LETTER

Commercializing bycatch can push a fishery beyond economic extinction

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Abstract

Tropical bottom trawling is among the most destructive fishing practices, catching large quantities of bycatch, which are usually discarded. We used questionnaire surveys of trawl fishers to look at changes in catches over the last 30 years (1978–2008) along India's Coromandel Coast. We show that catches and income from target species have declined sharply over the last two decades. Meanwhile, costs of fishing have increased substantially and now almost exceed income from target species. Over the same period, bycatch (which was traditionally discarded) has now become increasingly marketable, being sold for local consumption, and as fish meal to supply the region's rapidly growing poultry industry. Without this income from bycatch, the fishery would scarcely be economically viable. While such a change in the use of bycatch is good news in terms of reducing waste and improving livelihoods, it is also responsible for pushing the Indian bottom trawl fishery beyond the economic extinction of its target species.

Introduction

Commercial fishing is responsible for large-scale declines and local extinctions of many species (Dulvy *et al.* 2003; Jennings & Blanchard 2004; Scales *et al.* 2006; Scales *et al.* 2007) and presently 79% of fisheries worldwide are believed to be overexploited (FAO 2009). The nonspecific nature of many fishing gears means that these fisheries impact not merely their target species but many other species besides, commonly referred to as bycatch (Hall *et al.* 2000). Current estimates place annual global fisheries bycatch at around 38.5 million tonnes, representing ~40% of the total marine catch; most of it discarded (Davies *et al.* 2009). Shrimp trawling, especially in tropical waters, generates more bycatch than any other type of fishery, accounting for over one-third of the global total (Kelleher 2005). Shrimp trawlers in the tropics catch over 400 nontarget species, with a bycatch-to-shrimp ratio by mass as high as 10:1 (Alverson *et al.* 1994), with most of the bycatch traditionally discarded (Hall *et al.* 2000).

FAO estimates suggest that there have been reductions in the amount of discards over time (Kelleher 2005; Zeller & Pauly 2005). One factor contributing to this trend is an increase in the landing of previously discarded trash fish bycatch (Funge-Smith *et al.* 2005) that is processed as feed for aquaculture and livestock, used as farm manure, and in some cases, sold for human consumption (Nunoo *et al.* 2009).

In India, trawl fishing (aimed primarily at export markets) began in 1956 through funding provided by foreign aid organizations (Devaraj & Vivekanandan 1999). Its introduction led to an increase in commercial landings in the initial years. However, the trawlers' efficient gear led to a fairly rapid overfishing of commercially targeted stocks (Bavinck 2001; Bhathal & Pauly 2008). Most recently, like many other coastal nations of Asia and Africa, India has seen an increase in the landing and use of previously discarded bycatch (Biju Kumar & Deepthi 2006). In this article, we use interview techniques with local fishers to document changes in the use of bycatch along southeast India's Coromandel Coast, and investigate its

implications for the economics of shrimp trawling. We used interview techniques rather than relying on catch landing data because the fisheries statistics available for this coast are restricted to traditionally targeted species groups (Srinath 2006) with no data on bycatch.

Methods

Description of the trawl fishery along the Coromandel Coast

Trawl fishing along Tamil Nadu's Coromandel Coast started in the 1960s in Chennai, the northernmost fish-landing site, and was soon adopted at more southern bases (Pondicherry, Cuddalore, Mudasalodoi, Pazhaiyar, and Nagapattinam) between 1975 and 1985. Our study focused on Nagapattinam, the largest fish-landing site, with ~650 of the Coromandel's ~1,800 trawlers operating from here (CMFRI 2007). Our study excludes Chennai, whose ~650 trawlers operate mainly in Andhra Pradesh to the north and do not contribute significantly to trawling along the Coromandel Coast (Bavinck *et al.* 2008). To broaden our sample, we also conducted interviews at two of the smaller fish-landing sites—Pazhaiyar (~210 trawlers) and Mudasalodoi (~60 trawlers), located ~70 and ~100 km north of Nagapattinam, respectively. Fishing methods and target species are relatively homogenous along the entire Coromandel Coast, as a result of relatively similar environmental conditions and prevailing caste and kinship ties (Bavinck 2001).

Trawlers along the Coromandel Coast are restricted to a maximum length of 50 ft, and a maximum engine size of 110 hp. There is a strictly enforced 45-day fishing ban (15 April–29 May) each year, common to the entire state of Tamil Nadu (Bavinck *et al.* 2008) and the Tamil Nadu Marine Fisheries Regulation Act of 1983, requires that the first three nautical miles (5.56 km) from shore be reserved for artisanal fishing. However, this is not strictly enforced, and trawlers often fish closer to the coast (Bavinck *et al.* 2008). Trawling operations are mostly restricted to a depth of 50 m, and fishing trips generally last 1–3 days (Devaraj & Vivekanandan 1999; Bavinck *et al.* 2008). An average of five trawls is conducted over a 24-hour period, each lasting ~3 hour.

