Effect of shrimp trawling on the commercial ichthyofauna of the Gulf of Nicoya, Costa Rica

Jorge A. Campos, Bernal Burgos and Carlos Gamboa
Escuela de Biología y Centro de Investigación en Ciencias del Mar y Limnología. Universidad de Costa Rica

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Abstract: Shrimp trawling and industrial fishing has been limited to the outer Gulf of Nicoya, Costa Rica, since 1966 to protect spawning and breeding areas in the inner Gulf. Fish length frequency data gathered in several cruises and data on size at first sexual maturity were used to evaluate this sector as a nursery area and to assess the effects of shrimp trawling on commercial fishes in the outer Gulf. Results show that the inner Gulf serves as a nursery area at least for nine species. Ten or more of the fish species caught by shrimp boats in the outer Gulf are of a size at capture smaller than that at first sexual maturity. A management option is offered to minimize the stress exerted upon these fish populations.

The Gulf of Nicoya (Fig. 1) is the major tropical estuarine system of the Pacific coast of Costa Rica and according to Blair (1979) one of the most important bodies of water in the Pacific coast of Central America. Shrimp trawling as well as finfish exploitation take place both on artisanal and industrial bases and harvest mainly penaeid shrimp and over seventy commercial finfish species.

The inner Gulf has been closed to industrial fishing--thus excluding shrimp trawling--for the past 17 years, since it is considered a nursery area for shrimp and finfish species. This management strategy was taken to protect the faunal assemblages.

Shrimp trawling is permited in the outer Gulf and personal experience on board shrimp trawlers indicates that many "small" finfish species are discarded as by-catch on a regular basis in the outer Gulf (Campos, 1981).

This study is based on several research cruises in the Gulf of Nicoya where length frequency data were collected. Our goal is to investigate whether the inner Gulf is in fact a nursery area for fish species and to explore possible types of stress that shrimp trawling in the outer Gulf may pose for the commercial ichthyofauna.

MATERIAL AND METHODS

Nine stations were sampled on the eastern shore of the Gulf of Nicoya (Fig. 1) using a 30 foot, 1.5 inch stretched mesh shrimp trawl, towed for 10 minutes at each station from March to November 1982. The fish were kept in cold storage on board and transported to the laboratory where they were identified, measured (total length), weighed (wet weight) and dissected for estimation of gonadal ripeness (CAM in Table 1).

In Table 1, size at first maturity corresponds to the smallest female found with ripe gonads according to the scale provided by Laevastu (1971). The sizes provided for each species under each gear type and location are the midpoints of the modal classes. This is a very simple approach to compare the selectivity of each of the gears utilized.

Aside from our data, the following data sources were utilized to build a comparative table (Table 1):

Length data collected in 1981, on a monthly basis for the commercial finfish fishery of the Gulf of Nicoya, by the Department of Fisheries of the Ministry of Agriculture.

