

Bottlenose Dolphins, *Tursiops truncatus*, Removing By-catch from Prawn-trawl Codends During Fishing in New South Wales, Australia

M. K. BROADHURST

Introduction

Like the majority of otter trawls, prawn trawls typically are poorly selective fishing gears, and in addition to the targeted species they also catch and retain large quantities of nontarget species (termed by-catch), which often comprises a diverse assemblage of small fish, crustaceans, and cephalopods (for reviews see Andrew and Pepperell, 1992; Kennelly, 1995). While some of this by-catch may be retained and sold commercially (Broadhurst and Kennelly, 1997), large quantities are often discarded at sea.

Several studies have examined the fate of discarded by-catch from prawn

trawling and show that in some cases it may contribute significantly to the diets of various scavenging predators, including seabirds (e.g. *Phalacrocorax varius*, *P. melanoleucos*, *Anous stolidus*, *Sterna bergii*, and *S. hirundo*) (Blaber and Wassenburg, 1989; Hill and Wassenburg, 1990; Blaber et al., 1995), crustaceans (e.g. *Portunus pelagicus*) (Wassenburg and Hill, 1987; 1990), fish (e.g. *Nemipterus* spp. and *Pentapodus* spp.), sharks (*Carcharhinus* spp.) (Hill and Wassenburg, 1990), and dolphins (e.g. *Tursiops truncatus*) (Leatherwood, 1975; Corkeron et al., 1990; Hill and Wassenburg, 1990). Many of these studies have used either visual census or underwater camera and video, at the surface and on the sea bed, to document the feeding behavior of various predators scavenging by-catch discarded from prawn trawlers. There is also some anecdotal evidence to suggest that some predators, such as bottlenose dolphins, *Tursiops truncatus*, may feed at prawn trawls during towing (Leatherwood, 1975), however, there is an absence of information and visual evidence on the extent to which these sorts of predators interact with the trawl. This communication documents one such interaction by providing the first videographic evidence of dolphins at the sea bed actively manipulating the codend of a prawn trawl to remove by-catch.

Materials and Methods

These observations were made at night onboard a commercial prawn trawler (13.8 m) fishing on grounds northeast of Yamba, New South Wales

(NSW), Australia (Fig. 1) in September 1996 during a trip to record film of fish escaping from a composite square-mesh panel (a by-catch reducing device developed for NSW oceanic prawn-trawls—Broadhurst and Kennelly, 1996; 1997). Three Florida flyers (mesh size 42 mm) each with a headline length of 12.8 m were rigged in a triple gear configuration and towed at 2.5 knots in depths ranging from 18 m to 22 m. The starboard outside net was fitted with a codend containing a composite square-mesh panel (Fig. 2). A "Photosea cobra" underwater video camera was mounted over the anterior section of the composite square-mesh panel, facing aft along the top of the codend (Fig. 2). This camera was linked, via coaxial cable, to a control console and PAL video monitor onboard the vessel and supplied with 240 volts of electricity. Two 240 watt submersible lights, facing aft, were mounted anterior to the camera on either side of the codend (Fig. 2). These lights were necessary since the camera was used at night with zero visibility. The nets were set and towed according to normal commercial operations with the camera switched on immediately after the gear touched the sea bed and then turned off again prior to hauling.

Results and Discussion

During three successive 60–90 min tows during the night, approximately 10–20 min after the camera was switched on and shortly after the lights were activated (providing a visibility of about 1.5–2 m), two bottlenose dolphins were ob-

The author is with the N.S.W. Fisheries Research Institute, P.O. Box 21, Cronulla, NSW 2230, Australia. His present address is Universidade Federal Rural de Pernambuco-UFRPE, Departamento de Pesca, Laboratório de Oceanografia Pesqueira, Av. Dom Manuel de Medeiros, s/n, Dois Irmãos, Recife-PE, Brazil, CEP: 52.171-900.

