Mindanao
Mindanao Current
PACIFIC OCEAN
Celebes Sea
Image NASA
Image © 2007 TerraMetrics
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N
15°N
10°N
5°N
115°E
120°E
125°E


Mindanao Current
Mindanao Sea
Sulu Sea
Iligan Bay
Mindanao
Celebes Sea
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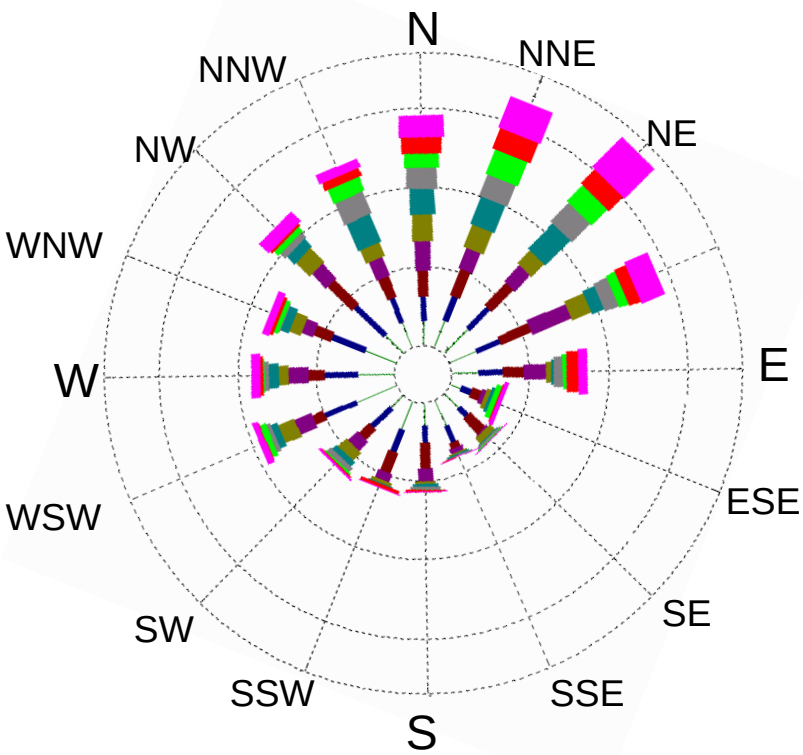
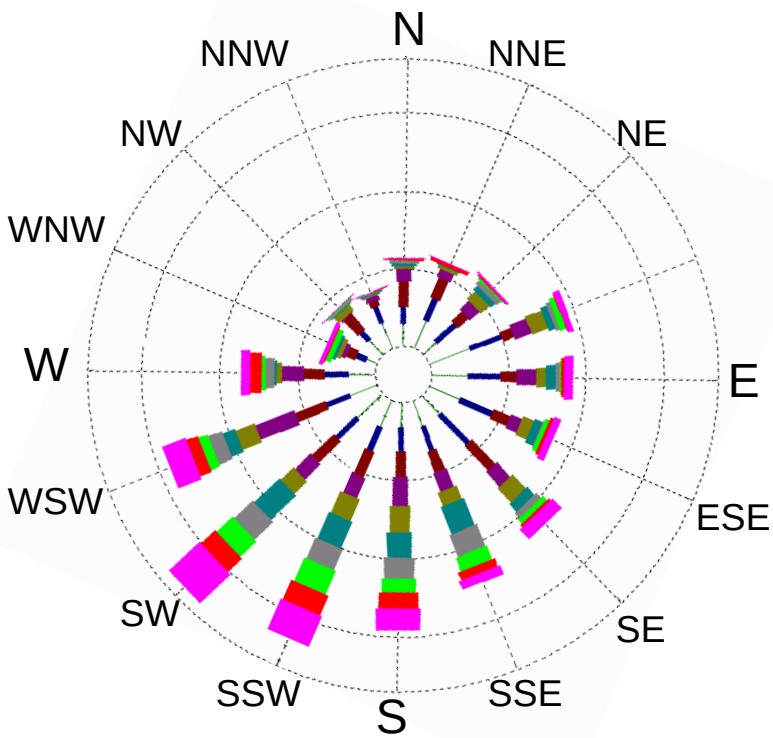
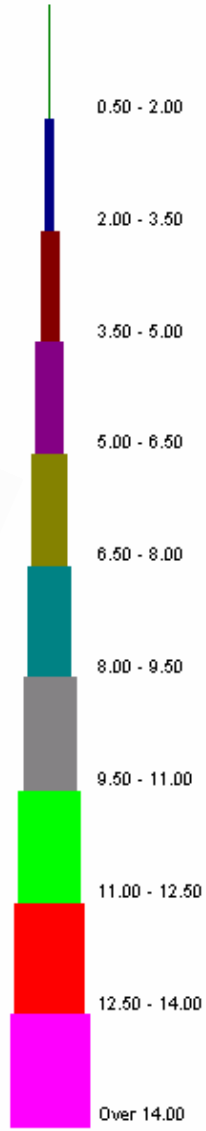
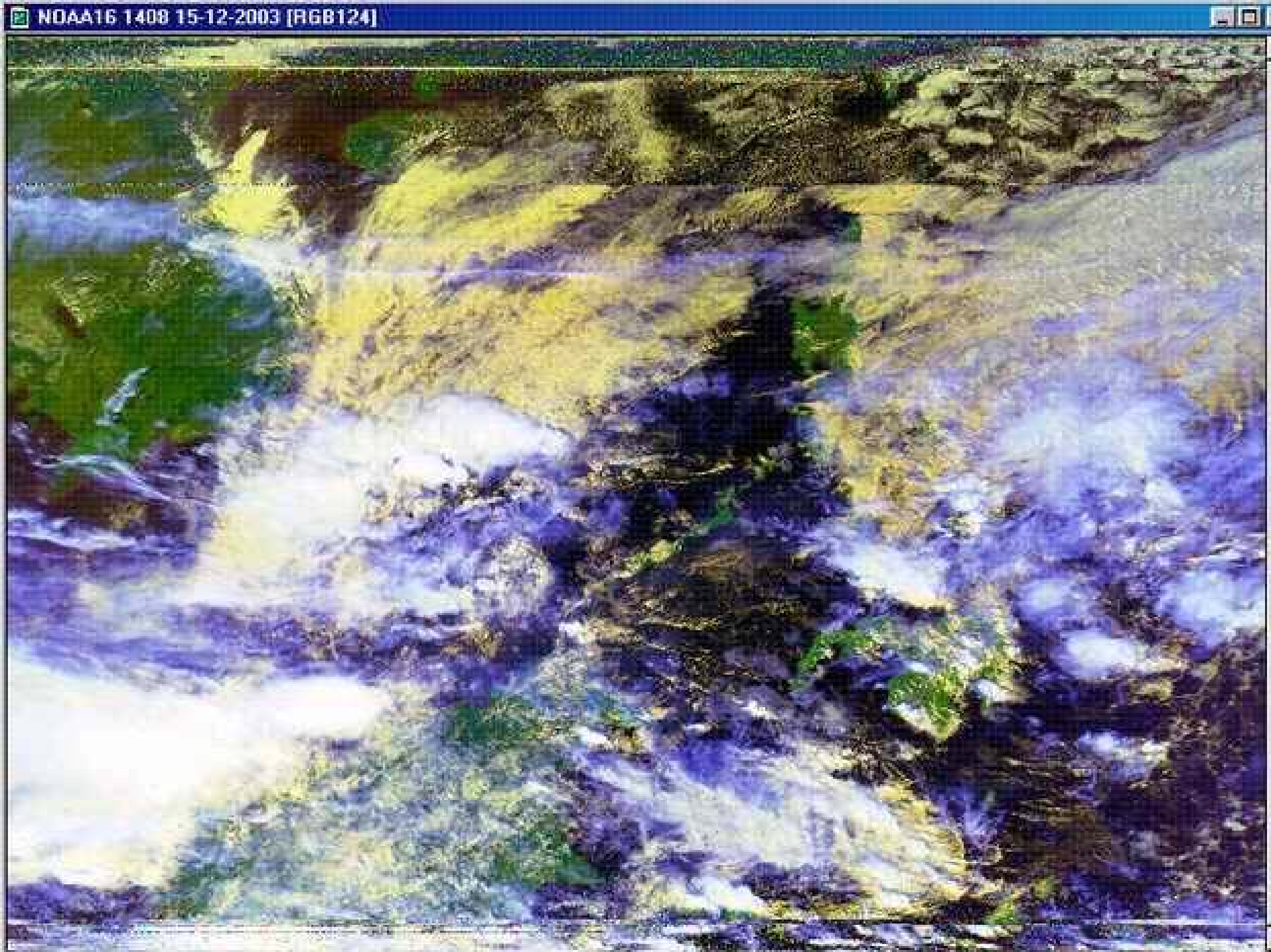
Northeast Monsoon Winds



Southwest Monsoon Winds



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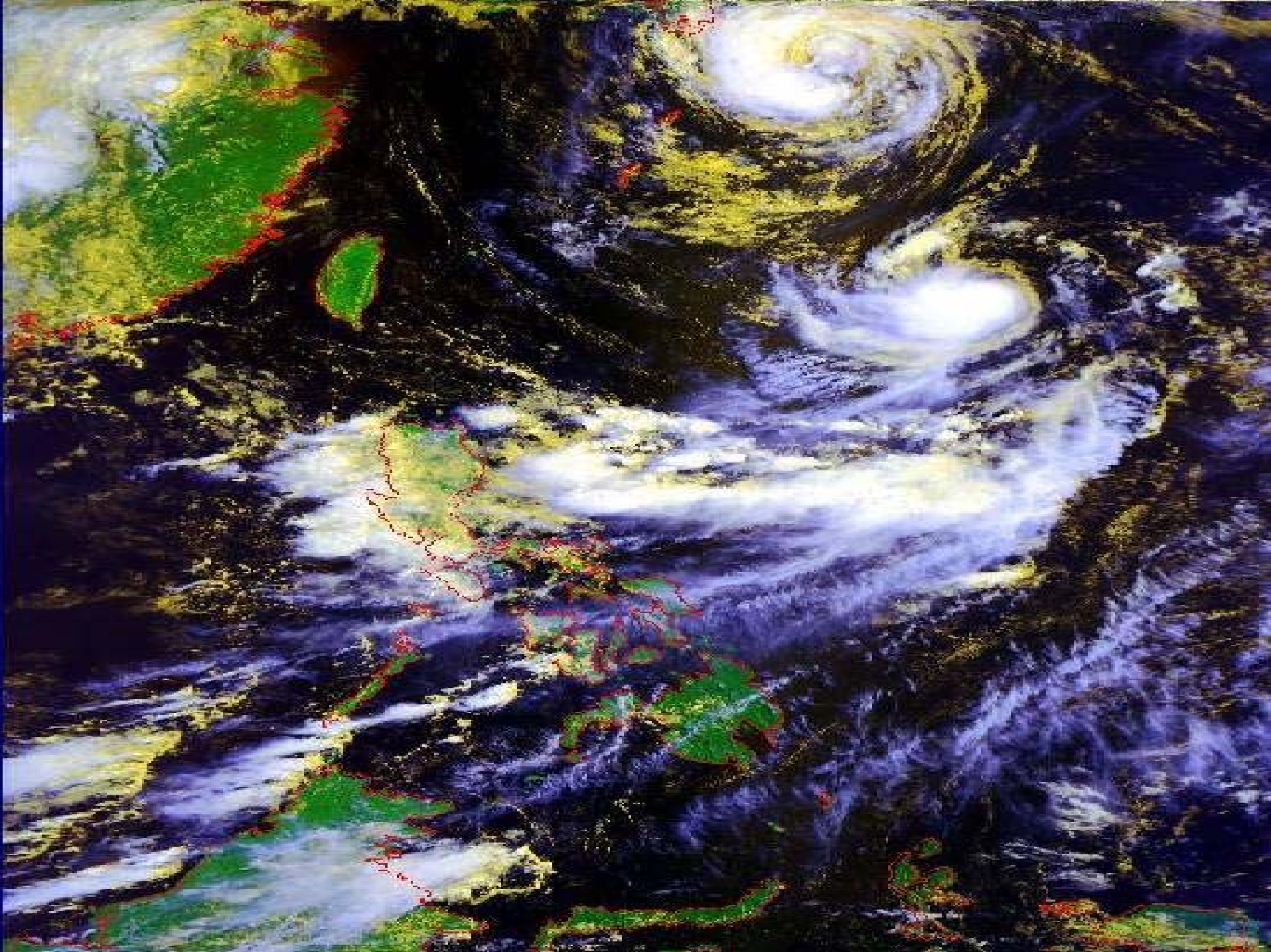
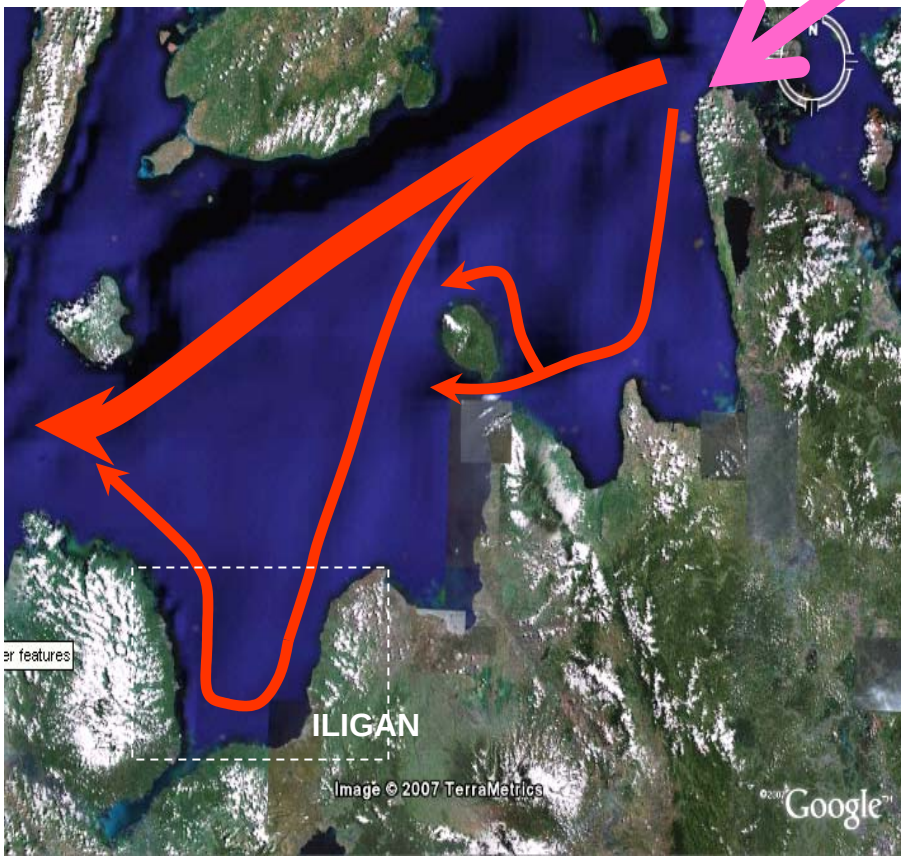
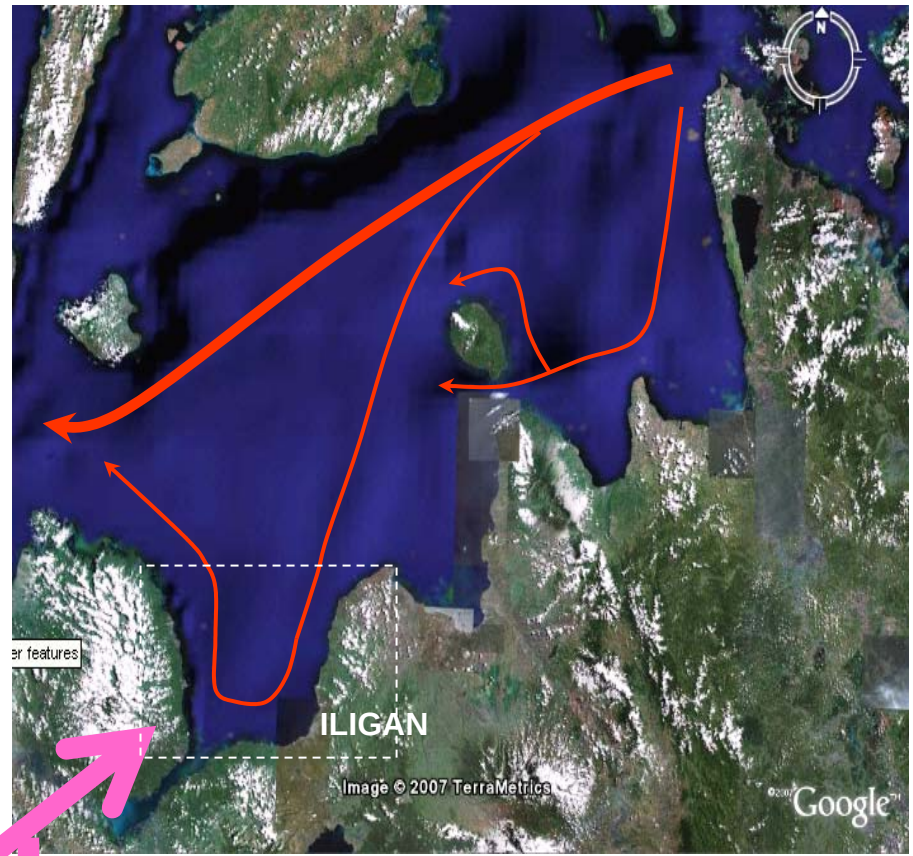
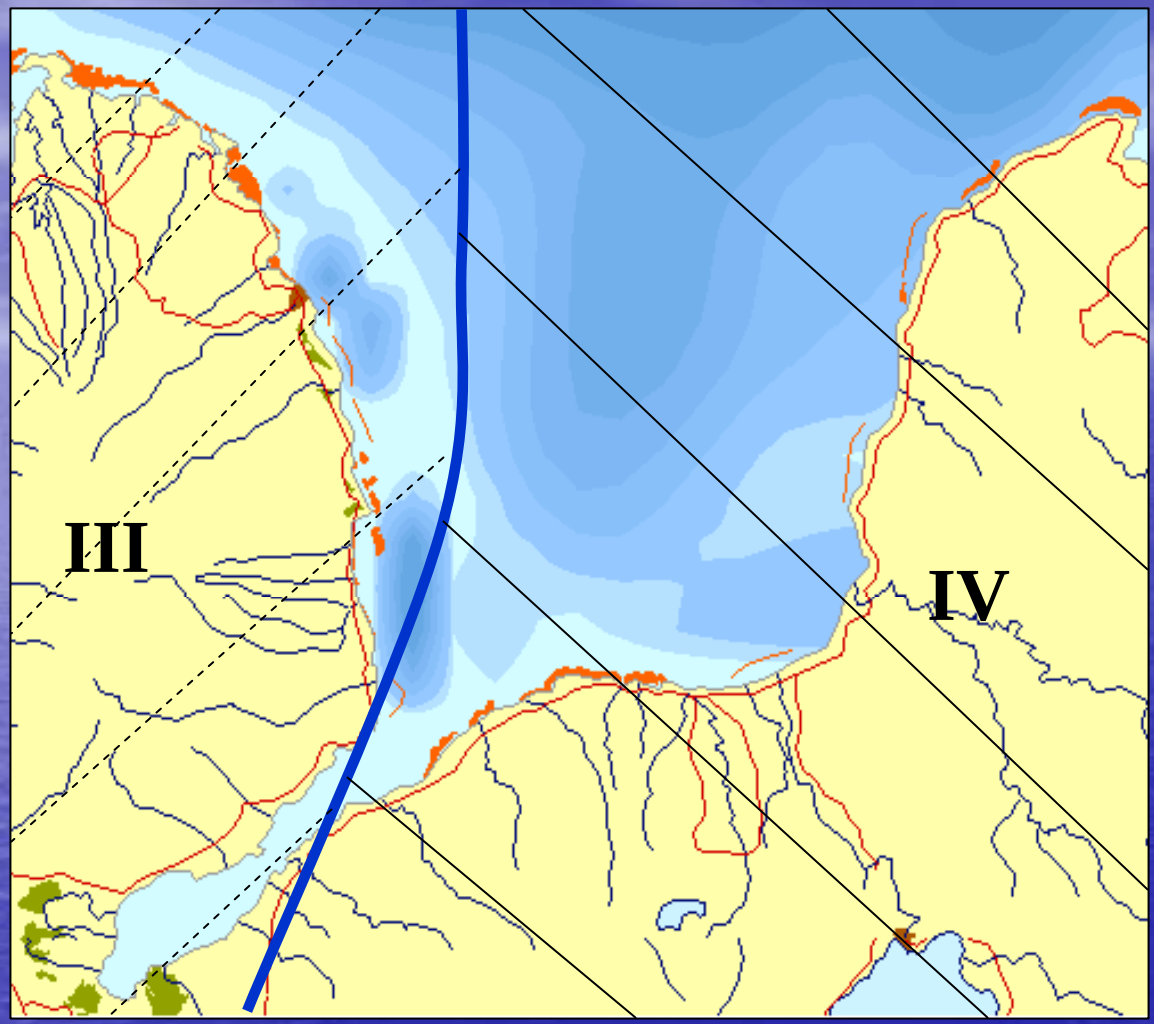


