Inventory and Stock Assessment of *Gracilaria* Spp. in Ilocos Sur

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ABSTRACT

The research study was aimed to inventory and assess the natural stock of Gracilaria spp. found along the coastal towns of /locos Sur for a period of two years from July 1996 to June 1998. The work was concentrated on the taxonomic studies, on the seasonal and spatial biomass production, and on the effect of temperature, salinity, and water movement on said biomass production.

Sinait, Cabugao, Santa Maria, and Santiago, /locos Sur were the specific sampling towns. Taxonomic studies of the collected species were done up to the species level. Standing crop studies were done monthly for a period of two years by the transects line method. Quadrat sampling was done at 20 m intervals along the transect. Collected Gracilaria were air-dried and the dry weights expressed in glm^2 to represent the biomass production. Temperature, salinity, and water movement variations were also monitored every sampling period.

Five species of Gracilaria abound the four coastal towns of /locos Sur, namely: G. *arcuata,* G. *coronopifolia,G. echeumoides, G. gigas, and* G. *salicornia. For the two-year study period, Gracilaria spp. found in Santa Maria had the highest record of mean dry weight (112.37glm^2), followed by those in Santiago (108.00 g/m'), Sinait (71.08 g/m?), and Cabugao (69.73 g/m^2). Two ecological factors, i.e. temperature and water movement, had negative significant relationship with seaweed biomass production.*

As evidenced by the data gathered, Graci/aria can be considered a potential resource of the province of /locos Sur.

Introduction

Background of the Study

The geographical location of Ilocos Sur is very suitable to seaweed production. Its western part is exposed to the physical effects of the South China Sea activities. The shallow coastal areas of the province support well-developed seaweed communities. Most of the coastal towns and barangays have reefs which extend up to several hundred meters seaward where seaweeds abound while only few have sandy beaches not suited for macrobenthic algae (Corrales-Domingo, 1988). *Gracilaria* has been reported to abound along the coastal barangays of the province.

Gracilaria species is consumed by the Ilocanos as part of their diet, either in salad form or mixed with other recipes. Since the seaweed is used not only as food but more as a source of agar (Trono and Ganzon-Fortes, 1988) and no report on the biomass production of the resource in the province of Ilocos Sur has been published, the researchers deemed this research necessary. Results of this study will serve as baseline information on the resource. Moreover, it is necessary for the conservation of the natural seaweed beds and for promotion of sound management schemes for sea farming areas.

Objectives

This research work was done to inventory and assess the natural stocks of *Gracilaria* found along the coastal towns of llocos Sur. In particular, it aimed to:

1. Conduct taxonomic studies on *Gracilaria* spp. found along the coastal towns of the province.
2. Study the seasonal and spatial biomass production of the seaweed.
3. Find out the effect of three ecological factors, namely, temperature, salinity, and water movement on the biomass production of the seaweed species.

Review of Related Literature

Seaweeds are the macrobenthic or bottom-dwelling primary producers of the fresh and aquatic environments. They are photosynthetic organisms capable of converting inorganic compounds of water and carbon dioxide in the presence of light into organic compound of simple carbohydrate (Trono and Ganzon-Fortes, 1988).

These algae play varied roles. They prevent coastal erosion, give habitat to highly diverse fonns of animal life, and are used as food for fish/other aquatic animals and man. According to the Philippine Council for Aquatic and Marine Research and Development - Department of Science and Technology (1989), seaweeds are good sources of carbohydrates, proteins, minerals, and vitamins A, B2, B12, and C, thus they are excellent food supplement. They are usually eaten raw or prepared as salad or used as an ingredient in local and foreign foods such as gelatin.

The global demand for seaweed products like alginates, agar, and carrageenan has rapidly grown in the last ten years. The natural resource has become important to developing countries, which have the majority of the world's seaweed resources. The Philippine demand for seaweed products is restrained by semi-refined carrageenan and gelatin (gulaman, Ilk.) bars (Anzaldo, 1987). Most of the total domestic supply is consumed locally as food, usually raw.

While the culture technology of *Gracilaria* is available, its local production has not been commercially applied. It has been found out that *Gracilaria arcuata* and G. *eucheumoides* contain good quality of agar, thus, they are good prospects for mass production through culture or gathering of their wild stocks. Two culture techniques of *Gracilaria* are being used, namely: the pond and field methods. The former utilizes the vegetative parts for propagation while the latter depends on natural spoil recruitment . According to Trono and Ganzon-Fortez (1988), field culture of G. *verrucosa* by the Bureau of Fisheries and Aquatic Resources utilizing natural spore recruitment through the use of adobe and hollow cement blocks substrata showed that the amount of seaweeds produced per unit area was more than twice the amount produced in the control (sandy-muddy) or natural substrata.

Trono (1997) reported the presence of *Gracilaria* spp. and other types of seaweeds in Ilocos Sur. This could be due to the presence of reefs which extend several meters seaward in most coastal towns of the province. These species grow in either subtidal areas or tidepools mostly attached to rocks or coral fragments.

Trono's lecture (1991) states that environmental conditions regulate the kind, nature, abundance, and productivity of seaweed communities. Areas influenced by fresh water have lower number of species than those in salty reef areas. But some can thrive in regimes with highly fluctuating salinity.

In shallow intertidal areas, tidepools, which become isolated and sometimes not subjected to free water circulation, can also affect the local distribution of seaweed species and can exclude many species from the area. Water movement caused by waves which aerates the water transports nutrients, prevents rising of water temperature, controls the nature of status of seaweed communities, and influences the amount of harvestable seaweed stocks. Waves mechanically remove significant amount of seaweed stocks (Trono, 1991).