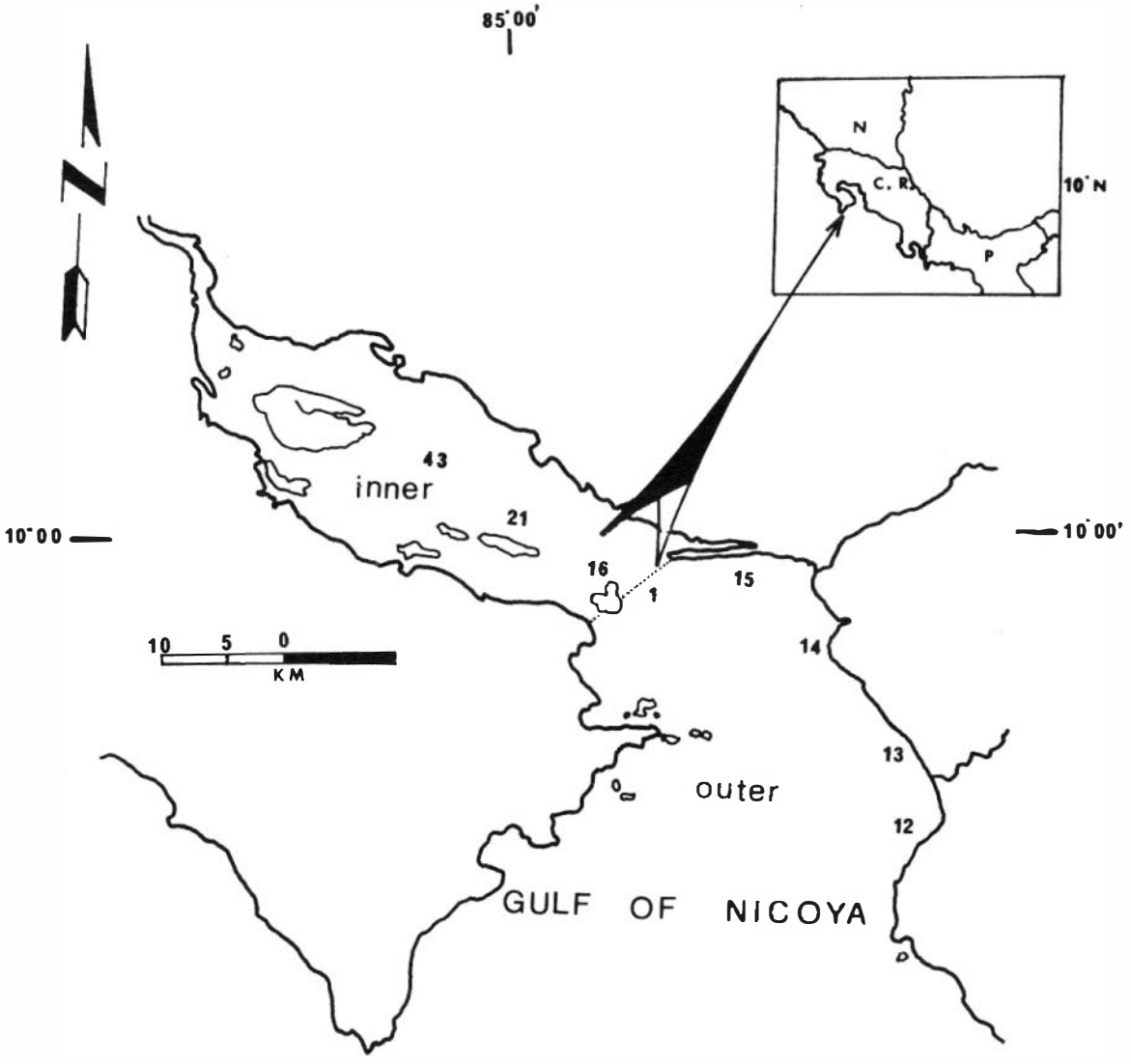

Fig. 1. Location of stations sampled in the Gulf of Nicoya, Costa Rica.

These data were collected for the 3½ gillnet (T 3½), the 6' gillnet (T 6') and longline plus hook and line data (L+C).

Length data from a thesis by León (1973) in the Gulf of Nicoya. Part of these data were published in his work listed in the references (P.L. in Table 1). This work is referred to as P.L.

Length data collected in two cruises–dry and rainy season– in the Gulf of Nicoya and published by Maurer *et al.*, (1980; DEL in Table 1).