Northeast Monsoon



Southwest Monsoon



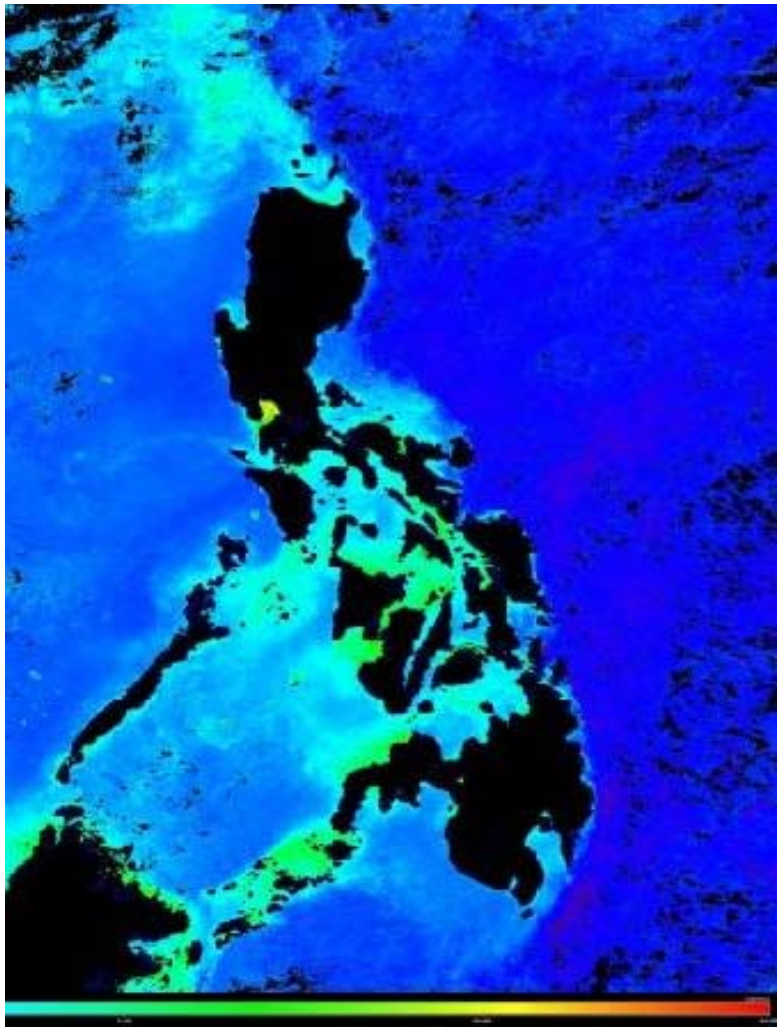


Rainfall: III-high, January to December, 48-220mm

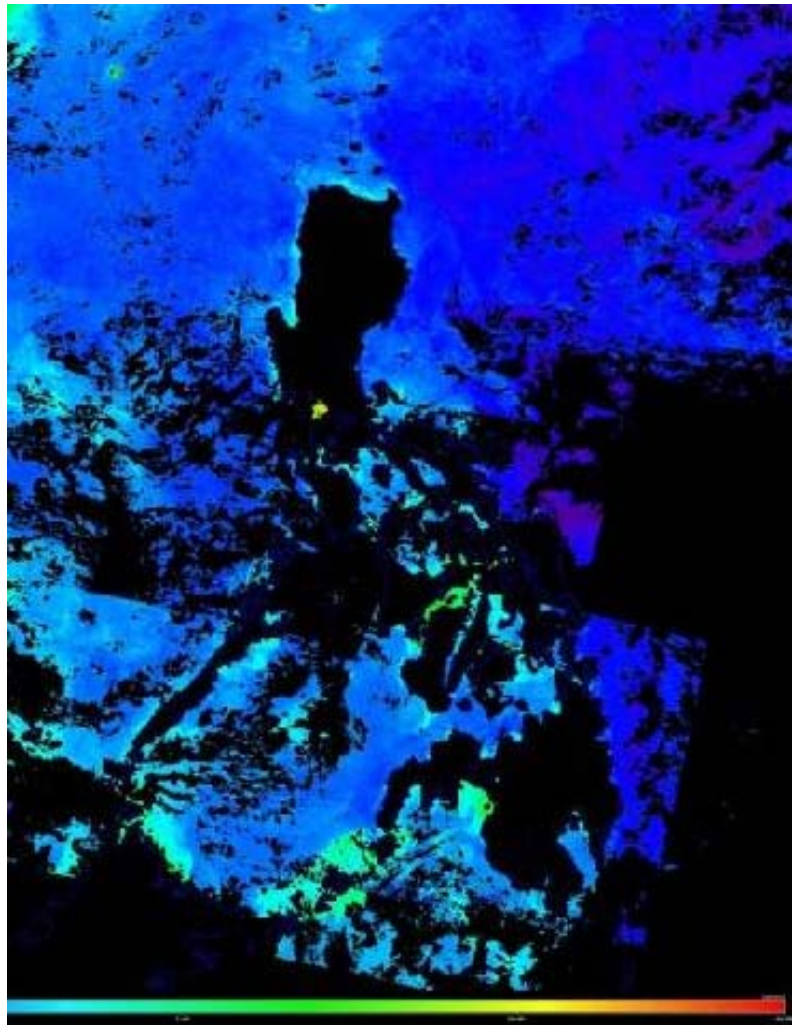
IV-Max. October to December, 60-360mm

Major River Systems = 31 Estuarised Bay

Mixed Tidal Regime: diurnal and semi-diurnal

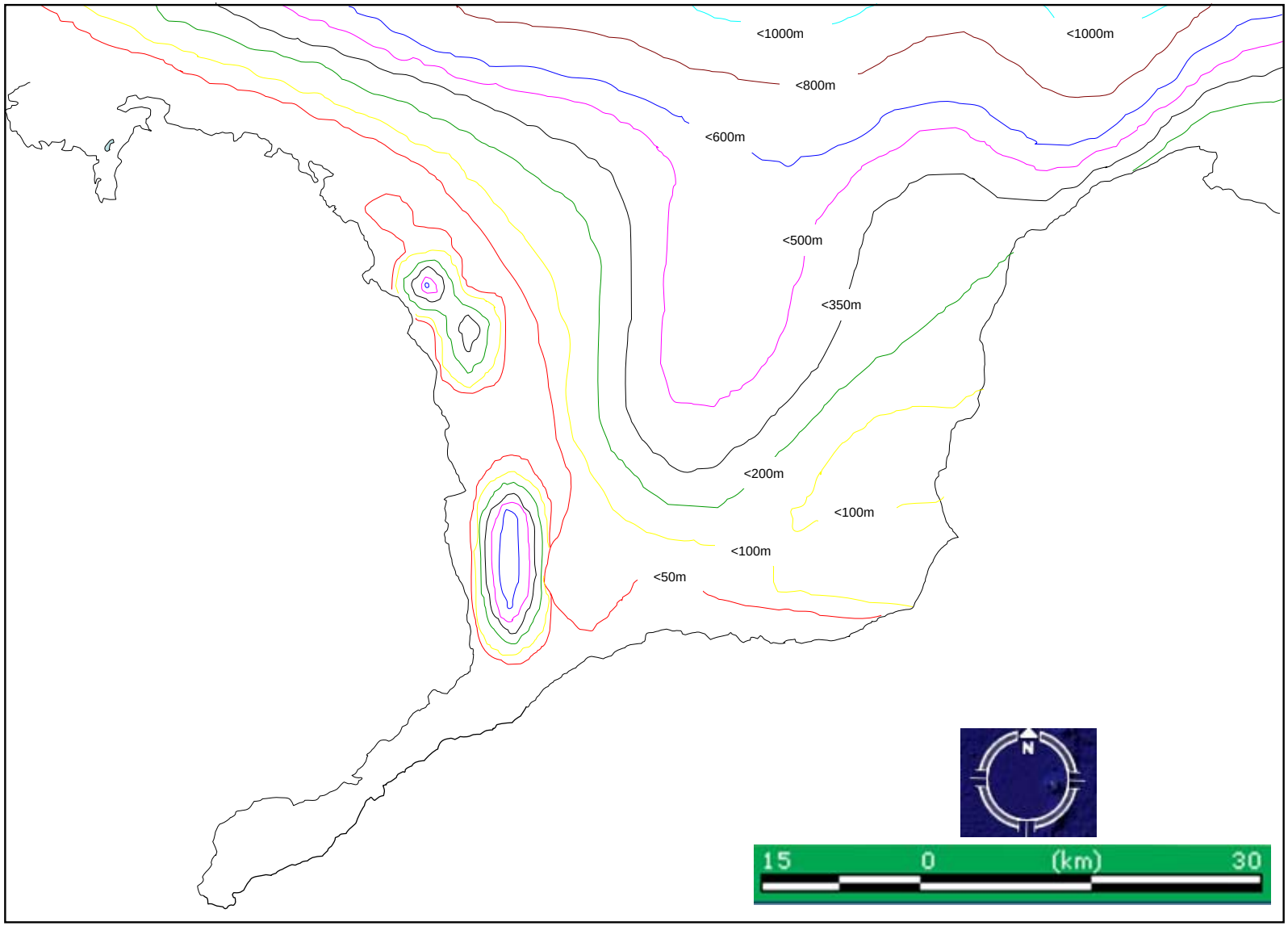


Ocean color (Chl *a*)
December 2000

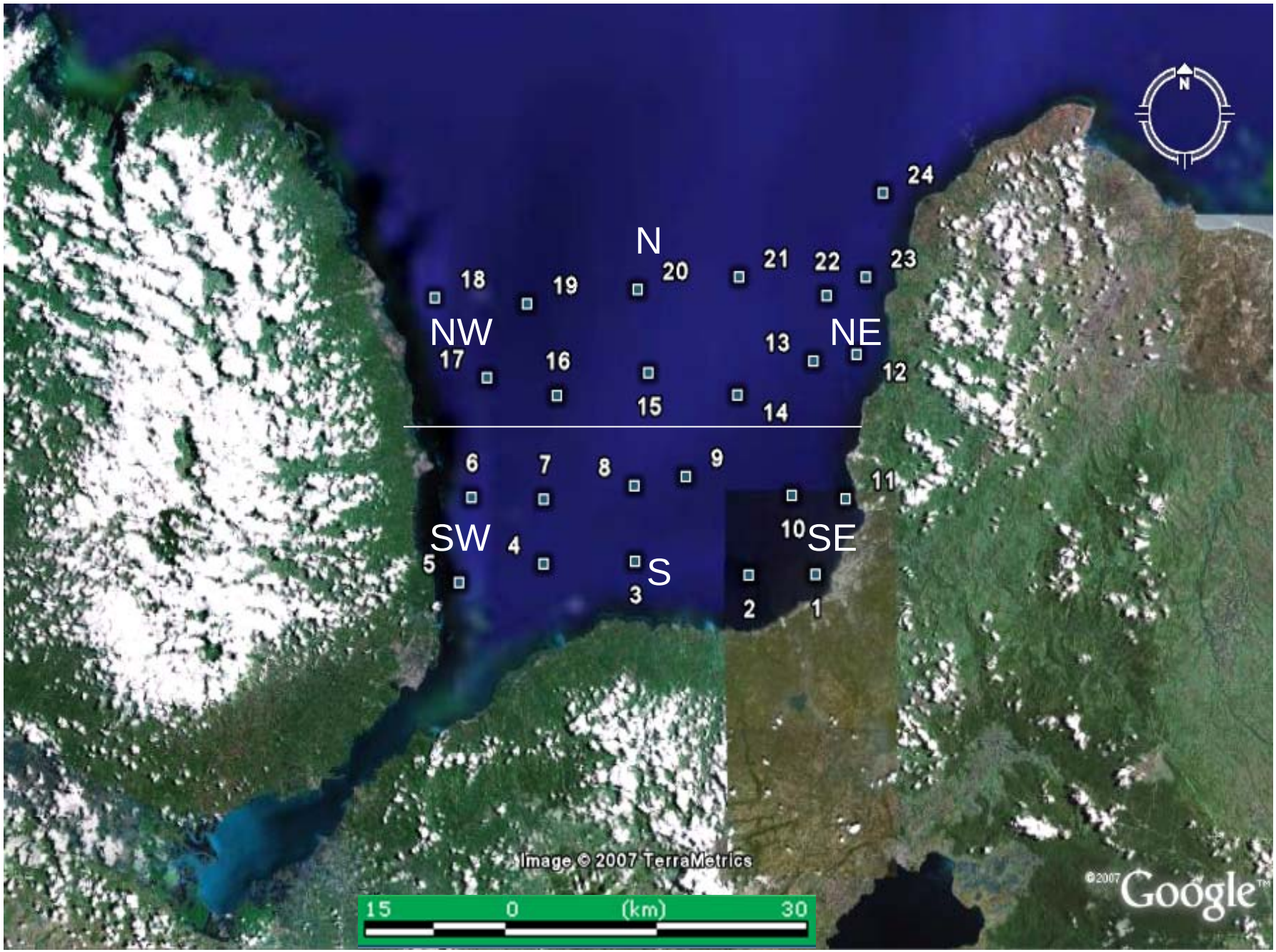


Ocean color (Chl *a*)
July 2000

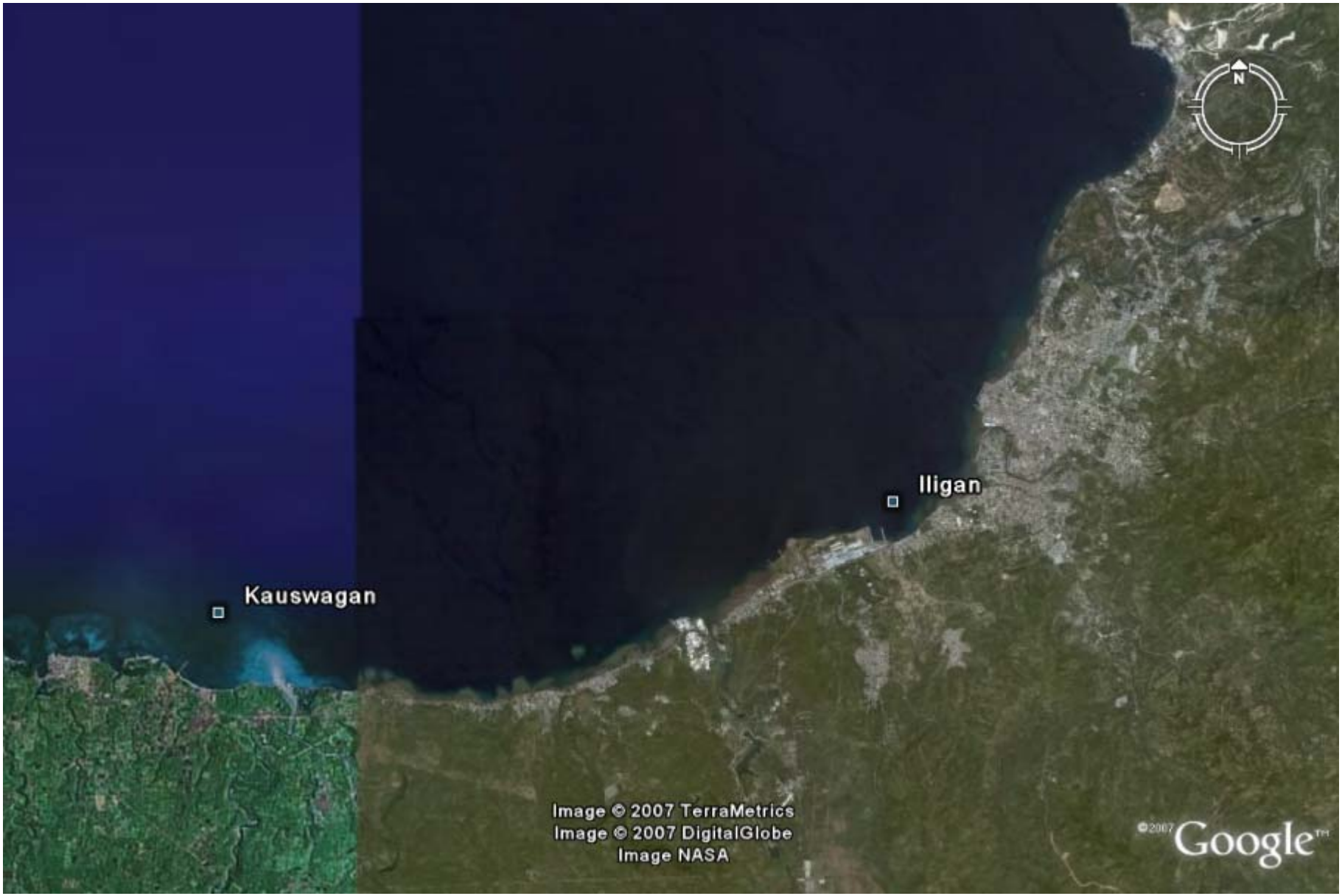
ILIGAN BAY BATHYMETRIC MAP (ReefBase GIS)



BAYWIDE SAMPLING STATIONS



OCTOBER 1998 - SEPTEMBER 1999 SAMPLING SITES



BAYWIDE SAMPLING

25-m Vertical Towing
General Oceanics
Conical Net (273 μm)

Sample Preservation

Measure: Temperature, P-PO_4, N-NO_2, Chl*a*, pH, dissolved oxygen, Secchi Depth, Total Suspended Solids, Salinity

1 YEAR SAMPLING

HorizontalTowing
General Oceanics
Conical Net (273 μm)

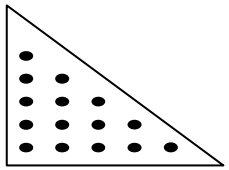
Sample Preservation

Measure: Temperature, Rainfall, Tidal Height, Total Suspended Solids, Salinity

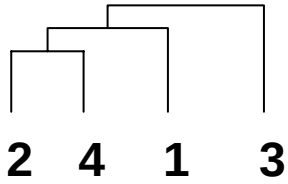
Laboratory Analysis: sample splitting (Folsom splitter), sorting, ID, and counting (Sedgewick rafter) using Zeiss Stemi 2000 Stereomicroscope

PRIMER-E v.5 Multivariate Analysis Stages

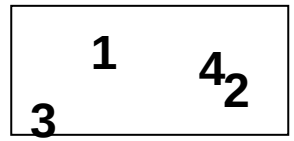
Transformed (to balance rarer and common species)



Sample Similarities (e.g. Bray-Curtis)



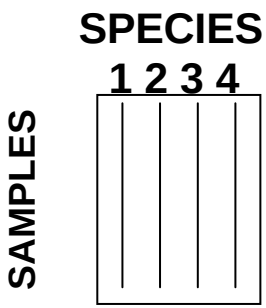
Clustering of Samples



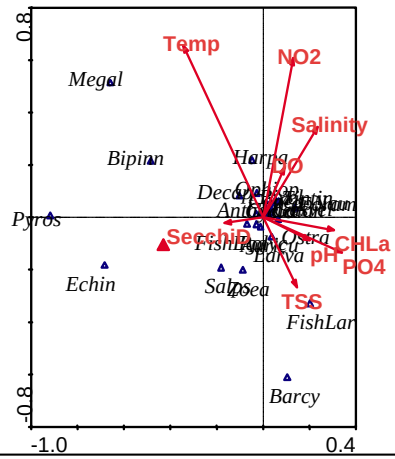
Ordination of Samples (rank based)

Community Parameters

Canonical Community Ordination (CANOCO v. 4.5) Analysis Stages



CANONICAL CORRESPONDENCE ANALYSIS: Eigenvalues, Monte Carlo Permutations, Forward Selection