Moreover, Trono mentioned in his lecture that the most pressing problem in the resource development and exploitation of economically important seaweeds is lack of information on the kind of species, the amount of harvestable biomass, and the places where they abound.

The productivity of the natural stocks must be maintained and harvesting be regulated. Thus, information is essential in the formulation of management program for the exploitation of the resource.

Methodology

Four municipalities of Ilocos Sur were taken as the sampling stations, namely: Sinait, Cabugao, Santa Maria, and Santiago. Selection was based on the results of the study conducted by Corrales-Domingo (1988). Data collectors were assigned in each of the study areas.

Collection of *Gracilaria* species for taxonomic studies was done bi-monthly. The species collected were brought to the laboratory of the College of Arts and Sciences for identification. Identification was done up to the species level using available algal literature.

Standing crop studies were done monthly for a period of two years by the transect-line method. At each station, two 200 m line transect was laid perpendicular to the shore. Quadrat sampling (with 50x50 cm iron quadrat) was done at 20 m intervals along the transect. *Gracilaria* samples were collected and then air dried, and the dry-weight recorded. Weights were expressed in g/m^2 to represent the biomass production.

Data on environmental parameters like water temperature, salinity, and water movement were also recorded every sampling period.

Results and Discussion

Taxonomic Studies

Five species of *Graci/aria* were found present in Ilocos Sur, namely: *Gracilaria arcuata, Gracilaria coronopifolia, Gracilaria eucheumoides, Gracilaria gigas,* and *Gracilaria salicornia.*

Key to species:

1. Branches compressed or flattened - G. *eucheumoides*
1. Branches terete -———————————— *2*
   2. Main branches less than 2.5 mm in diameter - G. *coronopifolia*
   2. Main branches more than 2.5 mm in diameter - 3
      3. Branches divided into clavate segments, with constrictions at ends —— — G, *salicornia*
      3. Branches not as above —————————————— 4
         4. Lateral branchlets curved upward and inward, almost parallel to the main axis ————————— G. *gigas*
         4. Lateral branchlets arcuate ——— G. *arcuata*

Standing Crop/Biomass Studies

Of the five species of *Gracilaria* observed in the province of Ilocos Sur, *G. coronopifolia,* G. *eucheumoides,* and G. *salicornia* were found to be abundant. These three species were, therefore, considered in the standing crop/biomass studies.

The mean seasonal and spatial biomass production of *Gracilaria* from July 1996 to June 1998 are shown in the Tables 1, 2, and 3.

Table 1 and Figure 1 present the mean seasonal and spatial biomass production of *Gracilaria* spp. in the first year of data gathering, July 1996-June 1997. *Gracilaria* abounds in November and December 1996 and in January, February, and March 1997. The highest seaweed biomass production was in the month of February with a mean dry weight of 220 g/m^2.

Table 1. Mean seasonal and spatial biomass production of *Gracilaria* spp. expressed in g/m^2 of dry weight from July 1996-June 1997.

YEAR	MONTH	STATION I Sinait	STATION II Cabugao	STATION III Sta. Maria	STATION IV Santiago	MEAN
1996	July	50.0	54.0	29.5	28.4	40.48
	August	52.4	48.0	135.0	52.0	71.85
	September	59.2	46.0	138.0	73.2	79.10
	October	60.4	48.0	137.6	54.0	75.00
	November	80.8	116.0	222.4	213.0	158.05
	December	110.4	122.0	243.2	177.0	163.15
1997	January	72.8	40.8	284.0	149.2	136.70
	February	82.0	61.2	334.0	402.8	220.00
	March	49.2	18.0	248.0	270.5	146.43
	April	46.0	28.4	102.4	152.8	82.40
	May	142.4	270	47.7	30.0	122.53
	June	74.1	31.0	62.5	51.2	54.70
Mean		73.31	73.62	165.36	137.01	112.53

Table 1 above and Figure 1 also show that Santa Maria station had the highest seaweed biomass production in June 1996 to July 1997 with a mean dry weight of 165.36 g/m^2. *Gracilaria* grew well, too, in Santiago Station as evidenced by the seaweeds mean dry weight of 137.01 g/m?. The least seaweed biomass production was in Sinait and Cabugao stations with 73.31 g/m' and 73.62 g/m, respectively.

Table 2 and Figure 2 show that the greatest seaweed biomass production in the second year of the study was in November and December 1997 and in January and February 1998 with mean dry weights of 124.43 g/m', 105.83 g/m, 82.70 g/m, and 96.40 gym', respectively. These months coincide with those of the first year of study in which *Gracilaria* produced much of its biomass. As to species spatial biomass production, Santiago Station had the highest seaweed mean dry weight with 79.10 g/m?, followed by Sinait and Cabugao stations (68.84 g/m? and 65.83 g/m, respectively). While the highest seaweed biomass production in the first year of study was in Santa Maria Station, it had the least biomass production (59.37 g/m? mean dry weight) during the second year of study.

To find out which among the four gathering stations yielded the highest *Gracilaria* biomass production within the two-year period, the mean dry weight for two years was computed. Table 3 and Figure 3 show that Santa Maria Station had the highest seaweed mean dry weight of 112.37 g/m^2, followed by Santiago Station (108.06 g/m) and Sinait Station (71.08 g/m^2). Cabugao had the least seaweed mean dry weight of 69.73 g/m.

