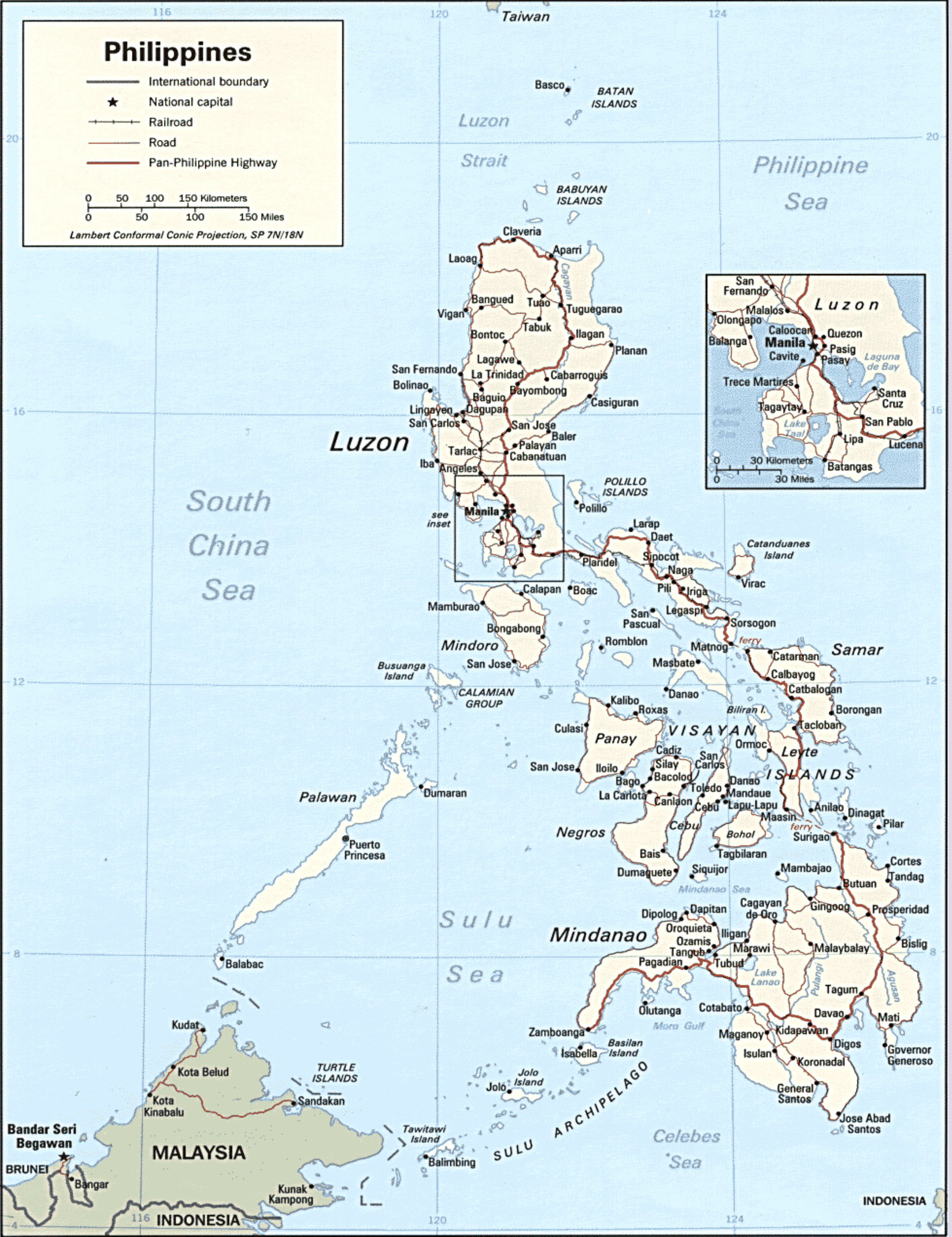
Science Interventions for Sustainable Marine Products Production: Case of Sardines and Seaweeds

M.N.E. Montaño*, C.L.Villanoy* and A. A. Pedrosa III**
*Marine Science Institute, University of the Philippines
**Seaweed Industry Association of the Philippines



Number of islands	7,107
Total land area	298,170 km^2 =22%
Sea area	1,039,190 km^2 =78%
Coastline	36,289 km
Coastal waters	226,000 km^2
Coastal provinces	64 (of 79) = 81%
Coastal municipalities	822 (of 1,502) = 55%
Population	94.01 million (2010)
Population in the coast	65 million (2000) = 74%

Science interventions for sustainable marine resource development and production is driven by:

1. Increasing population that exacts a greater burden from the environment to produce food and provide livelihood for the population.
2. Variability in natural conditions require deeper understanding to ensure greater, or at least more consistent, levels of productivity.
3. Philippine marine resources largely underutilized.

This presentation will focus on two (2) specific examples where science interventions can have significant impacts on resource productivity:

- Sardine production which is dependent on wild catch locally.
- Seaweed products in which the Philippines is a world leader in the development of the industry through cultivation and development.

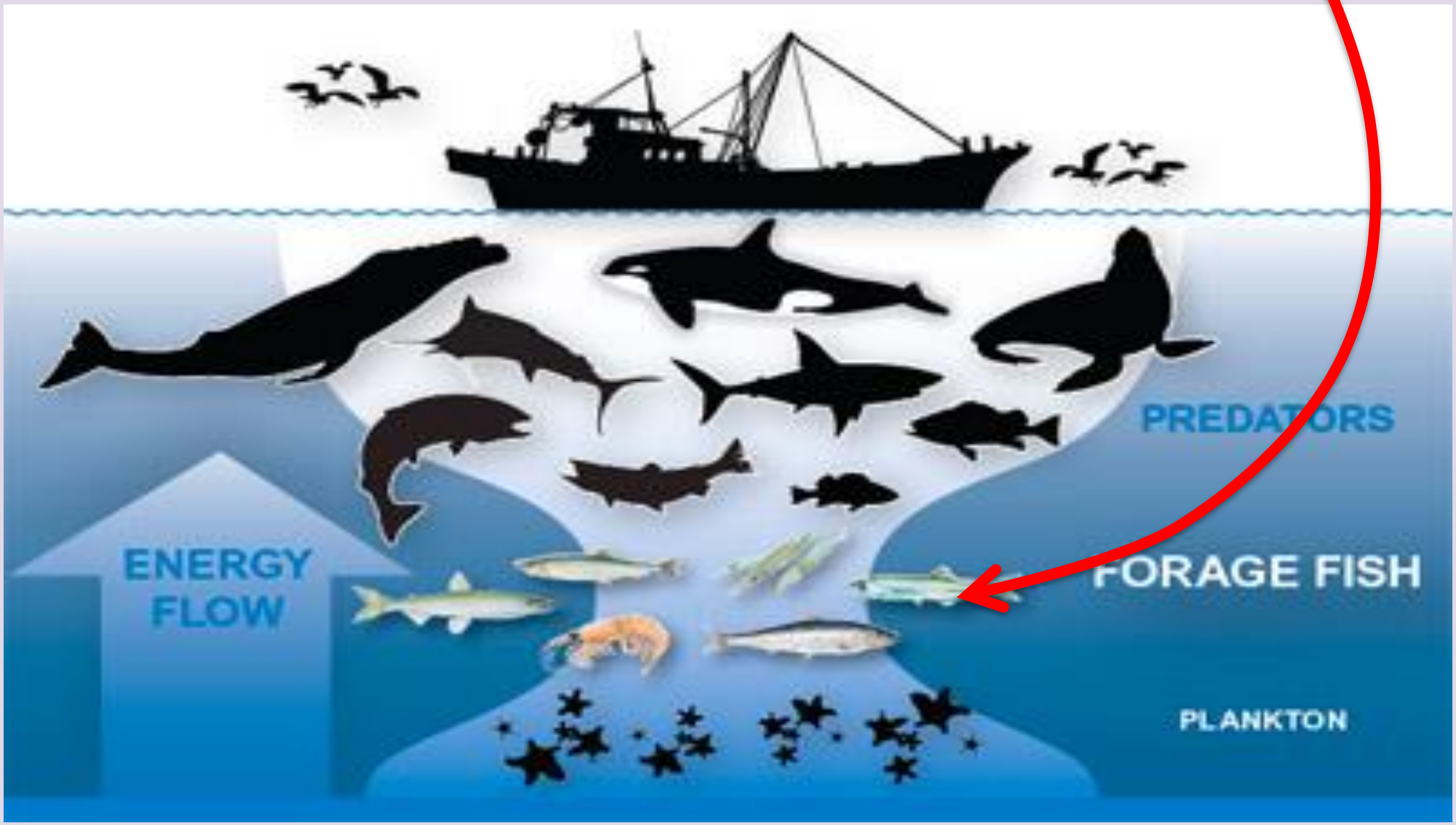
NAST Mindanao Regional Scientific Meeting
SMX Davao City, March 13-14, 2017

Sustainable Sardine Fisheries

[1]Cesar Villanoy, 2Wilfredo Campos, [1]Aletta Yniguez, [3]Asuncion de Guzman, [1]Dianne Deauna, [1]Jakellen del Prado, [1]Patrick Pata

[1]Marine Science Institute, University of the Philippines Diliman
[2]Oceanbio Lab, University of the Philippines in the Visayas
[3]Mindanao State University at Naawan

Sardines are found low in the food chain making it sensitive to environmental changes and also affected from the top



Factors Affecting the fluctuation of sardine abundance:

1. Upwelling
2. Circulation
3. Sea temperature
4. El Niño Oscillation (ENSO)
5. Monsoons, Rainfall
6. River discharge
7. Overfishing
8. Industry Demand
9. Management Policies
10. Food availability
11. Predation
12. Regime shift

upwelling circulation sea temperature ENSO
monsoons rainfall river discharge

Sardine abundance fluctuates

over-fishing management policies regime shift
food availability predation industry demand

What do we need to sustain the sardine fisheries?