TOTAL ZOOPLANKTON ABUNDANCE DURING JULY-AUGUST AND NOVEMBER-DECEMBER SAMPLING

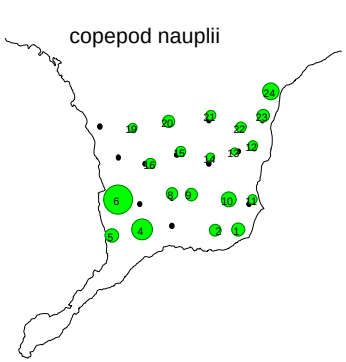
July-August

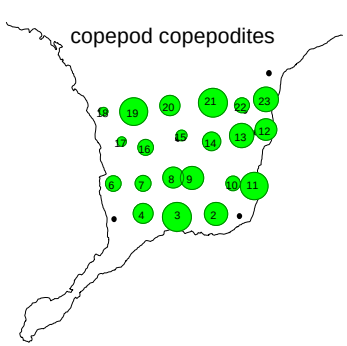
CATEGORY	COUNT m^3	%	RANK
Copepod nauplii	34940	33.24	1
Copepod Copepodites	14969	14.24	2
Calanoid copepods	11965.5	11.38	3
Tintinnids	8991	8.55	4
Gastropod veligers	6742	6.41	5
Fish Eggs	5240	4.98	6
Bivalve veligers	3656	3.48	7
Larvaceans	3250	3.09	8
Ostracods	3143	2.99	9
Chaetognaths	2836	2.70	10
Foraminifera	2483	2.36	11
Cyclopoid copepods	2438.5	2.32	12
Harpacticoid	1550	1.47	13
Ophioplutei	865	0.82	14
Anthomedusae	646.5	0.61	15
Barnacle cypris	474	0.45	16
Salps	339	0.32	17
Echinoplutei	186	0.18	18
Zoeae	89	0.08	19
Polychaete larvae	79.5	0.08	20
Fish larvae	59	0.06	21
Decapod shrimps	55	0.05	22
Auricularia	49.5	0.05	23
Cladocerans	34	0.03	24
Pyrosomes	20.55	0.02	25
Bipinnaria	17	0.02	26
Megalopae	6.5	0.01	27

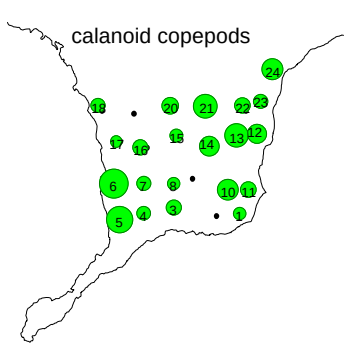
November-December

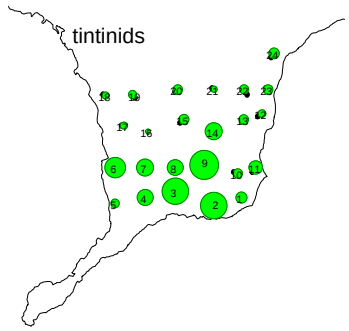
CATEGORY	COUNT m^3	%	RANK
Copepod nauplii	21605	27.31	1
Copepodites	14517	18.35	2
Calanoid	10357	13.09	3
Tintinnids	8876	11.22	4
Bivalve veliger	6527	8.25	5
Fish Egg	3099	3.92	6
Ostracod	2404	3.04	7
Gastropod vel	2277	2.88	8
Chaetognath	1943	2.46	9
Foraminifera	1708	2.16	10
Larvacean	1391	1.76	11
Cyclopoid	1389	1.76	12
Ophiopluteus	797	1.01	13
Harpacticoid	692	0.87	14
Anthomedusae	365.5	0.46	15
Polychaete	291.5	0.37	16
Salps	269	0.34	17
Zoea	180	0.23	18
Echinopluteus	117	0.15	19
Barnacle cypris	105	0.13	20
Decapod	82	0.10	21
Fish larvae	45.5	0.06	22
Pyrosome	32	0.04	23
Auricularia	23	0.03	24
Bipinnaria	23	0.03	25
Megalopa	9	0.01	26
Cladoceran	0	0.00	27