ABSTRACT—During a fishing trip to record video footage of fish escaping from a by-catch reducing device located in a commercial prawn trawl, two bottlenose dolphins, *Tursiops truncatus*, were observed to actively manipulate the codend at the seabed, removing and consuming components of catch (mostly juvenile whiting, *Sillago* spp.). The observed feeding pattern suggests a well established behavioral response to trawling activities and is discussed with respect to (1) the potential nutritional benefit that dolphins may derive from such activities and (2) the effects that scavenging may have on selectivity of the gear.

served to be in the process of slowly approaching the posterior end of the codend (Fig. 2 and 3A). The dolphins swam directly into the rear of the codend and using their rostrums and foreheads, pushed the diamond-shaped meshes forward and up with consider-

able force (Fig. 3B). This movement displaced the catch forward, effectively increased the fractional mesh openings in the codend, and resulted in the release of large numbers of small organisms and fish, mostly juvenile whiting (*Sillago* spp.). The dolphins retreated

and consumed some of these fish as they drifted from the codend (Fig. 3C) and also, by tilting their heads laterally, swam forwards and actively removed other individuals that were trapped between meshes. This behavior was repeated for up to 20 minutes during each tow. The dolphins were not observed to chase nor consume any of the live whiting that were escaping from the composite-square mesh panel. These fish tended to rise up above the dolphins and were quickly lost from view.

To determine if the lights attached to the camera had any contributing effect towards behavior, they were switched off (resulting in zero visibility), for up to 45 seconds, and then on again. This was repeated 7 times while the dolphins were at the codend, but had absolutely no effect on their feeding pattern, indicating that their behavior was well established. For example, at the exact moment the lights were switched on, the two dolphins were observed to be either in the process of (i) actively removing fish from the codend, (ii) forcing the codend forwards and upwards, or (iii) consuming fish that were released as a result of the previous action. Further, on two occasions when there were no dolphins at the codend, the lights were switched off for approx. 5 mins and then on again, revealing two dolphins displaying the same routine behavior as that discussed above.

Because it was necessary to turn the camera off prior to hauling the trawls, it was not possible to determine if any dolphins followed the codends to the surface. However, at the end of each tow up to 5 bottlenose dolphins were observed foraging around the vessel and at the trawl while the codends and camera were brought aboard. These individuals remained in close proximity while the catch was sorted, disappearing only when the vessel was underway and setting of the trawls began. It is possible that they followed the trawls to the seabed, although I have no evidence to support this hypothesis.

Bottlenose dolphins are endemic to many coastal areas throughout the world's tropic and temperate waters (Jefferson et al., 1993). They are regarded as catholic feeders, consuming