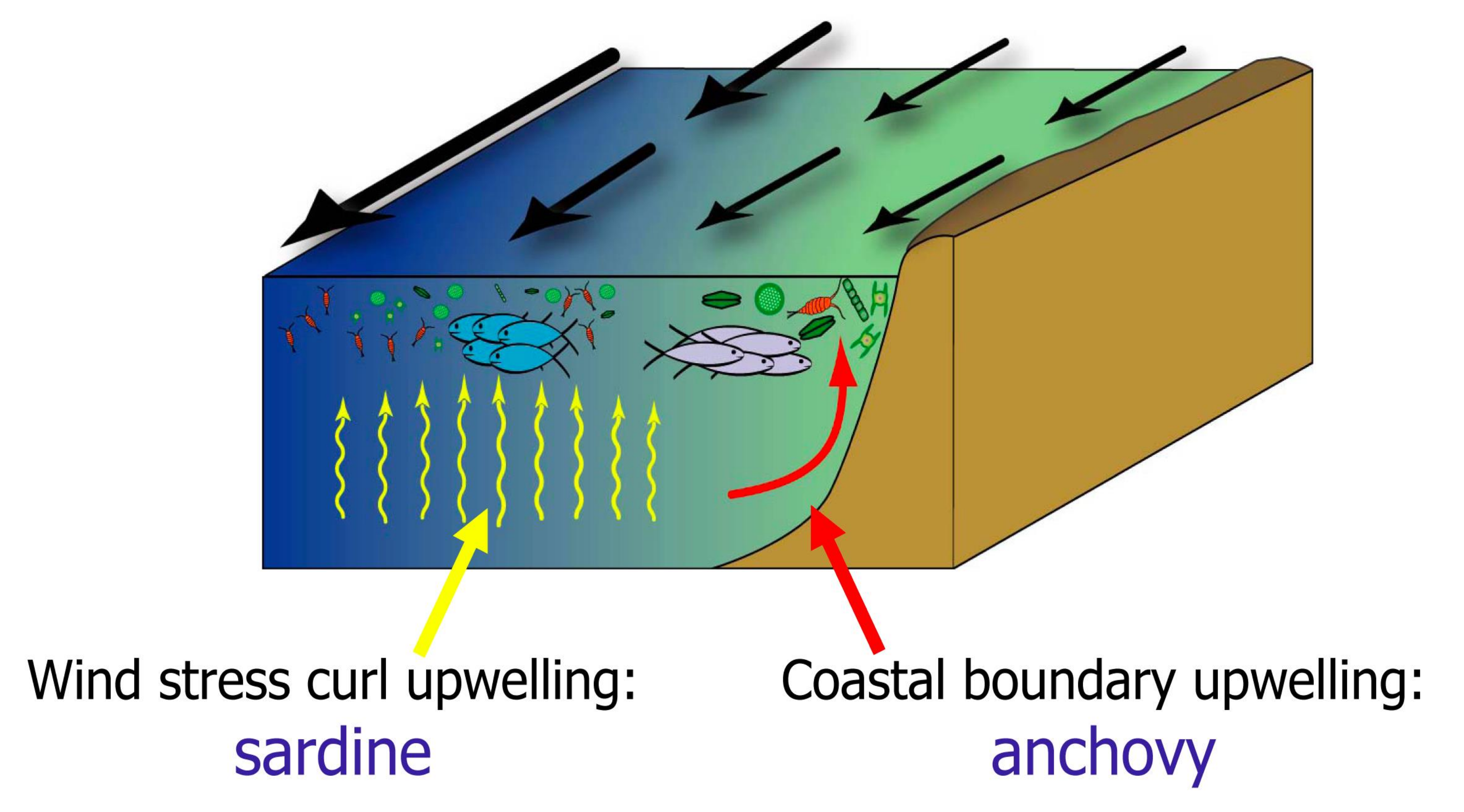
Understanding sardine abundance as influenced by:

- Environmental variability
- Sardine biology
- Fishing effort spatial and temporal variability

Sardine distribution related to plankton distribution

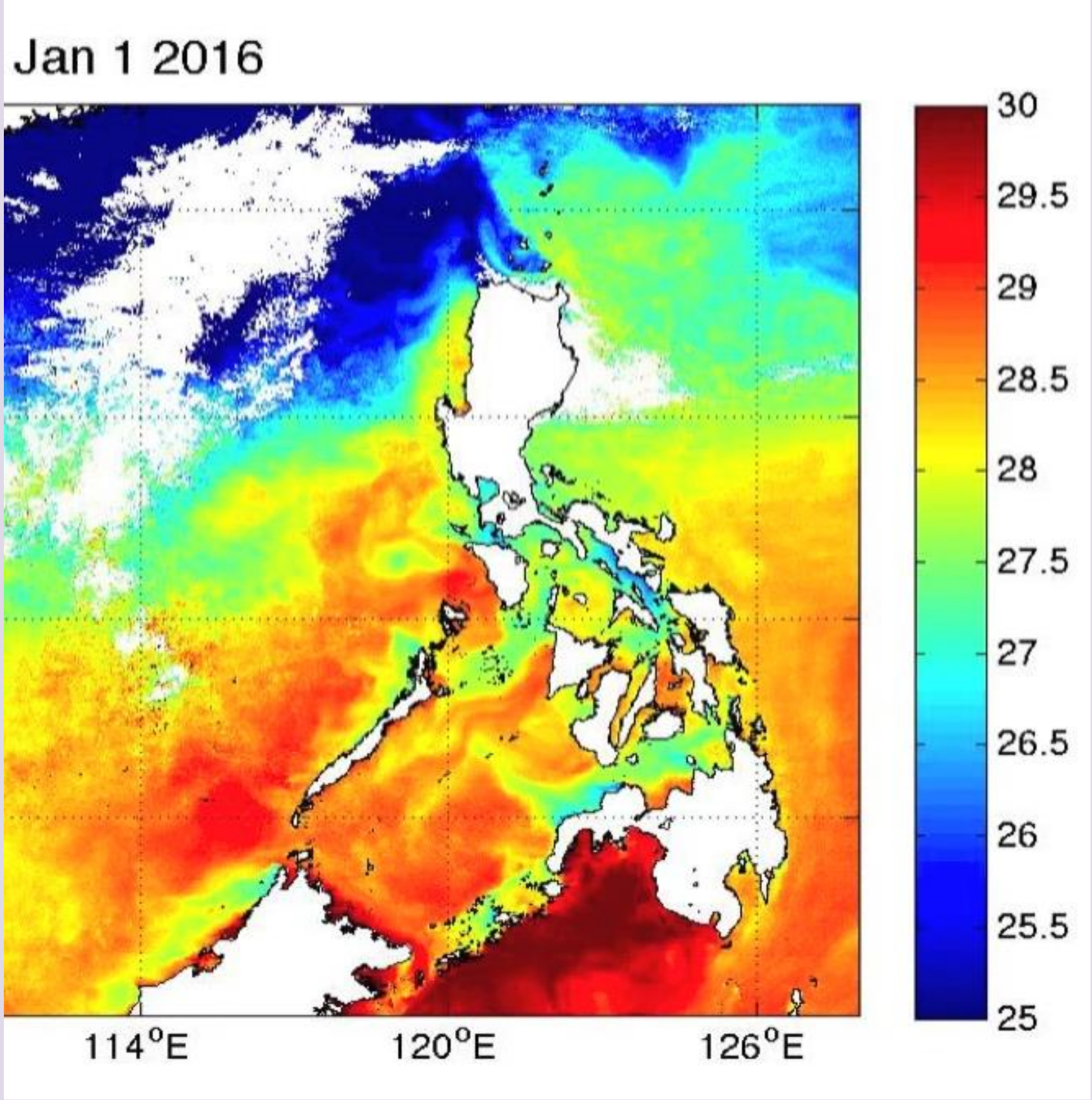
- Food predominantly plankton
- Plankton biomass highest in areas where both lights and nutrients are available at the surface
- Sources of nutrients:
  - River runoff
  - Subsurface waters in the ocean where nutrients can accumulate
- Nutrients needed by plankton from below can be brought up to the surface through upwelling and intense mixing

Types of upwelling

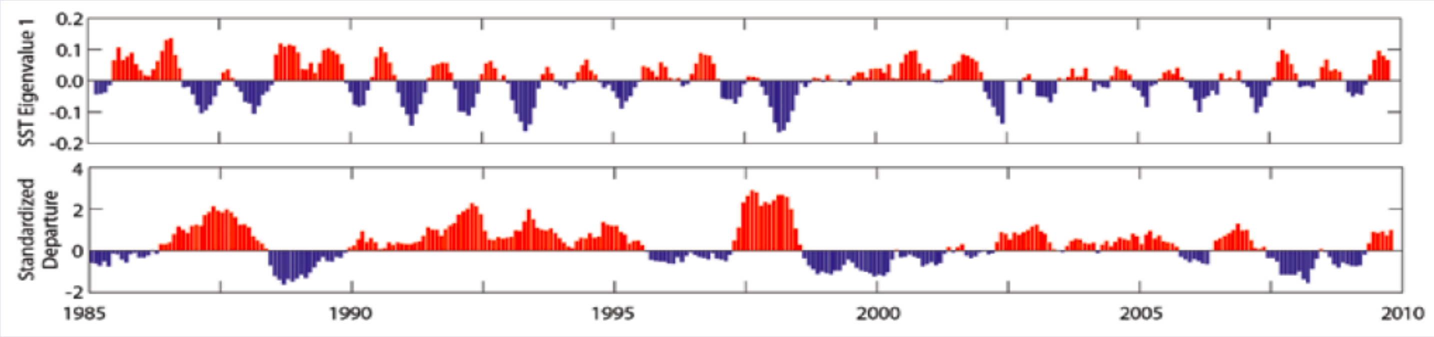


Rykaczewski et al, 2008.

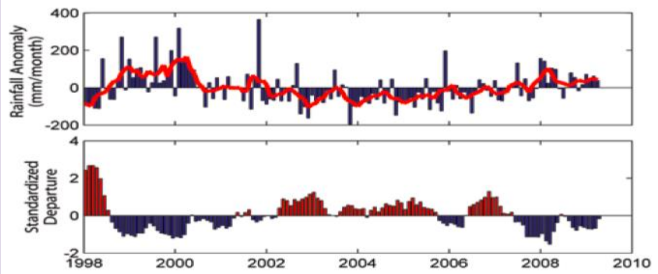
Areas with upwelling or strong vertical mixing identified by cooler sea surface temperatures and high chlorophyll a Note: Areas with blue green to yellowish color indicate mixing of hot and cold water and can indicate high upwelling.