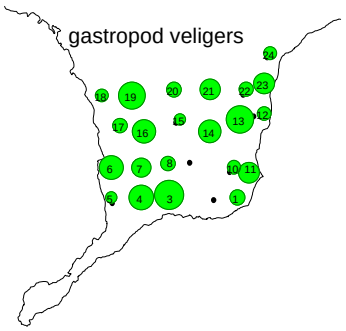
July-August

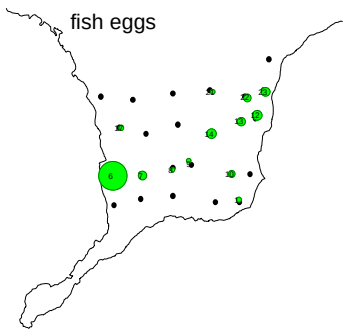

copepod nauplii

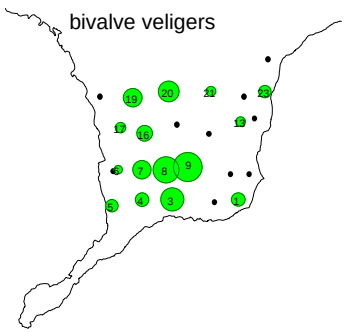

copepod copepodites

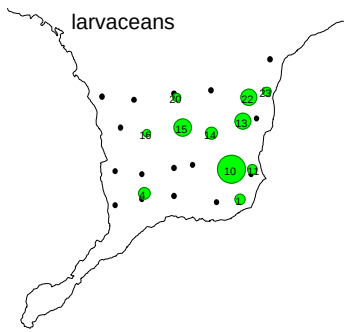

calanoid copepods

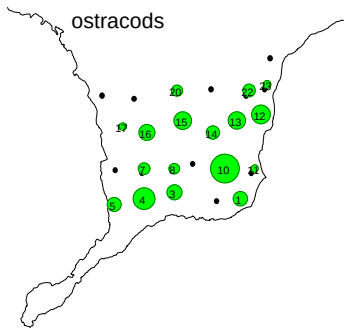

tintinids

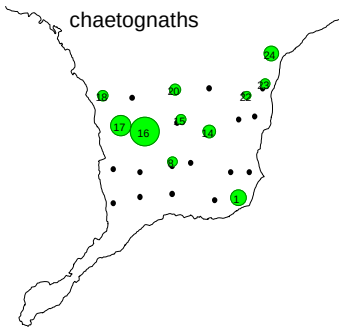

gastropod veligers

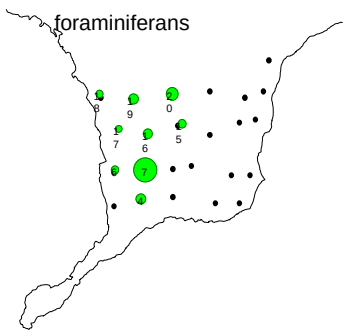

fish eggs

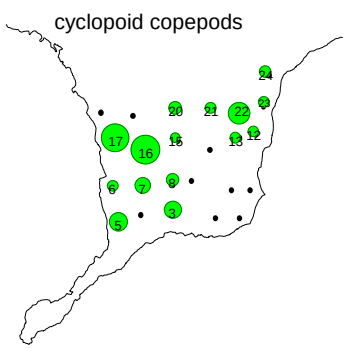

bivalve veligers

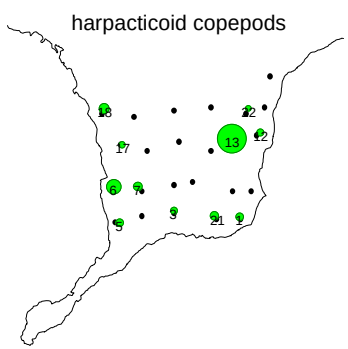

larvaceans

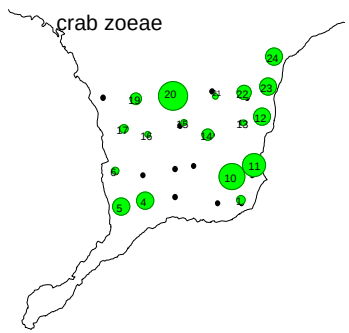

ostracods

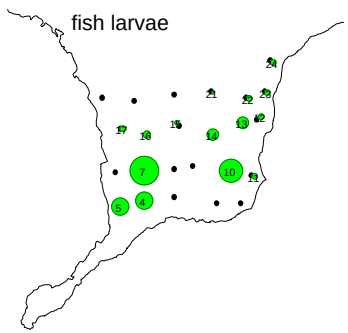

chaetognaths


foraminiferans

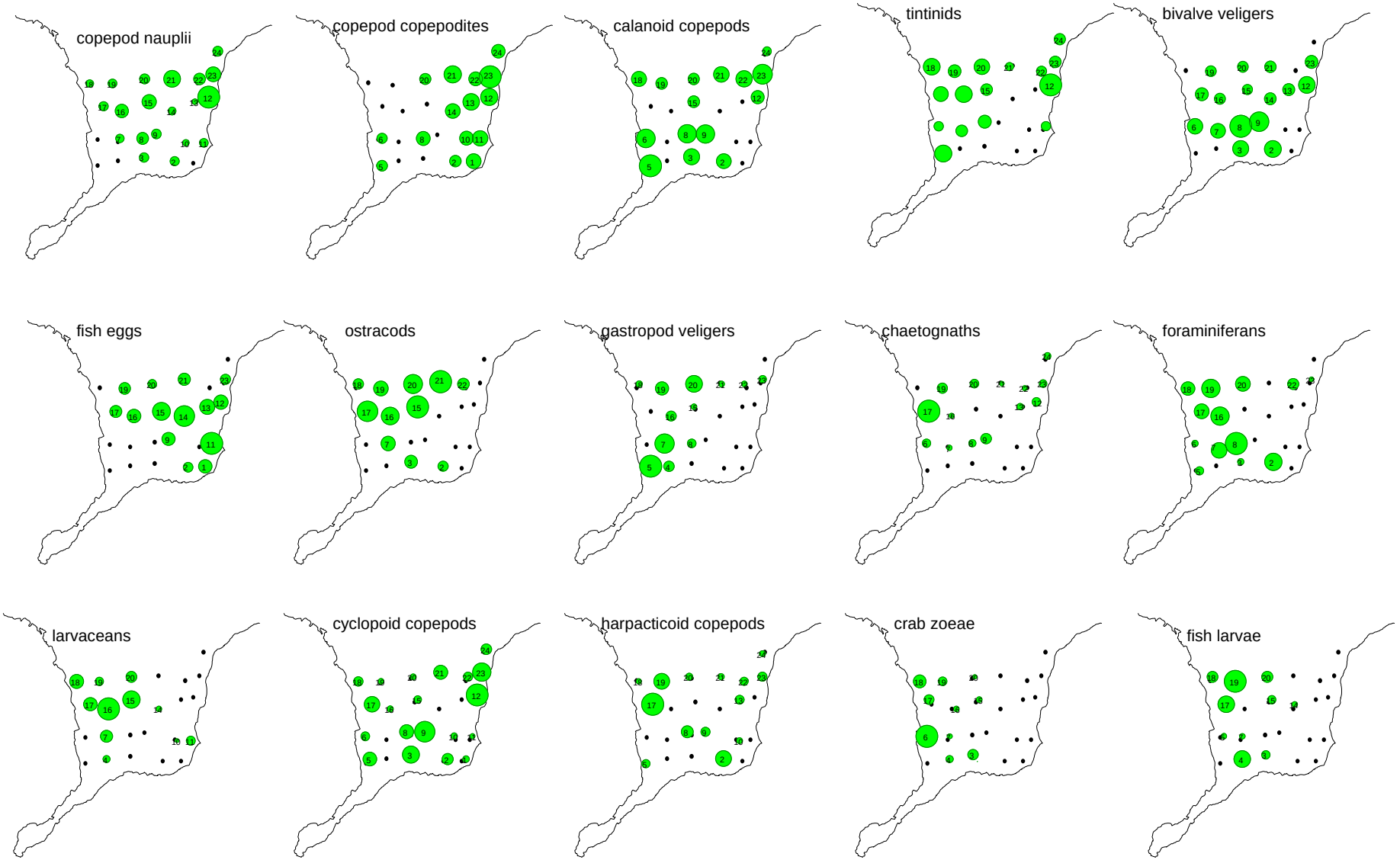

cyclopoid copepods


harpacticoid copepods


crab zoeae


fish larvae

November-December



Baywide Zooplankton Distribution

July-August

Taxonomic Category	NE	E	SE	S	SW	W	NW
Copepod nauplii					P	P	
Copepod copepodite				P			
Calanoid copepods					P	P	
Tintinids			P	P			
Gastropod veligers					P		P
Fish eggs						P	
Bivalve veligers				P	P		
Larvaceans			P				
Ostracods			P				
Chaetognaths						P	
Foramineferans						P	
Cyclopoid copepods						P	P
Harpacticoid copepods	P						
Crab zoeae			P				P
Fish larvae						P	

November-December

Taxonomic Category	NE	E	SE	S	SW	W	NW
Copepod nauplii	P						
Copepod copepodite	P	P	P				
Calanoid copepods	P				P		
Tintinids	P	P					
Bivalve veligers			P	P			
Fish eggs	P		P				
Ostracods	P						P
Gastropod veligers					P	P	P
Chaetognaths						P	
Foramineferans			P		P		P
Larvaceans							P
Cyclopoid copepods	P			P			
Harpacticoid copepods							P
Crab zoeae						P	
Fish larvae					P	P	P

TOTAL ZOOPLANKTON ABUNDANCE IN THE TWO SITES SAMPLED FOR ONE YEAR

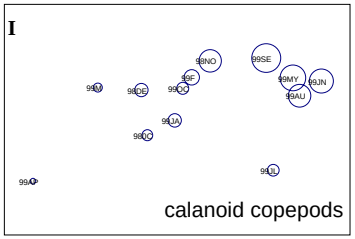
ILIGAN

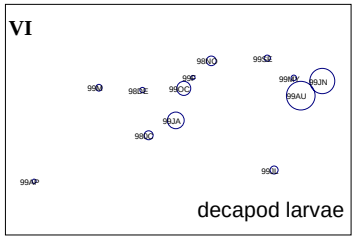
CATEGORY	COUNTm^3	%	RANK
Decapod shrimps	21160.5	37.6	1
Calanoid copepods	12069.3	21.5	2
Fish eggs	6298.3	11.2	3
Cyclopoid copepods	3101.7	5.5	4
Gastropod veligers	2605.0	4.6	5
Bivalve veligers	2368.3	4.2	6
Decapod larvae	1618.3	2.9	7
Crab Zoea	1365.0	2.4	8
Chaetognaths	1286.7	2.3	9
Tintinids	800.0	1.4	10
Larvaceans	556.7	1.0	11
Ostracods	518.3	0.9	12
Siphonophores	501.7	0.9	13
Cubomedusae	348.0	0.6	14
Amphipods	315.0	0.6	15
Bipinnaria	296.7	0.5	16
Ctenophores	216.7	0.4	17
Fish larvae	198.3	0.4	18
Polychaetes	188.3	0.3	19
Salps	171.7	0.3	20
Harpacticoid cop.	103.3	0.2	21
Flatworms	96.7	0.2	22
Barnacl nauplii	28.3	0.1	23
Copep nauplii	13.3	0.0	24

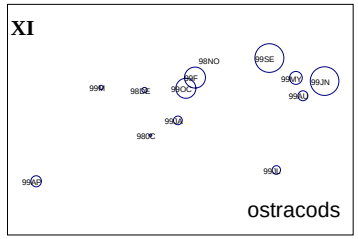
KAUSWAGAN

CATEGORY	COUNTm^3	%	RANK
Calanoid copepods	14157.2	31.4	1
Decapod shrimps	11910.5	26.4	2
Fish eggs	5860.8	13.0	3
Cyclopoid copepods	2988.9	6.6	4
Gastropod veligers	2166.9	4.8	5
Decapod larvae	1556.1	3.4	6
Chaetognaths	1366.1	3.0	7
Bivalve veligers	1065.8	2.4	8
Siphonophores	667.2	1.5	9
Crab Zoea	665.0	1.5	10
Ostracods	626.1	1.4	11
Larvaceans	485.0	1.1	12
Amphipods	397.2	0.9	13
Polychaete ;arvae	349.2	0.8	14
Barnacl nauplii	196.1	0.4	15
Ctenophores	146.7	0.3	16
Tintinids	121.4	0.3	17
Copep nauplii	108.9	0.2	18
Bipinnaria	80.3	0.2	19
Salps	52.2	0.1	20
Harpacticoid cop.	42.2	0.1	21
Cubomedusae	34.2	0.1	22
Flatworms	33.3	0.1	23
Fish larvae	32.9	0.1	24

Kauswagan


I
calanoid copepods


VI
decapod larvae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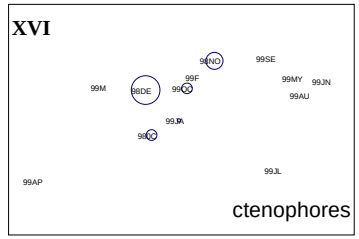
ostracods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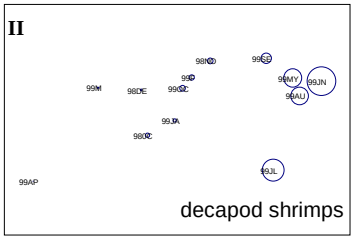
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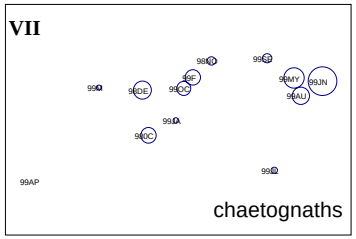
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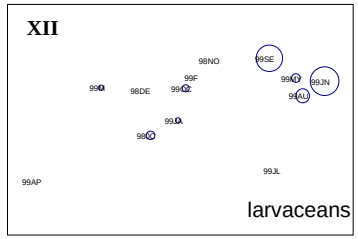
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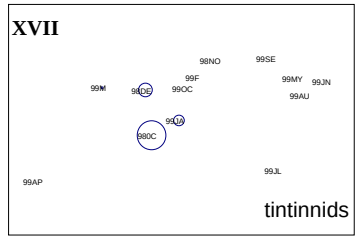
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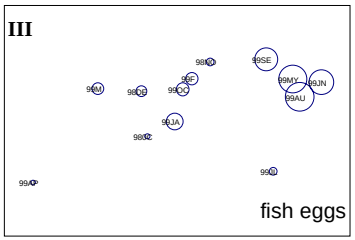
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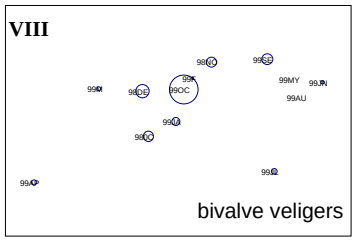
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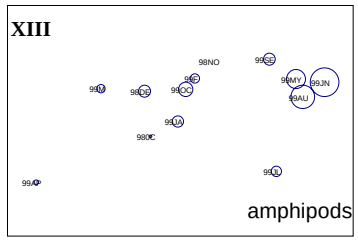
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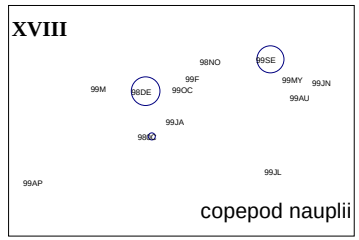
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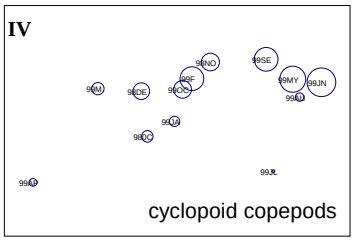
copepod nauplii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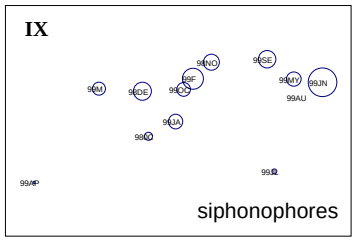
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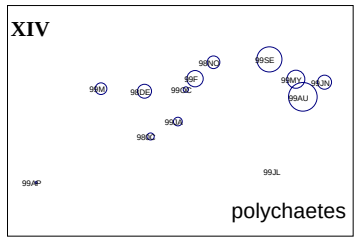
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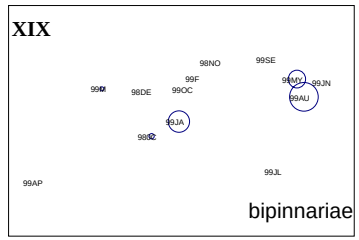
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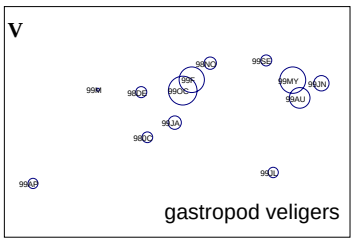
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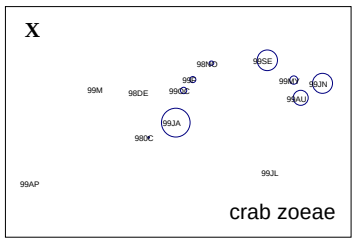
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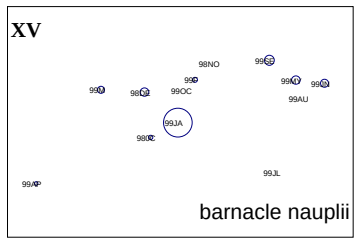
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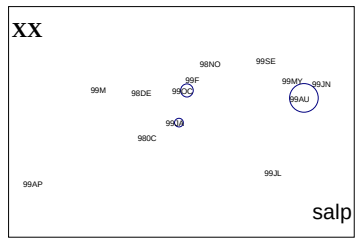
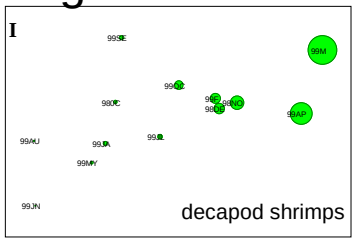