Components of the catch

Trawler catch is sorted as soon as it is hauled aboard, and can be broadly divided into three categories: target, bycatch, and discards (Figure 1). In this article, we use standard definitions from Kelleher 2005 and Funge-Smith et al. 2005, adapting them to the local situation as follows:

Target catch

Species or an assemblage of species primarily sought by the fishery (Kelleher 2005). The target catch for trawlers along the Coromandel Coast includes penaeid shrimps, swimming crabs, lobsters, cephalopods, and some high-value fish. This catch is primarily destined for the export markets (mainly Japan, U.S.A, European Union, and China) or distant domestic markets (Salagrama 1999; MPEDA 2009).

Bycatch

Nontarget animals (Kelleher 2005), excluding discards (see below). Along the Coromandel Coast, bycatch can further be subdivided into commercial bycatch and trash fish.

Commercial bycatch

Nontarget species sold for human consumption, generally through local markets, and either eaten fresh or dried and stored for later consumption.

Trash fish

Low-quality bycatch, generally of small-bodied species. It is rarely consumed by people but sold for fish meal manufacture (Funge-Smith *et al.* 2005).

Discards

Animal material in the catch that is thrown away at sea (Kelleher 2005). In India, and the Coromandel Coast in particular, most discards are of low-value species that would otherwise be used as trash fish (Salagrama 1999; Biju Kumar & Deepthi 2006).

While the distinction between Target and Bycatch is clear in terms of species composition, price, handling, and marketing, the boundaries between commercial bycatch and trash fish are fuzzier—neither is a monitored resource, and in interviews with fishers it was difficult to adequately resolve the bycatch category. We therefore use the term bycatch to include both commercial bycatch and trash fish.

Interviews

We used semi-structured interviews to reconstruct trends in fishing costs, landings and income from target species, and bycatch over the last 30 years. We interviewed 26 trawler owners from Nagapattinam, representing ~4% of trawler owners currently fishing from the base and over 50% of those who have owned trawlers continuously

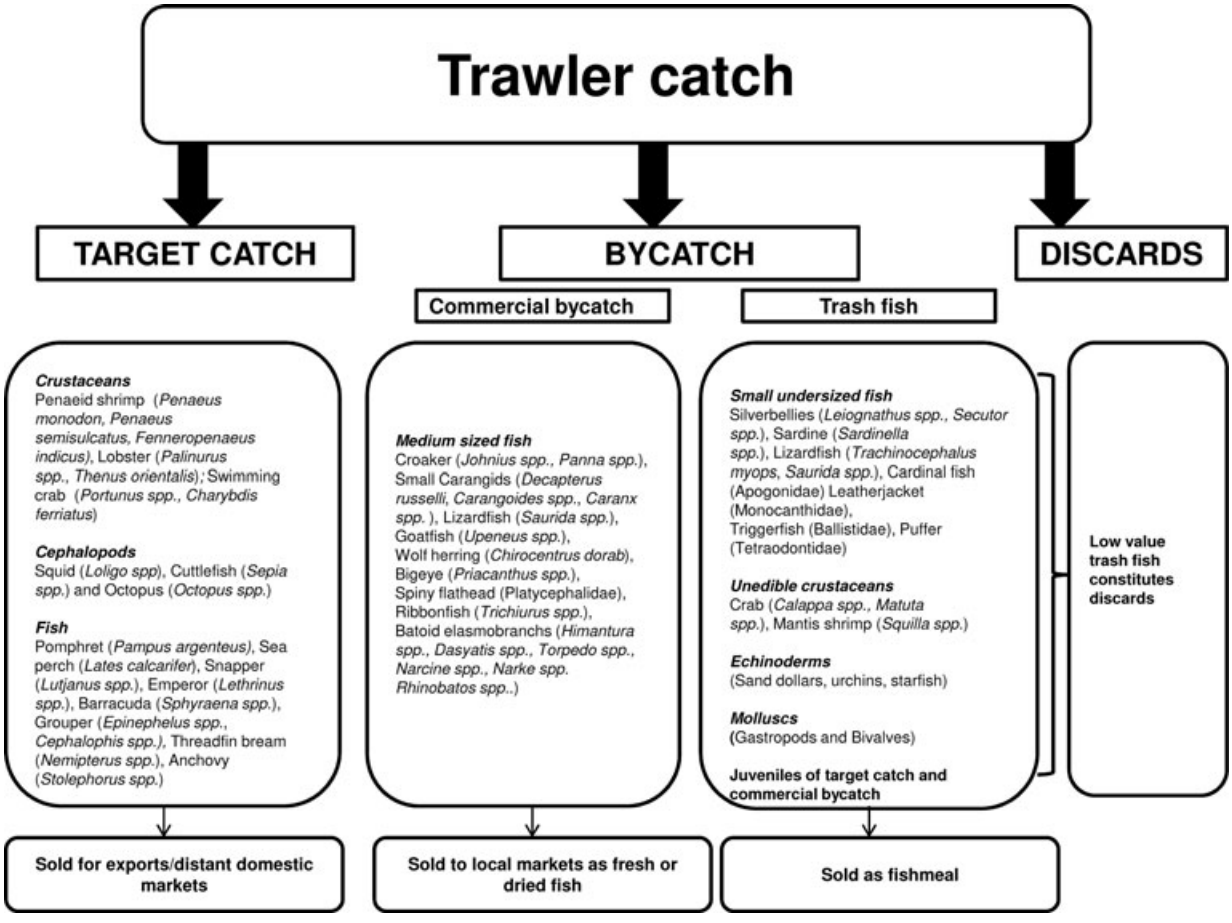

Figure 1 Diagrammatic representation of the categories and composition of the trawl catch along the Coromandel Coast. The lists are representative but not comprehensive.