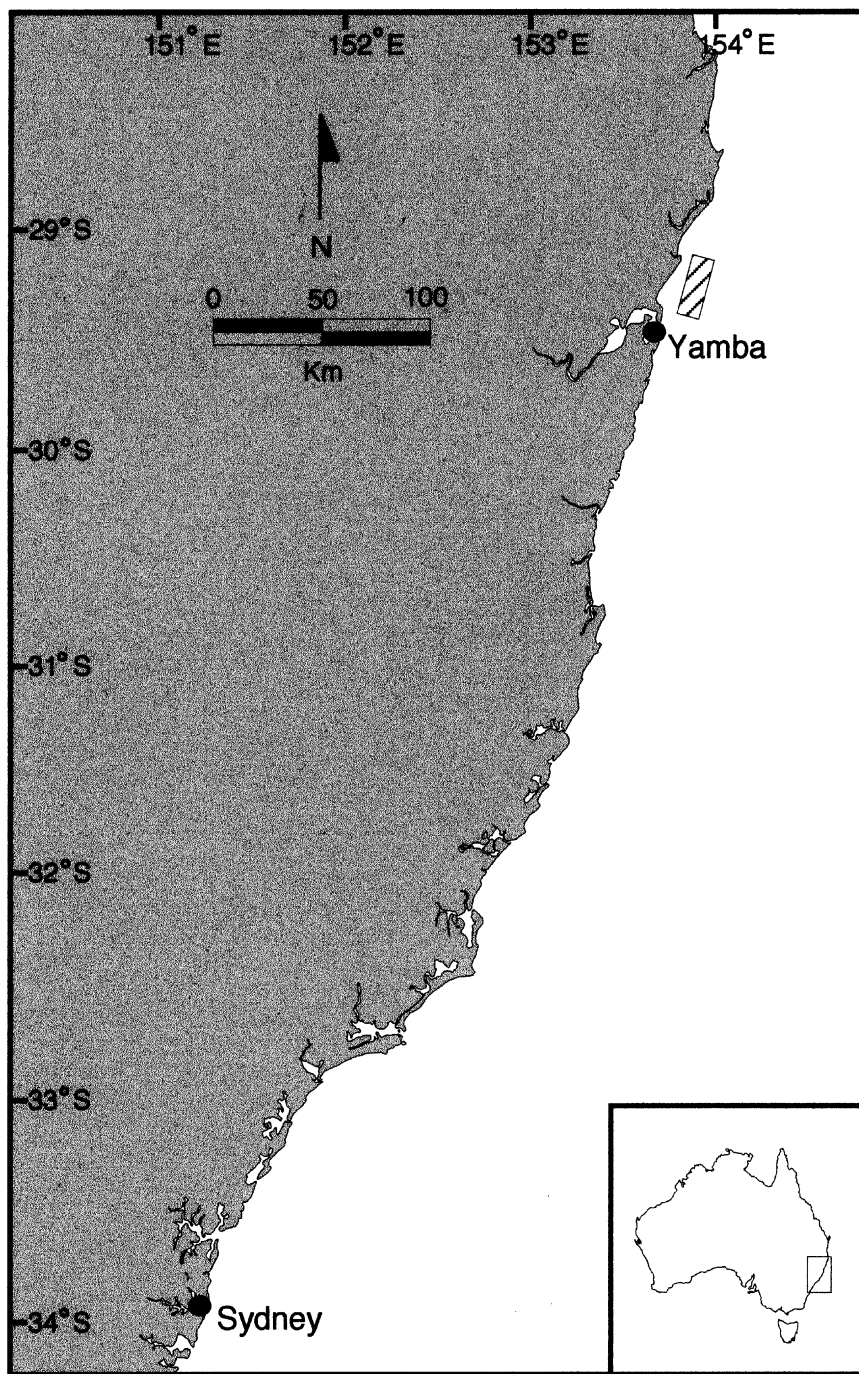


Figure 1.—New South Wales coast and location of area trawled.

