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Environmental Condition for the Oyster Culture in the Nicoya Gulf of Costa Rica

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A field survey and experiment on aquaculture in Costa Rica including Nicoya Gulf was carried out for a month, December 2~28, 1981.

1) Air temperature was 27~32°C, water temperature, 28~29.5 °C and salinity, 20~28.5 ‰ both in the surface and 5 *m* layer on December 22, 1981.
2) Dissolved oxygen plentiful, 7.3~9.95 *ml/l*.
3) Mean precipitation for the past ten years in Nicoya Gulf area was 1298.6~2196.3 *mm* near Puntarenas area and rainy days a year was 137.7. Most rainfalls was concentrated from May to November, the rainy season.
4) Precipitation in main oyster farms near Chungmu, Korea was 1836.0 *mm* a year and it was similar to that of Costa Rica.
5) Diatoms were 16 species belonged to 13 genera and dinoflagellates, 3 species belonged to 2 genera. Standing crops was 639~130,211 cells/*l* and dominant species were *Chaeteocros curvisetus, Chaetoceros decipiens, Nitzschia serata. Thalassiothrix mediterranca*, a tropical esturary species, was found.
6) Nicoya Gulf has the good environmental factors in the water temperature, salinity, dissolved oxygen and planktons, and it is desirable to experiment and culture the oyster (*Crassostrea rhrizophorae*).

Introduction

A feasibility study of aquaculture development in the oyster cultures of the Nicoya Gulf on the western coast of Costa Rica with accompanying experiment results from tests performed in December, 1981.

In Costa Rica, some species such as penaeus vannam, P. stylirostris, Macrobrachum sp. Tilapia sp. and oysters are currently under culture and among these the most promising species are shrimps and oysters.

On the eastern coast, oysters are farmed on a small acale around an estuary but production amounts to only several tons due to environmental disadvantages.

Therefore, the feasibility of oyster farming in the Nicoya Gulf on the west has been studied.

In addition, the current condition of shrimp, Tilapia, pearl oyster and other oyster cultures in Limon, papagoya, and puntarenas areas were surveyed(shown in Fig. 1).

I was received very warmly and was given much cooperation by the professors gerardo Rozas, Eduardo Minero, Luis Mira, Sebastian Salazer from University of Costa Rica Central America.

Description of the Study Area

The area of Costa Rica is 50,900 km^2 with a population of 2,110,000. Around 81% of the pop-

ulation is concentrated in San Jose, the capital city. The administrative districts are seven: Heredia, Ala Julela, Limon, Cartago, Puntarenas, Guana Caste, and San Jose. The climate is warm with a high humidity. The average annual temperature is 22°C in the central highlands and 27°C in the lowlands(Fig. 1).

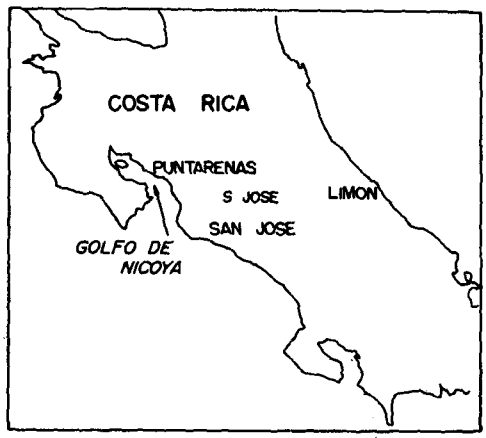

Fig. 1. Map showing the Costa Rica.