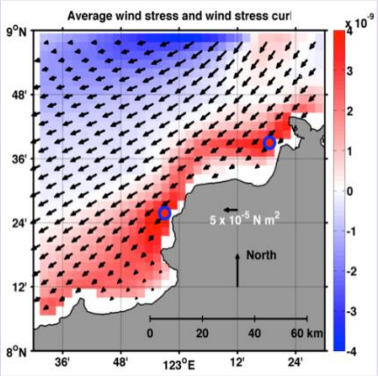


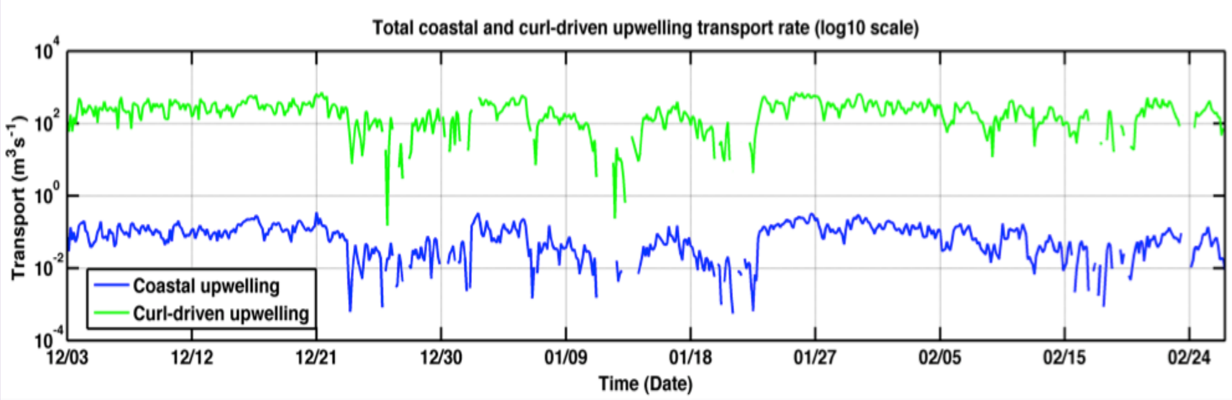
ENSO Variability



Upwelling intensity increases during El Niño, decreases during La Niña



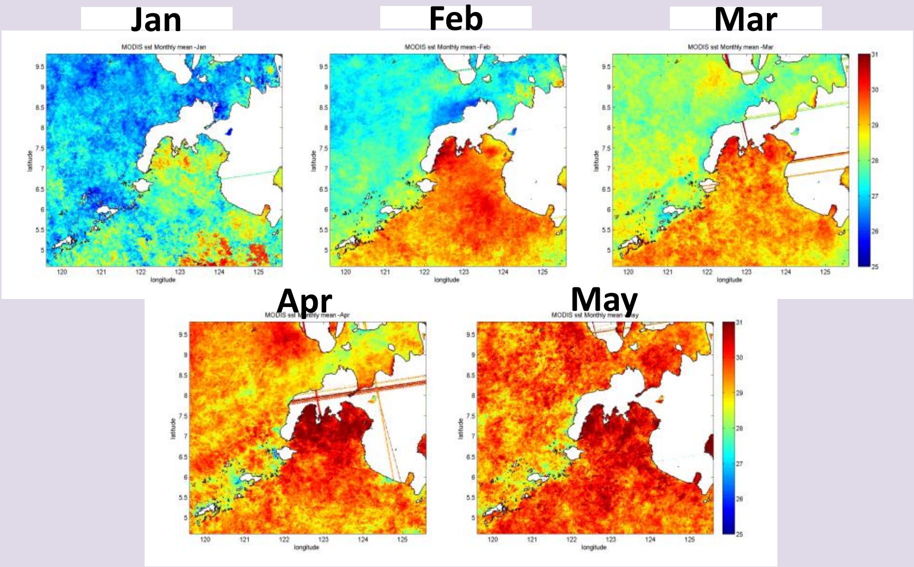




Curl vs Coastal Upwelling in Dipolog and Sindangan Bay

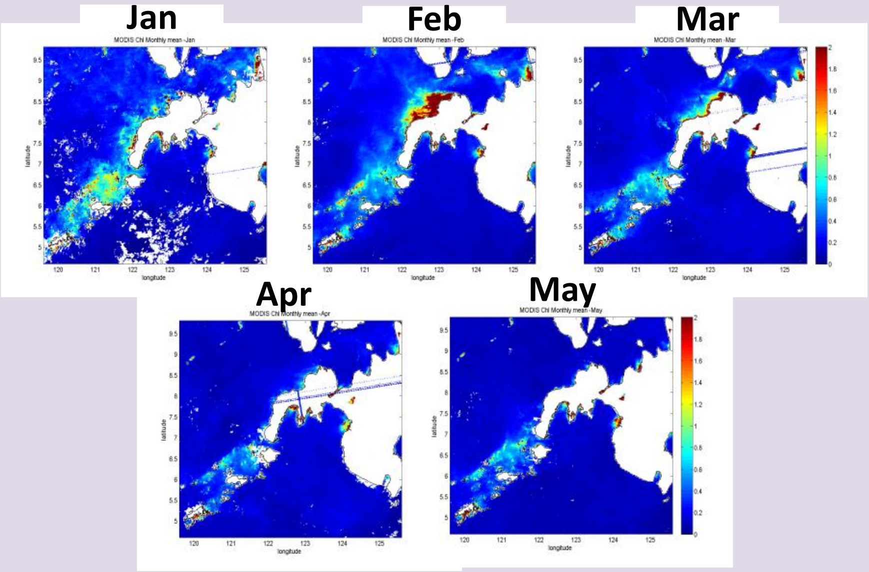
2013 Monthly SST

showing upwelling in the northern Zamboanga and very sharp SST difference between Sulu and Sulawesi Sea



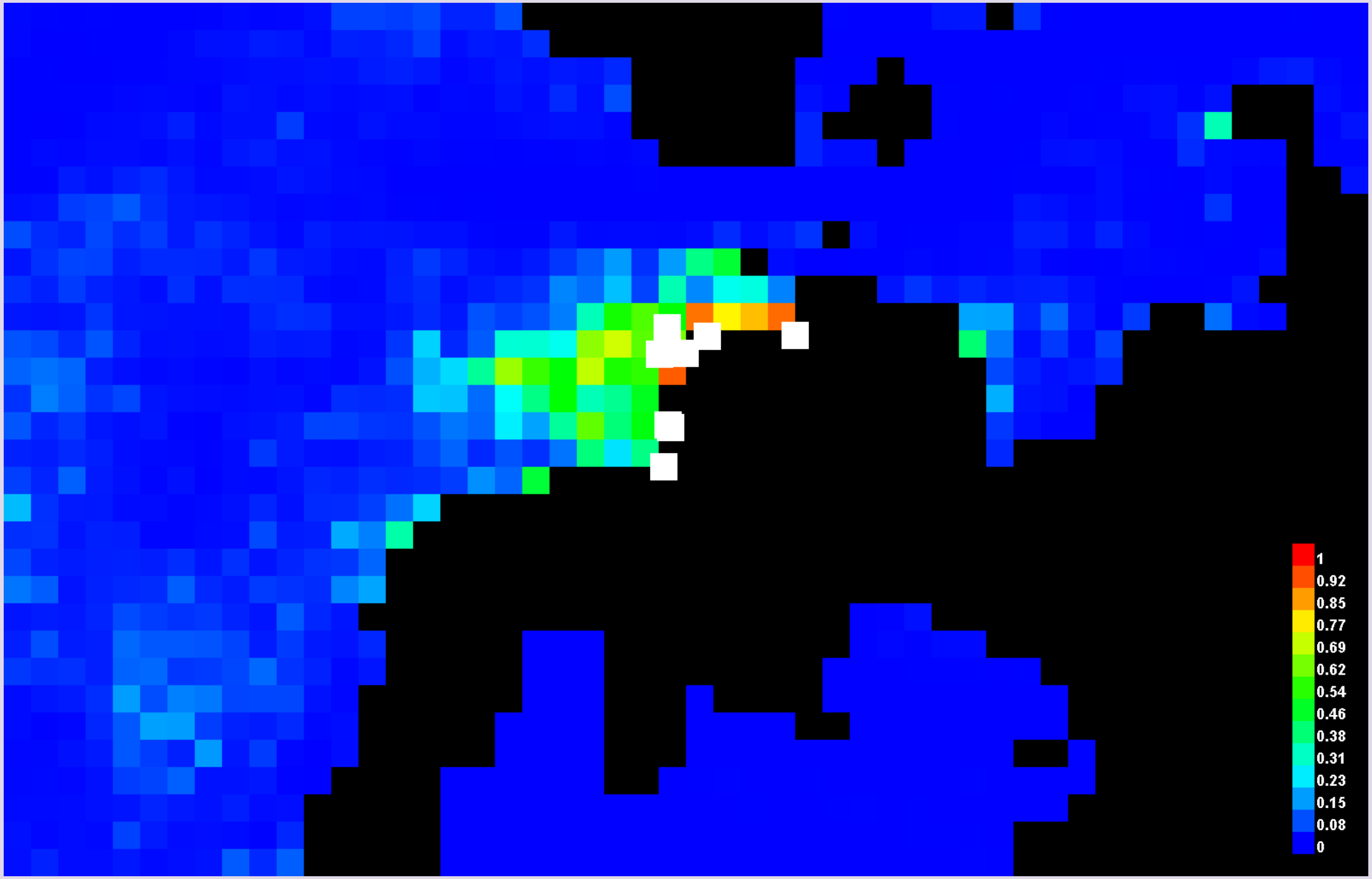
2013 Monthly Chlorophyll data showing peak Upwelling in Feb 2013

Elevated chlorophyll limited to northern Zamboanga Peninsula. High values along Sulu Archipelago mostly due to reflection of shallow bottom.