XX
salp

Iligan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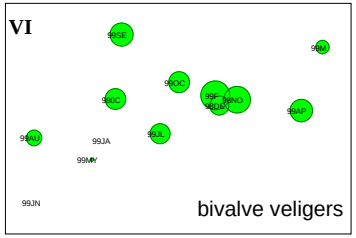
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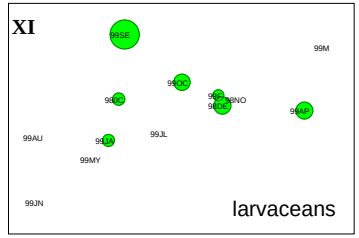
bivalve veligers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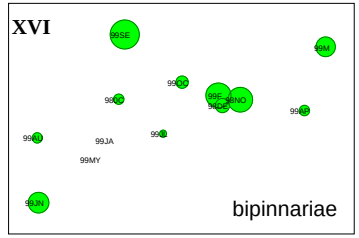
larvaceans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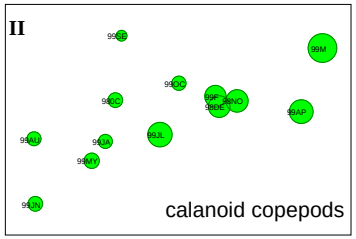
bipinnariae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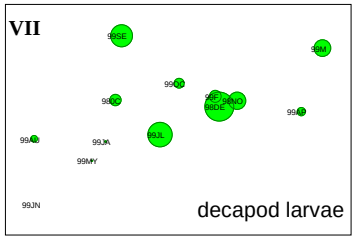
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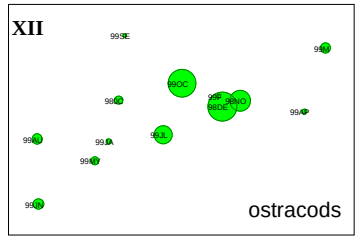
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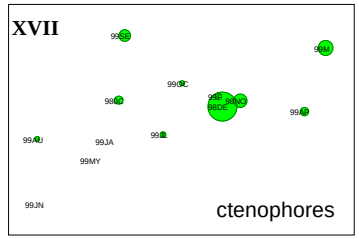
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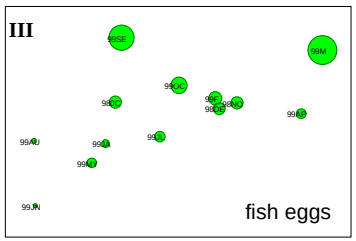
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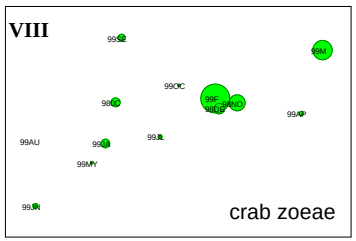
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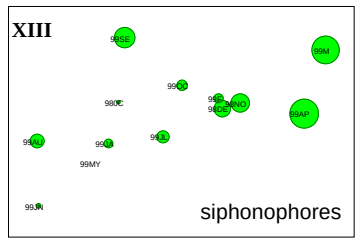
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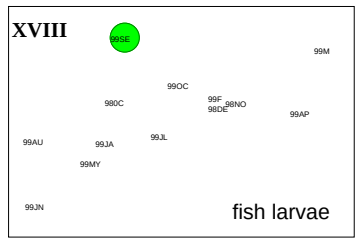
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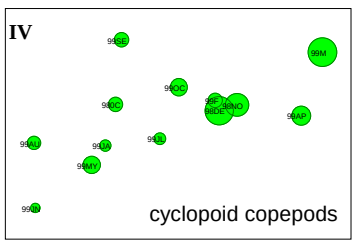
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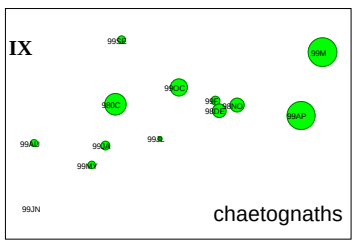
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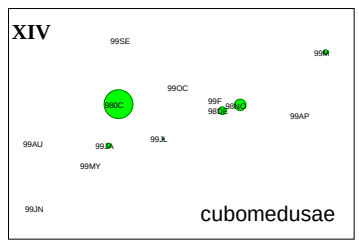
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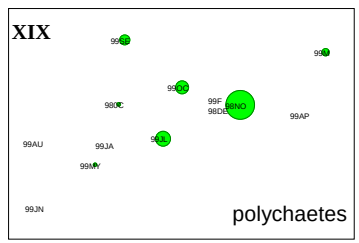
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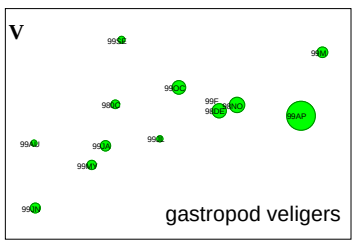
polychaetes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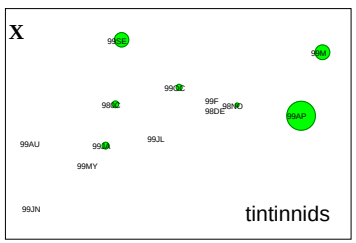
gastropod veligers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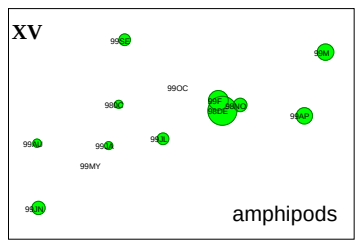
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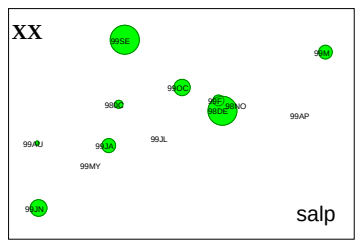
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salp

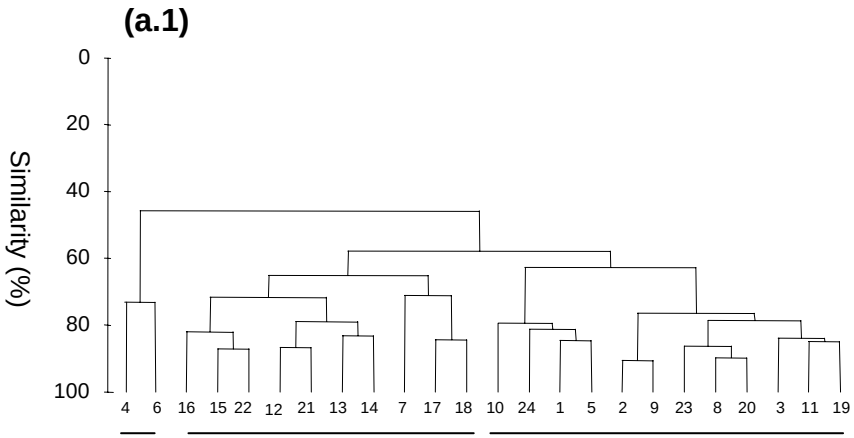
Iligan

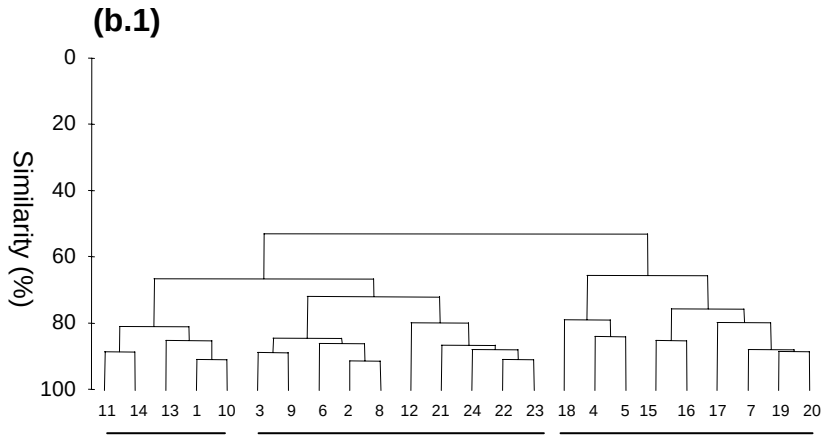
Taxonomic Categoriy	J	F	M	A	M	J	J	A	S	O	N	D
Decapod shrimps			P	P								
Calanoid copepods			P				P					
Fish eggs			P						P		P	P
Cyclopod copepods			P								P	P
Gastropod veligers				P								
Bivalve veligers		P									P	
Decapod larvae							P		P		P	P
Zoeae		P										P
Chaetognaths			P	P								
Tintinids			P	P					P	P		
Larvaceans									P			
Ostracods											P	P
Siphonophores			P	P					P			
Cubomedusa										P	P	P
Amphipods		P										P
Bipinnaria larvae			P						P	P	P	
Ctenophores											P	P
Fish larvae									P			
Polychaetes											P	
Salps									P			P

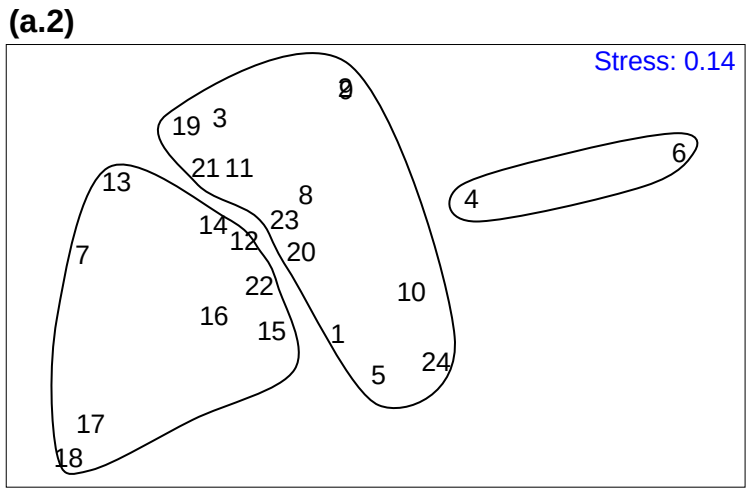
Kauswagan

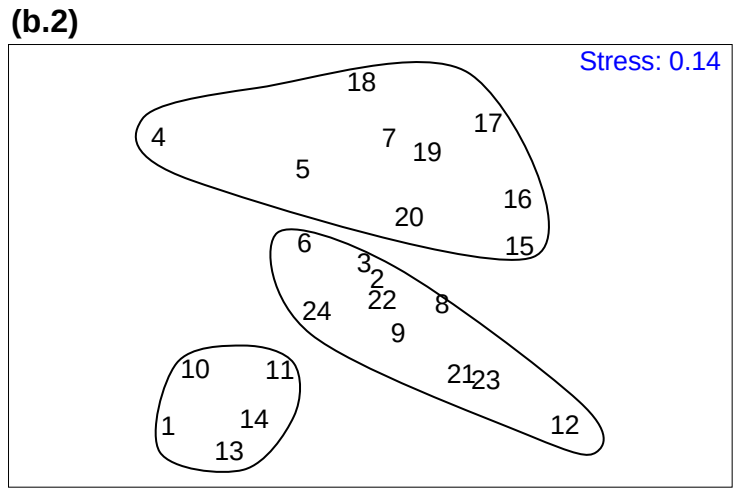
Taxonomic Categoriy	J	F	M	A	M	J	J	A	S	O	N	D
Calanoid copepods					P	P		P	P			
Decapod shrimps						P	P					
Fish eggs					P	P		P	P			
Cyclopod copepods		P			P	P			P	P	P	
Gastropod veligers		P			P	P		P		P		
Decapod larvae						P		P				
Chaetognaths					P	P						P
Bivalve veligers										P		P
Siphonophores		P				P						
Zoeae	P					P		P	P			
Ostracods						P			P			
Larvaceans						P			P			
Amphipods					P	P	P					
Polychaetes					P	P		P	P			
Barnacle nauplii	P											
Ctenophores												P
Tintinids										P		
Copepod nauplii									P			
Bipinnaria larvae	P				P			P			P	
Salps								P		P		

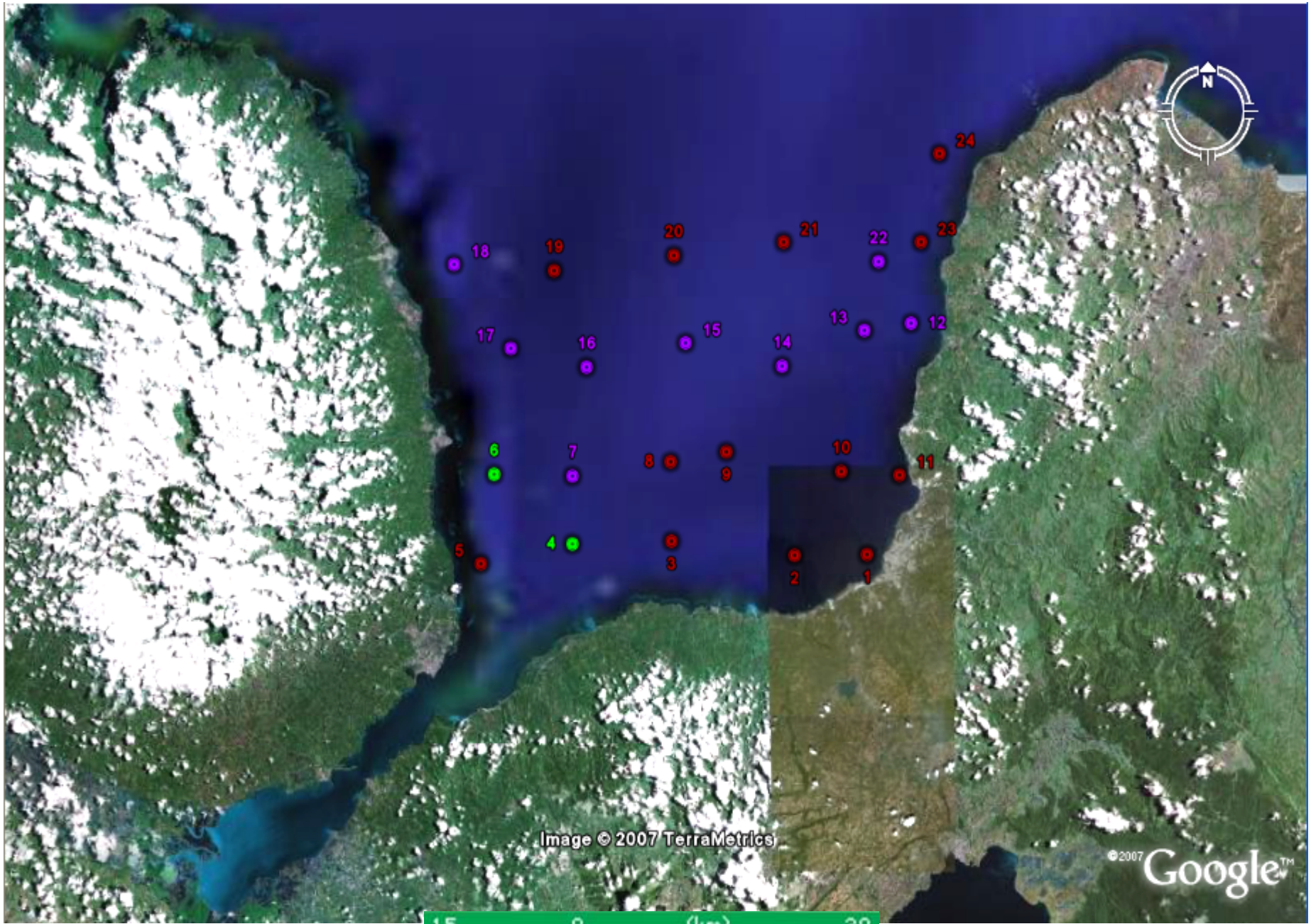
Cluster analysis dendrograms and NMDS plots for the (a) July-August and (b) November-December samples of zooplankton across Iligan Bay.







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©2007 Google™
15 0 (km) 30

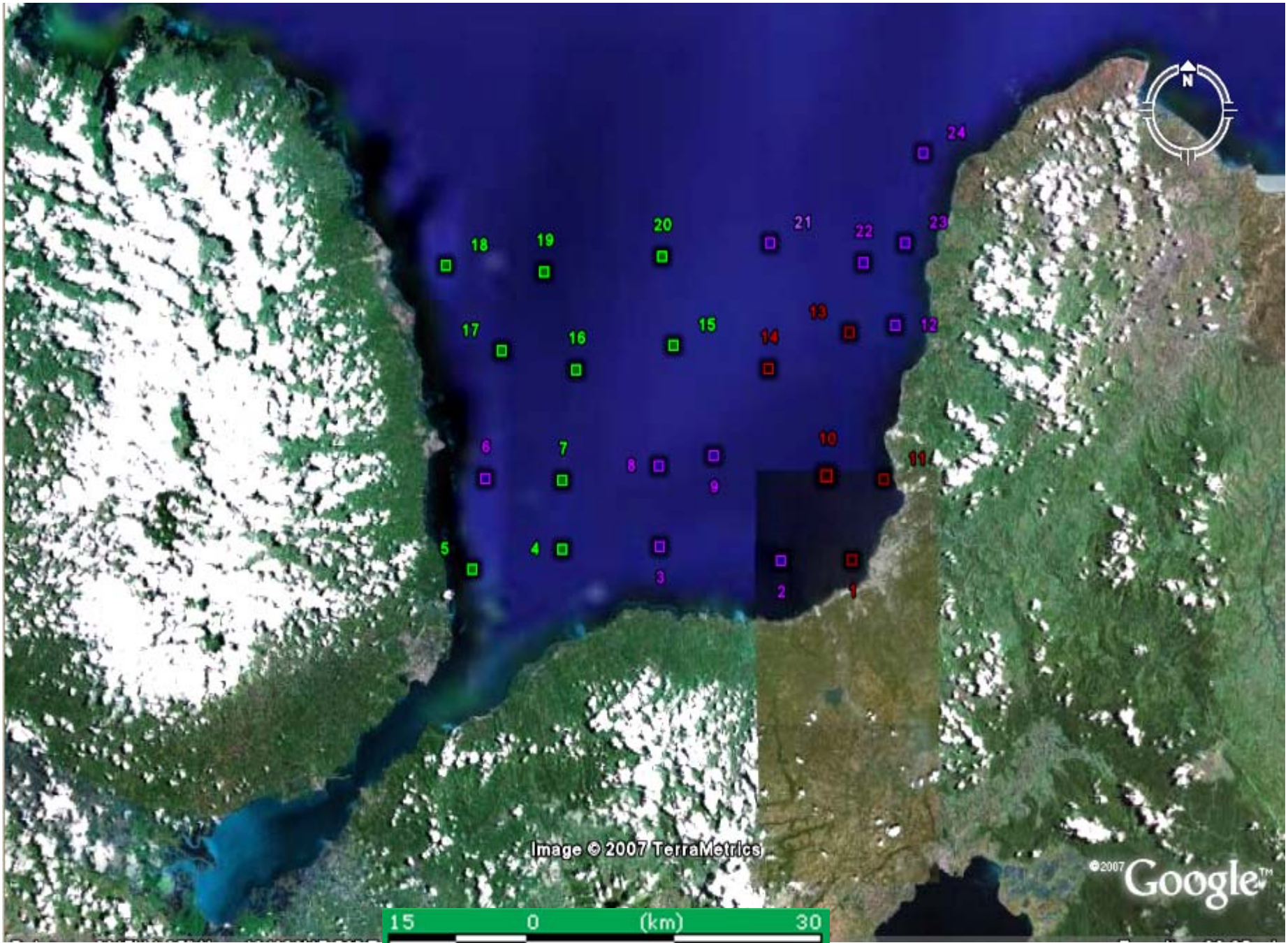
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Image © 2007 TerraMetrics
©2007 Google™
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30

Grouping of stations based on cluster analysis and community characteristics of each group during the two samplings. Community characteristics categories: low (L), moderate (M), high (H).