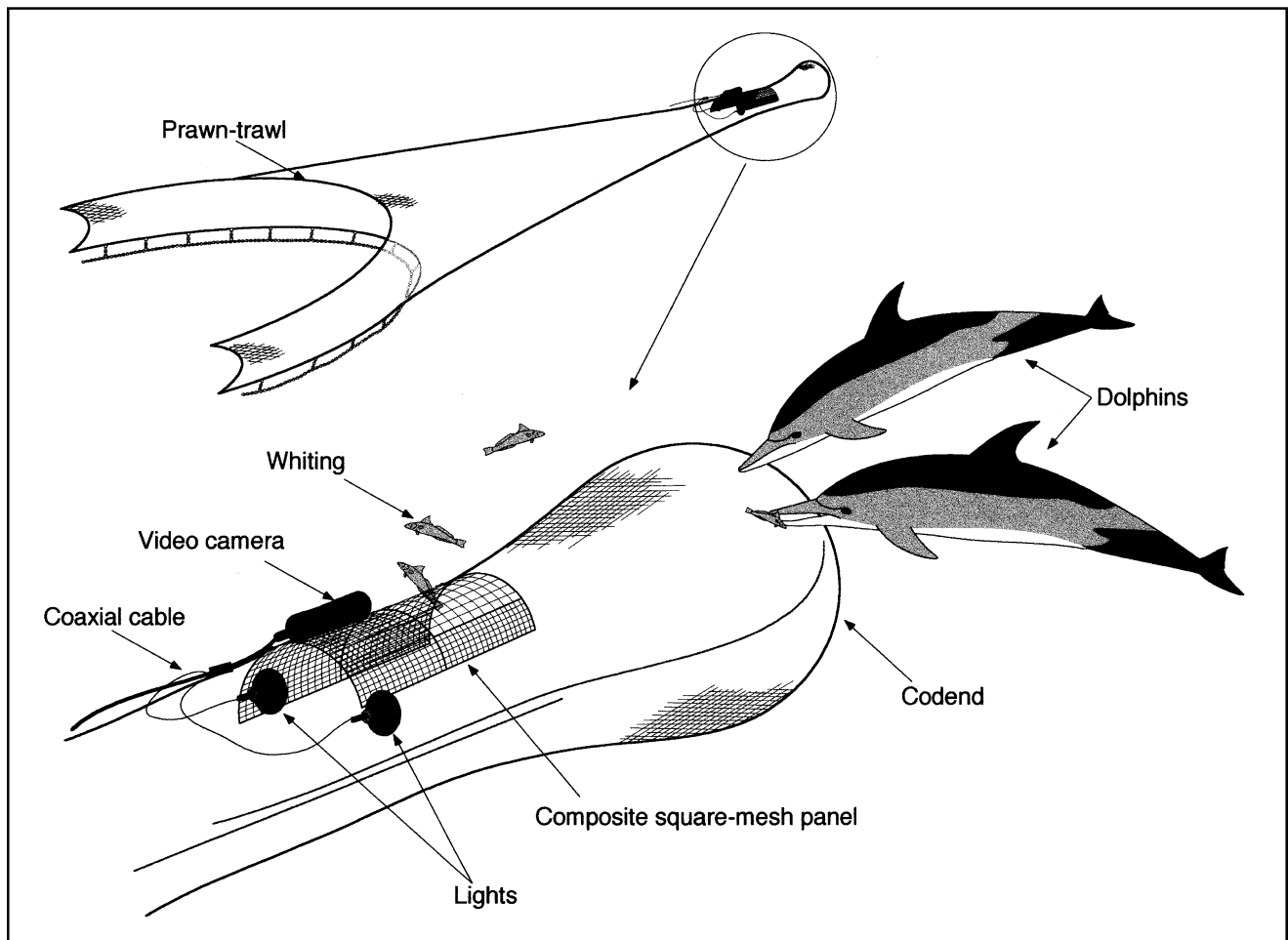


Figure 2.—Diagrammatic representation of prawn trawl, codend, location of camera and lights, and position of dolphins.

a range of fish and cephalopods (Corkeron et al., 1990; Santos, et al., 1994) and have frequently been observed to congregate and feed in close proximity to trawling operations (e.g. Leatherwood, 1975; Corkeron et al., 1990; Hill and Wassenburg, 1990; Shane, 1990). This latter observation is a common occurrence in NSW and in over 175 and 100 days spent onboard prawn and fish trawlers, respectively (operating both at night and during the day), I have regularly observed bottlenose dolphins at the surface either (1) removing catch from codends while the trawls were retrieved or alternatively, (2) scavenging the catch discarded during sorting. Although there are no published records of the types of species consumed by dolphins during these encounters in NSW, in another study Corkeron et al. (1990) examined the be-

havior of bottlenose dolphins feeding on by-catch discarded from prawn trawlers in Moreton Bay, QLD and concluded that while individual preference played a major role in determining what was eaten, several species, including whiting, *Sillago maculata*, flathead, *Platycephalus* sp., and squid, *Loligo* spp., were often consumed while crustaceans were always ignored.

In the present study, repeated manipulation of the codend and the associated routine feeding pattern was observed to occur for up to 20 minutes during each tow. It was not possible to quantify the amount of small organisms released from the codend nor the amount of fish consumed by the dolphins during this period, however, previous studies discussed by Shane (1990) suggest that an adult bottlenose dolphin may consume between 4% and 6% of

their body mass daily. A mature dolphin, 2.5 m long and weighing approximately 200 kg (Mead and Potter, 1990), therefore, could consume up to 12 kg of fish per day or the equivalent of 300 of the small whiting (40 g) or other similar-sized individuals of species that frequently appear in by-catches of trawlers working throughout the geographic range of the NSW oceanic prawn-trawl fishery (Broadhurst and Kennelly, 1997). This information, when considered along with the size of the prawn-trawl fleet in NSW (300 vessels) and their gear configuration (3 nets) illustrates the potential for dolphins to derive a substantial nutritional benefit from interactions with prawn trawls.