The Gulf Nicoya is situated on the Pacific coast of Costa Rica, at approximately 10N and 85 W. The general features of the Gulf are shown in Fig. 2. The Gulf is 52 miles long, penetrating the land first in a northerly and then in a northwesterly direction. It is 34 miles wide at the mouth, narrowing to 5½ miles at the post of Puntarenas and then expanding to an average width of eight miles at the head. The northern half of the Gulf is shallow with depths from two to five fathoms, while depths out of Gulf progressively increase in a southerly direction from 10 to 100 fathoms in the narrow channel between San Lucas Island and the Puntarenas Peninsula. There is a short through approximately 25 fathoms deep. The bottom of the Gulf between Chira Island and Bejuco Island has an extensive mud flat bottom covered by one to three fathoms of water at mean low tide. The mud on the flats is several feet deep and easily stirred up by tidal currents. Areas such as Ballena Bay, Barransca Bay, and the mouth of the Rio Tempisque have sandy bottoms, and the

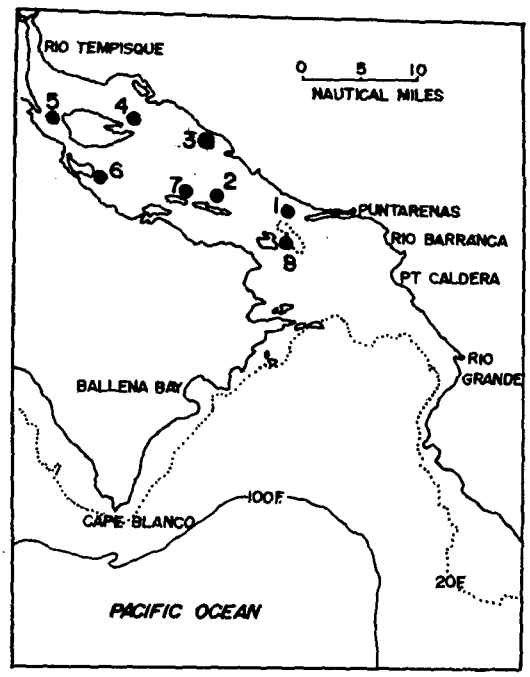

Fig. 2. Map showing the sampling stations.

area east of the Nergritos Island has a rocky bottom.

Materials and Methods

Salinity and dissoveled oxygen were determined with a salinometer and a Winkler method respectively. For plankton enumeration, 4.5 liter of water was filtered through a gauge No. xx13 and cells were counted in cells per litre.

And St. 1~8 shown in Fig. 2 was observed on the boat in Nicoya Gulf.

Results and Discussion

Salinity and Oxygen: Air temperature was 27~32 °C and surface water temperature was 28~29.5 °C in Nicoya Gulf on December 22, 1981 (shown in Table 1).

Salinity was 20~28.5 ‰ in the surface water and that of 5 *m* layer was same as the surface. Salinity at St. 5 near river-mouth Rio Tempisque was 20 ‰, the lowest, and salinity at St. 6 was

Table 1. Temperature, salinity and dissolved oxygen in the Nicoya Gulf, December 1981

St.	Air temp. (°C)	Water temp. (°C)	Salinity (‰)	Oxygen (*ml/l*)	Depth (*m*)
1	27.5	28.0	0*m*: 28.0 5*m*: 〃	7.60	20.0
2	32.0	28.0	0*m*: 28.0 5*m*: 〃	7.30	2.8
3	29.0	29.0	0*m*: 28.5 5*m*: 〃		16.0
4	29.0	29.5	0*m*: 27.0 5*m*: 〃	8.50	8.4
5	30.0	29.0	0*m*: 20.0 5*m*: 〃	7.40	4.2
6	29.0	28.0	0*m*: 25.5 5*m*: 28.0		9.9
7	27.0	28.5	0*m*: 27.5 5*m*: 28.5	9.95	10.0
8	28.2	28.0	0*m*: 28.0 5*m*: 〃	8.60	32.0

Table 2. Observed values of salinity at station 1, 2, 3 occupied in the Nicoya Gulf from 1980 to 1981

