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Reducing humpback dolphin bycatch in the shark nets in KwaZulu-Natal, South Africa: past, present, future

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INTERNATIONAL WHALING COMMISSION

Reducing humpback dolphin bycatch in the shark nets in KwaZulu-Natal, South Africa: past, present, future.

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ABSTRACT

Indian Ocean humpback dolphins are endangered and bycatch in KwaZulu-Natal's shark nets (set to protect bathers from sharks) continues to be a concern, though mitigation actions are being taken by the KwaZulu-Natal Sharks Board. Bycatch statistics have been examined; 236 humpback dolphins have been caught since 1980, most of them at one of 38 protected beaches, Richards Bay. Overall, bycatch in KwaZulu-Natal has declined with a reduction in fishing effort in the province. However, there has not been a significant decline in bycatch rates over time at Richards Bay, though progress has been made. A net loss of humpback dolphins was evident at Richards Bay, at least partially due to mortality in the shark nets, which possibly affects the wider population. Attempts at mitigation using pingers were not successful but changing gear (setting baited hooks instead of gillnets) has had a measurable effect. Currently the issue is being viewed more holistically as a human-wildlife conflict, rather than just a bycatch issue, and stakeholders' perceptions of the bather protection system are being examined. In the future, non-lethal methods of protecting bathers are desired and requires the support of local, provincial and national government.

BACKGROUND

Indian Ocean humpback dolphins, *Sousa plumbea*, are an endangered species throughout their range (Braulik et al., 2015). In South Africa, they are considered endangered because of their limited near-shore distribution, continuing decline in habitat quality, likely fragmentation of subpopulations, and anthropogenic-related mortality (Plön et al., 2016). In KwaZulu-Natal, South Africa, a quantifiable threat is the bycatch in shark nets — gillnets set to catch and kill large sharks in order to reduce their population size so as to reduce the probability of a shark attack on bathers (Dudley, 1997). Bycatch has been a concern since the 1980s (Cockcroft, 1994, 1990) and shark nets continue to be a major threat for the persistence of humpback dolphin populations (Plön et al., 2016). These gillnets are made of black multifilament polyethylene, weaved to a stretched mesh size of 51 cm. Most nets are 213.5 m long by 6.3 m deep and are permanently anchored parallel to the coast beyond the surf, 300–500 m offshore, at 10–14 m depth. There are currently 37 beaches in KwaZulu-Natal with shark nets (Figure 1). The nets are maintained and managed by the KwaZulu-Natal Sharks Board — a "provincial public entity" within the provincial department of Economic Development, Tourism and Environmental Affairs — which also conducts research and education. The Sharks Board is contracted to most of the coastal municipalities which pay for their services, while the research, education and the administrative costs are covered by Provincial Treasury. Permits for the operation are issued by the National Department of Environmental Affairs.

Humpback dolphins and their bycatch in the shark nets has been a topic of interest at the IWC's Small Cetaceans and Human Induced Mortalities sub-committees many times. The aim of this report is to collate new information on the threat of shark nets to Indian Ocean humpback dolphins in South

Africa to highlight the progress in reducing the impact of these nets and identify ways forward to minimise the bycatch.