July-August Sampling

Sectors	Stations	Richness	Abundance	Pielou's Evenness (*J'*)	Shannon-Weiner Index (*H'*)
SW	4,6	20-22 (L)	5616-7939 (H)	0.5985-0.6289 (L)	1.850-1.884 (L)
NW-NE	7,12,13, 14, 15,16, 17,18,21, 22	20-26 (H)	2500-4947 (M)	0.5961-0.7922 (H)	1.919-2.550 (H)
N&S	1,2,3,5, 8,9,10,11, 19,20,23,24	21-24 (M)	3966-4919 (M)	0.6179-0.7764 (M)	1.851-2.400 (L)

November-December Sampling

	Stations	Richness	Abundance	Pielou's Evenness (*J'*)	Shannon-Weiner Index (*H'*)
NE-SE	1,10,11, 13,14	17-21 (L)	2151-2878 (L)	0.6352-0.6834 (L)	1.903-1.975 (L)
NE&S	2,3,6,8,9, 12,21,22, 23,24	19-24 (L)	2903-5058 (H)	0.6423-0.7320 (M)	1.827-2.31 (M)
NW-SW	4,5,7,15, 16,17,18, 19,20	20-25 (M)	2763-3870 (M)	0.7037-0.7797 (H)	2.108-2.510 (H)

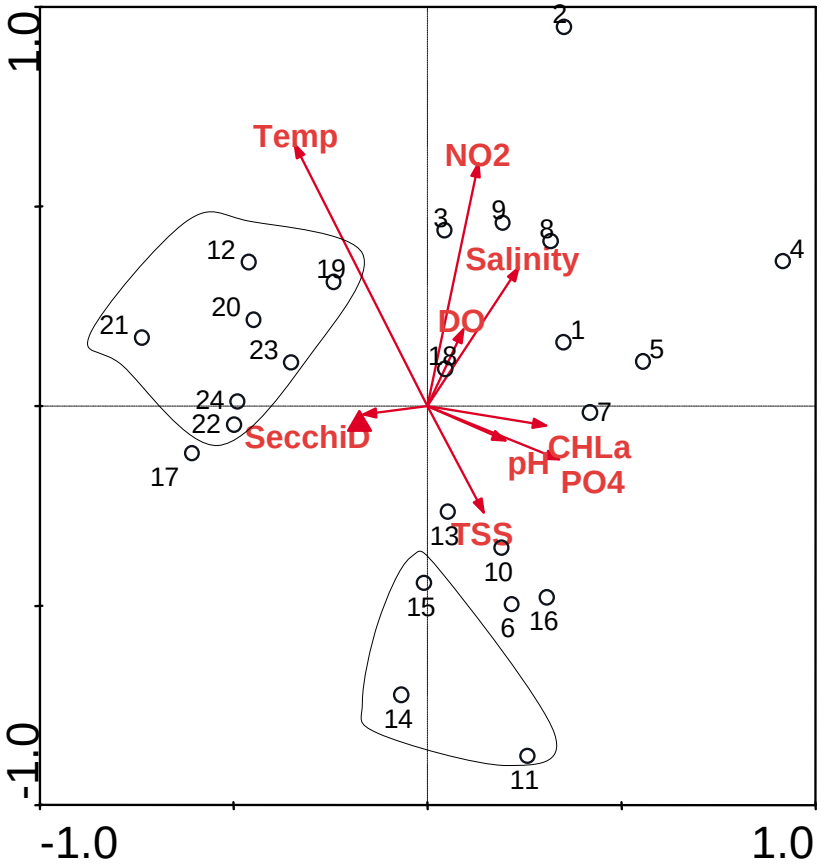
CANONICAL CORRESPONDENCE ANALYSIS (JULY-AUGUST SAMPLES)

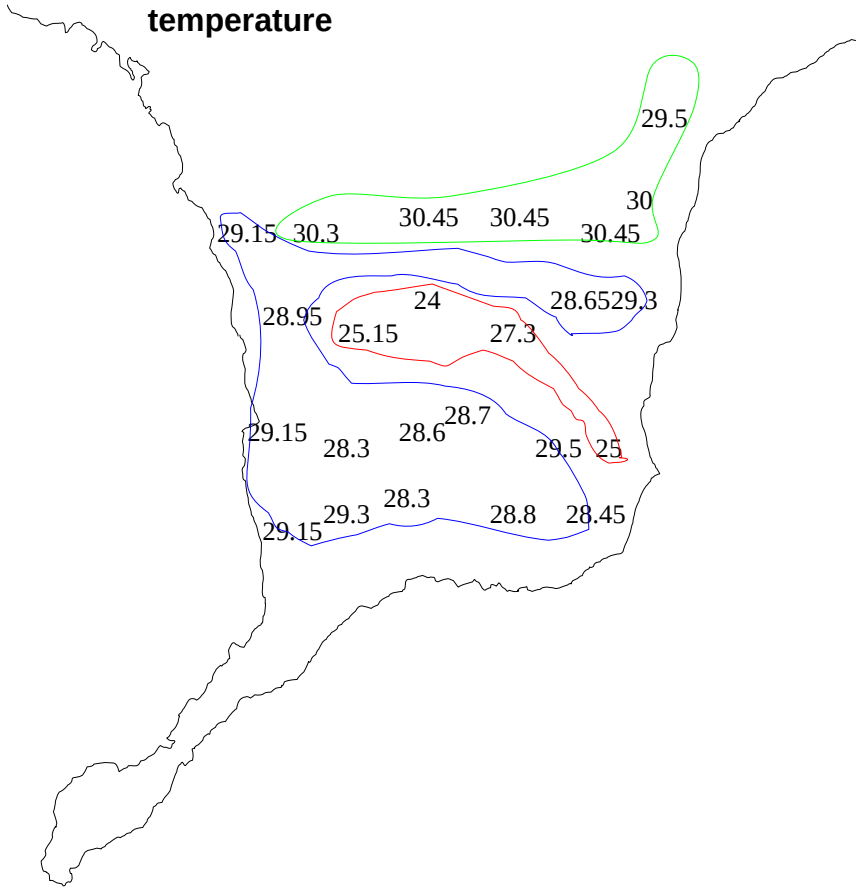
Axes	1	2	3	4
Eigenvalues:	0.017	0.015	0.010	0.006
Species-environment correlations:	0.894	0.753	0.859	0.727
Cumulative percentage variance				
of species data:	14.5	27.4	35.8	41.0
of species-environment relation:	28.3	53.4	69.9	79.9

Test of significance of first axis: eigenvalue = 0.017 (F = 2.21, P = 0.55)
Test of significance of all axes: Trace = 0.060 (F = 1.37, P = 0.04)

Forward Selection of Environmental Variables

	λA	P	F
Temp	**0.10**	**0.020**	**2.45**
PO4	**0.07**	**0.050**	**1.77**
NO2	**0.07**	**0.060**	**1.85**
CHLa	0.06	0.096	1.67
pH	0.06	0.106	1.61
DO	0.04	0.330	1.08
Secchi Depth	0.02	0.614	0.79
Total Susp Solids	0.03	0.806	0.59
Salinity	0.02	0.802	0.56

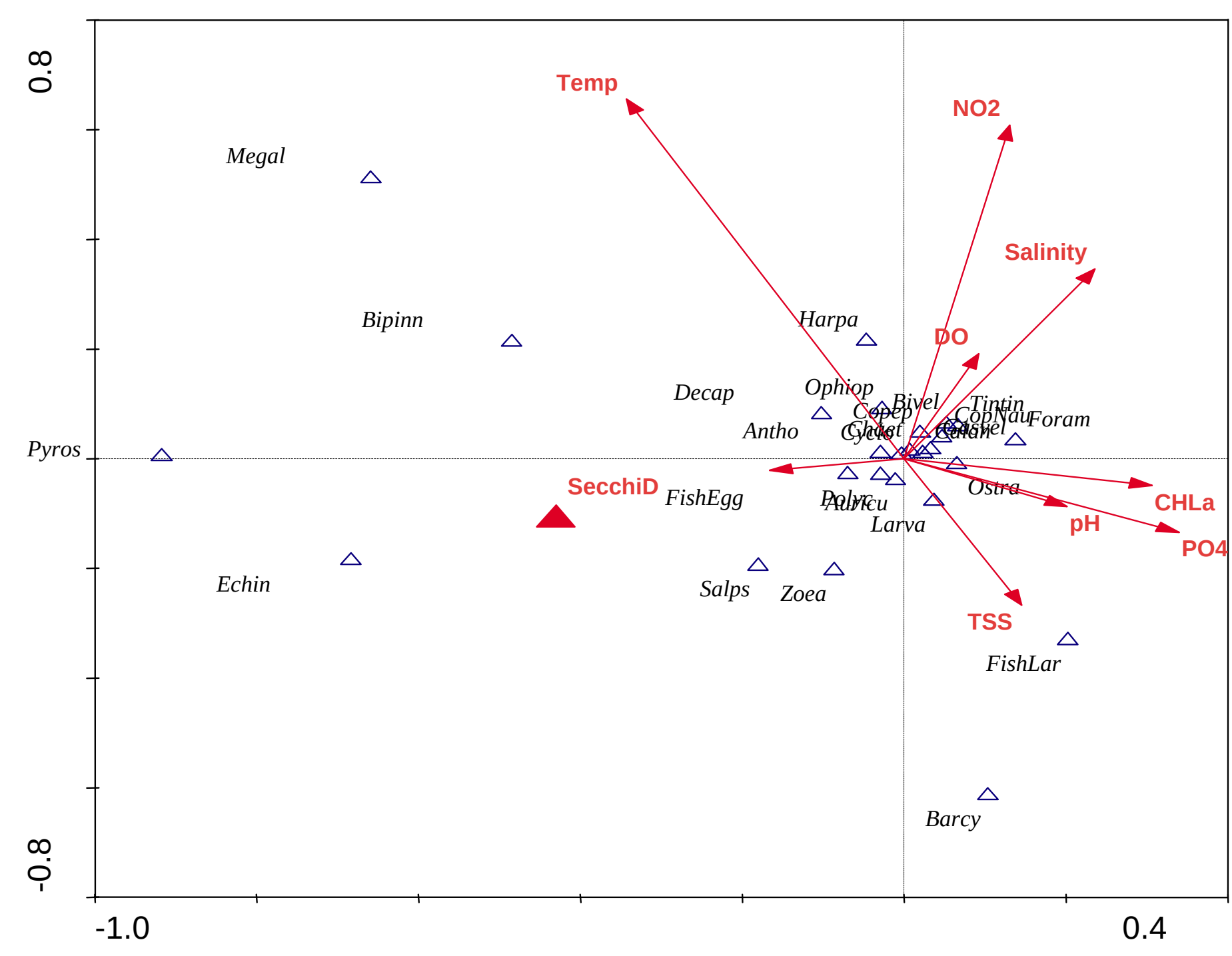




High temperatures (30-30.5ºC) in the mouth (northeast and northwest) of bay.

Gradient of temperature from estuarine to marine (offshore). Zooplankton categories with peak abundances: ophioplutei, megalopa, decapod shrimps, bipinnaria, anthomedusae, and harpacticoid copepods.

Colder temperatures are found in stations 11 (SE,NE), 14 and 15 (NW) = freshwater input.


0.8
-0.8
-1.0
0.4
Temp
NO2
Salinity
DO
pH
CHLa
PO4
TSS
SecchiD
Megal
Bipinn
Pyros
Echin
Harpa
Decap
Ophiop
Antho
Bivel
Copep
Chaet
Cyclo
Tintin
CopNau
Foram
Ostra
FishEgg
Polyc
Auricu
Larva
Salps
Zoea
FishLar
Barcy

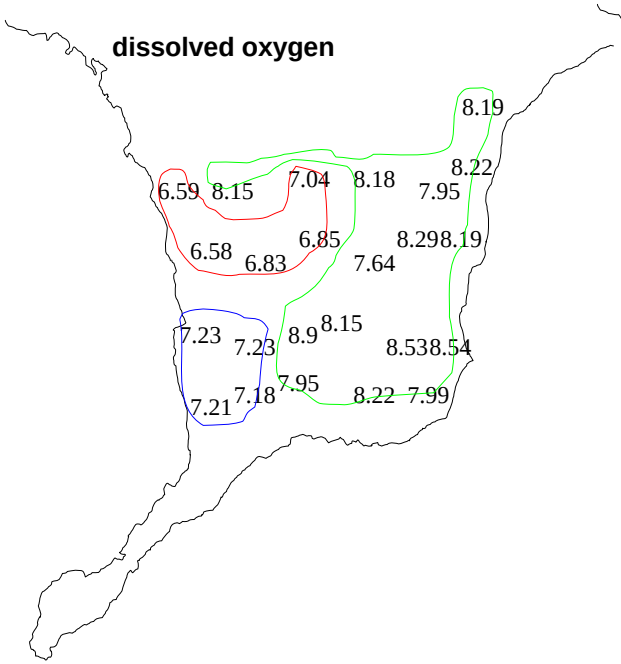
CANONICAL CORRESPONDENCE ANALYSIS (NOVEMBER-DECEMBER SAMPLES)

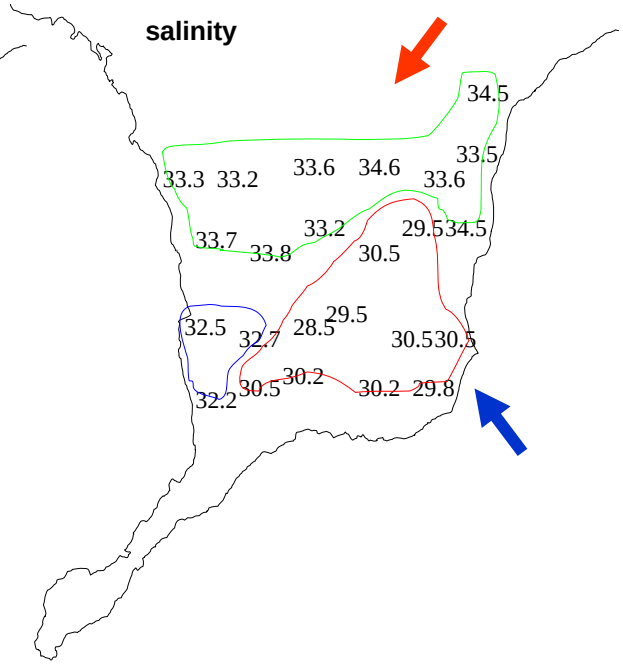
Axes	**1**	**2**	**3**	**4**
Eigenvalues:	**0.037**	**0.021**	**0.013**	**0.009**
Species-environment correlations:	**0.917**	**0.879**	**0.913**	**0.818**
Cumulative percentage variance				
of species data :	**22.9**	**36.0**	**44.2**	**49.6**
of species-environment relation:	**39.2**	**61.5**	**75.6**	**84.8**