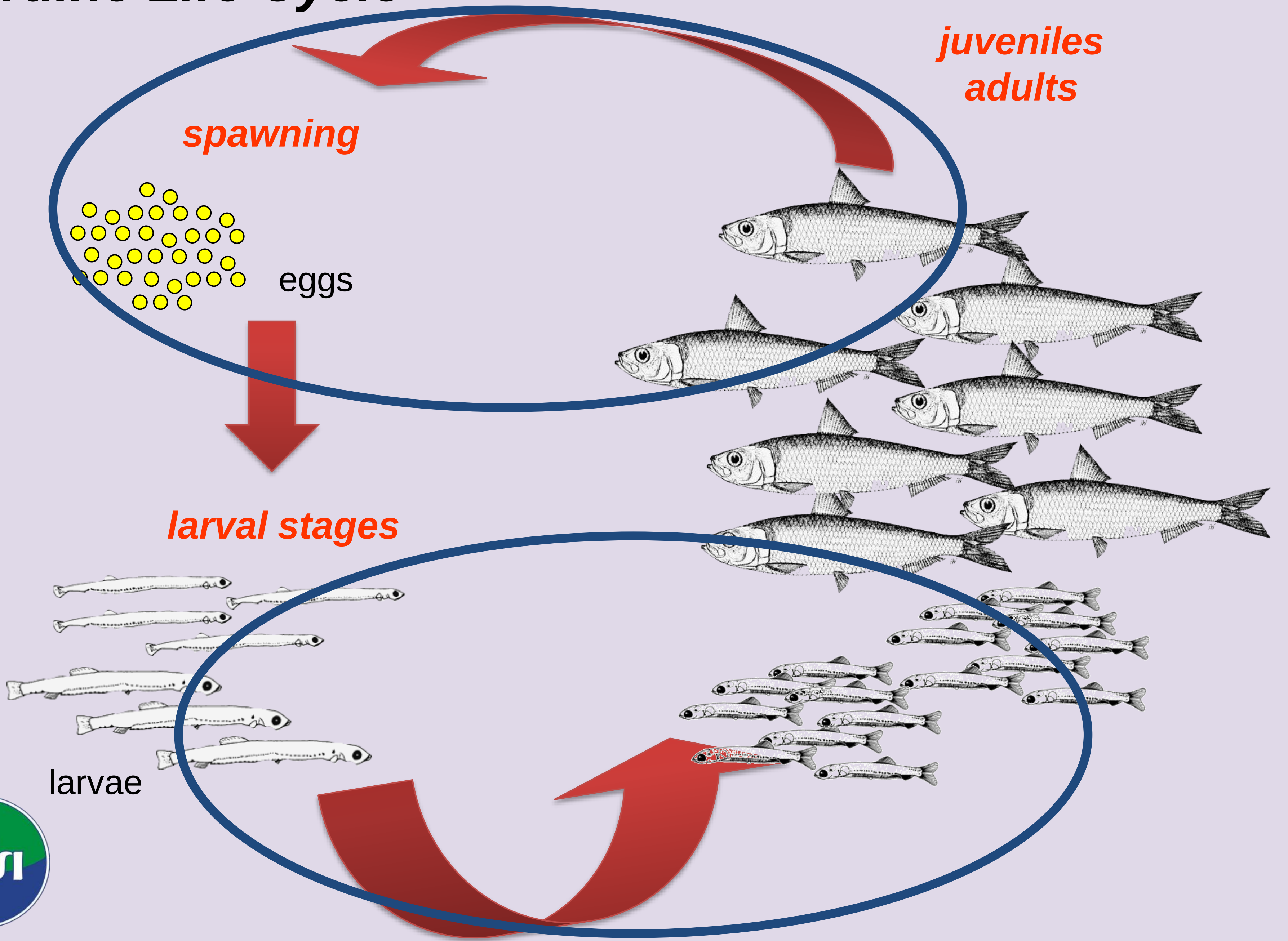


Feb 2013 : SST, Chl, Currents (MODIS + HYCOM)