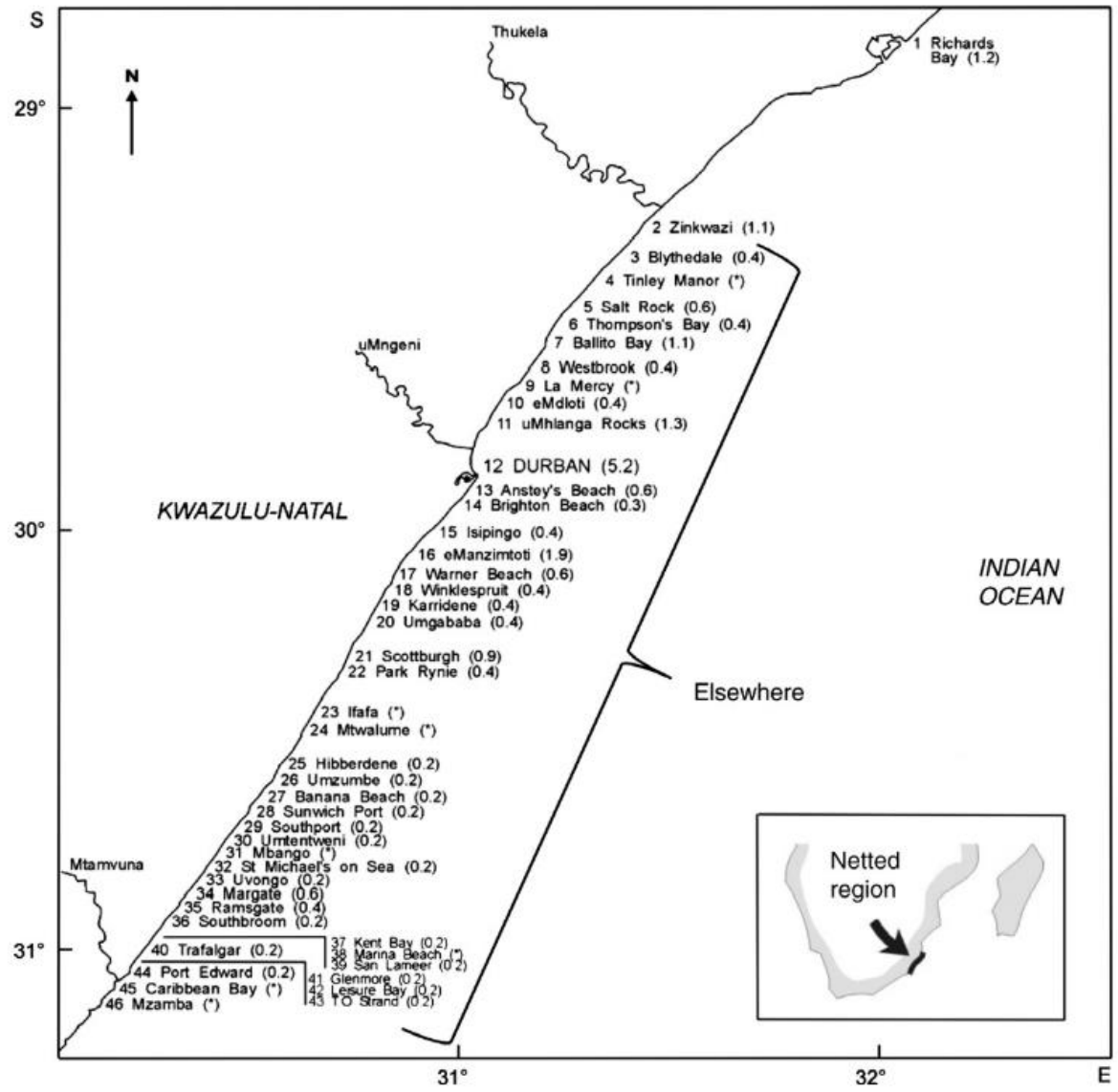

Figure 1. Beaches with shark nets on the KwaZulu-Natal coast and, in parentheses, the length (km) of nets in December 2009. Several net installations (*) were permanently removed during the study period, 1980–2009. Due to low catch rates, beaches from Blythedale to Mzamba were combined and designated "Elsewhere".

IMPROVED KNOWLEDGE

Bycatch statistics

Between 1980 and 2009, 203 humpback dolphins were caught (and died) in the shark nets in KwaZulu-Natal, an annual average of 6.77 ± 3.77 SD dolphins (Atkins et al., 2013). Most (60%) of these were caught at Richards Bay which constitutes only 5% of the fishing effort (at an annual average of 4.36 ± 2.82 SD dolphins). The catch fluctuated drastically from year to year, with no clear increasing or decreasing trends, or seasonality. The bycatch at Richards Bay was male-biased (2.1:1) and skewed towards adolescents (i.e. few adults and few calves).