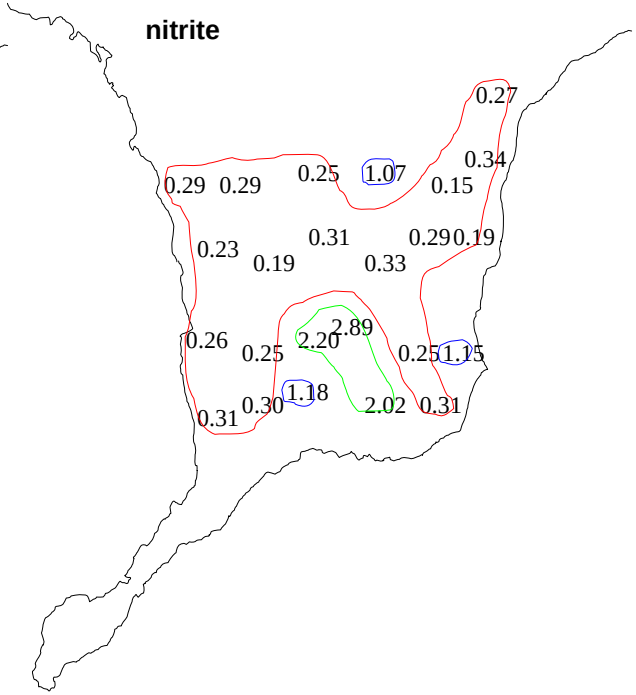
Test of significance of first axis: eigenvalue = 0.037 (F = 4.162, P = 0.006)
Test of significance of all axes: Trace = 0.093 (F = 2.189, P = 0.002)

Forward Selection of Environmental Variables

	λA	P	F
DO	**0.03**	**0.002**	**4.82**
Salinity	**0.01**	**0.008**	**2.40**
NO2	**0.01**	**0.022**	**2.05**
Total Susp. Solids	0.01	0.098	1.59
PO4	0.01	0.082	1.64
pH	0.01	0.084	1.72
Secchi Depth	0.00	0.132	1.42
CHLa	0.01	0.260	1.30
Temperature	0.00	0.820	0.61







Low: Stations 15-17,19 low levels - runoff from urban area? ZOOP: larvaceans peak

High: Stations 1,10, 11, 13, 14 (poor ZOOP)

- FW input (see salinity)

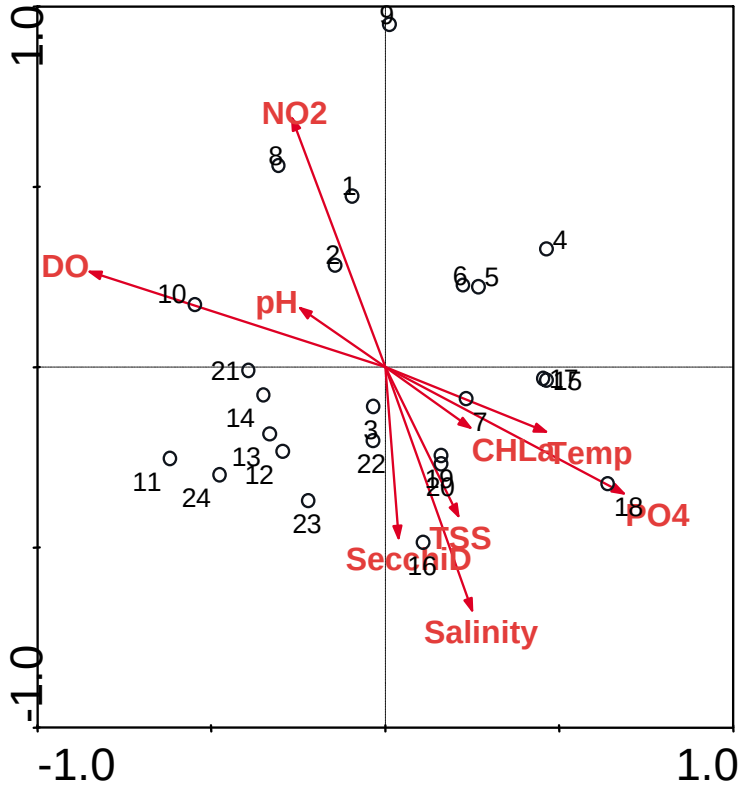
High: offshore, wind driven (from Mindanao Sea); ZOOP – chaetognaths, gastropod veligers, larvaceans, anthomedusae

Low: Stations 1,10, 11, 13, 14 - FW input (see dissolved oxygen)

(Temp [not shown]: low levels)

High: Stations 2,3,8,9 – agricultural runoff?

Low abundance for larvaceans, gastropod veligers, and anthomedusae


1.0
-1.0
-1.0
1.0
NO2
DO
pH
CHLa
Temp
PO4
TSS
SecchiD
Salinity
1
2
3
4
5
6
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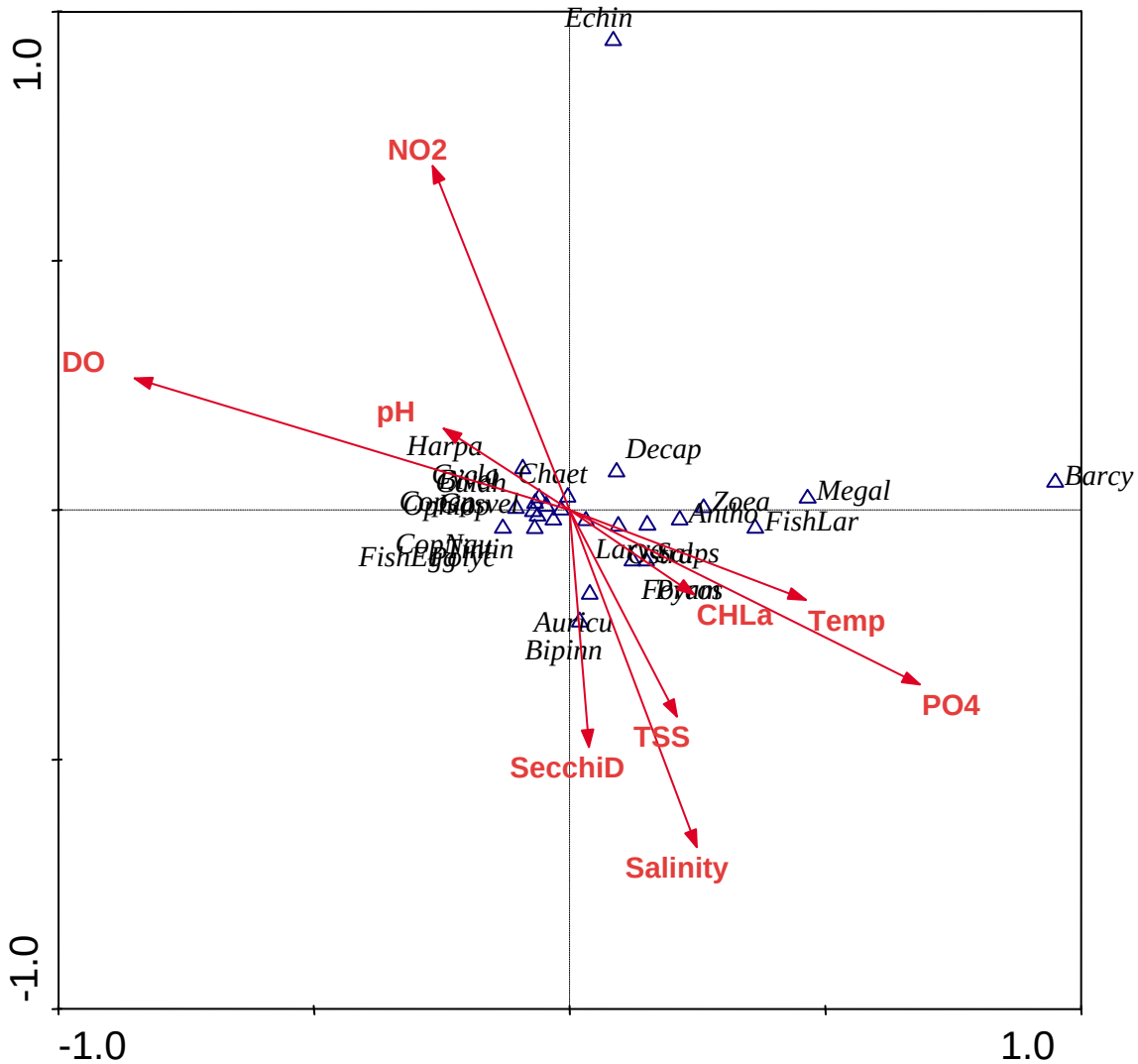
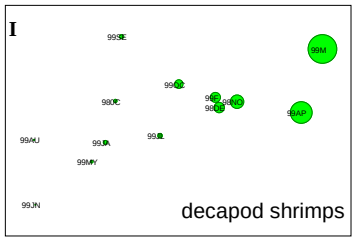
23
24


1.0
-1.0
-1.0
1.0
Echin
NO2
DO
pH
Harpa
Decap
Chaet
Barcy
Megal
Zoea
Antho
FishLar
Auricu
Bipinn
CHLa
Temp
PO4
TSS
SecchiD
Salinity

Iligan


I
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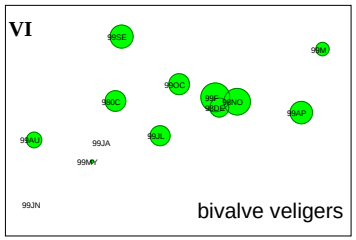
99JN
decapod shrimps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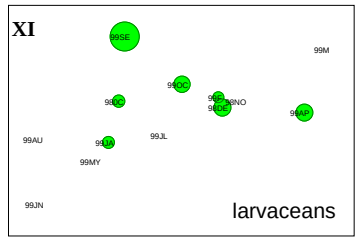
bivalve veligers


XI
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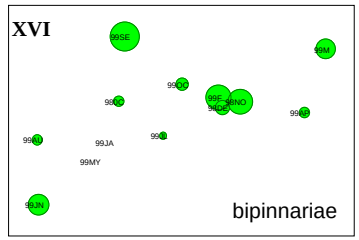
larvaceans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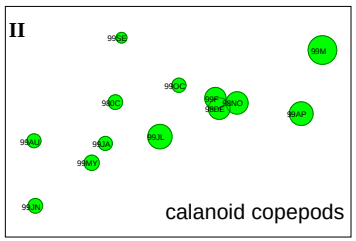
bipinnariae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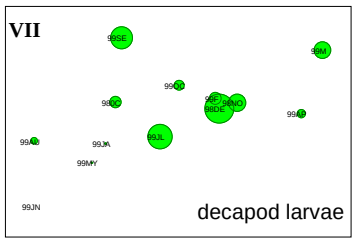
calanoid copepods


VII
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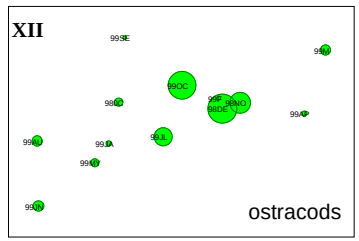
decapod larvae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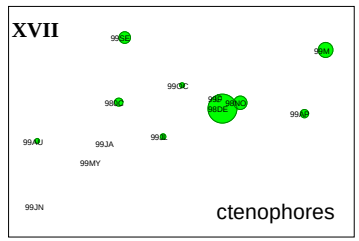
ostracods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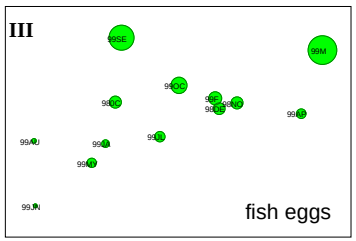
ctenophores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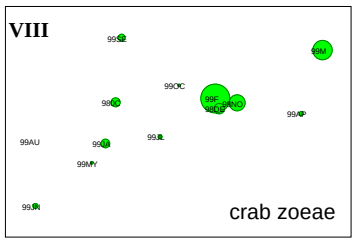
fish eggs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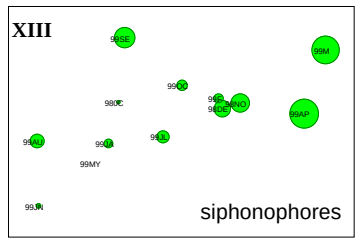
crab zoeae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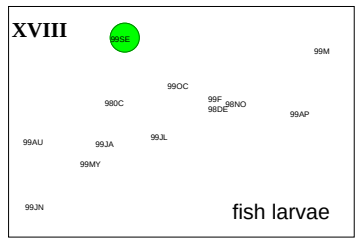
siphonophores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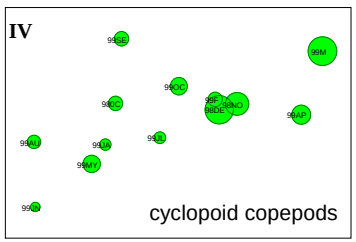
fish larvae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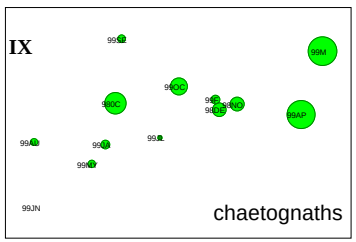
cyclopoid copepods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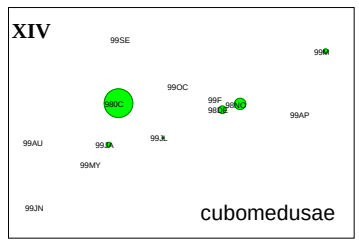
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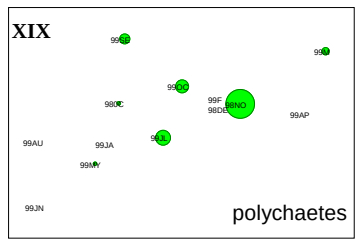
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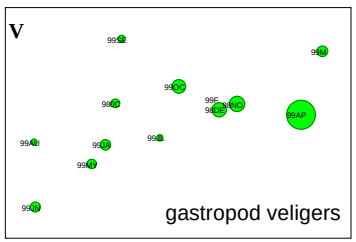
polychaetes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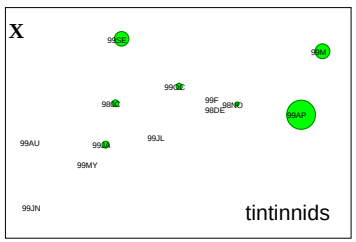
gastropod veligers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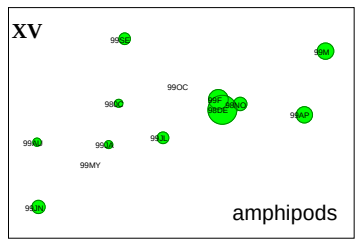
tintinnids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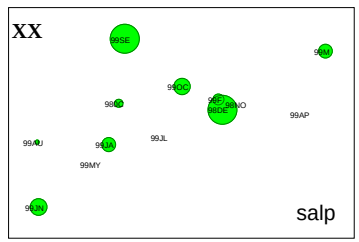
amphipods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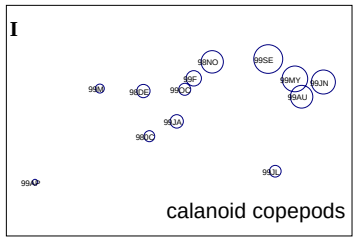
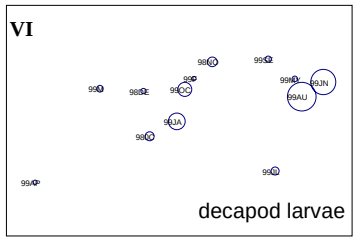
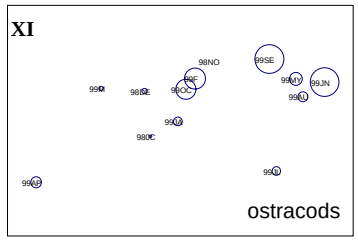
Kauswagan


I
calanoid copepods


VI
decapod larvae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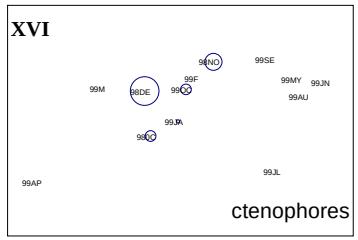
ostracods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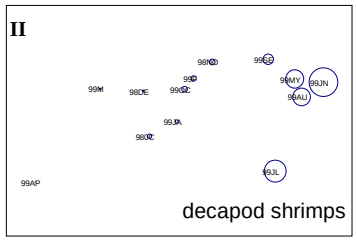
ctenophores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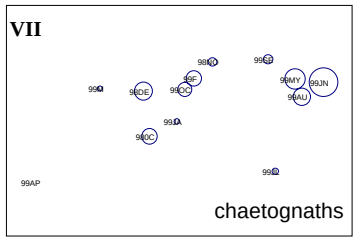
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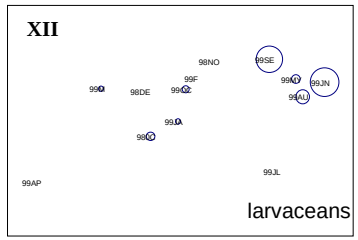
chaetognaths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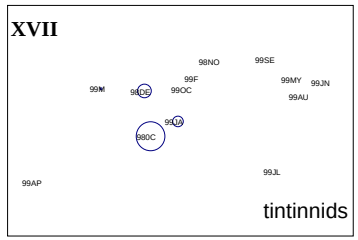
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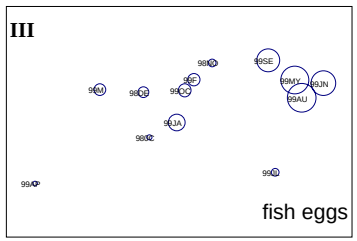
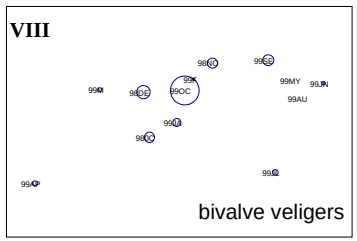
tintinnids