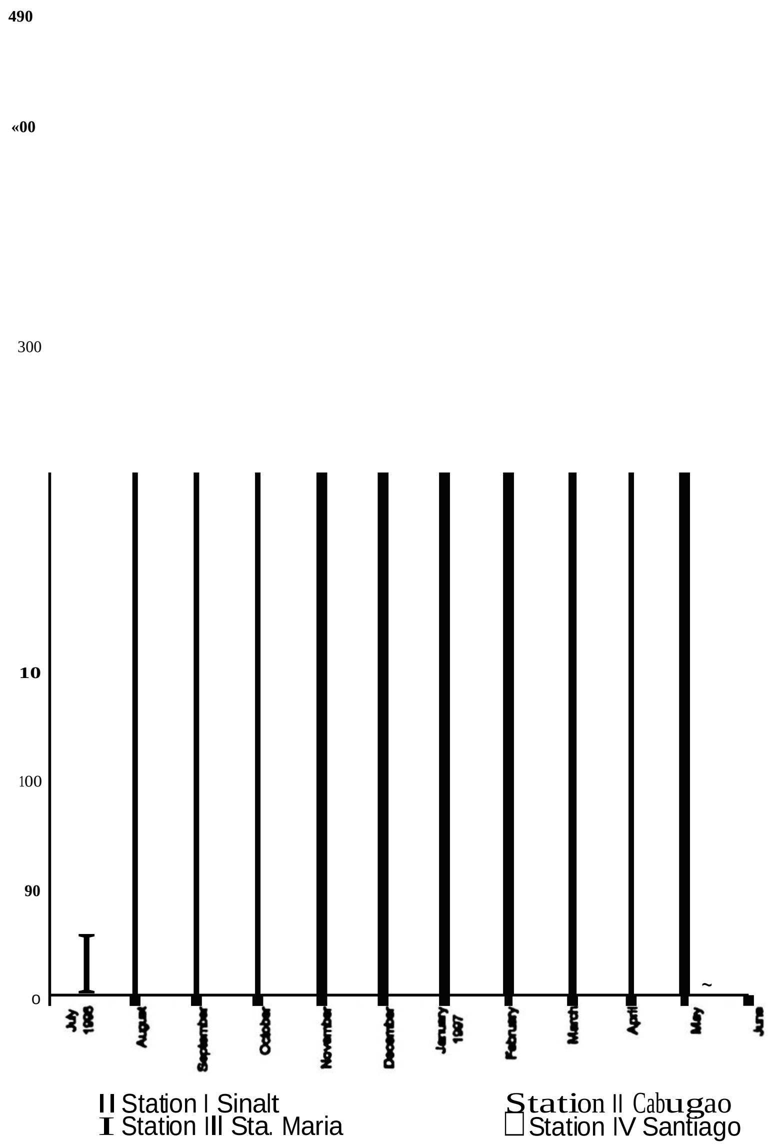


Fig. 1. Mean **seasonal and** spatial biomass production of *Gracilaria* spp. expressed in g/m' of Dry Weight from July 1996June 1997.

Table 2. Mean seasonal and spatial biomass production of *Gracilaria* spp. expressed in g/m^2 of dry weight from July 1997-June **1998.**

YEAR	MONTH	STATION I SINAIT	STATION II CABUGAO	STATION III STA. MARIA	STATION IV SANTIAGO	MEAN
1997	July	43.0	42.5	50.0	44.8	45.08
	August	39.0	36.2	73.0	41.2	47.35
	September	29.7	39.9	64.6	50.4	46.15
	October	76.0	29.2	48.0	49.2	50.60
	November	108.0	200.0	92.0	97.7	124.43
	December	106.0	117	100.0	100.3	105.83
1998	January	92.0	69.0	43.6	126.2	82.70
	February	90.0	86.0	72.2	137.4	96.40
	March	50.4	57.9	56.4	124.4	72.28
	April	47.9	49.6	35.0	68.6	50.28
	May	62/8	34.4	32.4	61.4	47.75
	June	81.3	28.2	45.2	47.6	50.58
Mean		68.84	65.83	59.37	79.10	68.28

Table 3. Mean biomass production (g/m^2 dry weight) of the *Gracilaria* spp. in the four stations of Ilocos Sur within the two-year period of the study.

Year	Station I Sinait	Station II Cabugao	Station III Sta. Maria	Station IV Santiago
1996-1997	73.31	73.62	165.36	137.01
1997-1998	68.84	65.83	59.37	79.10
Mean Dry Weight	71.08	69.73	112.37	108.06

Environmental Parameters

Mean monthly variation of three ecological factors (temperature, salinity, and water movement) in the four stations are presented in Tables 4 and 5.