over the last 30 years. We also conducted five interviews each at two other fish-landing sites—Pazhaiyar and Mudasalodoi. In Mudasalodoi, we were only able to obtain data for three points in time (1988, 1998, and 2008), as trawling at this site only began in 1985.

Interviews were conducted between October and December 2008, in the homes of the trawler owners (to ensure the independence of responses). This work was conducted after a 2-year long engagement with the fishers of this region sampling trawl catches, giving us sufficient time to gain their trust.

We asked trawler owners to estimate their average catch masses (kg), gross incomes (in Indian Rupees, INR), and costs (in INR) per fishing trip for the years 2008, 1998, 1988, and 1978. We also questioned them about the number of trips they made per year for each time period, and the average duration of each of these trips.

Finally, we conducted a series of interviews to track the changing fate of the trash fish bycatch after it was landed. We questioned five trash fish dealers in Nagapattinam (representing ~12% of the dealers in the region) to clarify the trash supply chain, and interviewed five poultry feed manufacturers in Nammakkal, the largest poultry center in this region to determine the proportion of fish meal in chicken feed. To put this trade within a larger temporal context, we obtained data on the growth of the poultry industry in India from the FAO statistics database (http://faostat.fao.org).

Analysis

We used responses to our interviews with trawler owners to express temporal trends in the Coromandel trawl fishery in four ways: (1) annual catches of target species and bycatch (average catch per trip multiplied by the number of trips per year); (2) catch per unit effort (CPUE) for target and bycatch (average catch per trip divided by

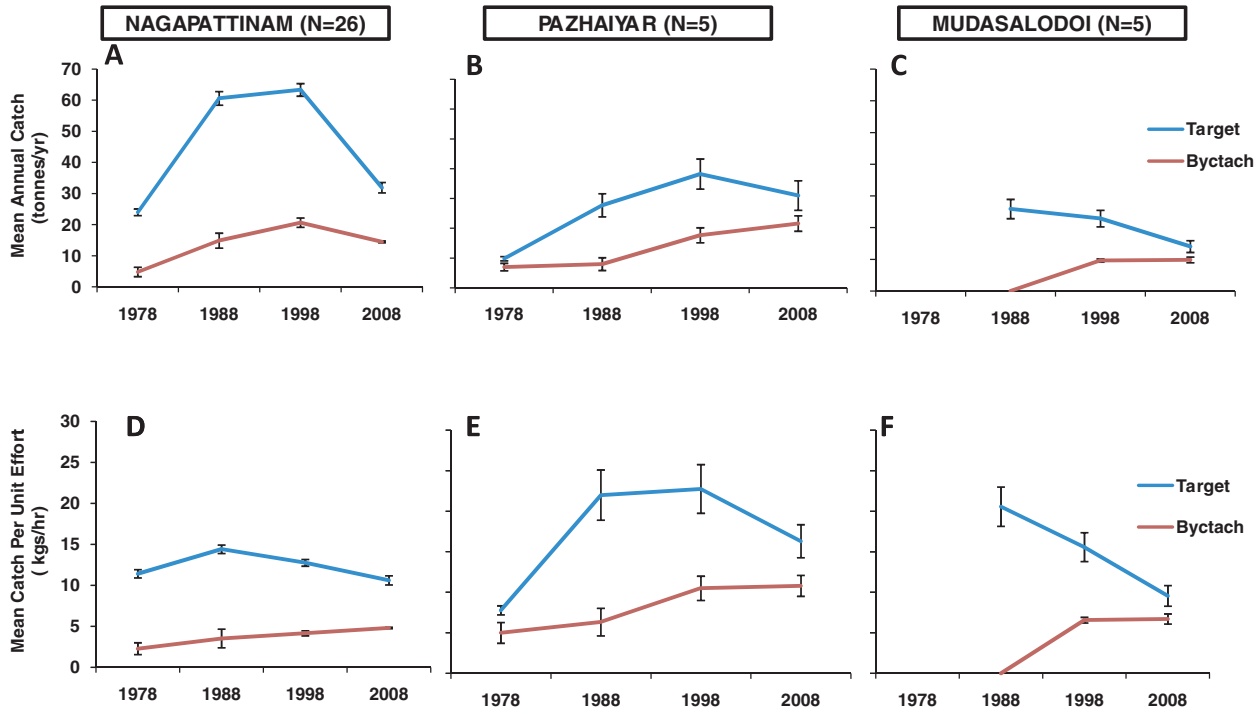

Figure 2 Changes in means (with standard errors) of annual catch (A, B, and C) and catch per unit effort (D, E, and F) of target and bycatch over the last 30 years, at Nagapattinam, Pazhaiyar, and Mudasalodoi. Numbers next to place names indicate number of trawler owners interviewed.

average trip duration); (3) mean annual income from target and bycatch, and costs (reported trip averages multiplied by the number of trips per year); and (4) net income (costs subtracted from total income). All economic values were adjusted to 2008 for inflation and expressed in million INR using a GDP Deflator index for India (www.econstats.com/weo/V005.htm).