Despite the evidence to suggest that dolphins occur in close proximity to trawling operations off NSW and inter-



Figure 3.—Frames of (A) one dolphin (top right) approaching the posterior section of the codend (bottom), (B) dolphin (top) pushing the posterior section of the codend (bottom) forwards, and (C) two dolphins (side view - top left) feeding on small fish escaping from the codend. Because visibility was low and the frames were taken from video, picture quality is very poor.

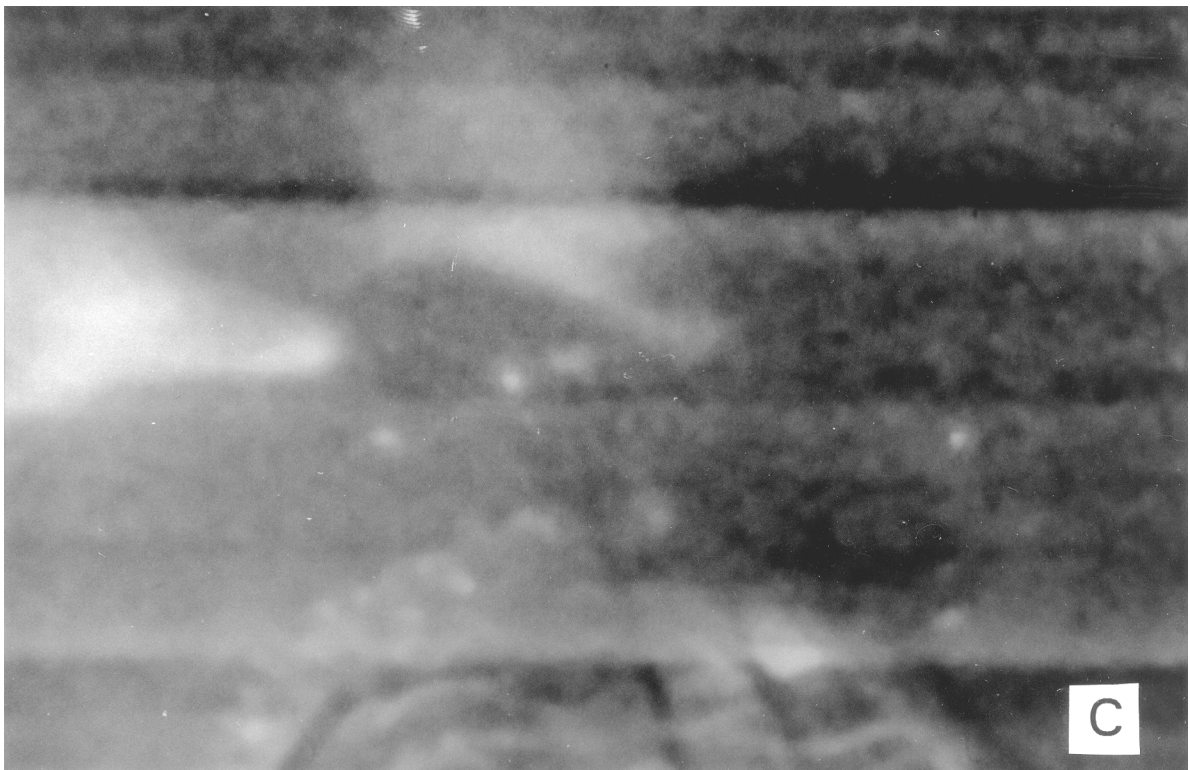
act with the trawls (either at the surface or on the seabed), there is little indication that this behavior results in any mortality due to entanglement. For example, as part of a 3-year observer-based study to examine the by-catch of prawn trawlers in NSW (Liggins et al., 1996; Liggins and Kennelly, 1996; Kennelly et al., 1998), a total of 579 fishing trips were sampled with no record of any cetacean deaths. In addition, interviews and discussions with commercial fishermen have revealed that such deaths are apparently quite rare. These observations are supported by previous studies examining the interaction between bottlenose dolphins and commercial fishing operations (e.g. Corkeron et al., 1990).