In the time since this analysis, i.e. from 2010 to 2018, 34 humpback dolphins were caught in the shark nets in KwaZulu-Natal (3.78 ± 2.11 SD dolphins per year; KwaZulu-Natal Sharks Board,

unpublished data). Again, most (76%) of these were caught at Richards Bay (2.89 ± 2.20 SD dolphins per year on average). One of the animals (caught at Leisure Bay on the KwaZulu-Natal south coast) was found alive and released. Sex and body length data were available for 33 individuals. The strong male bias was not evident (0.8:1), even at Richards Bay (0.9:1). Using the same age/sex classification system detailed in Atkins et al (2018), the previous skew towards adolescent male mortalities at Richards Bay was not evident and there was a greater proportion of adult females caught there.

	KZN	R.B	ZIN	ELS
Total catch (n)	33	26	6	1
% Male calves	9	8	0	100
%Male adolescents	21	**23**	17	0
%Male adults	15	15	17	0
% Males - total	**45**	**46**	**33**	**100**
% Female calves	12	8	33	0
%Female adolescents	18	15	33	0
%Female adults	24	**31**	0	0
% Females - total	**55**	**54**	**67**	**0**

Table 1. The percentage of each age/sex class caught in the shark nets between 2010 and 2018 in KwaZulu-Natal (KZN) Province and constituent areas, Richards Bay (R.B), Zinkwazi (ZIN) and the 44 other beaches combined (Elsewhere; ELS). Noteworthy differences to the 1980-2009 data are in blue.

Impact on the Richards Bay population

Although mark-recapture data has not been examined for population trends, there is evidence that the shark nets have had a significant effect on Indian Ocean humpback dolphins at Richards Bay. Here, residency of humpback dolphins was low (they did not spend a long time) but site fidelity was high (they returned often), leading to high population turnover in the short term but low turnover over the longer term (>6 months) (Atkins et al., 2016). Between 1998 and 2006, there was a net loss of individuals from the Richards Bay population. While it is possible that some individuals may have permanently emigrated from the area, there is evidence of mortality caused by the shark nets: 9 out of the 109 photo-identified individuals were bycaught, and the resident individuals were over-represented among the bycatch. Richards Bay may represent an ecological trap for Indian Ocean humpback dolphins—while the high site fidelity indicates dolphins perceive the area as ecologically attractive, the high mortality in shark nets makes it risky. Bycatch of humpback dolphins in shark nets at Richards Bay may be negatively affecting the wider population, especially given the evidence that some individuals travel hundreds of kilometres (Vermeulen et al., 2017).

In Richards Bay, shark nets are set near the entrance of the harbour. This is a core feeding area for humpback dolphins (Keith et al., 2013), where they are highly likely to be encountered (Atkins et al., 2004). Simultaneously, this is an area of high anthropogenic activity where every commercial and recreational boat enters and exits the harbour, and where land-based pollution enters the marine environment.

Mitigation

Aiming to mitigate the bycatch, acoustic warning devices (pingers) of 10kHZ and 3kHz were tested on the nets of Richards Bay and other netted beaches (Erbe et al., 2016). The low absolute bycatch rates of humpback dolphins made it difficult to detect any effect of the pingers, suggesting that they did not reduce bycatch of humpback dolphins (KwaZulu-Natal Sharks Board, unpublished data). Bottlenose dolphins are also incidentally caught in KwaZulu-Natal's shark nets, in larger

numbers than humpback dolphins, and pingers were not effective at reducing their bycatch either (Erbe et al., 2016). Humpback dolphins in KwaZulu-Natal are unlikely candidates for successful pinger use with their coastal distributions and high site fidelity (Dawson et al. 2013). Consequently, the KwaZulu-Natal Sharks Board decided to abandon their use (Cliff and Dudley, 2011).

The spatial distribution of humpback dolphin bycatch at Richards Bay was not even (de la Mere, 1999). In 2005, the shark net with the highest bycatch rate in Richards Bay was halved from 212 m to 106 m by the Sharks Board, and substituted with three baited hooks to maintain the levels of bather safety. This change of gear significantly reduced the bycatch rate in this net, from 1.55 $\pm$ 0.35 SE humpback dolphins per year between 1991-2004 to 0.50 $\pm$ 0.25 SE between 2005-2014 (Appendix 1). Overall, the humpback dolphin bycatch rate in all the Richards Bay nets tended to reduce from 4.82 $\pm$ 0.71 SE between 1991-2004 to 2.90 $\pm$ 0.69 SE humpback dolphins/year between 2005-2014 (Appendix 1). This reduction may be due to a combination of the gear change and a slight shift in the position of the shark nets away from the breakwater.

