Survival of trawl-caught fish in experimental fishing in the Gulf of Mannar and Palk Bay off southeast coast of India

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ABSTRACT

Survival of injured fish caught in a series of experimental trawl hauls conducted in the Gulf of Mannar and Palk Bay (8°55' – 9°20'N; 79° - 79°40'E) in the southeast coast of India has been examined. Larger size groups of trawl-caught finfish survived longer, while inedible organisms showed shorter duration of survival. Among the target groups, the blue crab, *Portunus pelagicus* had the greatest survival ratio. Among the non-target groups, molluscs and stomatopods survived better than others. Generally, inedible taxa were relatively more resilient to trawling pressures, showing better survival and reduced injury.

Introduction

The effect of trawl fishing on the marine ecosystem and its biodiversity has come under increasing scrutiny in recent years (Jennings and Kaiser, 1998). Worldwide concern has been raised on the loss of 'non-target' species in shrimp fisheries, including 'bycatch' and 'discards' (Saila, 1983; Andrew and Pepperell, 1992; Alverson, *et al.*, 1994). The issue of survivability of animals discarded in the shrimp or selected finfish targeted bottom trawl fishery has been addressed (Wassenberg and Hill, 1989; Hill and Wassenberg, 1990; Kaiser and Spencer, 1995, 1996a; Matsushita and Inoue, 1998). Saila (1983) opined that virtually all discarded fish and crustacea in tropical shrimp fisheries are dead. The duration of the trawl, the time spent out of water on deck and the extent of damage from nets, otter boards and other animals in the trawl may result in physical and physiological trauma leading to death (De Veen *et al.*, 1975; Nielson *et al.*, 1989; Wassenberg and Hill, 1989).

Gulf of Mannar, which is recognized as a marine bio-reserve along with the adjacent Palk Bay in the southeast coast of India harbour rich biodiversity. Mechanized trawling has become an important method of fishing since '70s in the region. Although some information is available on the commercial trawling in the Gulf of Mannar and Palk Bay (James and Adolf, 1965; Pillai and Dorairaj, 1985; Jayasankar, 1997, 2003), no data are available on the impact of bottom trawling on the survival of the fauna landed onboard and subsequently released. The present study, based on experimental fishing, primarily examines the survivability of the trawl-

caught animals, which are deposited on the deck and trawl-induced damages to selected fauna.

Materials and methods

A total of 18 experimental trawling voyages covering 21 stations were carried out from a 35-footer boat using shrimp trawl net of 25 mm codend mesh size with a tow duration of 1-2 h during March 2000 - March 2001 in the Gulf of Mannar and the Palk Bay in the south east coast of India (8°55' – 9°20'N; 79° - 79°40'E). Depth of sampling locations in the present study ranged from 6 to 16 m. Description of the commercial shrimp trawling grounds of this region is given elsewhere (Jayasankar, 1995).

Broadly the catch was grouped into 'target' groups (commercial sized finfish, shrimp, crabs, lobsters and cephalopods) and 'non target' groups (low value ground fish, undersized shrimp and inedible biota). After taxa-vise segregation of the hauled catch, the specimens were placed in 50 l bins filled with fresh seawater, renewed, temperature and salinity were recorded at hourly intervals. Not more than 10 small animals (less than about 100 mm TL) were kept in one bin. Fish larger than 200 mm were held individually, and animals in between these sizes were held at densities of 2-5 per tank, depending on their size. Survival ratio (SR) by elapsed time (t) was calculated for each species as the ratio of number of survivors after time 't' to the number placed in the bins for experiment. Mortality and injuries were monitored at 30 min intervals and all observations were terminated at the end of 21 h. The criteria used to determine whether an individual was alive were adopted from Kaiser and Spencer (1995). Lacerations, loss/damages of appendages/carapace and loss of spines/ scales were taken as criteria for assessing

injuries among the survivors (Wassenberg and Hill, 1989).

Differences among selected trawl-entrapped species representing target and non target groups in their survival duration and percentage of injuries in relation to tow durations (1 h and 2 h) were ascertained by 1-way ANOVA and comparisons of means were made using Duncan's multiple range test at 5% level of significance using SPSS/PC software (Version 10.0). Effects of tow duration on the proportion of injured taxa were tested using G-test at 1% of level of significance using SAS software (Version 8.1).