Unit: ‰

Date	Depth (*m*)	Puntarenas (St. 1)	R. Carballo (St. 2)	P. Morales (St. 3)	Ent. Tempisqeu (St. 5)
March 28, 1980	0	33.75	33.53	—	1.76
	5	33.26	33.47	—	27.57
April 10, 1980	0	33.53	33.73	—	22.29
	5	33.57	33.57	—	30.14
April 24, 1980	0	33.66	33.48	—	23.03
	5	33.73	33.75	—	—
May 8, 1980	0	33.57	33.42	32.90	22.65
	5	33.42	34.01	33.03	27.52
May 22, 1980	0	32.90	32.54	33.08	17.86
	5	32.70	32.60	32.63	25.32
June 12, 1980	0	28.68	29.67	31.53	11.95
	5	16.37	32.59	31.53	—
June 26, 1980	0	30.37	31.18	29.78	—
	5	31.35	29.38	30.33	—
July 24, 1980	0	31.92	21.22	30.19	20.09
	5	31.87	31.71	31.18	20.26
Aug. 7, 1980	0	30.86	30.86	28.81	29.19
	5	30.77	31.22	30.07	20.93
Sept. 4, 1980	0	30.61	—	29.36	13.03
	5	30.70	—	29.72	22.29
Sept. 18, 1980	0	29.31	30.28	28.33	—
	5	31.69	30.49	—	—
Dec. 4, 1980	0	24.16	—	20.36	—
	5	29.29	—	29.74	—
Jan. 15, 1981	0	—	—	17.16	19.92
	5	29.74	—	27.52	22.18
Jan. 29, 1981	0	28.69	—	30.12	31.87
	5	31.36	—	30.05	27.25
Feb. 27, 1981	0	32.61	31.88	30.50	16.72
	5	32.06	32.34	30.23	29.58
March 12, 1981	0	32.79	32.70	31.73	20.72
	5	32.70	32.66	31.64	24.24
March 26, 1981	0	32.88	33.20	31.84	17.24
	5	32.79	33.24	31.74	18.00

a little lower than that of St. 4. The reason why the salinity at St. 6 was lower than that of St. 4 is perhaps that more fresh-waters flow into St. 6. Other stations, except for St. 7, which was 27.5 ‰, were a little over mean salinity. At all stations except for St. 6, salinities at 5*m* layer were almost same as surface water. At St. 6, it was lower and it is perhaps due to the fresh-water inflows.

Dissloved oxygens were 7.3~9.95 *ml/l*. At St. 5, it was 7.4 *ml/l* and it was 9.95 *ml/l* at St. 7. Dissolved oxygens at St. 1 near Puntarenas determined by research members belonged to National University in 1980~1981 was as shown in Table 2.

It shows that salinity in the surface water was 24.16~33.75 ‰ and in the 5 *m* layer, 16.37~33.73 ‰.

Both 16.37 ‰ in the 5*m* layer on June 12, 1980 and 24.16‰ in the surface on December 4, 1980 were rather low, and the others were over 28.69 ‰, which means they were not largely affected by the fresh water inflow.

At St. 2, salinities in the surface water and 5*m* layer were same, 21.22~33.75 ‰. At St. 3, it was 17.16~33.08 ‰. It shows that the salinity was generally maintained in 27~29 ‰ except for 17.66‰ on January 15, 1981 and 20.36 ‰ on December 4, 1980.

Average salinities were 31.14 ‰ at St. 1, 31.87 ‰ at St. 2, and 29.85 ‰ at St. 3, and it means there was a little varience among stations in salinity.

Salinites at St. 1 near Puntarenas were 31.27 ‰ in the surface water and 21.02 ‰ at the 5*m* layer, with an average 31.4 ‰ at St. 2, they were 31.36 ‰ and 32.39 ‰ respectively, with a mean 31.87 ‰ at St. 3, they were 29.05 ‰ and 32.39 ‰ with an average 29.86 ‰. It shows that both the surface water at St. 3 and the 5*m* layer at St. 3 were relatively low in salinity.