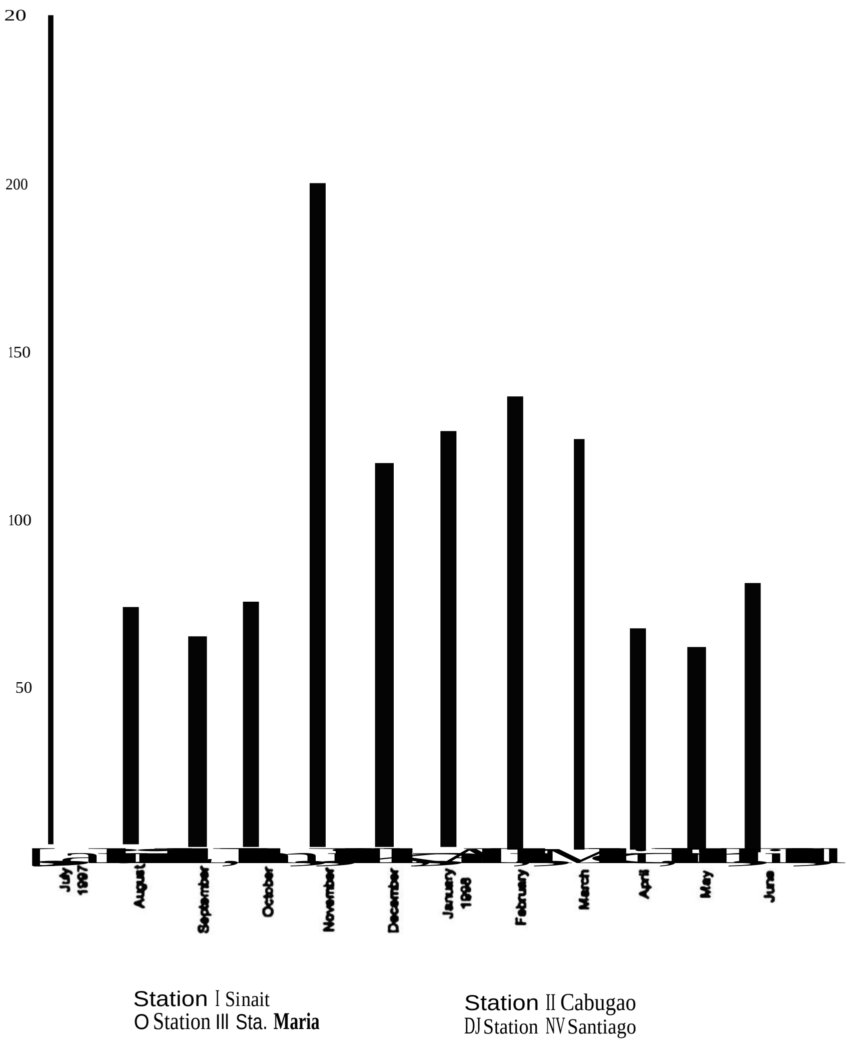


Fig. 2. Mean seasonal and spatial biomass of *Gracilaria* spp. expressed in g/m' of dry weight from July 1997-June 1998.

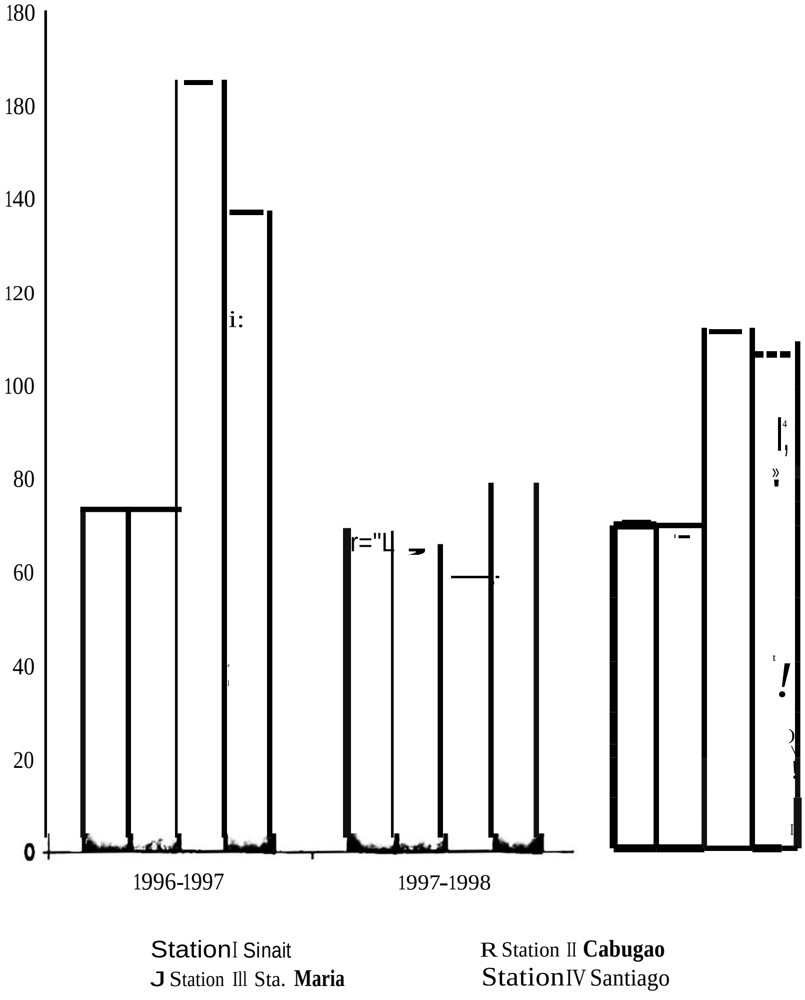


Fig. 3. Mean biomass production of *Gracilaria* spp in the four stations of 1locos Sur within the two-year period of the study.

Table 4. Mean monthly variation of three ecological factors in four stations from July 1996-June 1997.