Results

The data on quantity of various taxa represented in experimental fishing in the Gulf of Mannar and Palk Bay show that about 60% of the catch consisted of non-target groups with seaweeds/sea grass alone forming almost 50% of the total catch (Table 1). Among the other taxa, silverbellies dominated in terms of weight and number. Proportion of shrimp which is the major target group,was less than 2%. Finfishes of commercial value formed less than 4%.

Survival experiments were carried out for selected taxa of finfish, shellfish and inedible biota. In *Sardinella* spp. survival duration increased with size but gradually declined upwards of 100 mm. A similar trend was seen in *Therapon jarbua*. On the contrary, in *Leiognathus* spp., *Lethrinus nebulosa, Selaroides leptolepis, Upeneus sundaicus, Siganus canaliculatus* and *Gerres filamentosus* survival duration has improved in larger size groups (Fig.1 a). Among shellfishes, survival time was better among middle size groups, viz, 70-99 mm in *Penaeus semisulcatus*, and 70-89 mm in *Portunus pelagicus*. In cuttlefish, survival duration declined with size (Fig.1 b).

TABLE 1 : *Proportion of various taxa averaged by weight and number for 18 trawl catches collected from the Gulf of Mannar and Palk Bay during March 2000 to March 2001*

	Average Weight {Kg}	Average Number	Proportion of Total Catch [%]
Silverbellies	114.55	7863	24.11
Catfish	3.22	117	0.68
Perches	9.31	669	1.96
Cephalopods	6.92	390	1.45
Shrimps	6.91	737	1.45
Sea cucumber	26.82	201	5.65
Barracuda	1.63	20	0.34
Sardines	5.60	391	1.18
Blue Crab	1.94	43	0.41
Stomatopods	15.71	811	3.31
Gastropods	11.33	459	2.38
Bivalves	10.75	1691	2.26
Inedible crabs	4.43	194	0.93
Sea urchins	4.1	504	0.86
Starfish	1.7	66	0.36
Sponges	2.089	70	0.44
Puffer fish	3.42	65	0.72
Goatfish	1.23	67	0.26
Carangids	1.68	127	0.35
Jellyfish	4.48	60	0.94
Seaweeds/ Seagrasses	228.30	—	48.06
Others	8.98	169	1.89

In Puffer fish, *Arothron hispidus*, maximum survival duration was among 70-99 mm size range and there was markedly faster deaths in higher size groups, till 190-199 mm group. Similar trend was seen in inedible crabs, sea urchins and starfish (Fig. 1 c). Stomatopods (*Oratosquilla* sp.) of 70-109 mm length groups survived longer period.

Duncan's multiple range test indicated homogeneity among *Sardinella longiceps, Penaeus semisulcatus* and *Sepia pharaonis* with reference to post-trawl survival, while *Oratosquilla* spp., and *Arothron* spp., were significantly different from other species (Table 2).

Among the target groups, survival ratio was above 0.7 in all the species at the end of 30 minutes since capture (Fig. 2 A). Cephalopods appeared to be most vulnerable to the trawling pressure. Finfish in which observations were made included species of *Sardinella, Lethrinus, Leiognathus, Gerres, Therapon, Sphyraena, Upeneus, Selaroides, Tachysurus, Siganus, Stolephorus* and *Cynoglossus*. Except blue crab (*Portunus pelagicus*), all other species died before 150 minutes of capture. Blue crab showed marked mortality after 180 minutes of capture.

Non-target groups appeared relatively hardier than the target groups to trawling pressures (Fig. 2 B). Among the non-target groups, small inedible crabs were most sensitive to the effects of trawling, frequently having cracked carapaces. Sea urchins were also vulnerable to trawling pressure, though

TABLE 2 : *Mean survival duration of species tested. Mean values having dissimilar superscripts indicate significant differences (P<0.05, Duncan's multiple range test)*