Quantity of fresh water inflow from both precipitation and river in 1952~1953. It was remarkable in October 1952 and in May 1953. The lowest fresh water addition was during the 3-month period from January to March 1952 and there was almost none during the same period in 1953. Generally, precipitation was small from November to April the following year but it increased in May, which shows a significant difference between the rainy season and the dry season. Accordingly, fresh water addition from river and precipitation were in proportion to each other.

Precipitaion, surface salinity and temperature during 1954~1957(Peterson, 1960). It shows that aforementioned three parameters in the rainy season from May to October and in the dry season from December to April were similar tendency. That is to say, salinities were 20~34 ‰ from October, 1954 to October, 1955 and 22~34 ‰ from October, 1955 to October, 1957. Water temperature was 24.4~30.0 °C and it kept 30 °C from May to September 1957.

Salinity, water temperature, and dissolved oxygen at 0 *m*, 5 *m*, and 10 *m* layers in Nicoya Gulf in 1952~1957 were compared to those of St. 8 near Data. Salinity was 23~33.1 ‰ in the surface water, 25.79~33.03 ‰ at the 5 *m*, and 28.5~33.42 ‰ at the 10 *m* layer. It means that salinity increases vertically from the surface to the bottom. Water temperatures were 24.8~33.2 °C with a mean 28.5°C in the surface water, 25.8~33.0 °C with an average 27.9 °C at the 5 *m* layer, and 28.0~33.4 °C with a mean 27.3 °C at the 10 *m* layer. The total average was 27.9 °C. Oxygen were 4.7 *ml/l* in the surface water, 4.40 *ml/l* at the 5*m* layer, and 4.14 *ml/l* at the 10 *m* layer. The total mean was 4.12 *ml/l*.

Water temperature, salinity, and dissolved oxygen in Oyster ground, Goeje-Hansan Bay in Korea in 1979.

Water temperatures were 8.0~30.0 °C from February to November. The lowest was found in February and the highest in August. Salinities were 29.0~34.3 ‰ and dissolved oxygens were 4.7~8.3 *ml/l*.

In oyster growth, the growing period is from May to October. During the low water temperature from November to the following March oyster meat hardens rather than maintaing growth

and it is presumed that temperature difference affects oyster meat.

Temperature range in a reproduction period is 22~26 °C and spawning is due to a stimulation. Growth can be hindered owing to energy loss by a reproduction development and spawnings. Therefore, appropriate managements in farming in accordance with oyster species is desirable since water temperature is high enough to spawn throughout the year in Costa Rica. In the oyster farms of Korea the salinity is generally ideal. and oyster culture in Costa Rica will be possible because salinity in the rainy season keeps over 29.0 ‰ except for the 25~26‰ on October, 1957. Dissolved oyxgen in Nicoya Gulf is plentiful according to data determined in December, 1981.

Phosphate-P was 0.1 $\mu g \cdot at/l$ and nitrate-N was 0.02~19.32 $\mu g \cdot at/l$ in the oyster farms, Goeje-Hansan Bay, Korea from February to November.

In Goeje-Hansan Bay, Korea, a seed oyster suspended in July grows to 7.6 *cm* in shell height, to 4.6 *cm* in shell length, and to about, 7.7 *g* in meat weight by March the following year. Oyster meat production from a raft, 9 *m*×18 *m* in size, is about 4.44 ㌧.

A hardened seed oyster suspended in July grows to 8.5 *cm* in shell height, to 5.3 *cm* in shell length, and to 10.2 *g* in meat weight.

Precipitation in Nicoya Gulf for the past ten years from 1970 to 1980.

Rainfalls were 1298.6~2196.3 *mm* at Puntarenas, 1087.2~2048.1 *mm* at Morote, and 1328.7~2077.2 *mm* at Lepanto. The highest value was found at St. 1, Puntarenas. Rainy days a year were 112~170 with a mean 137.7. It shows monthly mean rainy days was 11.5. In Costa Rica, however, from May to November it rains much and from January to April, the dry season, it rains little. So it is assumed that salinity is affected by fresh water inflow during the rainy season. Yearly precipitation in Chungmu area where large oyster farms are located in Korea, is 1796.7 *mm* and it is similar to that of Costa Rica(Table 3).