	STA-TIOM	1996 J	A	S	O	N	D	1997 J	F	M	A	M	J	MEAN
€]	I	34	33.5	23.5	30	29.5	25	27	24	26	27	30	29	28.96
	II	34	35.5	36	32	31.5	31.5	28	28.5	30	31.S	32	33	31.96
	Ill	33	33.5	33.S	32	31.5	30	29	28	29	31	31.5	32	31.17
	IV	33.5	3S	35.5	33	30	31.5	28	28	29	31	31.5	32	31.75
£ $ a	I	29	30	32	31	31	30	32	38	38	30	35	28	32.00
	II	28	28	27.S	27.'	28	30	33	34	34	35	34	33	31.00
	II	31	31	31.5	32	32.5	33.5	34.5	35	35	36	35	34	33.42
	IV	30	30	31	31	31	33	35	35	35	35	34	34	32.92
6 .£ H ±J J&	I	5.1	6.2	7	6.9	7.2	7.77	11.16	9.96	10.34	11.16	11.01	11.99	8.85
	II	3.2	5.4	5.6	5.8	5.6	5.1	4.6	4.4	4.2	4.8	6.6	10.2	5.46
	m	10.2	14.6	16.2	14.2	8.2	10.4	10.2	7.4	2.6	8.1	10.2	14	7.36
	IV	6.2	5.6	6.4	8.4	10.1	5.8	5.2	5	4.8	5.6	14	11.2	7.36

Among the four stations, data in 1996-1997show that Station 11-Cabugao had the warmest water and Station I-Sinait, the coldest, with mean surface temperature readings of 31.96C and 28.96C, respectively (Table 4 and Figure 4). Readings on the salinity of water show that Station ill-Santa Maria had the highest mean of 33.42/00 and the least mean was Station 11-Cabugao with a mean of 31.00 %/0o (Table 4 and Figure 5). Water movement in Santa Maria Station was the strongest among the stations as evidenced by the mean diffusion factor of clod-cards which was 10.538 g (Table 4 and Figure 6).

In the second year, July 1997-June 1998, Table 5 and Figure 7 show that Station II-Cabugao and Station I-Sinait still had the highest (31.88°C) and lowest (28.67C) mean surface temperature readings, respectively. Likewise, Station III-Santa Maria had the highest mean water salinity reading of 33.00 °/oo and Station 11-Cabugao had the lowest mean reading of 31.25/00 (Table 5 and Figure 8). As to the diffusion factor of the clod cards which indicates the degree of water movement, Santa Maria had greatest water movement among the four stations an evinced by the mean diffusion factor of clod-cards which was 11.6 g (Table 5 and Figure 9).

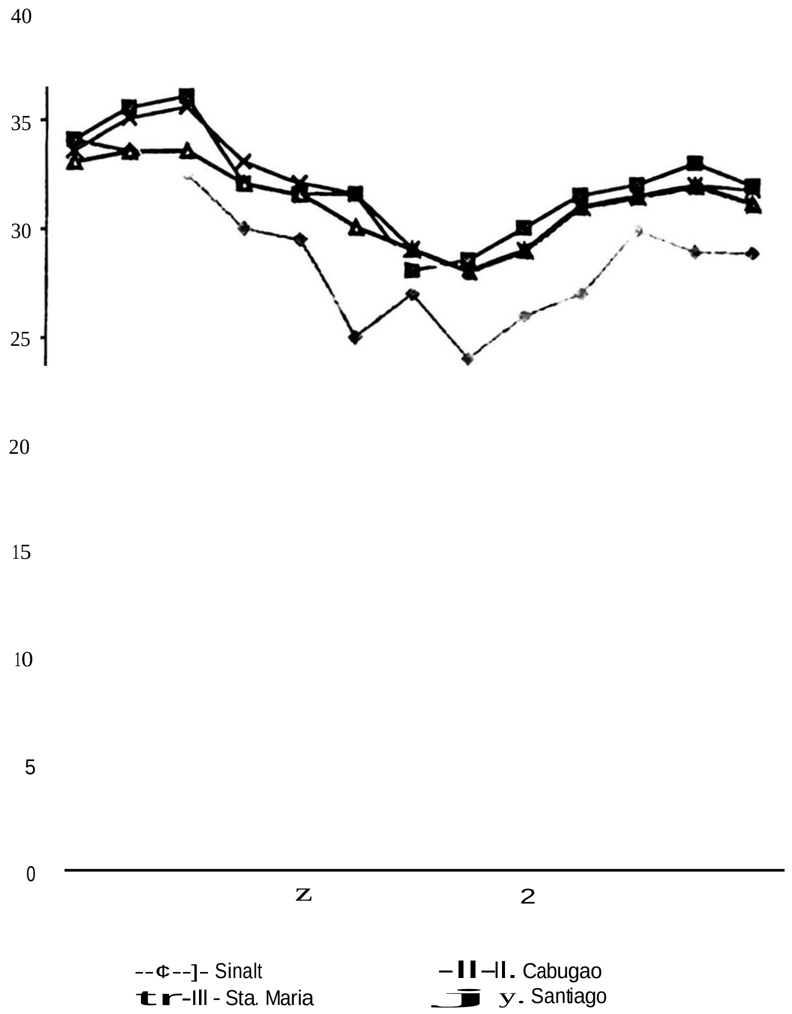
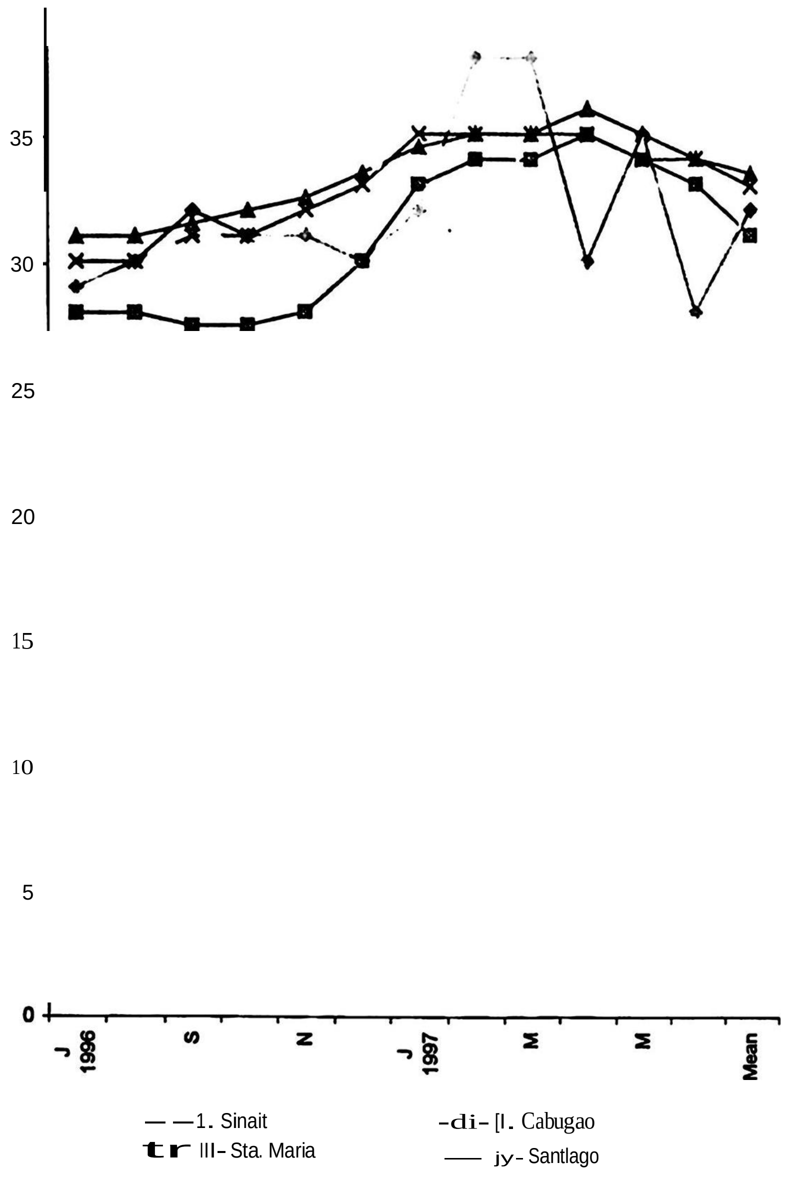