Over the past decade, the Sharks Board has replaced many of the shark nets on the KwaZulu-Natal coast with baited hooks. These baited hooks (known locally as drumlines) work on the same principle as the shark nets—killing sharks to reduce the probability of shark attacks—but bycatch is lower (Dudley et al., 1998; Cliff and Dudley, 2011). Since the start of this province-wide replacement programme in 2007, the initial 27 km of shark netting in KwaZulu-Natal has been halved (KwaZulu-Natal Sharks Board, unpublished data). The humpback dolphin bycatch rate in KwaZulu-Natal has declined slightly since 1980 and this is likely to be due to a decline in the fishing effort in the province as the catch per unit effort was low and stable (Appendix 1). There is no evidence of a linear decline over time at Richards Bay nor Zinkwazi, the two beaches with the highest bycatch.

CURRENT ACTIONS

Following the positive effect of the spatially strategic gear change at Richards Bay, the net with the next highest bycatch was identified (net 99, Appendix 1) and in 2016, the KwaZulu-Natal Sharks Board asked the municipality for permission to replace that net with hooks. The municipality ignored the request for 2.5 years. In 2019 the municipality was notified that the changes would take place unless they objected. The municipality did not issue an objection. In April 2019, the Sharks Board removed two of the Richards Bay shark nets (including the highest bycatch net) and replaced them with six baited hooks. Given that net 99 caught 11 humpback dolphins in the past 10 years, removing it potentially reduces the annual bycatch by at least one dolphin. The Richards Bay shark net installation currently consists of 4 shark nets (total 700 m) and 9 baited hooks.

During the delay, it became clear that approaching the issue as simply a bycatch issue was inadequate and that a wider view was required. Therefore, the issue is now being viewed as a human-wildlife conflict. In 2018, a project commenced to map the human-wildlife conflict around shark nets. Currently, the leader of this project is interviewing stakeholders to investigate their perceptions and requirements about the shark nets and to better understand the decision pathway when it comes to eliciting management of the system. The current results indicate that the stakeholders consider the current, lethal method being used to protect bathers from shark attack as old-fashioned; they say that newer, non-lethal methods are worth investigating and developing. The need for improved public education has also been a recurring theme. Conflict around the financial issues (high costs and a lack of clarity between the local and provincial governments about who should bear the responsibility of payment) has surfaced.

Of great concern, the municipality of Richards Bay has recently requested a new shark net installation to protect another beach which is 25 km southwest of the current shark net installation. It is in an area which is known to be used by Indian Ocean humpback dolphins (Durham, 1994). If shark nets were to be set in this area, they are very likely to increase bycatch rates significantly. New

installations have characteristically high initial catch rates. This is true for sharks (Dudley, 1997) and for humpback dolphins; the first year that shark nets were installed at Richards Bay (1980) was year with the highest bycatch – 13 humpback dolphins died (Atkins et al., 2013).

By April 2019, the KwaZulu-Natal Sharks Board had changed as many gillnets for baited hooks as they believe they can without forgoing the high levels of bather safety. And it should be noted that the baited hooks are not popular with the general public. Therefore, there do not appear to be many more opportunities for further change in terms of net reductions or replacement with baited hooks. The KwaZulu-Natal Sharks Board has been experimenting with an electric shark repellent for many years. Other non-lethal methods and technologies exist to detect and deter sharks (McPhee et al., 2015). Managing the human-wildlife conflict will include exploring non-lethal alternatives and assessing the feasibility of each relative to the conditions at Richards Bay. The aim is then to test the most feasible alternatives.