In Costa Rica, however, precipitations are concentrated from May to November. Therefore, a large part of fresh water inflow is perhaps impossible.

Phytoplankton: Phytoplankton composition in Nicoya Gulf in December, 1981 is shown in Table 4.

Diatoms were 26 species belonged to 13 genera and dinoflagellates, 3 species belonged to 2 genera.

Diatoms were more in quantity number, standing crops were 639~130,211 cells/*l* with the minimum at St. 5 and with the maximum at St. 8. Those cell numbers are less than those of Saryangdo areas, Korea, where cell density are 20,000~450,000 cells/*l*.

Table 3. Monthly rainfall in the Chungmu Jejudo area of Korea(*mm*)

Month	Chungmu area('80)	Jeju area('80)	Jeju area('81)
January	16.3	87.1	33.1
February	30.8	45.8	76.7
March	104.6	120.0	19.7
April	158.5	79.3	86.6
May	246.5	166.8	27.7
June	99.6	121.9	187.4
July	357.4	195.3	113.8
August	392.0	372.5	327.2
September	167.4	55.3	464.5
October	196.5	112.9	109.2
November	4.3	128.6	86.2
December	22.8	60.1	20.3
Total	1796.7	1545.6	1552.4

Table 4. Composition of phytoplankton in the Nicoya Gulf, December 1981

Station→	2	4	5	6	7	8	Papagoya
Species ↓ Total No. (cells/*l*)→	29, 225	7, 681	2, 629	21, 544	99, 678	130, 211	639
(Diatom)							
Actinoptychus undulatus	1, 677(5. 7)		78(3. 0)	933(4. 3)	1, 511(1. 5)	444(0. 3)	
Bacteriastrum varians	1, 677(5. 7)		78(3. 0)	933(4. 3)	2, 456(2. 5)		47(7. 3)
Biddulphia aurita							62(7. 9)
Bid. sinensis	111(0. 4)		78(3. 0)	78(0. 4)	1, 133(1. 1)	333(1. 1)	16(2. 5)
Chaetoceros curvisetus	19, 333(66. 1)	2, 276(29. 6)	1, 400(53. 2)	4, 744(22. 0)	68, 376(68. 6)	53, 556(41. 1)	249(38. 9)
Ch. decipiens	222(0. 75)	3, 058(39. 8)	700(26. 6)	7, 311(33. 9)	4, 099(4. 1)	36, 000(27. 6)	124(19. 4)
Coscinodiscus gigas	889(3. 0)	498(6. 5)		1, 400(6. 5)	2, 267(2. 3)	778(0. 6)	16(2. 5)
Ditylum brightwellii	111(0. 4)			5, 133(23. 8)	378(0. 4)	222(0. 2)	16(2. 5)
Ditylum sol					189(0. 2)		
Nitzschia seriata	4, 333(14. 8)	427(5. 6)		78(0. 4)	14, 733(14. 8)	37, 333(28. 7)	47(7. 3)
Rhizosolenia alata	111(3. 0)				756(0. 8)	333(0. 3)	
Pleurosigma sp.						111(0. 1)	
Skeletonema costatum		284(3. 7)					31(4. 8)
Stephanopyxis palmeriana	889(3. 0)				378(0. 4)	778(0. 6)	
Thalassiosira mala			373(14. 2)				
Thalassiothrix mediterranea	1, 559(5. 3)	1, 138(14. 8)		1, 867(8. 7)	3, 400(3. 4)	2, 000(1. 5)	31(4. 8)
(Dinoflagellata)							
Ceratium massilience						111(0. 1)	
Peridinium oceanicum						111(0. 1)	
Per. pentagonum						111(0. 1)	

* Classified list by Lee sang goun. (Fisheries Res. & Develop, Agency)

Domineant species were *Chaetoceros curvisetus, C. decipiens,* and *Nitzschia serat. Thalassiothrix mediterranea* was found and it seems that the species belonge to Tropical estuary species. The other species were similar to species found in Korean-coastal waters.