Fig.4. Mean monthly variations of surface water temperature ("C) in the four stations from July 1996-June 1997.



Fig, 5. Mean monthly variations of salinity (o/oo) in the four stations from July 1996-June 1997.

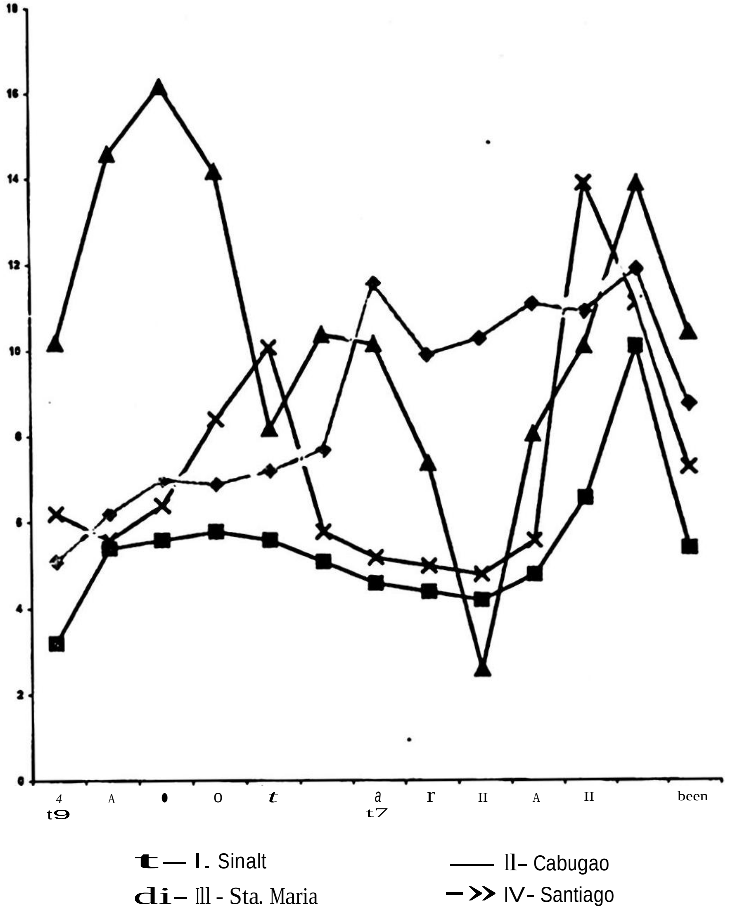


Fig. 6. Mean monthly variations of diffusion factors (g) in the four stations from July 1996-June 1997.