While it is evident that dolphins regularly aggregate around trawling operations in NSW, the absence of any data describing the feeding behavior and composition of diets precludes any es-

timation of the extent or scale of any interactions. Nevertheless, assuming the potential for at least some interaction, the evidence presented here may have important implications for quantifying the selectivity of prawn trawls and estimating rates of by-catches from prawn trawlers. For example, it is evident that dolphins interacting with the trawl during fishing can cause significant changes in the fractional mesh openings in the codend resulting in alterations to the overall selectivity of the trawl (especially for prawns). More importantly, however, the scavenging and associated release of by-catch from the codend (either at the surface or on the seabed) represents one component of fishing-induced (F) mortality (see Chopin et al., 1996) that can not be easily estimated, but which nevertheless may contribute quite significantly to the overall fishing mortality of particular by-caught species (e.g. whiting). The potential for

this type of bias has generally been ignored in studies that have quantified by-catches, since it is almost always assumed that the catch landed at the end of each tow represents the total catch caught and retained during fishing. Given the observations made in the present study, future research into gear performance, selectivity and quantification of by-catches may benefit from some assessment of the potential extent of such interactions.

One relatively inexpensive method of quantifying the extent of the interaction observed in the present study would be to conduct paired gear comparisons, using twin or tripled rigged trawls (Broadhurst and Kennelly, 1997) with a large-meshed, rigid cover or cage attached to one net so that it encompasses and extends beyond the posterior section of the codend to prevent dolphins from interacting with the main codend. The catch from this “modified” trawl



could then be compared to the normal commercially rigged “control” net. Assuming no differences in the fishing performances or selectivities of the two nets (due to the presence or absence of the cover), which in any case could be tested for, the differences in catch rates across replicate tows should provide an estimate of the component of by-catch released due to interactions by dolphins.

Commercial fishermen in NSW may also consider using similar sorts of modifications to the posterior sections of their codends (behind the composite square-mesh panel) on a regular basis to prevent dolphins from manipulating the codend and inadvertently releasing commercially important prawns and cephalopods. Figure 4 shows one possible modification, comprised of a panel of large, heavy mesh (e.g. 4 mm braided, mesh size 90 mm) sewn around the posterior section and extending for up to 1 m past the end of the codend, that may prevent physical contact by dolphins. Variations of this type of modification have been successfully used by fishermen for many years to prevent sharks from damaging the codend and catch during fishing, with no recorded deaths of cetaceans due to entanglement. Alternatively, it may be feasible to examine the utility of trawl-mounted, battery-operated acoustic deterrents, similar to those used to reduce the by-catch of dolphins in gillnet fisheries in the northeastern United States (Lien, 1995). Further research on a fishery-specific basis is needed, however, to assess the extent to which dolphins rely on food from trawls during fishing and, if any modifications to trawls to prevent removal of by-catch would negatively influence their abundances.

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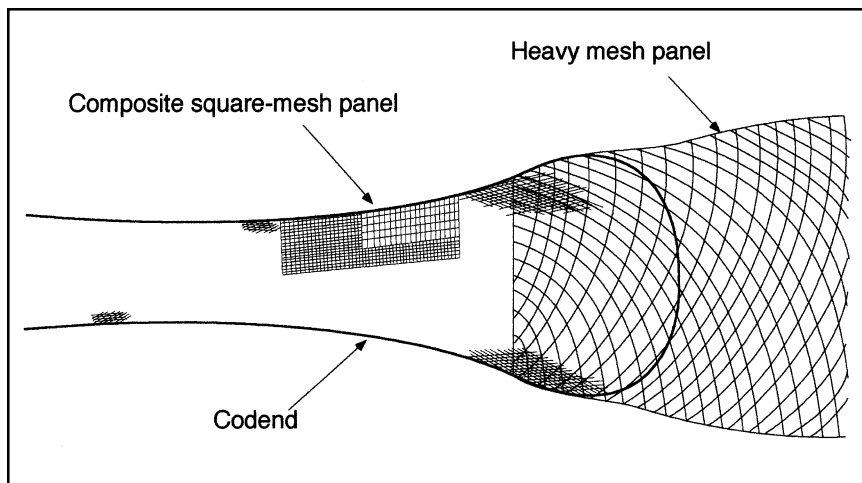


Figure 4.—Diagrammatic representation of proposed modification to posterior section of codends to prevent interaction of dolphins.

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