Results

At Nagapattinam, reported annual catches of target species rose steeply from 1978 to 1988, and less so in the following decade (to 1998), before falling steeply to 2008 (Figure 2A). Reported landings of bycatch showed a different pattern, rising steadily through to 1998 and declining slightly since—though these figures exclude any discards and, as such, are hard to interpret because the proportion of bycatch caught that was landed has probably increased over time (Gordon 1991; Biju Kumar & Deepthi 2006). Changes in CPUE (Figure 2D) on the other hand show that for the target species there was a rise in CPUE between 1978 and 1988, followed by a steady decline over the following 20 years (1998–2008). This decrease is likely to be an underestimate of the real decline in target stocks over this interval, because the trawlers in this region have steadily improved in efficiency over the last 30 years (Bhathal & Pauly 2008). The CPUE of bycatch on the other hand increased consistently over the last 30 years (Figure 2D).

Though represented by small sample sizes, the other two fish landing sites followed similar catch trends as Nagapattinam. At Pazhaiyar, the reported annual target catches grew between 1978 and 1998 and then declined (Figure 2B). The target CPUE at this site increased in the first decade (1978–1988) and marginally through to the next decade, after which it declined. On the other hand, both the annual catches and CPUE of bycatch increased consistently over the last 30 years (Figure 2B and E). Unlike other sites, at Mudasalodoi, reported target catch (total catch and CPUE) has declined over the last 20 years (Figure 2C and F). At this location, all bycatch was discarded in 1988, but trawlers were landing bycatch in 1998 and continued to do so at similar levels in 2008.

Turning to trends in the economic performance of the fishery, gross income from target species at Nagapattinam increased in the first decade (1978–1988), and have since declined (Figure 3A). Meanwhile, the costs of trawling increased fourfold between 1978 and 2008. Although