Species	Sample size	Length/weight range	Mean survival duration (min±SE)
Sardinella longiceps	*64*	*50-139 (TL, mm)*	*43.5[a] (±3.1)*
Penaeus semisulcatus	89	40-149 (TL, mm)	53.7[a] (±1.0)
Portunus pelagicus	31	30-109 (CL, mm)	174.1[a, b] (±15.4)
Sepia pharaonis	23	5-49 (W, g)	44.3[a] (±1.0)
Oratosquilla spp.	68	40-139 (TL, mm)	359.2[c] (±34.9)
Pentaceraster spp.	36	5-129 (W, g)	205.0[a, b, c] (±12.4)
Arothron spp.	27	70-199 (TL, mm)	255.0[b] (±20.6)

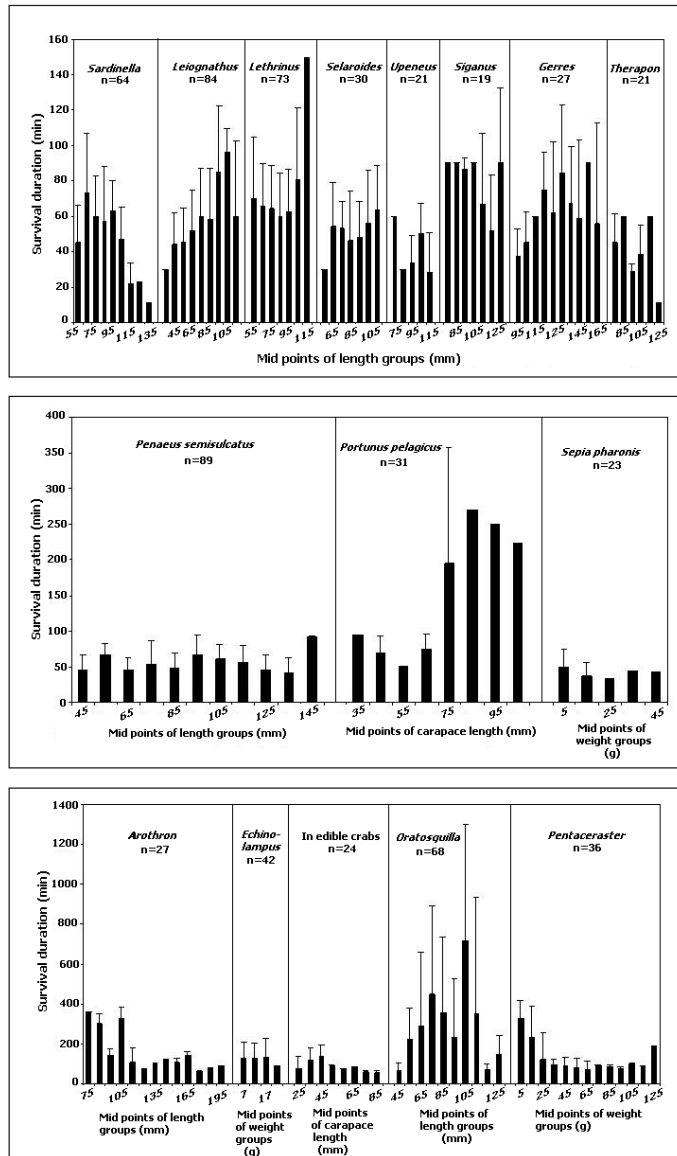Abbreviations: TL, Total Length; CL, Carapace Length; W, Weight.

holding. Gastropods, bivalves and stomatopods were robust and had survived till the end of the experiments (21 h); mortality was high after about 480 minutes of capture.

Commercially important shrimp sustained maximum injuries (36%; n=737) followed by sardines (18%; n=391). Shrimps sustained damages of carapace and appendages whereas sardines sustained lacerations and loss of scales due to trawling. Stomatopods (n=811) and sea urchins (n=504) were more resilient, with only about 12% of individuals of both the groups sustaining injury. Stomatopods were partially crushed and lost appendages, while spines were broken in sea urchins.