Table 5. Mean monthly variation of three ecological factors in four stations from July 1997-June **1998.**

	STA-TIOM	1007						tong						MEAN
		J	A	S	O	N	D	J	F	M	A	M	J	
€ I £	I	30	30	30	27	26	27	27.5	27.5	28	30.5	30.5	31.5	28.67
	II	34	35.5	**35**	33	32	31.5	**28.5**	29	29.5	32	32	34	**31.88**
	m	32.5	33	33.5	3	31.5	31	29	**28**	29	30	30	31.5	30.88
	IV	33	35	35	34	33	31	**28**	**28**	29	31	31	32	31.46
£ + ‒	I	31	30	30	30	30	30	30.5	31	36	37	37.5	38	**32.58**
	II	31	30	29	**28**	**28**	30	32	34	34	35	33	31	31.25
	m	32	31	30	31	32.5	33	**34**	35	**35**	36	**34**	32	33.00
	IV	33	31	**29**	30	32	32.53	33	35	35	35	32	32	32.50
a .s H #	I	13.07	14.7	11.65	12.0	10.6:	10.5	10	7.3	**8.5**	7.9	8.7	7.2	10.20
	II	12.1	10.1	**6.2**	**6.4**	7.2	7.4	7.1	**6.8**	**6.4**	6.2	6.4	6.6	7.41
	m	22.1	**18**	**6.2**	15	12.2	10.1	10.2	**8.2**	**7.8**	**8.2**	9.2	12	11.60
	IV	14.2	12.2	**8.1**	7.8	7.6	**8**	**8.2**	**8.1**	7.1	**6.6**	6.6	7.2	**8.48**

Relationship Between Variables

To find out if the mentioned environmental factors have any effect on the biomass production of *Gracilaria,* the Pearson Product Moment of Correlation was used and the results were further subjected tot-test to determine any significant relationship between biomass production of *Gracilaria* and the three environmental parameters, namely: water temperature, salinity, and movement.

Table 6 shows that two ecological factors have significant relationship with *Gracilaria's* biomass production, namely, water temperature and water movement as evinced by the computed t-values, 3.2837 and 1.9251, respectively, which are higher than the tabular t-value of 1.717 of both factors. These values, though significant, have negative relationships, which means that the lower the water temperature and the calmer the water, the higher the biomass production of the *Gracilaria* spp. In contrast to the aforementioned ecological parameters, salinity was found out to have no significant relationship with the seaweed biomass production. Though, there were slight fluctuations in water salinity readings in the four stations, the species production was adaptable to the changes.

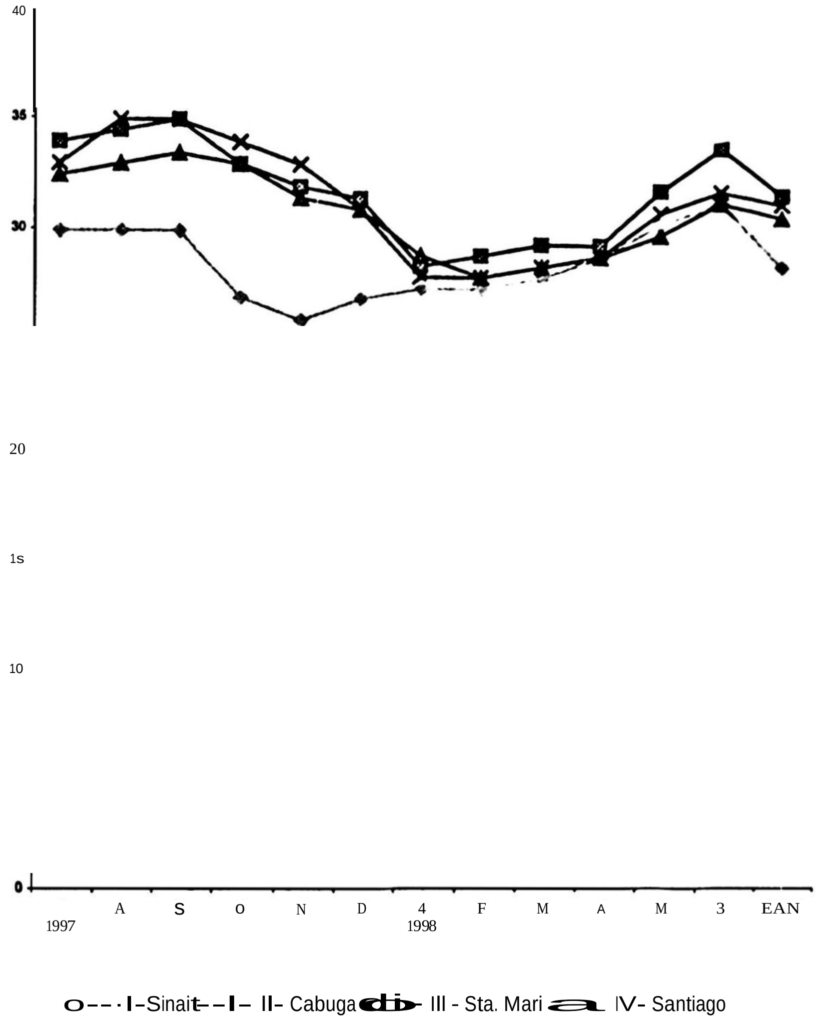
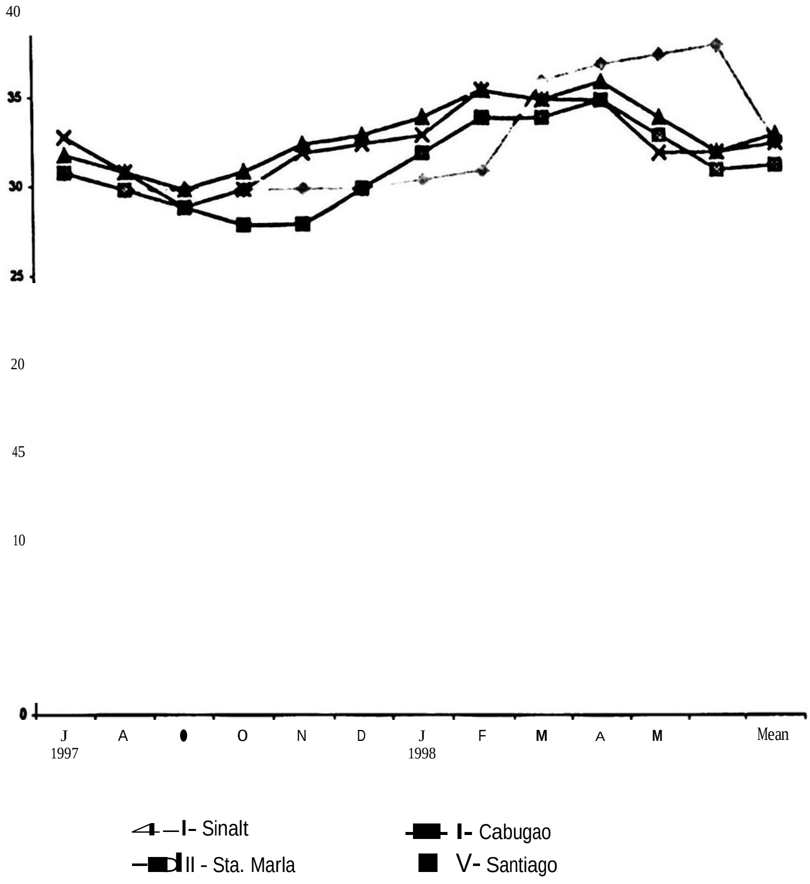