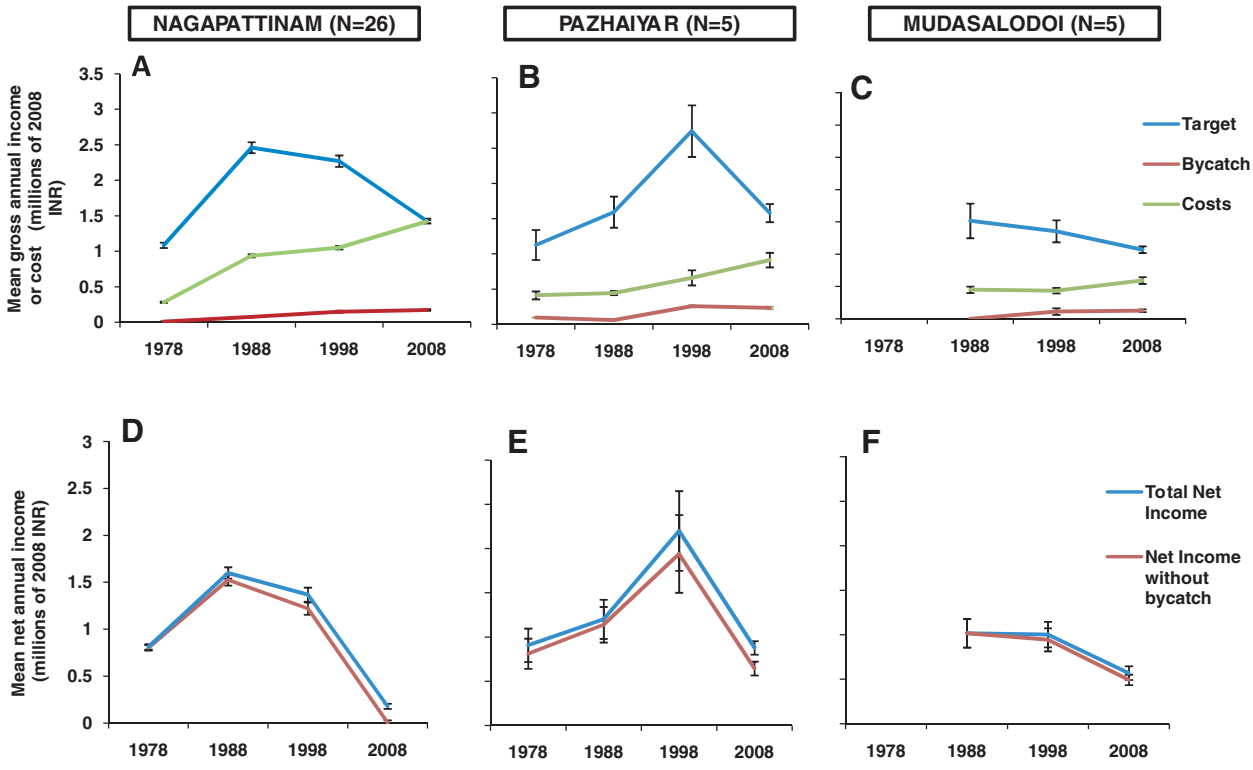

Figure 3 Changes in means (with standard errors) of gross annual incomes from target, bycatch, and annual costs (A, B, and C), and net incomes (D, E, and F) with and without bycatch over the past 30 years, at Nagapattinam, Pazhaiyar, and Mudasalodoi. All prices are adjusted for inflation and expressed as 2008 INR (1USD = 46 INR).

the rise in gross income from target species outstripped cost increases between 1978 and 1988 (so that net income rose—Figure 3D), the subsequent declines in gross income and increases in cost together mean that net income from fishing target species has since fallen steeply, and is now near-zero. However, trawler operations are still profitable (though barely so) because of the consistent increase in income from bycatch over the last 30 years (Figure 3A). Though this is still much lower than income from target species, money from the sale of bycatch keeps overall net income (just) above zero (Figure 3D). At Pazhaiyar, gross income increased in the first two decades (1978–1998) and then declined in 2008 (Figure 3B). At Mudasalodoi, the gross income of target catch started high in 1988 and has since declined (Figure 3C). In terms of net income, at Pazhaiyar, this increased 1978–1998, but has since declined (with or without considering bycatch; Figure 3E). At Mudasalodoi, net income was roughly similar 1988–1998 but has since declined (Figure 3F). Unlike at Nagapattinam, both these sites continued to remain profitable from the earnings of target catches alone, with the income from bycatch making only marginal improvements.

Interviews with trawler owners, trash fish dealers, and poultry feed manufacturers revealed that during the first decade of trawl fishing in this region, the trash fish was either discarded or sold as cheap manure for agricultural fields (Gordon 1991; Salagrama 1999). However over the last two decades, there has been a growing demand for trash fish from the poultry and (to a lesser extent) aquaculture sectors. Trawler owners now sell the trash fish to dealers, who partially process it before selling it to poultry feed manufacturers. Fish meal comprises around 6% of the final, processed feed. FAO data confirm the steady growth in the poultry industry over the past 30 years (Figure 4).

Discussion

All three sampled locations along the Coromandel show sharp declines in target catch over the last decade (1998–2008). The resulting decline in net income in Nagapattinam meant that the fishery has become reliant on the income from bycatch to remain economically viable. In Pazhaiyar and Mudasalodoi, the fishery continued to remain profitable, with overall profits buffered by the

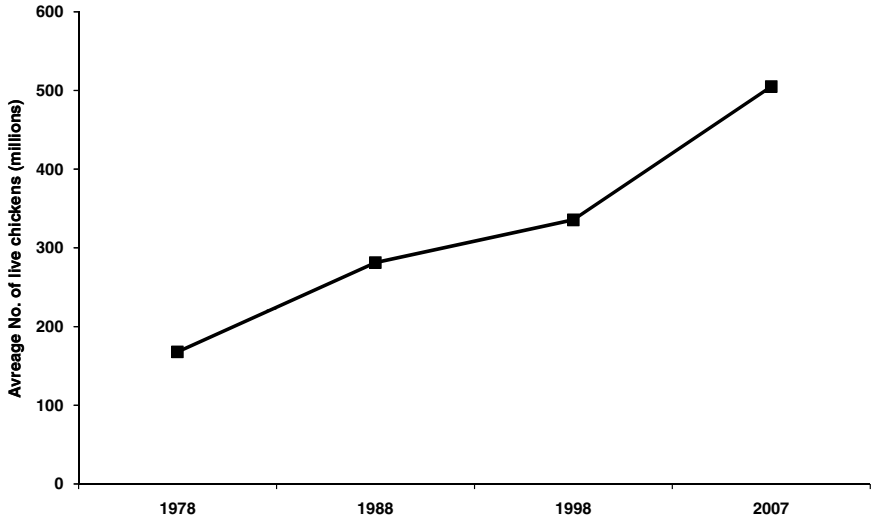

Figure 4 Growth of the poultry industry in India expressed as the average number of live chickens per year (in millions). (source: http://faostat.fao.org).

extra income earned from bycatch. These two locations presumably performed economically better than Nagapattinam because they had fewer trawlers (CMFRI 2007). In addition, trawling was only introduced to Mudasalodoi in 1985.