The available data were analyzed separately for the inner and outer Gulf to better compare what effects trawling may have upon the commercial ichthyofauna. Since in most cases the 3½' gillnet is selective for the smaller size spectrum of the species under study, catch data with the 3½' gillnet were compared with the trawl data, also selective for small species, in

TABLE 1

Comparative table showing the size of fish and the gear utilized by the artisanal finfish fishery and by trawlers in the inner and outer Gulf of Nicoya, Costa Rica

	Inner Gulf									
	T 3½	n	T 6'	n	L+C	n	CAM	n	DEL	n
Anisotremus dovii	27.5	23	35	10	28.5	3	28.5	27	–	–
Paralonchurus dumerilli	32.5	46	37.5	7	39.5	5	37.5	182	12.5	81
Cynoscion phoxocephalus	42.5	760	40.4	55	42.5	41	7.5	87	–	–
Nebris occidentalis	32.5	16	–	–	–	–	11.5	11	36.5	6
Anisotremus pacifici	27.5	19	–	–	–	–	25.5	15	29	5
Sphyraena ensis	27.5	11	–	–	–	–	–	–	–	–
Cynoscion albus	45	421	57.5	251	52.5	225	15	13	8	112
Cynoscion squamipinnis	45.5	700	47.5	328	45.4	75	11.5	289	8.5	66
Cynoscion stolzmanni	52.5	588	50.1	109	62.5	76	42.5	1	–	–
Micropogonias altipinnis	32.5	458	62.5	436	67.5	270	27.5	64	28	2
Eucinostomus gracilis	20	17	29	1	–	–	–	–	–	–
Ophioscion sciera	27.5	68	34	5	29.5	48	29.5	23	27.5	64
Polydactylus approximans	27.5	6	26.5	2	26.5	3	21.5	34	13	51
Polydactylus panamensis	27.5	16	38	1	–	–	–	–	24.3	3
Menticirrhus nasus	37.5	68	27.5	3	42.5	4	25.5	15	16	2
Larimus acclivis	–	–	–	–	28	1	17.5	4	–	–
Isopisthus remifer	30	49	–	–	27.5	3	12.5	111	–	–
Lutjanus guttatus	34.5	90	47.5	5	34.7	26	10.5	1	–	–
Cynoscion reticulatus	45	41	37.5	2	32.5	1	19.5	1	5.5	83
Ophioscion imiceps	–	–	–	–	–	–	31.5	69	17.5	4

	Outer Gulf											
	T 3½	n	T 6'	n	L+C	n	CAM	n	P.L.	n	DEL	n
*Anisotremus dovii**	30	3	42.6	1	27.5	12	26.5	7	–		–	–
*Paralonchurus dumerilli**		–	52.5	1	37.5	5	36.5	7	–	–	7.5	51
*Cynoscion phoxocephalus**	42.5	183	39.3	13	42.5	87	5	284	–	–	–	–
*Nebris occidentalis**	–	–	–	–	–	–	10	23	–	–	6.5	2
*Anisotremus pacifici**	27	4	44.5	6	–	–	10.5	8	–	–	–	–
*Sphyraena ensis**	42.5	13		–	35	29	13	5	–	–	–	–
*Cynoscion albus**	47.5	10	67.5	6	52.5	8	20	4	–	–	–	–
*Cynoscion squamipinnis**	47.5	175	42.2	38	47.5	6	11.5	60	20	349	10.5	50
*Cynoscion stolzmanni**	54.7	97	72.5	6	57.5	30	11.5	1	–	–	9.5	22
*Micropogonias altipinnis**	37.5	207	57.5	253	57.5	370	24	39	21	423	35	22
*Eucinostomus gracilis**	27.5	28	25.5	8	–	–	–	–	–	–	9	85
Ophioscion sciera	27.5	23	–	–	–	–	27.5	24	–	–	33.5	17
*Polydactylus approximans**	25	4	–	–	–	–	23	66	–	–	23.5	23
*Polydactylus panamensis**	–	–	–	–	–	–	14.8	1	–	–	–	–
*Menticirrhus nasus**	37.5	20	–	–	37.5	2	24.5	10	–	–	31	2
*Larimus acclivis**	32.5	6	–	–	–	–	12.5	639	–	–	13.5	24
*Isopisthus remifer**	32.5	15	24.8	1	–	–	7.5	303	18	186	7.5	47
*Lutjanus guttatus**	32.5	208	52.5	71	34.9	257	14	7	–	–	14	11
*Cynoscions reticulatus**	42.5	103	39.7	60	37.5	13	14.5	55	–	–	–	–
*Ophioscion imiceps**	32.5	20	–	–	–	–	27.5	25	–	–	–	–