III
fish eggs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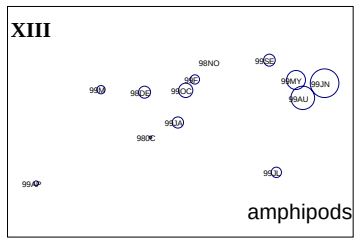
bivalve veligers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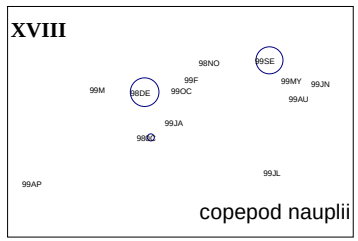
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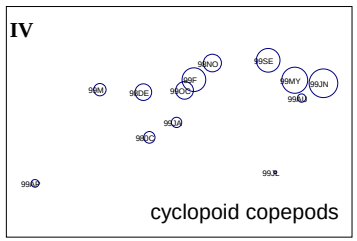
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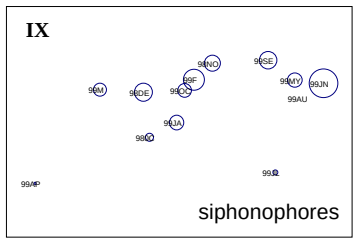
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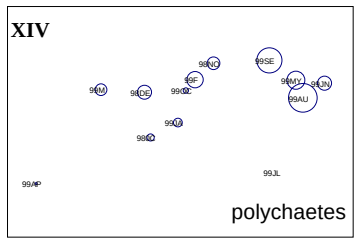
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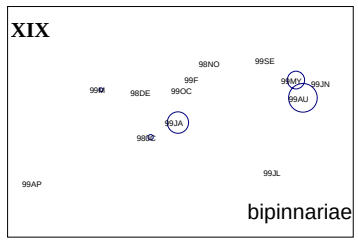
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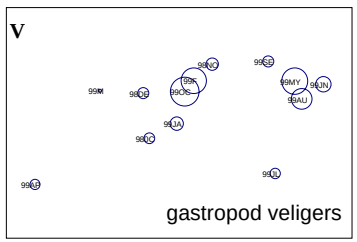
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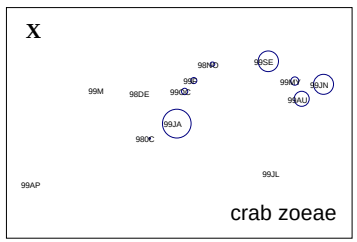
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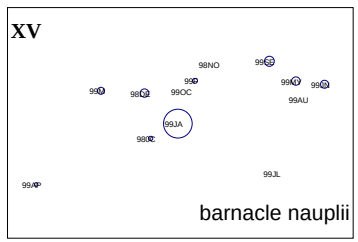
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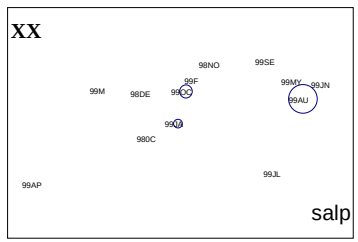
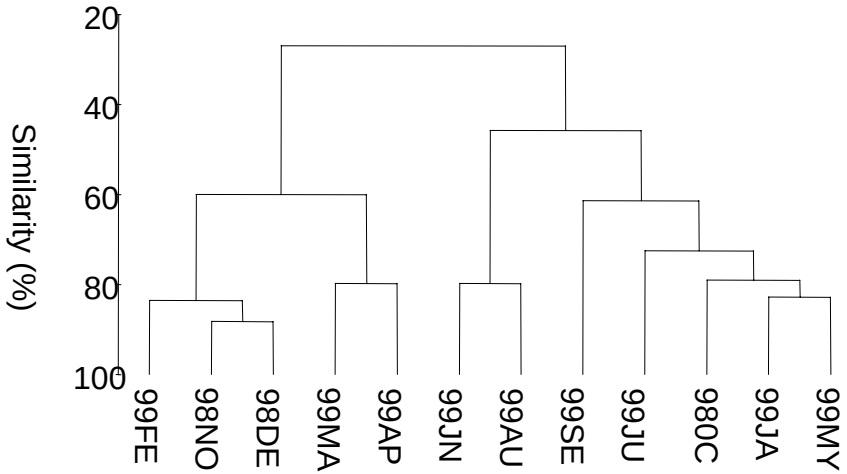
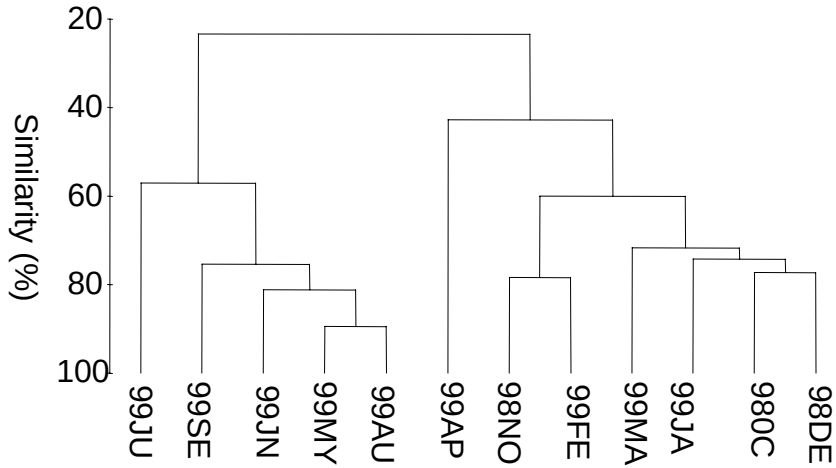
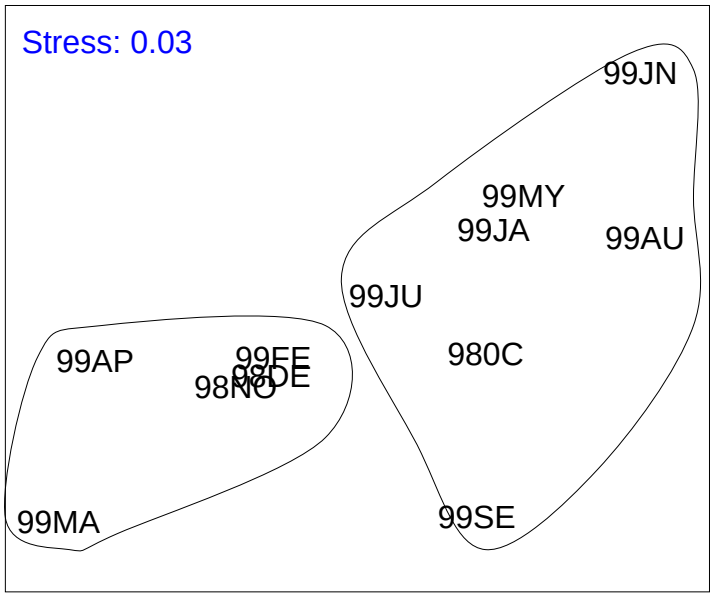

XX
salp

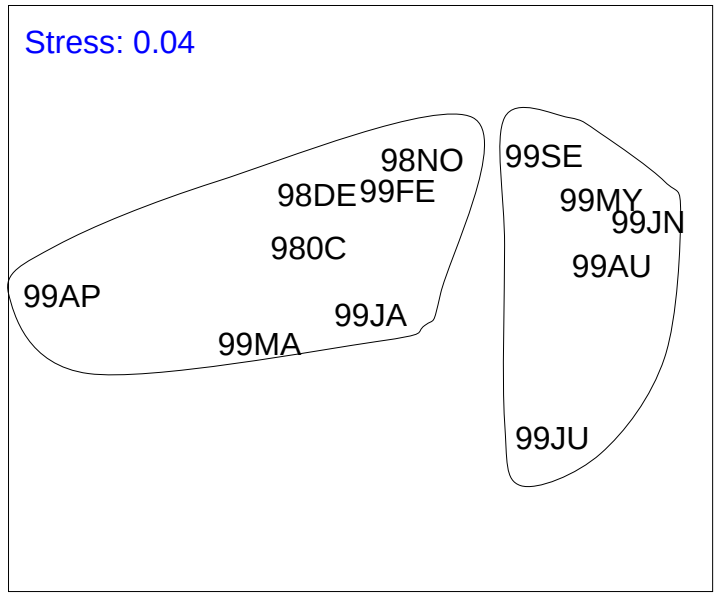
ILIGAN CITY



KAUSWAGAN







Community characteristicsfor the one-year zooplankton samples in the Iligan City and Kauswagan sites in Iligan Bay

Iligan City

Sampling Time	Richness	Abundance	Pielou *J'*	Shannon *H'*(loge)
98Oct	20	3220	0.7764	2.326
98Nov	20	5823	0.6684	2.002
98Dec	17	5310	0.7298	2.068
99Jan	15	2497	0.7308	1.979
99Feb	15	4681	0.6701	1.815
99Mar	20	9755	0.5415	1.622
99Apr	17	7572	0.5902	1.672
99May	11	2250	0.7362	1.765
99Jun	12	1551	0.7154	1.778
99Jul	17	3506	0.6864	1.945
99Aug	16	1827	0.7293	1.922

Kauswagan

Sampling Time	Richness	Abundance	Pielou J'	Shannon H'(loge)
98Oct	22	2119	0.7082	2.189
98Nov	14	3104	0.6629	1.750
98Dec	18	2416	0.7637	2.207
99Jan	21	2775	0.7327	2.231
99Feb	14	2955	0.7586	2.002
99May	17	1632	0.7055	1.999
99Apr	12	924	0.7290	1.811
99May	16	5503	0.6505	1.804
99Jun	15	6826	0.6840	1.852
99Jul	13	3527	0.5151	1.321
99Aug	15	5234	0.6796	1.840

ILIGAN CANOCO ANALYSIS RESULTS

Axes	1	2	3	4	Total inertia
Eigenvalues :	0.039	0.029	0.024	0.011	0.314
Species-environment correlations :	0.858	0.813	0.938	0.540	
Cumulative percentage variance					
of species data :	12.5	21.8	29.5	32.9	
of species-environment relation:	35.4	61.9	83.9	93.6	
Sum of all eigenvalues				0.314	
Sum of all canonical eigenvalues				0.110	

Test of significance of first canonical axis: eigenvalue = 0.039; *F = 0.853; P = 0.954*

Test of significance of all canonical axes : Trace = 0.110; *F-ratio = 0.650; P = 0.962*

KAUSWAGAN CANOCO ANALYSIS RESULTS

Axes	1	2	3	4	Total inertia
Eigenvalues :	0.086	0.043	0.030	0.023	0.334
Species-environment correlations :	0.917	0.837	0.870	0.934	
Cumulative percentage variance					
of species data :	25.8	38.8	47.8	54.8	
of species-environment relation:	45.9	68.9	84.8	97.3	
Sum of all eigenvalues				0.334	
Sum of all canonical eigenvalues				0.188	

Test of significance of first canonical axis: eigenvalue = 0.086; *F = 2.09; P = 0.112*

Test of significance of all canonical axes : Trace = 0.188; *F-ratio = 1.546; P = 0.058*

FORWARD SELECTION OF PHYSICO-CHEMICAL PARAMETERS

Site: Off Iligan City

Variable	λA	P	F
Salinity	0.11	0.290	1.23
Rainfall	0.07	0.666	0.80
Temperature	0.08	0.688	0.80
Tidal Height	0.06	0.766	0.62
Total Susp. Solids	0.05	0.844	0.49

Site: Off Kauswagan

Variable	λA	P	F
Tidal Height	0.15	0.094	1.76
Total Susp. Solids	0.11	0.148	1.40
Temperature	0.09	0.386	1.06
Salinity	0.06	0.718	0.74
Rainfall	0.06	0.750	0.65

CONCLUSIONS

- **Dominance of crustaceans (copepods, decapods, tintinids, veligers) in time and space**

- **Multivariate analysis and community parameters analysis are helpful in understanding their distribution and abundance patterns in time and space**

- **Patterns are caused by a collection of environmental parameters, but the ultimate driving force is the reversing wind patterns brought about by the monsoon phenomenon**

New questions raised as basis for future studies:

What are the small-scale current patterns in the Bay?

Species identification

ACKNOWLEDGEMENTS

- International Foundation for Science, Sweden (Research Grant)
- Parents of Anelyn Dapanas (financial support for MSc Thesis expenses)
- Rosabeth Morandarte and Jullibert Castillon (sampling assistance)
- Commission on Higher Education, Manila, Philippines (90% Travel Funds)
- Mindanao State University-Iligan Institute of Technology (10% Travel Funds)
- Dr Shin Ichi Uye, Hiroshima University, Japan (visa application documents)
- Dr Maria Tranquilina Rachel Sanchez-Metillo (technical assistance)

Appendix

SPATIAL PATTERNS

July-August

(Zooplankton peaks in abundance at S, SW, W, NW or western half of the bay)

Grouping of Stations	*Zooplankton Assemblage (most common in bold)*
Southwest (4,6)	**fish eggs**, **copepod nauplii**, copepod copepodites, tintinids, ostracods, zoeae
Northwest to Northeast	gastropod veligers, **chaetognaths**, calanoid copepods, **cyclopoid copepods**
Mouth and Southeast, South	**copepod copepodites**, tintinids, calanoid copepods, **gastropod veligers**, **larvaceans**, **ostracods**, **crab zoea**, **fish larvae**, **bivalve veligers**

November-December

(Some zooplankton peaks at the eastern sector but others have peaks spread throughout the bay)

Grouping of Stations	*Zooplankton Assemblage (most common in bold)*
Northwest, Southwest	calanoid copepods, tintinids, ostracods, **gastropod veligers**, **chaetognaths**, **larvaceans**, harpacticoid copepods, zoea, **fish larvae**
Northeast, South	**copepod nauplii**, copepod copepodites, calanoid copepods, tintinids, **bivalve veligers**, **ostracods**, foraminiferans, **cyclopoid copepods**
Southeast	**copepod copepodites**, **fish eggs**, few nauplii, foraminiferans, cyclopoid copepods, few larvaceans

TEMPORAL PATTERNS

Separation into two groupings of months corresponding to the northeast and southwest monsoon months. Each group had zooplankton categories that showed peaks in abundance.

Grouping of Months	Most Abundant Zooplankton Categories
Iligan	
January, May, June, July, August, September	tintinids, calanoid copepods, decapod larvae, **larvaceans**, fish eggs, **fish larvae**, salp
March, April, November December, Februrary	**decapod shrimps**, calanoid copepods, fish eggs, **cyclopoid copepods**, **gastropod veligers**, **bivalve veligers**, **decapod larvae**, crab zoea, chaetognaths, tintinids, ostracods, siphonophores, cubomedusae, amphipods, bipinnaria larvae, ctenophores, polychaete larvae, salps
Kauswagan	
May, June, July, August September	calanoid copepods, **decapod shrimps**, **fish eggs**, cyclopoid copepods, **gastropod veligers**, **decapod larvae**,**chaetognaths**, siphonophores, **ostracods**, **larvaceans**, **polychaete larvae**, copepod nauplii, **amphipods**, **bipinnaria larvae**, **salps, fish larvae**
October, November, December, January February, March April	cyclopoid copepods, **bivalve veligers**, siphonophores, gastropod veligers, **ctenophores**, tintinids, **zoeae**, **barnacle nauplii**, **copepod nauplii**, **tintinids** gastropod veligers