We recognize that relying on interviews with fishers to reconstruct catch data across time is subject to error because of imprecise recall. Interview techniques have however been shown to be effective, and often the only available way to garner information from data-poor fisheries (Drew 2005; Saenz-Arroyo *et al.* 2005; Moreno *et al.* 2007; Ban *et al.* 2009), including information on fishing effort and bycatch (Foster & Vincent 2010; Moore *et al.* 2010). It is also possible to validate interviews by comparing certain responses with other quantitative sources (Gilchrist *et al.* 2005). We were unable to crosscheck our interview data on bycatch, because standard monitoring programs for marine landings in India focus largely on target species (Srinath 2006). However, trends derived from our interviews for target species broadly match those from three other published datasets for target trawl catches, one for the entire state of Tamil Nadu (Srinath 2006), and the other two for the Chennai fish landing site for total target catches (Devaraj & Vivekanandan 1999) and penaeid shrimp catches (Thangaraj Subramaniam 2002). The catches in these three separate studies peaked around the same period (1995–1998), which conforms to the trends in our study (Figure 5).

The increase in total catch of target species in Nagapattinam, during the first two decades of our study (1978–1998) could be attributed to the introduction of trawlers equipped with novel and efficient technology to a region predominantly fished by nonmotorized artisanal craft (Bavinck 2001). Over the past decade, however, total catch has declined steeply, reflecting a sustained fall in CPUE of target species beginning in the 1990s (see also Devaraj & Vivekanandan 1999). These declines are almost certainly due to increasing fishing effort, common across India, which is now exhausting near-shore resources (Bavinck 2005). Across southeast India as a whole (of which the Coromandel Coast constitutes nearly a third), the mechanized fleet (trawlers) expanded eightfold between 1961 and1998 (Vivekanandan *et al.* 2005). The effects of increasing trawler capacity have probably been compounded by large-scale motorization of artisanal craft in the last decade, particularly in the wake of the 2004 tsunami (Pomeroy *et al.* 2006), a process that has further increased fishing effort in this region (Salagrama 2006; Salagrama & Koriya 2008).

Even at Pazhaiyar and Mudasalodoi, this increased effort is associated with falling catches, CPUE, and income. At Nagapattinam, CPUE and income from target species have fallen so greatly that, coupled with rising costs, the fishery is no longer profitable based on its target catch alone. By analyzing rarely reported data on nontarget groups, we have been able to show that the Nagapattinam fishery has remained economically viable (albeit barely) by landing increasing amounts of bycatch. This shift in behavior has been catalyzed by several changes in the market for bycatch.

On the one hand, seafood (including commercial bycatch) has become an increasingly important part of the diet of the expanding middle class in India (Salagrama 2004). Several species of commercial bycatch are now