Predicted suitable habitats for sardines

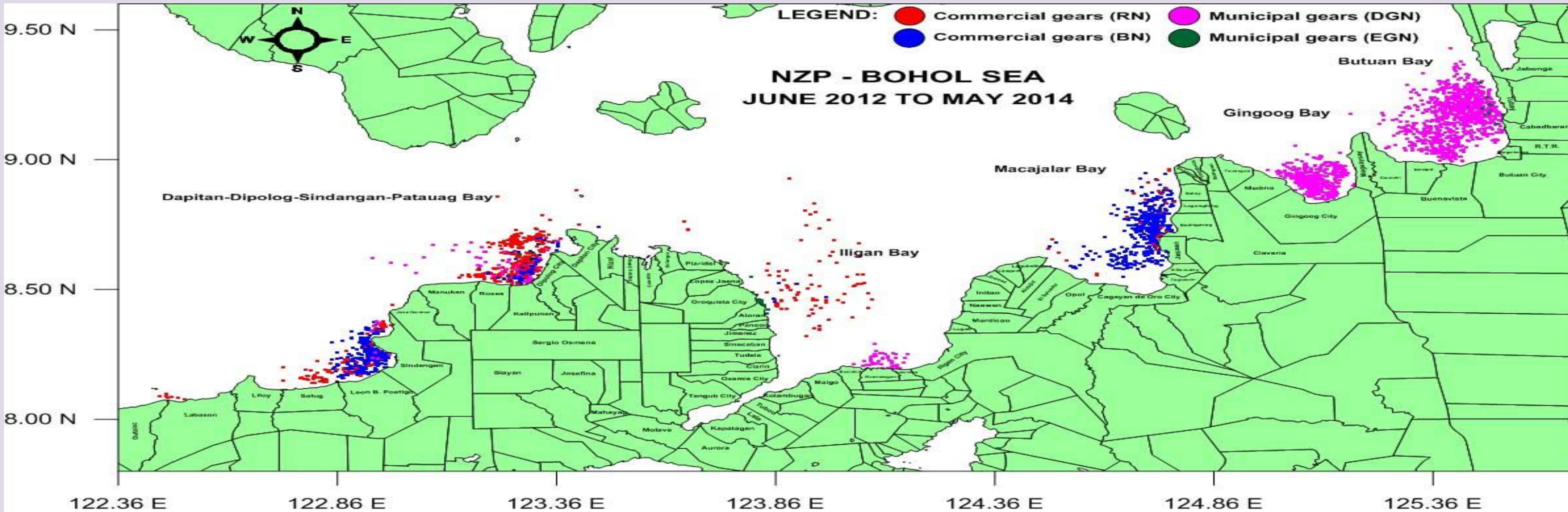


Sardine Life Cycle

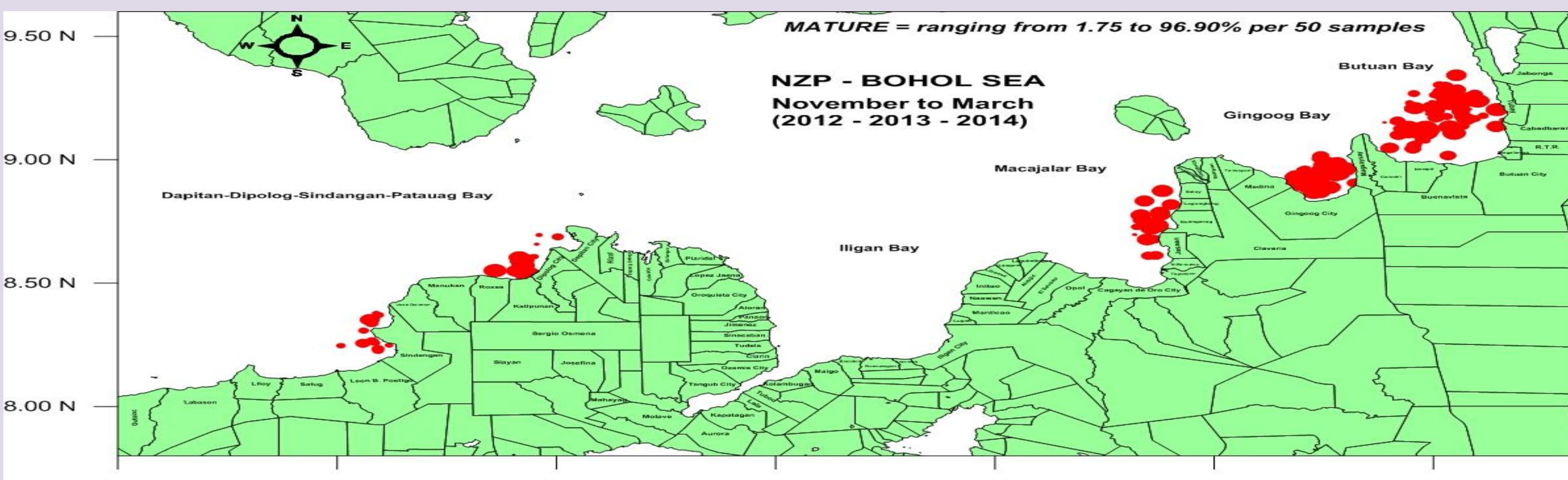


Mapping fishing effort through RSVP

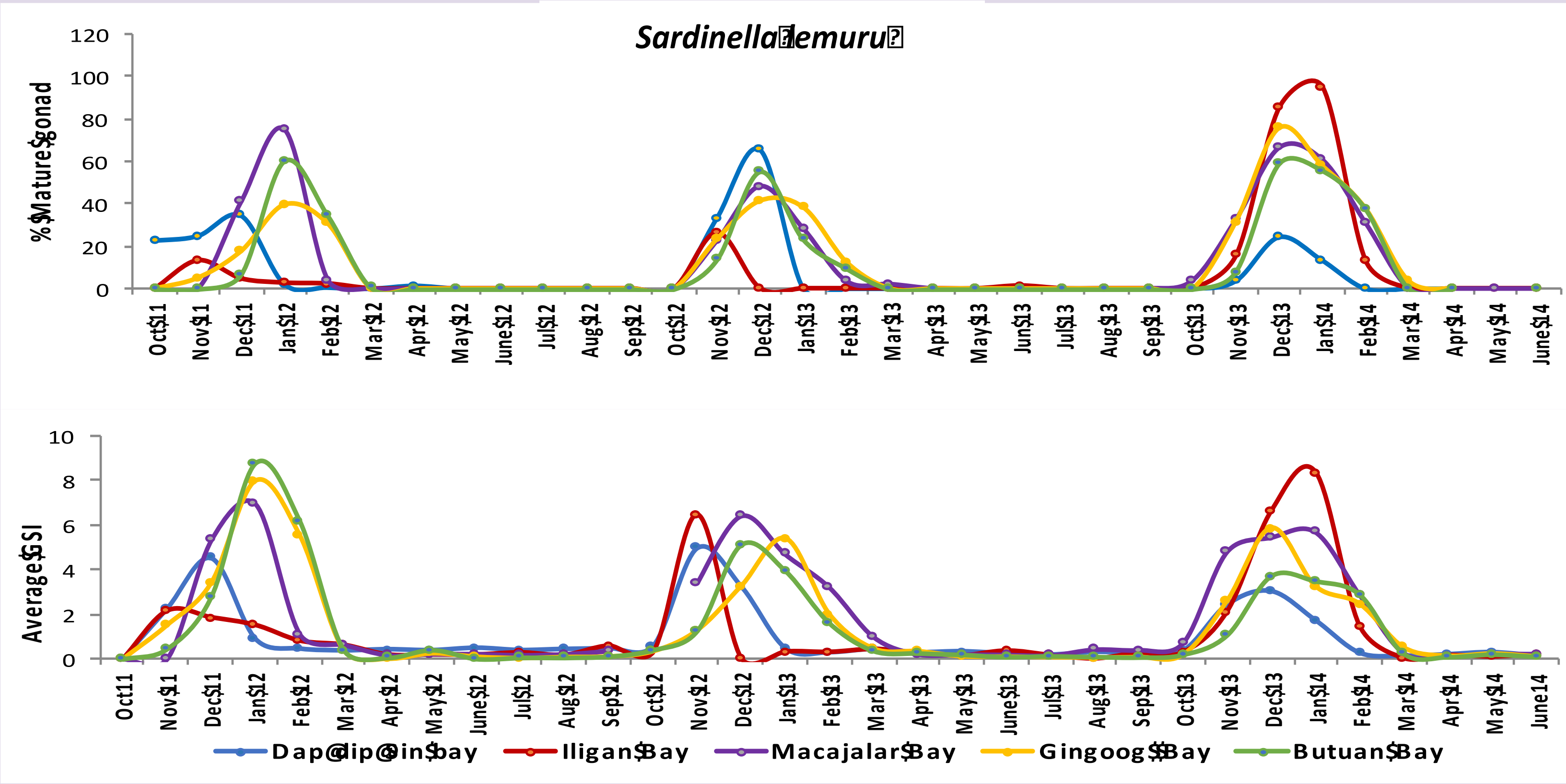
(Research on Sardines Volunteer Program)



Identifying spawning areas for more targeted management interventions

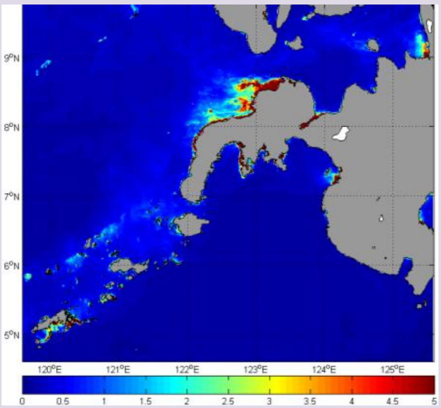


Catch monitoring provides information on spawning and production

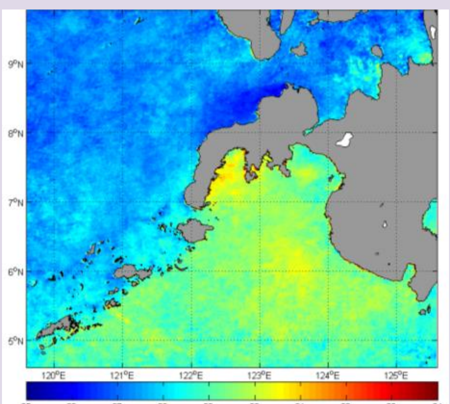


Habitat Index

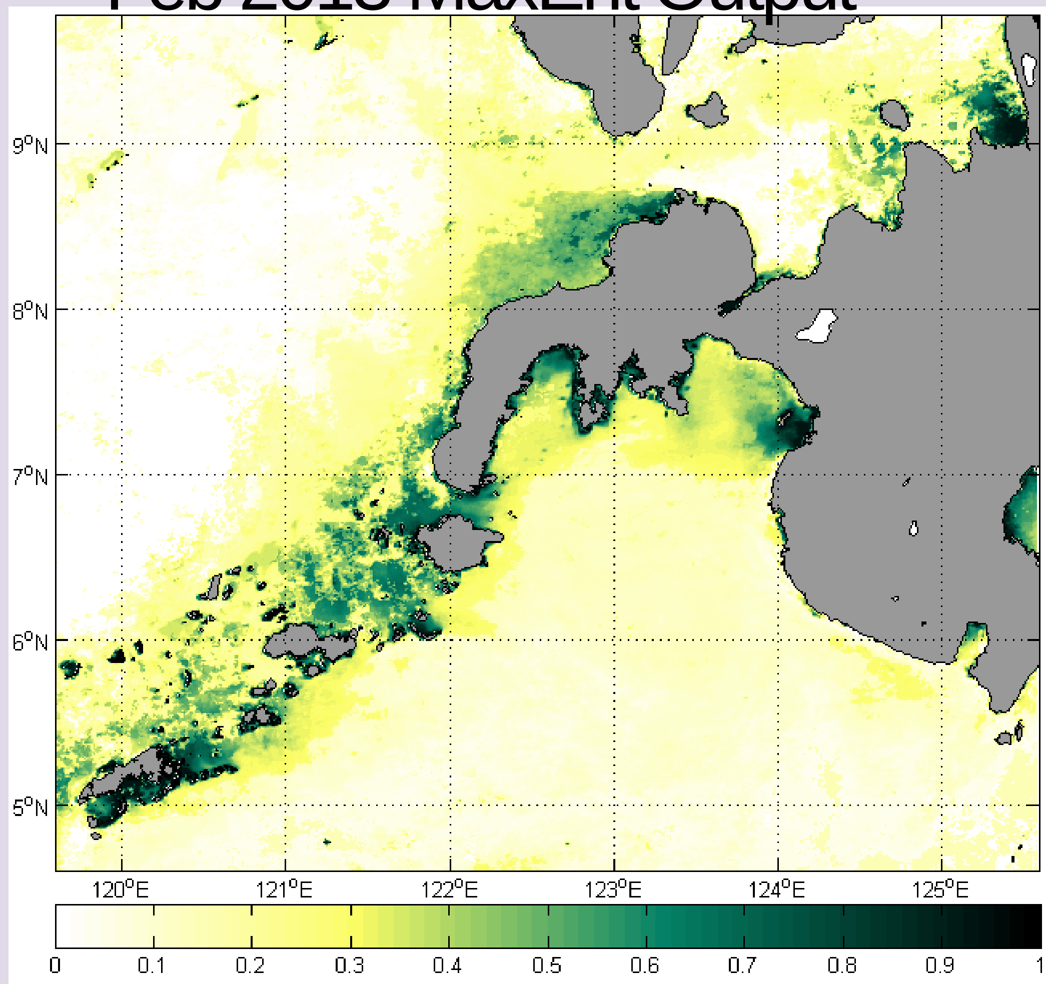
Chlorophyll-a



Sea Surface Temp.