List of phytoplankton species in the Nicoya Gulf, A Tropical Estuary.

Station 2

Bacteriastrum varians
Biddulphia sinensis
Chaetoceros curvisetus
Chaetoceros decipiens
Detylum brightwellii
Coscinodiscus gigas
Nitzschia seviata
Rhizosolenia alata
Staphanopyxis palmeriana
Thalassiothrix mediterranea

Station 4

Chaetoceros curvisetus
Chaetoceros decipiens
Coscinodiscus gigas
Skeletonema costatum
Nitzschia seriata
Thalassiothrix mediterranea

Station 5

Bacteriastrum varians
Biddulphia sinensis
Chaetoceros decipiens
Chaetoceros curvisetus
Thalassiosira mala

Station 6

Bacteriastrum varians
Baddulphia sinensis
Chaetoceros curvisetus
Chaetoceros decipiens
Coscinodiscus gigas
Nitzschia seriata
Rhizosolenia alata
Thalassiothrix mediterranea

Station 7

Actinoptychus undulatus
Biddulphia sinensis
Bacteriastrum varians
Chaetoceros curvisetus
Chaetoceros decipiens
Coscinodiscus gigas
Nitzschia seriata
Rhizosolenia alata
Ditylum sol
Stephanopyxis palmeriana
Thalassiothrix mediterranea
Ditylum brightwellii

Station 8

Actinoptychus undulatus
Biddulphia sinensis
Chaetoceros curvisetus
Chaetoceros decipiens
Coscinodiscus gigas
Nitzschia seriata
Pleurosigma sp.
Rhizosolenia alata
Ditylum brightwellii
Stephanopyxis palmeriana
Thalassiothrix mediterranea
Ceratium massiliense
Peridinium pentagonum
Peridinium oceanicum

Station: Papagoya

Bacteriastrum varians
Biddulphia aurita
Biddulphia sinensis
Coscinodiscus gigas aurit
Chaetoceros curvisetus
Chaetoceros decipiens
Nitzschia seriata
Skeletonema costatum
Thalassiosira mediterranea
Ditylum brightwellii

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코스타리카國의 니코야灣에 있어서의 굴養殖을 위한 環境에 관하여

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1. 1981年 12月 22日에 調査한 니코야灣의 氣溫은 27～32°C 였고, 水溫은 28～29.5 °C, 鹽分濃度는 表面과 5 *m* 層이 共히 20～28.5 ‰ 였다.
2. 溶存酸素量은 7.3～9.95 *ml/l* 範圍로서 大體로 豊富한 편이었다.
3. 니코야灣附近의 10年間 平均降雨量은 Puntarenas 附近이 平均 1298.6～2196.3 *mm* 이며, 年內降雨平均日數는 137.7日이며, 5～11月의 雨期에 大部分의 降雨量을 나타내고 있다.
4. 韓國의 굴 主産地인 忠武附近의 降雨量은 年間 1836.0 *mm* 로 비슷한 量이나 11月～2月을 除하고는 大體로 비슷한 降雨量을 나타내고 있다.
5. 12月 22日 니코야灣에서 採集된 植物性프랑크톤의 出現種은 규조류 13屬 16種, 편모조류 2屬 3種이며 現存量은 639～130,211 cell/*l* 였고, 우점종은 *Chaetoceros curvisetus*, *Chaetoceros decipiens*, *Nitzschia serata* 등의 규조류였고 *Thalassiothrix mediterranca*는 Tropical Estuary에서 出現하는 것으로 보였다
6. 니코야 灣에서의 水溫, 比重, 溶存酸素量등 水質狀態로 보아 試驗養殖이 要望된다.