RECOMMENDATIONS

Considering the current knowledge and state of affairs, we advance the following recommendations:

- Support (financial and logistical) should be given to extend the search for, and development of, a variety of potential, non-lethal methods of protecting bathers from shark attacks in KwaZulu-Natal.
- The deployment of lethal methods of protecting bathers at previously unprotected beaches should not be allowed. If any protection from shark attacks is required, only non-lethal methods of bather protection should be considered.
- Participation of stakeholders from all three levels of government (local, provincial and national) in the stakeholder process should be encouraged to improve understanding of the human-wildlife conflict around the shark nets.

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Appendix 1

Changing gears: an update on humpback dolphin bycatch in the shark nets in KwaZulu-Natal following a substitution of baited hooks in place of a gillnet.

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This unpublished report was written in 2015.

INTRODUCTION

Bycatch in the KwaZulu-Natal shark nets is a threat to Indian Ocean humpback dolphin populations (Cockcroft, 1994, 1990; Peddemors and Oostehuizen, 2004). Various mitigation strategies have been trialled, including attempts at warning dolphins, modifying fishing gear and decreasing effort. Warning devices that target acoustic or echolocation sensory systems were tested but were not successful, e.g. bell buoys at Richards Bay and air-filled floats at Zinkwazi (Peddemors et al., 1990; KwaZulu-Natal Sharks Board unpublished). A variety of pingers (10kHZ and 3 kHz of four different brands) were used in the Richards Bay shark nets (between 1998 and 2011). They did not reduce the bycatch of humpback dolphins and the KwaZulu-Natal Sharks Board stopped using them (Cliff and Dudley, 2011; KwaZulu-Natal Sharks Board unpublished). Modifying the fishing gear by increasing the mesh size was successful in reducing bycatch but was not a viable option in terms of effective bather protection (Cliff and Dudley, 2011). In an experimental shark net installation 5 km northeast of Richards Bay, baited hooks were tested as alternative fishing devices, and although adjacent nets caught humpback dolphins, the hooks did not (KwaZulu-Natal Sharks Board unpublished; Cliff and Dudley, 2011).

Humpback dolphin bycatch is unevenly distributed in KwaZulu-Natal and occurs predominantly at Richards Bay, one of 46 beaches with shark nets since 1980. The Richards Bay shark nets were responsible for 60% of the KwaZulu-Natal humpback dolphin bycatch despite representing only 5% of the fishing effort in KwaZulu-Natal (Atkins et al., 2013). Moreover, because the shark nets are set permanently and anchored in the same place, it is possible to test if all nets are equally likely to catch animals. We found that the spatial distribution of bycatch within the Richards Bay installation was uneven—one net, “net 5” caught disproportionately more humpback dolphins , totalling 15% of all bycatch despite representing only 0.5% of the province’s fishing effort (de la Mere, 1999). Another net, “net 99” was also identified as a high-catch net. Bycatch mitigation measures were focussed on these two nets and the effect of these measures are assessed in this report.

Temporal trends are of interest too. The annual number of bycaught humpback dolphins at all netted beaches in KwaZulu-Natal fluctuated drastically between 1980 and 2009 and there was no trend in Catch Per Unit Effort, which is the number of dolphins caught relative to the amount of netting (km per year) (Atkins et al., 2013). Similarly, at the two beaches with the highest humpback dolphin bycatch, Richards Bay and Zinkwazi, there was fluctuation in the annual number of catches and annual catch per unit effort. More recent humpback dolphin bycatch data from 2010-2014 extends the previously analysed period and the temporal trends are re-examined here.

The objective of this report is to 1) assess the effects of removing portions of the two the high-catch nets at Richards Bay, and 2) extend the temporal analysis of humpback dolphin bycatch in KwaZulu-Natal by 5 years.