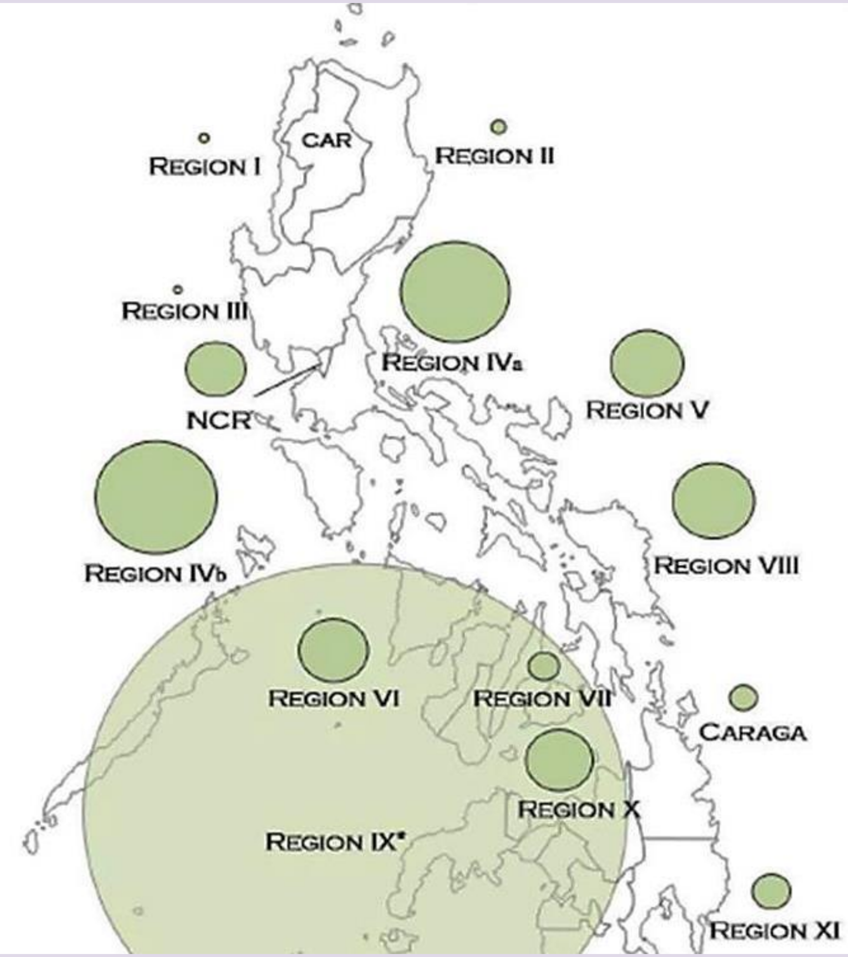
Feb 2013 MaxEnt Output

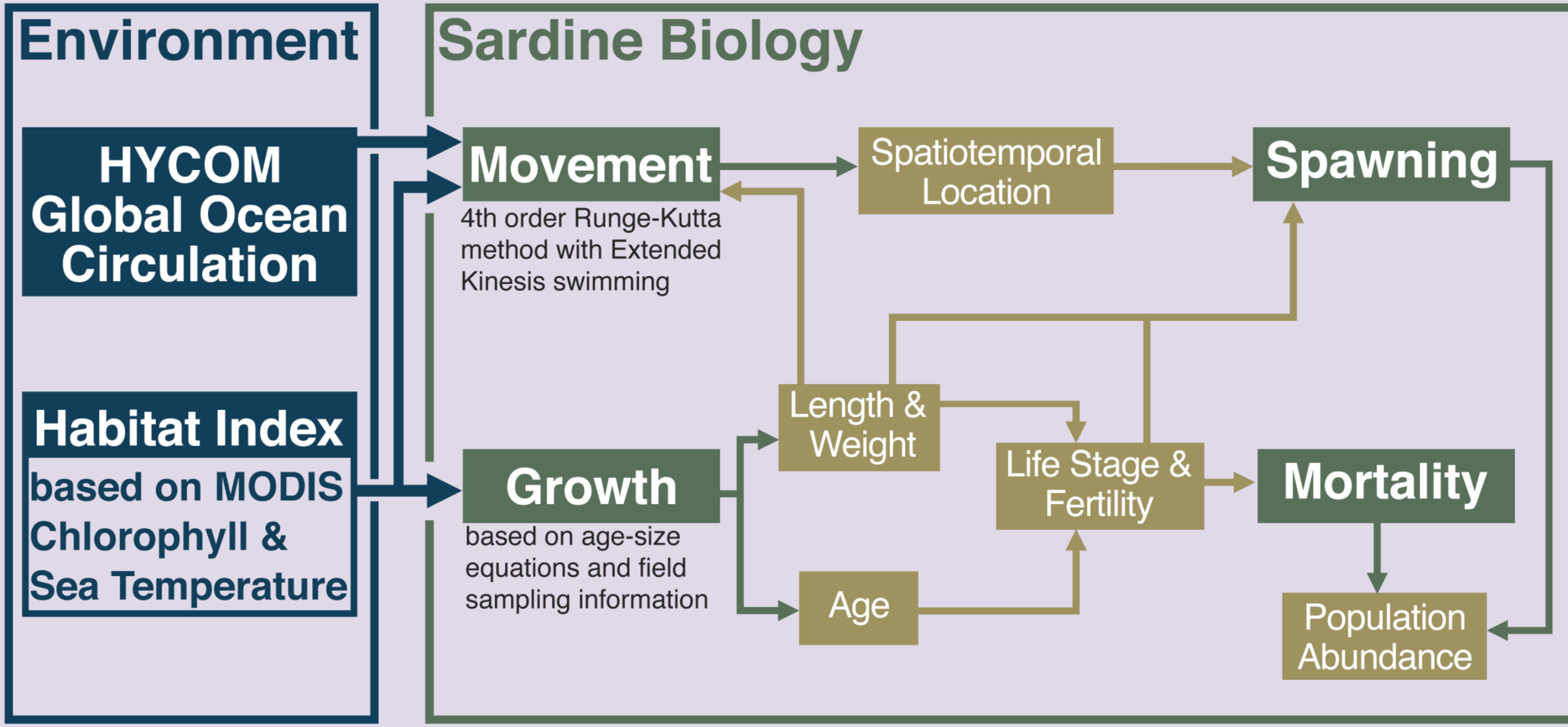


Habitat Suitability Index – Greener is better

Challenges to a nationwide scaling up of the habitat preference model

- Absence or inaccessible spatial fish catch and effort data
- Presence data based on fish catch only. No available fishery-independent data





Track Sardines & Environmental Conditions

Understand Biophysical Interactions

Management tool to protect fisheries

Science Based Policy Interventions

1. Fishing bans in specific locations and for specific periods will assure that sardines are able to spawn optimally ensuring greater supply.
2. Mapping of fishing effort and gonad index to identify spawning areas as input to policy refinement.
3. Further studies.

Further studies recommended because:

1. Conditions vary at different locations.
2. The greater the available data, the better the models for prediction of sardine productivity nationwide may be made to develop policy interventions to help assure sustainable levels of supply.
3. Investigations of the scheduling of area specific interventions will help minimize disruptions in supply (from bans).
4. Sardine as an input to increasing production of larger pelagic species will only lead to greater overall supply.
5. Science based interventions will consider cross effects of interventions ensuring minimal stresses to other marine resources that may be impacted by policies.

Sustaining the sardine fisheries requires more information

1. Egg/Larvae distribution
2. Catch Monitoring at specific landing sites (adults, juveniles – lupoy)
3. GPS tracking of fishing activities (fishing effort and gonadal index distribution mapping to identify spawning grounds)

Sardine Production in the Philippines
BFAR Statistics – Zamboanga Peninsula

	% Change in Production		
	Commercial	Municipal	Consolidated
2011-2012	05.90%	08.25%	06.35%
2012-2013	-07.53%	20.00%	-02.80%
2013-2014	20.00%	-07.00%	14.56%
2014-2015	10.26%	10.80%	10.36%

*Statistics after the implementation of fishing season (close and open)

Seaweed Industry Association of the Philippines

REGIONAL SCIENTIFIC MEETING
ATTAINING SUSTAINABLE DEVELOPMENT GOALS:
PHILIPPINE FISHERIES AND OTHER AQUATIC RESOURCES 20/20

Current Status of Philippine Seaweed Industry

Alfredo A. Pedrosa III

SMX Convention Center, Davao City
March 13-14, 2017 (Monday-Tuesday

Philippine Seaweed

1. Philippine scientists were able to develop the technology for seaweed farming. The Philippines has one of the most abundant number of identified seaweed species in the world.
2. The Philippines used to be number 1 in terms of seaweed production worldwide. Now we are number 2.
3. Of the over 100 edible species of seaweed, we have only developed cultivation technology for 4.
4. Seaweed cultivation can be done concurrently with other marine products. Synergistic production of multi marine species has not been fully studied.
5. The absolute economic potential of seaweed production has not yet been fully identified. Available areas for development are largely unused.

Seaweed Industry Stakeholders

Input supply – nursery operators > 130

Farm Production - > 200,000 fisherfolks families

Postharvest – same as above

Marketing and trading - > 20,000 to 30,000 traders

Processing – 5 multinationals (with rated plant capacity of 12,200 MT)

9 local (with rated plant capacity of 25,800 MT)

Export – 14 processors and > 10 seaweed traders

Note: Data in this presentation (i.e. yields, cultivated area, etc. are for Kappaphycus spp. And Eucheuma Denticulatum only.

Philippine Seaweed Abundance

197 species in 20 families for green algae

153 species in 10 families for brown algae

543 species in 52 families for red algae

893 identified species in the Philippines

PHOTO SOURCE: © Joanna Michelle Chua

REFERENCE: Ang et al, 2013. A Verification of Reports of Marine Algal Species from the Philippines. Philippine Journal of Science, 142, 5-49.

Species Presently Being Cultured

Kappaphycus spp.

Eucheuma spp.

Caulerpa spp.

Gracilaria spp.

Note: Data in this presentation (i.e. yields, cultivated area, etc. are for Kappaphycus spp. And Eucheuma Denticulatum only.

Kappaphycus spp.

Kappaphycus alverizii

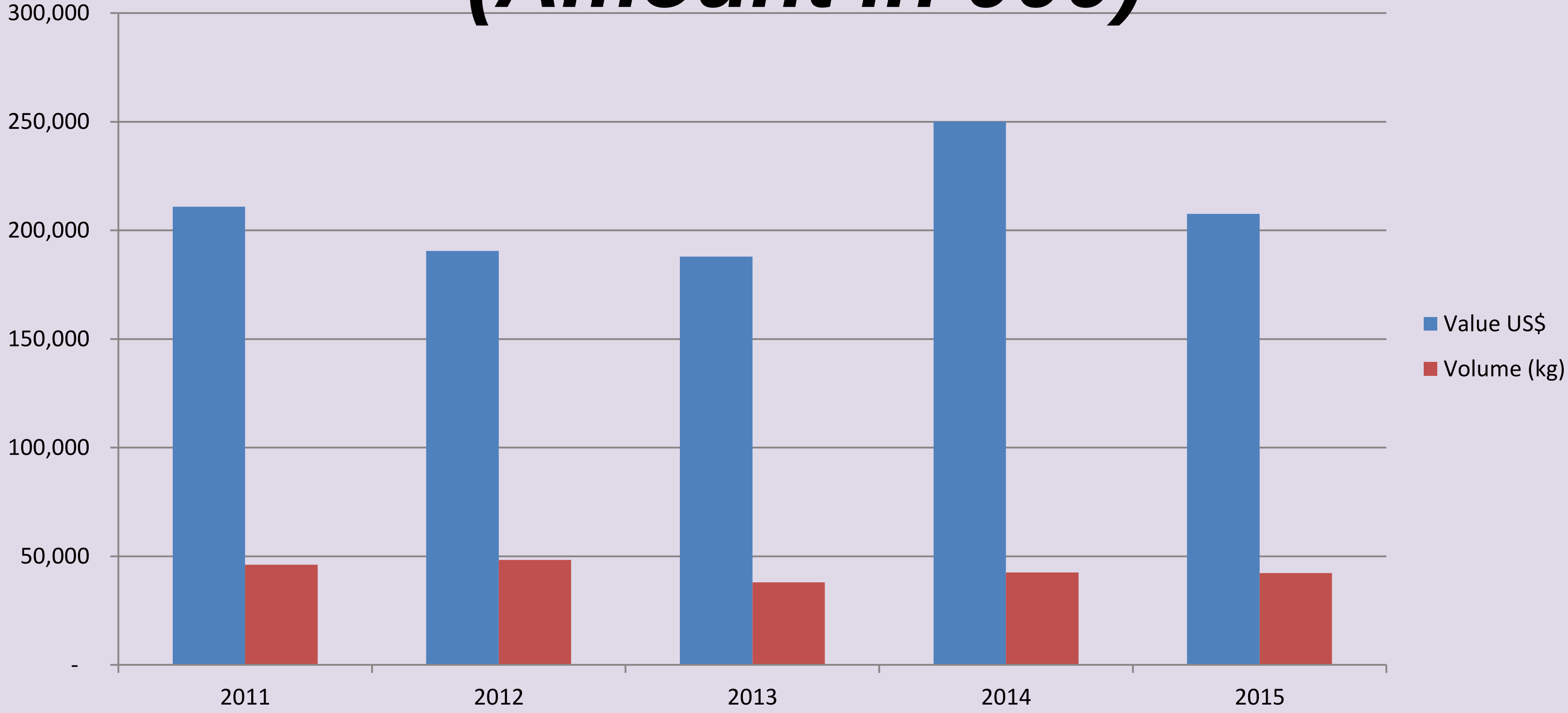
Kappaphycus striatum

Courtesy of EGFortes

Kappaphycus Farm

Courtesy of EGFortes

Philippine Export Earnings in US$ (Amount in 000)



Source: Seaweed Industry Association of the Philippines (SIAP)

Note: Data in this presentation (i.e. yields, cultivated area, etc. are for Kappaphycus spp. And Eucheuma Denticulatum only.