Tow duration had no significant effect on the degree of injuries on the species (P>0.05). Duncan's multiple range test indicated homogeneity among sardines, stomatopods and sea urchin with reference to post-trawl injuries, while shrimp differed significantly from others (Table 3). A similar proportion of all the four taxa had injuries regardless of tow duration (G-test between each taxon and between tow duration, all non-significant at P>0.01).
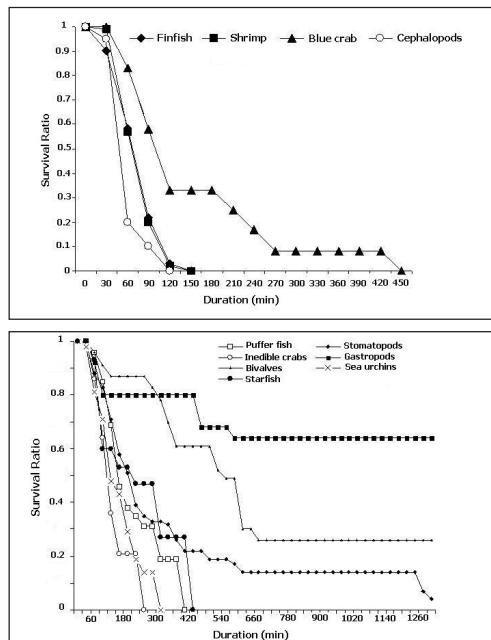

Fig. 1. Survival duration of mean size groups of finfish (a), shellfish (b) and inedible biota (c) caught during experimental trawling in the Palk Bay and Gulf of Mannar (the vertical bars represent standard deviation)

starfish was more resilient. Death in sea urchins was characterized by extreme loss of spines (>50%) and the inability to attach themselves to the side of the bins with their tube feet. Puffer fish showed complete mortality within 7 hours of

Fig. 2. Survival ratio by elapsed time in trawl-captured target groups (a) and non-target groups (b)

Discussion

The results indicate that survival of trawl-caught animals vary between taxa. Survival duration in several species of fish and shellfish of different size groups caught in trawl nets present some interesting results hitherto not reported. The smaller individuals of most of the inedible taxa had lesser damages and greater survivability.

Among the target groups, cephalopods

TABLE 3 : *Mean percentage of injured among taxa tested. Mean values having dissimilar superscripts indicate significant differences (P<0.05, Duncan's multiple range test)*

Taxa	Sample size	Length/weight range	Mean% injured (±SE)
Sardines	391	50-139 (TL, mm)	17.0[a] (±0.2)
Shrimp	737	40-149 (TL, mm)	36.0[b] (±0.1)
Stomatopods	811	40-139 (TL, mm)	12.0[a] (±0.1)
Sea urchin	504	5-129 (W, g)	12.0[a] (±0.2)

were most vulnerable to trawling impact, while blue crabs had maximum survival ratio. Swimming crabs of genus *Liocarcinus* and other portunids exhibited long duration of post-trawl survival in Dulas Bay (Kaiser and Spencer, 1995) and Torres Strait (Wassenberg and Hill, 1993). Finfish and shrimps had similar tolerance limits to trawling effects. Generally the cause of death was not apparent, although few soft-shelled *P. pelagicus* had usually been squashed in the trawl. Some individuals of cephalopods and finfish showed bruises, shrimps had broken appendages and crabs had cracked carapaces. An individual animal's ability to survive the fishing process could be directly related to its physiology, morphology and behaviour in response to the gear (Kaiser and Spencer, 1995).

Resistance of starfish to the effects of trawl entrapment seems to be related to the flexibility of the test, e.g. the test of starfish is constructed of interlinked plates, which allows greater flexibility than the larger plates of a brittle star species. The fused plates of test in sea urchins make them vulnerable to damage, leading to high mortality (Kaiser and Spencer, 1995).

The present figures of mortality, based on tows of 1-2 h duration, underestimate total mortality in commercial tows, which are usually 4-5 h long, depending on the catch rate and ground type. Van Beek *et al.* (1990) have demonstrated a negative exponential relationship between the survival of sole and plaice with haul duration.

The present findings that generally most of the inedible taxa were relatively less damaged and survived longer after capture in trawl nets, should encourage the fishers to return these uneconomic catches to the sea for their continued

survival. On the other hand, if they are brought to the shore, only a portion of them would find any use in the form of raw material for poultry feed and fertilizers, besides some molluscan shells for ornamental purpose. However, very few studies have attempted to understand the probable fate of discards from commercial trawlers and have indicated low survival rate on return to the sea (Hill and Wassenberg, 1990; 2000). Scavengers, including birds, sharks, and dolphins are usually benefited from the trawl discards. Further investigations are required to determine the fate of animals thrown back into the sea from trawlers, before any reliable estimates of total discard mortality can be formulated.

Acknowledgements

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