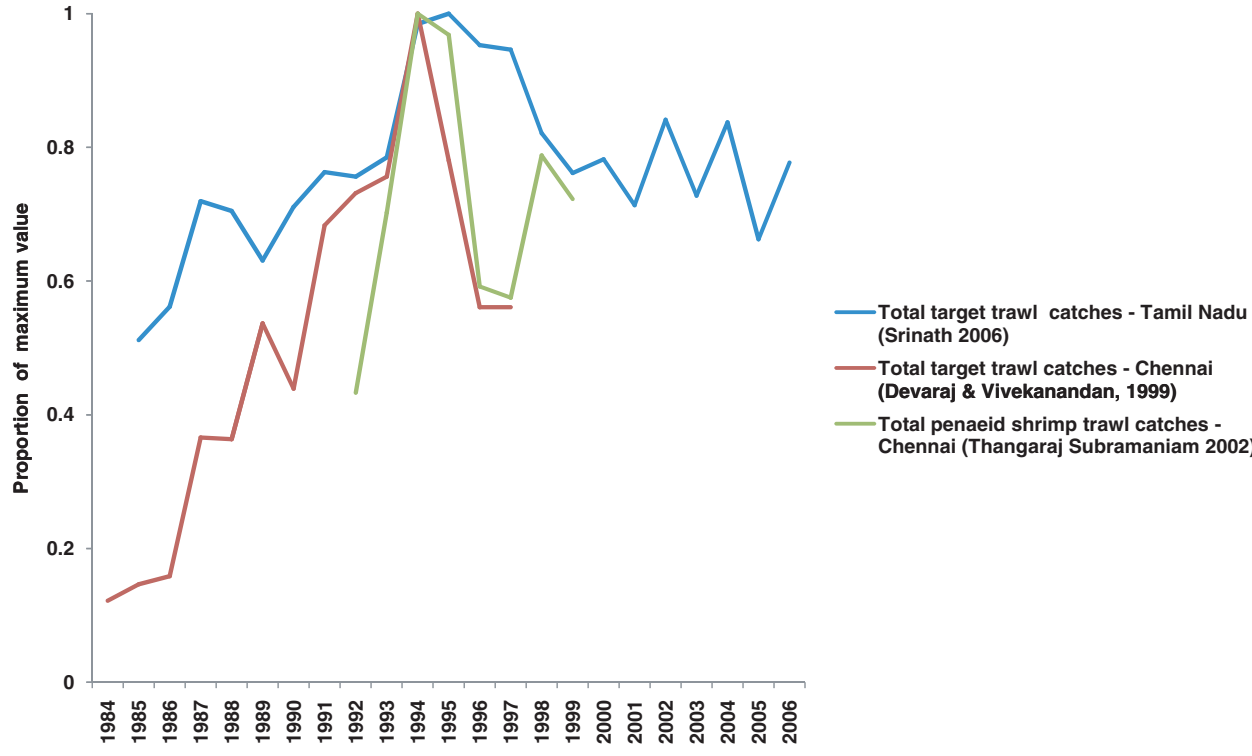

Figure 5 Comparative trends of target trawl catches expressed as proportion of the maximum value for (A) Total target trawl catches for Tamil Nadu (Srinath, 2006); (B) Total target trawl catches landed at Chennai (Devaraj & Vivekanandan 1999); and (C) Total penaeid shrimp trawl catches landed at Chennai (Thangaraj Subramaniam 2002).

entering the market place, sold either fresh or dried for later consumption. There is also a growing market for processed bycatch food products (Zynudheen et al. 2004) and nonfood fish products (Salin et al. 2005).

Alongside these new uses, the past two decades have also seen growth in demand for trash fish, which is processed to make fish meal for India's rapidly expanding poultry sector. Poultry production is currently growing faster in India than elsewhere in Asia (Evans 2008) as the country's rising affluence fuels a shift away from vegetarianism (Mehta *et al.* 2008). These trends are likely to continue through the next decade (Mohanty & Rajendran 2003), further increasing demand for fish meal.

The implications of these changes for fish stocks and trawling are profound. Bycatch appears to have served as an important buffer sustaining the fishery, with target stocks near collapse and profits low. This has important advantages. Trawlers are now wasting less bycatch than they did when trawling first began (Gordon 1991; Biju Kumar & Deepthi 2006), and the trash fish industry generates employment for many (e.g., trash fish dealers, sorters, and fish meal processors) and sustains the livelihoods of trawl fishers. However, as the fishery begins to increasingly depend on bycatch as a source of income, there is a very real danger of fishing beyond the point of collapse of the target species, which may never be able to recover. We suggest that without greater consideration of its ecosystem-wide effects, and far greater efforts to manage it sustainably, the bycatch-supported prolongation of trawl fishing along the Coromandel Coast will lead to an ecological catastrophe for nearshore marine populations as well as the permanent loss of livelihoods for fishers, and the large number of other individuals who presently work in the bycatch industry.

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References

Alverson, D.L., Freeber, M.H., Murawski, S.A., Pope J.G. (1994) A global assessment of fisheries bycatch and discards. *FAO Fisheries Technical Paper* 339, p. 235.

Ban, N.C., Hansen G.J.A., Jones M., Vincent A.C.J. (2009) Systematic marine conservation planning in data-poor regions: socioeconomic data is essential. *Marine Policy* **33**, 794–800.

Bavinck, M. (2001) *Marine Resource Management. Conflict and regulation in the fisheries of the Coromandel Coast*. Sage Publications India Pvt Ltd, New Delhi.

Bavinck, M. (2005) Understanding fisheries conflicts in the South: a legal pluralist perspective. *Soc Nat Resour* **18**, 805–820.

Bavinck, M., de Klerk L., van Dijk D., *et al*. (2008) Time-zoning for the safe-guarding of capture fisheries: a closed season in Tamil Nadu, India. *Marine Policy* **32**, 269–378.

Bhathal B., Pauly D. (2008) Fishing down marine food webs' and spatial expansion of coastal fisheries in India, 1950–2000. *Fish Res* **91**, 26–34.

Biju Kumar, A., Deepthi G.R. (2006) Trawling and by-catch: implications on marine ecosystem. *Curr Sci* **90**, 922–931.

CMFRI (2007) *Marine fisheries census 2005. Part 1*. Central Marine Fisheries Research Institute, Cochin.

Davies R.W.D., Cripps S.J., Nickson A., Porter G. (2009) Defining and estimating global marine fisheries bycatch. *Marine Policy* **33**, 661–672.

Devaraj M., Vivekanandan E. (1999) Marine capture fisheries of India. Challenges and opportunities. *Curr Sci* **76**, 314–332.

Drew, J.A. (2005) Use of traditional ecological knowledge in marine conservation. *Conserv Biol* **19**, 1286–1293.

Dulvy, N.K., Sadovy, Y., Reynolds J.D. (2003) Extinction vulnerability in marine populations. *Fish Fish* **4**, 25–64.

Evans, T. (2008) Asia captures 34% of global output. India leads Asian poultry meat growth, quadrupling output since 1997. *Poultry International*, 22–25.

FAO (2009) *The state of world fisheries and aquaculture 2008*. FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, p. 176.

Foster, S.J., Vincent A.C.J. (2010) Tropical shrimp trawl fisheries: fishers' knowledge of and attitudes about a doomed fishery. *Marine Policy* **34**, 437–446.