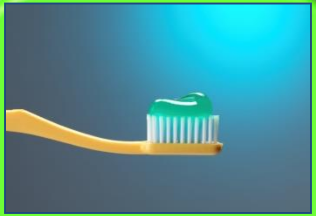
Marine Aquaculture (Needs more input/researches)

- Occurrence of “ice-ice” affects the seaweed farmers as well as the industry.
- Bleaching of seaweeds affecting the quality and price of farmers’ produce
- Stunted growth and deformities in eucheuma plantations
- Massive fish kill phenomenon of farmed milkfish in marine cages in Region I almost annually.

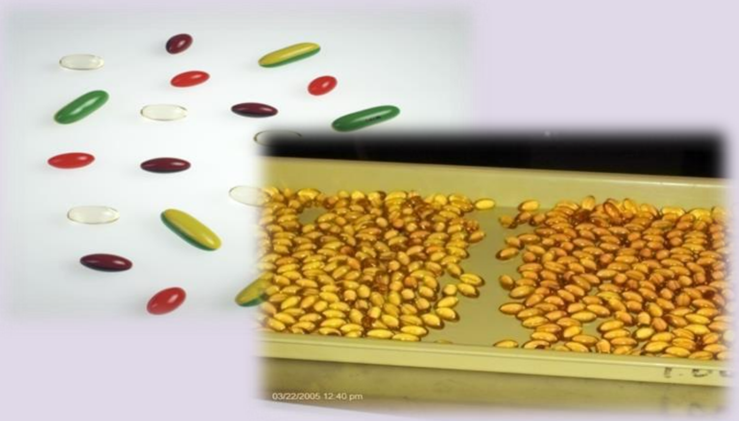


Uses of Carageenan

Research and Development



Other Uses of Seaweed for Development



Animal Free Soft Gel Capsules

Biodegradable, Digestible Films

Microbicides: HIV/AIDS/HPV Prevention

Other Seaweeds that are planned to be cultured

Halymenia spp.

Sargassum spp.

Porphyra spp.

Ulva Lactuca spp.

Looking Forward

- Needed :Screening for active components;
- Research and Development in the ff. fields
  - Bioenergy
  - Pharmaceuticals
  - Food
  - Medicine and Personal Health Care
  - Agricultural and horticulural uses – feeds, bioremediation
  - Paper and other technical products
- Technical and skilled personnel
- Strategic National Research and Development Plan

Seaweed Production Volume vs. Poverty Indices -2012

Regions	Production Vol. (MT)	Ave Poverty Index %PI	PI	High PI
ARMM	627,435.50	43.20	21.90	67.3
8	18,513.40	41.56	31.40	55.4
12	358.65	39.25	25.80	46.0
9	240,180.45	36.97	25.90	48.0
10	39,409.13	35.36	19.10	41.5
CARAGA	14,798.71	31.78	27.70	37.3
5	55,382.09	31.05	21.70	40.6
11	8,384.02	28.17	20.00	37.8
4B	395,125.83	25.22	20.50	30.4
6	80,572.11	24.69	16.19	43.9
7	96,588.56	23.60	18.90	30.6
2	266.46	19.00	48.20	27.1
1	26.47	13.08	8.40	15.3
4A	23,492.73	9.44	2.60	20.3
3	1,827.50	5.35	4.50	12.1

Environmental impacts of seaweed farming

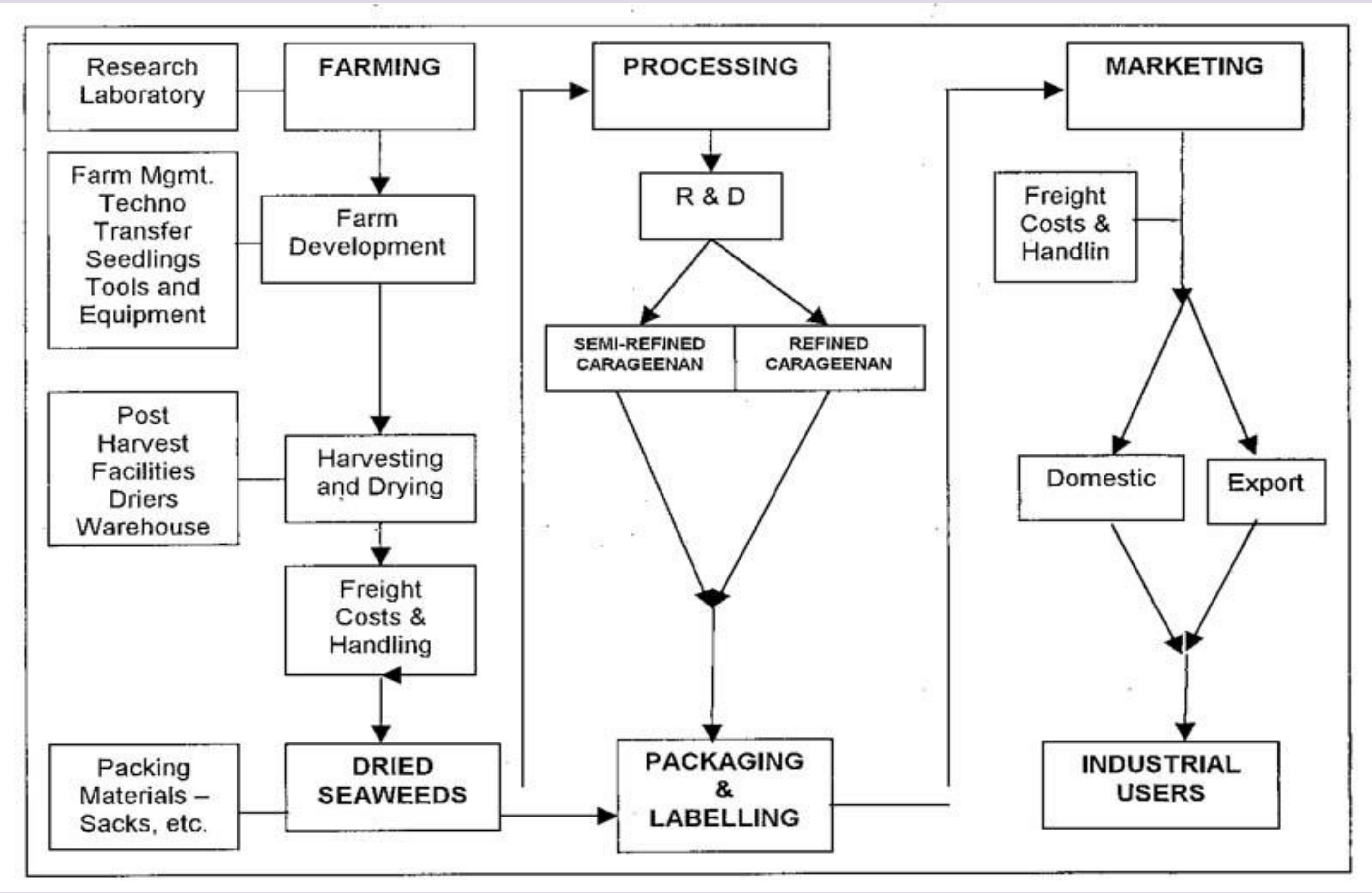
- As primary producers- provides energy to organisms at higher trophic level.
- Fixes CO2 from the atmosphere
- Provides habitat and cover for organisms; increase fish stocks (Russel,1983; Rincones in press)
- Seaweed losses due to breakages and herbivory decomposes to contribute to the carbon budget

Science Interventions

1. Science interventions are needed to increase productivity and ensure available seedling stock and technological information.
2. Additional research on benefits of seaweed consumption/use other than as additives.
3. Maintenance and increase of genetic strains to aid future research.
4. Conduct collaborative research to use seaweed in marine multi-species aquaculture.
5. Provide greater opportunities to poorer coastal communities by developing techniques for good technology transfer.

Science Interventions

Every step in the value chain below can be enhanced/improved by science interventions.



Source: http://www.dipolognon.com/zamboanga/InvestmentSeaweeds.htm

Using research to develop benefits from negative impacts of seaweed processing.