	Size at First sexual maturity	n
Anisotremus dovii	25.5	*30*
Paralonchurus dumerilli	30.5	204
Cynoscion phoxocephalus	23.5	525
Nebris occidentalis	29.5	32
Anisotremus pacifici	24.5	19
Cynoscion albus	35	19
Cynoscion squamipinnis	38	345
Cynoscion stolzmanni	42.5	3
Micropogonias altipinnis	17.5	99
Ophioscion sciera	30	52
Polydactylus approximans	*33*	*86*
Menticirrhus nasus	28	38
Larimus acclivis	21	623
Isopisthus remifer	24.5	985
Ophioscion imiceps	30.5	94

T 3½' = gillnet 3½ inches stretched mesh; T 6 = gillnet 6 inches stretched mesh; L +C = long line plus hook and line; CAM = a yearly study in the Gulf (see text); DEL = two cruises in the Gulf (see text) and P.L. = the study by Pedro León (1973; see text).

order to evaluate trawling impact to the ichthyofauna under study.

RESULTS AND DISCUSSION

Inner Gulf: An analysis of Table 1 shows that when catches from all three, or at least two gears of the species listed are compared, 65% are captured at smaller sizes with the 3½' gillnet than with the 6' gillnet, the longline or the hook and line. Trawling data (CAM or DEL) show that for 90% of the species listed in Table 1, the sizes of the specimens captured are smaller than the ones captured with the other gear.

For some species, the difference in the sizes captured by the 3½' gillnet and the trawl net is considerable; *Cynoscion phoxocephalus* is captured 35 cm larger with T 3½' than with the trawl net. If the data given under T 3½' which correspond to the smaller specimens are compared with those in columns CAM or DEL, it seems that based on the size and number of organisms present, the inner Gulf could be a nursery area for: *Cynoscion albus, C. squamipinnis, C. reticulatus, Paralonchurus dumerilli, Anisotremus pacifici, Polydactylus approximans* and, *Isopisthus remifer. Cynoscion phoxocephalus, Nebris occidentalis, Micropogonias altipinnis,Ophioscion sciera* and, *Menticirrhus nasus* are only tentatively added to this list since the data are not as clear. When biological criteria such as the size at first sexual maturity (SFSM) were used to discriminate between mature and immature organisms, the following species were found to be immature at capture: *Cynoscion phoxocephalus, C. albus, C. squamipinnis, Paralonchurus dumerilli, Nebris occidentalis, Ophioscion sciera, Polydactylus approximans, Menticirrhus nasus* and, *Isopisthus remifer. Anisotremus pacifici, Larimus acclivis* and, *Ophioscion imiceps* are included tentatively in this list.

Based on these results and on preliminary observations by personnel of the Fisheries Department, the use of the T 3½' is considered to be harmful for the species under exploitation in the inner Gulf of Nicoya. The fishermen are asking the Fisheries Department to prohibit its use since they feel its efficiency has provoked a decline in catch abundance. The trawl net, as mentioned before, is even more selective for small fish than the T 3½'. Therefore, trawling should continue to be prohibited in the inner Gulf since it seems to serve as a nursery for juveniles of various commercial fish species; otherwise growth overfishing could take place or be enhanced.