Fig. 7. Mean monthly variations of surface water temperature (C) in the four stations from July 1997-June 1998.



Fig, 8. Mean monthly variations of salinity ("loo) in the four stations from July 1997-June 1998

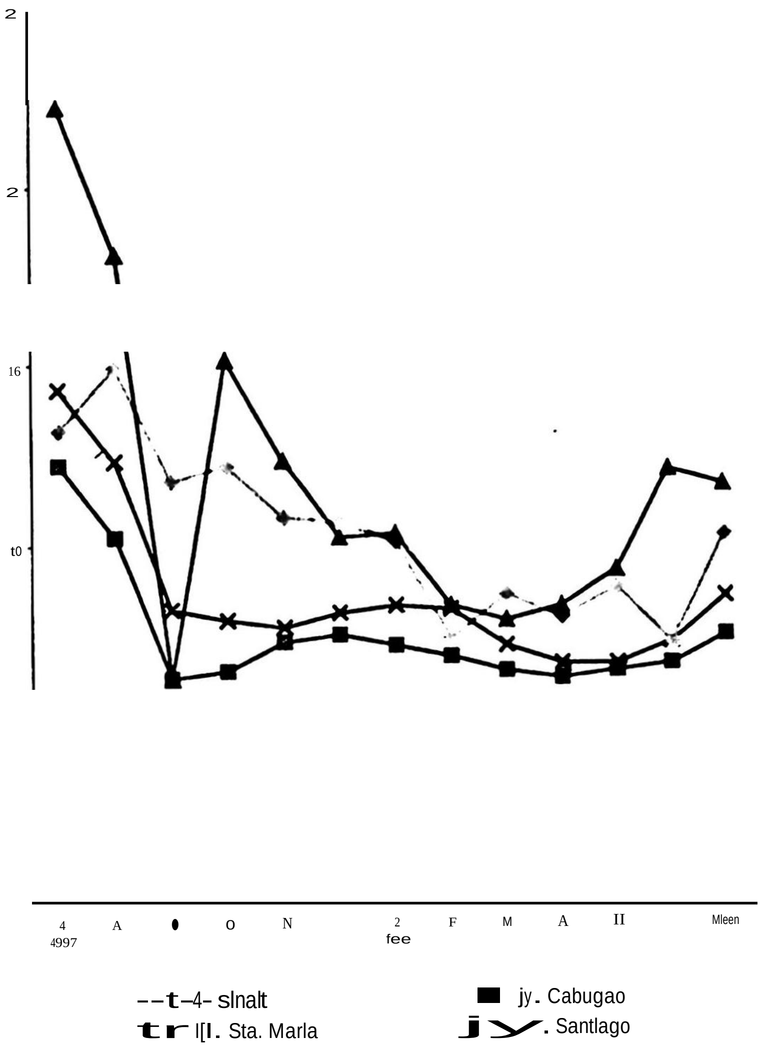


Fig. 9. Mean monthly variations of diffusion factors (g) in the four stations from July 1997-June 1998.

Table 6. Relationship between *Gracilaria* biomass production and three

ECOLOGICAL FACTOR	**t-COMPUTED**	**t-TABULAR**	**RELATIONSHIP**
Temperature	3.2837 (r=-0.5682)	1.717	Significant
Salinity	0.9949 (r = 0.2075)	1.717	Not significant
Water Movement	1.9251 (r =-U.5/91)	I.HIT	1gnutlcant

Conclusions and Recommendations

Gracilaria thrives throughout the year, but harvesting the resource is best in November, December, J anuary, and February when they are most abundant. Santa Maria is the top identified municipality where *Graci/aria* abounds, followed by the town of Santiago. Both towns are located on the southern part of the province of Ilocos Sur.

Based on the data gathered, *Graci/aria,* though scarce on some months of the year and can be slightly affected by environmental factors like temperature and water movement, can be considered as a potential resource of the province of Ilocos Sur. This is evidenced by the very high biomass production on some months of the year.

Therefore, everybody must be informed and educated regarding community-based coastal resource management to maintain/preserve/intensify natural stocks of *Gracilaria* and other seaweeds for the present and future generations. Moreover, government and non-government agencies should extend full assistance to institutions researching on seaweeds product formulation so that people can really benefit from the resource.

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