Funge-Smith, S., Lindebo E., Staples D. (2005) *Asian fisheries today: the production and use of low value/trash fish from marine fisheries in the Asia-Pacific region*. Food and Agricultural Organization of the United Nations, Regional office for Asia and the Pacific, Bangkok, p. 38.

Gilchrist, G., Mallory M., Merkel F. (2005) Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. *Ecology and Society* **10**, 20.

Gordon, A. (1991) *The by-catch from Indian shrimp trawlers in the Bay of Bengal: the potential for its improved utilisation*. Bay of Bengal Programme, Madras, India, p. 27.

Hall, M.A., Alverson D.L., Metuzals K.I. (2000) By-catch: problems and solutions. *Mar Pollut Bull* **41**, 204–219.

Jennings, S., Blanchard J.L. (2004) Fish abundance with no fishing: predictions based on macroecological theory. *J Animal Ecol* **73**, 632–642.

Kelleher, K. (2005) *Discards in the world's marine fisheries. An update*. Food and Agriculture Organization of the United Nations, Rome, p. 131.

Mehta, R., Narrod, C.A., Tiongco, M.M. (2008) *Livestock industrialization, trade and social-health-environment impacts in developing countries: a case of Indian poultry sector*. Research and Information System for Developing Countries, RIS-DP # 146, p. 61.

Mohanty, S., Rajendran K. (2003) 2020 Vision of the Indian poultry industry. *International Journal of Poultry Science* **2**, 139–143.

Moore, J.E., Cox T.M., Lewison R.L., *et al*. (2010) An interview-based approach to assess marine mammal and sea turtle captures in artisanal fisheries. *Biol Conserv* **143**, 795–805.

Moreno, G., Dagorn, L., Sancho G., Itano D. (2007) Fish behaviour from fishers' knowledge: the case study of tropical tuna around drifting fish aggregating devices (DFADs). *Can J Fish Aquat Sci* **64**, 1517–1528.

MPEDA (2009) Export of marine products from India 2008–2009. Available from: URL http://www.mpeda.com/inner_home.asp?pg=publications/exportreview/trends.htm. Accessed 28 February 2010.

Nunoo, F.K.E., Boateng J.O., Ahulu A.M., Agyekum K.A., Sumaila U.R. (2009) When trash fish is treasure: the case of Ghana in West Africa. *Fish Res* **96**, 167–172.

Pomeroy, R.S., Ratner B.D., Hall S.J., Pimoljinda J., Vivekanandan V. (2006) Coping with disaster: rehabilitating coastal livelihoods and communities. *Marine Policy* **30**, 786–793.

Saenz-Arroyo, A., Roberts C.M., Torre J., Carino-Olvera M. & Enrıquez-Andrade R.R. (2005) Rapidly shifting environmental baselines among fishers of the Gulf of California. *Proceedings of the Royal Society B: Biological Sciences* **272**, 1957–1962.

Salagrama, V. (1999) Bycatch utilisation on the east coast of India: experiences of the DFID post harvest fisheries project. Pages 146–147 in I.J. Clucas & F. Teutscher, editors. *Expert Consultation on bycatch utilization in tropical fisheries*. NRI/DFID/FAO, Beijing, China.

Salagrama, V. (2004) *Policy research: implications of liberalisation of fish trade for developing countries. A case study for India*. Food and Agriculture Organization, Rome, p. 121.

Salagrama, V. (2006) Post-tsunami rehabilitation of fishing communities and fisheries-based livelihoods in Tamil Nadu, Kerala and Andhra Pradesh, India, pp. 159–210.

Salagrama, V., Koriya T. (2008) *Assessing opportunities for livelihood enhancement and diversification in coastal fishing communities of Southern India*. United Nations team for tsunami recovery support. United Nations India, Chennai, p. 123.

Salin, K.R., Yohannan T.M., Nair C.M. (2005) Fisheries and trade of seahorses, *Hippocampus spp*., in southern India. *Fish Manage Ecol* **12**, 269–273.

Scales, H., Balmford A., Liu M., Sadovy Y., Manica A. (2006) Keeping Bandits at Bay?. *Science* **313**, 612–613.

Scales, H., Balmford A., Manica A. (2007) Impacts of the live reef fish trade on populations of coral reef fish off northern Borneo. *Proceedings of the Royal Society B: Biological Sciences* **274**, 989–994.

Srinath, M. (2006) *Marine fish landings in India, 1985–2004: estimates and trends*. Central Marine Fisheries Research Institute, Cochin.

Thangaraj Subramaniam, V. (2002) Prawn fishery along Chennai coast in North Tamil Nadu. *Indian J Fish* **49**, 335–349

Vivekanandan, E., Srinath, M., Kuriakose S. (2005) Fishing the marine food web along the Indian coast. *Fish Res* **72**, 241–252

Zeller, D., Pauly D. (2005) Good news, bad news: global fisheries discards are declining but so are total catches. *Fish Fish* **6**, 156–159

Zynudheen, A.A., Ninan G., Sen A. & Badonia, R. (2004) Utilization of bycatch in Gujarat (India). *NAGA*, World Fish Center Q., 20–23.