Outer Gulf: The same general pattern observed in the inner Gulf is present here. Nineteen (identified with an asterisk in Table 1) out of the 20 species listed show smaller sizes when captured by trawl nets than when captured with T 3½'. Again, using number and size of the organisms captured, when the T 3½' is compared with CAM or DEL the outer Gulf functions as a nursery area for: *Cynoscion phoxocephalus, C. squamipinnis, C. reticulatus, Paralonchurus dumerilli, Anisotremus pacifici, Micropogonias altipinnis, Eucinostomus gracilis, Menticirrhus nasus, Larimus acclivis, Isopisthus remifer*, and *Ophioscion imiceps.* Tentatively included are: *Sphyraena ensis, Cynoscion albus, C. stolzmanni,* and *Lutjanus guttatus.* When SFSM was utilized, the following species were found to use the outer Gulf as a nursery area: *Cynoscion phoxocephalus, C. albus, C. squamipinnis, C. stolzmanni, Nebris occidentalis, Anisotremus pacifici, Polydactylus approximans, Larimus acclivis,* and *Isopisthus remifer.* The data are not conclusive for: *Ophioscion sciera, Ophioscion imiceps,* and *Menticirrhus nasus.*

The presence of such "small" and immature organisms indicates that the outer Gulf is also utilized as a nursey area. This is a very general statement since we do not have data regarding migrating patterns. That is, some of the species we have discussed may migrate along the inner and the outer Gulf for reproduction and feeding. Therefore, the presence of juveniles in the outer Gulf does not imply that they will stay there until they recruit to the parental stock. They could migrate to the inner Gulf and grow there. However, the fact that juveniles were present in the captures indicates that the outer Gulf is at some point in time, utilized by non-recruited juveniles and trawling undoubtely imposes a serious fishing pressure on them.

Species like *Cynoscion albus* live almost exclusively in the inner Gulf (Madrigal, 1983) and move within a relatively reduced area, where most of reproduction and feeding take place. Other species like *Isopisthus remifer* or *Cynoscion reticulatus* may show a wider

distribution, using both the inner and the outer Gulf in their life cycles. Then if a species resides in the inner Gulf but its larval or juvenile stages live temporarily in the outer Gulf, any strategy aimed to manage the resource will be only partially effective if applied only to the inner Gulf.

Therefore, in order to adequately manage the dynamics of the species in the Gulf of Nicoya, it is vital to identify the distribution of the fish stocks and for those that move along the inner and outer Gulf or those that reside mainly in the outer Gulf. Detailed biological studies should be directed towards identification of areas and seasons (months) used for reproduction and juvenile growth, and to quantify the mortality exerted by shrimp trawlers upon commercial juvenile fmfish stocks. A management option would be to close the outer Gulf for shrimp trawling during those months when the main peaks of reproduction of the commercial inchtyofauna take place. Criteria regarding which fish species should be protected must be based on their life histories and susceptibility to fishing pressures and other man-made alterations of the environment.

As stated above, this work is to be considered as preliminary. There is a need for acurate data regarding size at first sexual maturity and on the selectivity of fishing gear in order to better assess the effects of capturing what we have called "small" fish. However, considering that it may take months or years before we have these data at hand the present research can serve as a preliminary tool to aid in assigning adequate priorities.

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RESUMEN

La pesca industrial fue prohibida en la parte interna del Golfo de Nicoya en 1966. Desde entonces, se ha practicado la pesca de arrastre del camarón en la parte externa del Golfo. Basados en datos sobre frecuencia de tallas de peces capturados en varios cruceros en este Golfo y en información sobre tallas a la primera madurez sexual, este estudio evalúa en forma preliminar, la función de la parte interna del Golfo como área de crianza para peces y el efecto de la pesca de arrastre sobre la ictiofauna comercial en la parte externa. Los resultados muestran que la parte interna del Golfo sirve como área de crianza por lo menos para 9 especies. Diez o más especies son capturadas por barcos de arrastre, en la parte externa del Golfo, antes que alcancen la primera madurez sexual. Se ofrece una alternativa simple de manejo para evitar el "stress" que se está imponiendo sobre estas poblaciones de peces.

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