Processing Industries are dumping potassium hydroxide (KOH) liquid wastes in receiving waters

- Industrial effluents are regulated by DENR Administrative Order or DO 2016-18 Water Quality Guidelines and General Effluents Standards
- Compliance with Philippine Clean Water Act - Republic Act No. 9275
- Compliance to the EEC (Environmental Compliance Certificate) and regular monitoring (See ECC samples)
- Presence of water treatment plants.
- Waste utilization in KOH-rich washings as fertilizer and soil ameliorants.(Montaño and Tupas, 1990)

Sustainability

BFAR Response to NOSB

1. Establishment of gene banks of different seaweed varieties (BFAR Reports 2015)
2. Tissue cultures of farmed seaweeds (Trono et al, 2000,Dawes et al., 1993,1994)
3. Seaweed seedlings bank in strategic locations of country(BFAR Report)
4. Preservation of the natural environment for natural growth and regeneration in the wild(Azanza-Corrales et al ,1996)
5. Seedlings for seaweed farming are taken from seedlings nurseries or bank (BFAR report)

Indoor Seaweed Laboratory and Gene Bank

In UP Diliman:

ISL at the UP Marine Science Institute, Diliman, Quezon City

Courtesy of EG Fortes

Outdoor Land-Based Nursery

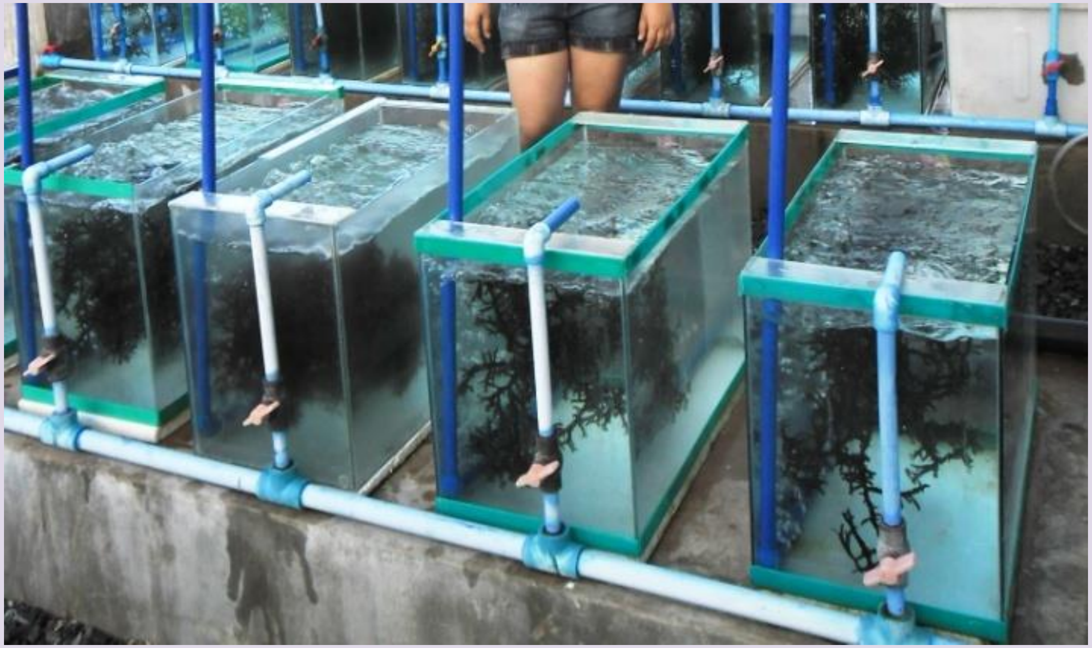
Bolinao Marine Laboratory, Pangasinan

OLBN at the Bolinao Marine Laboratory of the UP Marine Science Institute

Courtesy of EG Fortes

Generation of **farming seed stocks** in the UP-MSI **Outdoor Land-Based Seaweed Nursery**

Day 1



After 5 weeks

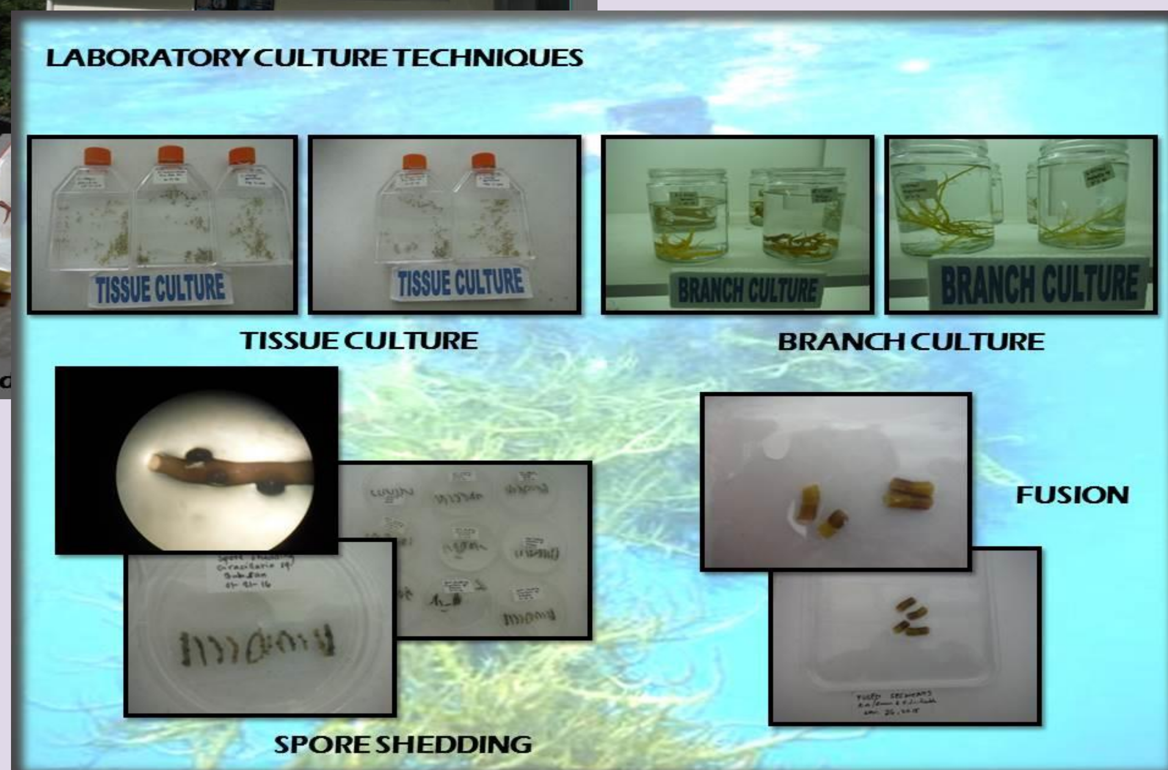
Courtesy of EG Fortes

Sea Out-Planting: ‘Milyon-Milyon’

BRANCH cultures

Courtesy of EG Fortes

Institutional Support



Courtesy of BFAR -NSTDC

On the Job Training using collapsible, transferrable seaweed greenhouses

Courtesy of BFAR -NSTDC

Further Interventions

- Establishment of gene banks of different seaweed varieties
- Tissue cultures of farmed seaweeds
- Seaweed seedlings bank in strategic locations of country
- Preservation of the natural environment for natural growth and regeneration in the wild
- Continued research to find more uses for seaweed and its development.

PHILIPPINE NATIONAL STANDARD

PNS/BAFPS 85:2012
ICS 67.120.30

Dried Raw Seaweed – Specification

Carageenan and Processed Euchema Seaweeds - Specification

PNS on Carageenan

Wednesday, 14 December 2011 00:00

The Department of Trade and Industry's Bureau of Product Standards (DTI-BPS) informs the concerned sectors that **PNS 601:2011** – Carageenan and Processed Eucheuma Seaweeds –Specification ICS 67.220.20 has been developed as Philippine National Standard.

The DTI-BPS developed the standard through the Technical Committee on Food Subcommittee on Carrageenan (BPS/TC 20/SC3). They are composed of represent-atives from academe, government and industry sectors. .

The standard aims to promote common understanding among sectors concerned and provide a level playing field for businesses locally as well internationally.

A copy of the standard can be purchased from the BPS Standards Data Centre at 751.4736.

International Journal of Food Sciences and Nutrition (1999) **50**, 283–289

Carbohydrate availability of *arroz caldo* with λ-carrageenan

Benelyn D. Dumelod,[1] Rachel Patricia B. Ramirez,[1] Cecile Leah P. Tiangson,[1] Erniel B. Barrios[2] and Leonora N. Panlasigui[1]

[1] *Department of Food Science and Nutrition, College of Home Economics and* [2] *The Statistical Center, University of the Philippines, Diliman, Quezon City 1101, Philippines*

Total available carbohydrate (sugars and starches) and total dietary fiber (soluble and insoluble) make up the total carbohydrate content of a food. Soluble fiber decreases the availability of glucose by delaying its absorption in the proximal small intestine, thus reducing the postprandial glucose levels (Jenkins *et al.*, 1978; Schneeman, 1987a). Carrageenan, a seaweed extract, is a good source of soluble fiber (Montaño *et al.*, 1985). This study aimed to determine the effect of carrageenan incorporation into *arroz caldo* on carbohydrate availability by monitoring the postprandial blood glucose levels of normal subjects. Control and experimental *arroz caldo* samples were prepared and subjected to proximate analysis and feeding studies. The total dietary fiber (TDF) content of the experimental (2.03%) was about thrice that of the control (0.68%). Using randomized crossover design, preweighed 55 g available carbohydrate serving portions of control and experimental *arroz caldo* samples, with 3.45 and 14.84 g TDF, respectively, were fed to ten fasting normal subjects then their postprandial blood glucose levels were determined at 15, 30, 45, 60 and 90 min intervals. Results of the short-term *in vivo* study showed that the mean postprandial glycaemic responses of subjects after consuming the experimental sample were significantly lower than the levels after consuming the control at 15, 45, and 90 min ($P \leq 0.05$) and at 30 min ($P \leq 0.001$). Likewise, the mean glucose area under the curve was significantly lower ($P \leq 0.01$) after consumption of experimental (69.22 ± 32.94) *arroz caldo* than control ($147.29 \pm$

Eucheuma sp.

- *Eucheuma denticulatum* (N.L. Burman) Collins and Hervey
  - "Endong" variety

E. denticulatum

"Endong"

NOTE: Need for gene bank and identification technology is emphasized by example below. Seaweed at right is E. denticulatum. Seaweed at right is actually Iota Carageenan bearing but was not accurately identified prior. Hence when seaweed at left was processed for Kappa carageenan, yield was zero. Investigation was needed to differentiate the two.

Conclusion

We have massive resources that are, as yet, not used to its fullest potential.

Simple interventions like timed fishing bans and deeper understanding of seaweed resources can unlock great stores of food and other benefits to the people – if implemented with the bases of sound science.

Acknowledgements

Mr. Carlos Y. Lerias, Ida Capacio,
Irma Ortiz and Roy Ortega of BFAR,
BFAR NSTDC SORSOGON,
Dr. Edna G. Fortes, Rafael Gipaya,
NAST staff, SIAP Secretariat,
Mr. Matin Wee of DOST Region XII
and other Seaweed Supporters

Thank you!