METHODS

Temporal analysis

Shark nets are set at a number of beaches along most of the KZN coast (see Fig. 1 in main report) and are managed by the KwaZulu-Natal Sharks Board (KZNSB). We re-examined temporal trend of catches over time after adding humpback dolphin bycatch data from 2010-2014. To assess the catch rate over time, we regressed 1) annual catch data, and 2) catch per unit effort (CPUE; dolphin catch/km of netting) for KwaZulu-Natal (KZN) against year from 1980-2014. We then repeated the analyses for the two beaches with the highest bycatch, Richards Bay and Zinkwazi. Due to under-reporting of bycatch at Richards Bay in 2000 and 2001, these years were excluded from the analyses for Richards Bay and KZN. The Zinkwazi analyses were performed for years in which data were available, i.e. from 1984-2014. The remaining 44 beaches with shark nets from Blythedale to Mzamba catch very few humpback dolphins. Therefore, we combined the data for those 44 beaches and refer to them as ‘‘Elsewhere’’ (Fig. 1). Thus, the netted area in KZN has been divided into three areas, hereafter: Richards Bay (beach 1), Zinkwazi (beach 2) and Elsewhere (beaches 3–46).

Spatial analysis

The shark nets are made of black multifilament polyethylene, weaved to a stretched mesh size of 51cm. Most nets are 212m long by 6m deep, though other nets are 106m or 318m . They are permanently anchored parallel to the coast beyond the surf 500 m offshore, at 10–14 m depth. In 1991 at Richards Bay there were seven “double” nets (212m long) and one “triple net” (318m long). The triple net, “net 99” was set slightly apart from the others, inside the harbour entrance, 250m offshore. In April 2005, this 318m net was reduced to 212m and the 212m net, “net 5” was halved in length. Three baited hooks (suspended from anchored buoys, called drumlines) were placed next to the reduced net 5. Figure 1 shows the configuration of anti-shark gear after the change in April 2005

To assess the success of removing part of the high-catch nets at Richards Bay, we calculated the mean ($\pm$SE) annual catch at Richards Bay as a whole, and in the five double nets (212 m) and the triple net (318 m, net 99), for 2 periods: 1) April 1991-March 2005, and 2) April 2005-Dec 2014. Although shark nets were first introduced at Richards Bay in 1980, there were changes in the configuration and number of nets. Therefore, for the spatial analysis, only the period from 1991 is considered (which is also the first time that net 99 was deployed). (In 1998, two low-catch double nets were removed from the northern side of the installation; bycatch in these two nets were not included in the spatial analysis.) The annual number of humpback dolphin catches in the two periods were compared them using a two-tailed student’s t-test assuming equal variance.

RESULTS

Temporal analysis

There was a significant but weak relationship between the total catch and year for KwaZulu-Natal which indicated a very slight decline ($y = 234 - 0.11x$, Adjusted $R^2 = 0.09$, $F_{32} = 4.31$, $p = 0.046$). There was no relationship between total catch and year in the Richards Bay and Zinkwazi, nor between CPUE and year anywhere (Table 1).

Fig. 1. The configuration of shark nets at Richards Bay in April 2005, following a change to mitigate humpback dolphin bycatch. The red lines represent the shark nets, set in 2 parallel rows, and the 3 crosses mark the baited hooks (drumlines). Net numbering starts at the far left with nets 1, 3 and 5 on the inshore line and nets 2 and 4 on the offshore parallel line. Net 99 is set apart from the others, closer to shore, on the far right. The other nets are in 2 parallel rows; net 5 is smallest and set furthest right on the inshore line and net 4 is further offshore of net 5.

Table 1. Results of regression analyses of catch rate (total annual catch and Catch Per Unit Effort; CPUE) over time by area: KwaZulu-Natal as a whole, Richards Bay, and Zinkwazi. Results in bold show significant trends (i.e. *p<0.05).

Area	Adjusted R^2	F	Degrees of Freedom	Beta Coefficient	p
KwaZulu-Natal annual catch	**0.10**	**4.38**	**32**	**-0.12**	**0.045***
KwaZulu-Natal CPUE	-0.03	0.00	32	0.00	0.958
Richards Bay annual catch	0.01	1.38	32	-0.05	0.249
Richards Bay CPUE	-0.03	0.08	32	0.00	0.779
Zinkwazi annual catch	-0.03	0.01	30	0.00	0.917
Zinkwazi CPUE	-0.03	0.06	30	0.00	0.802
Elsewhere annual catch	**0.20**	**9.85**	**34**	**-0.08**	**0.004***
Elsewhere CPUE	**0.12**	**5.47**	**34**	**0.00**	**0.025***

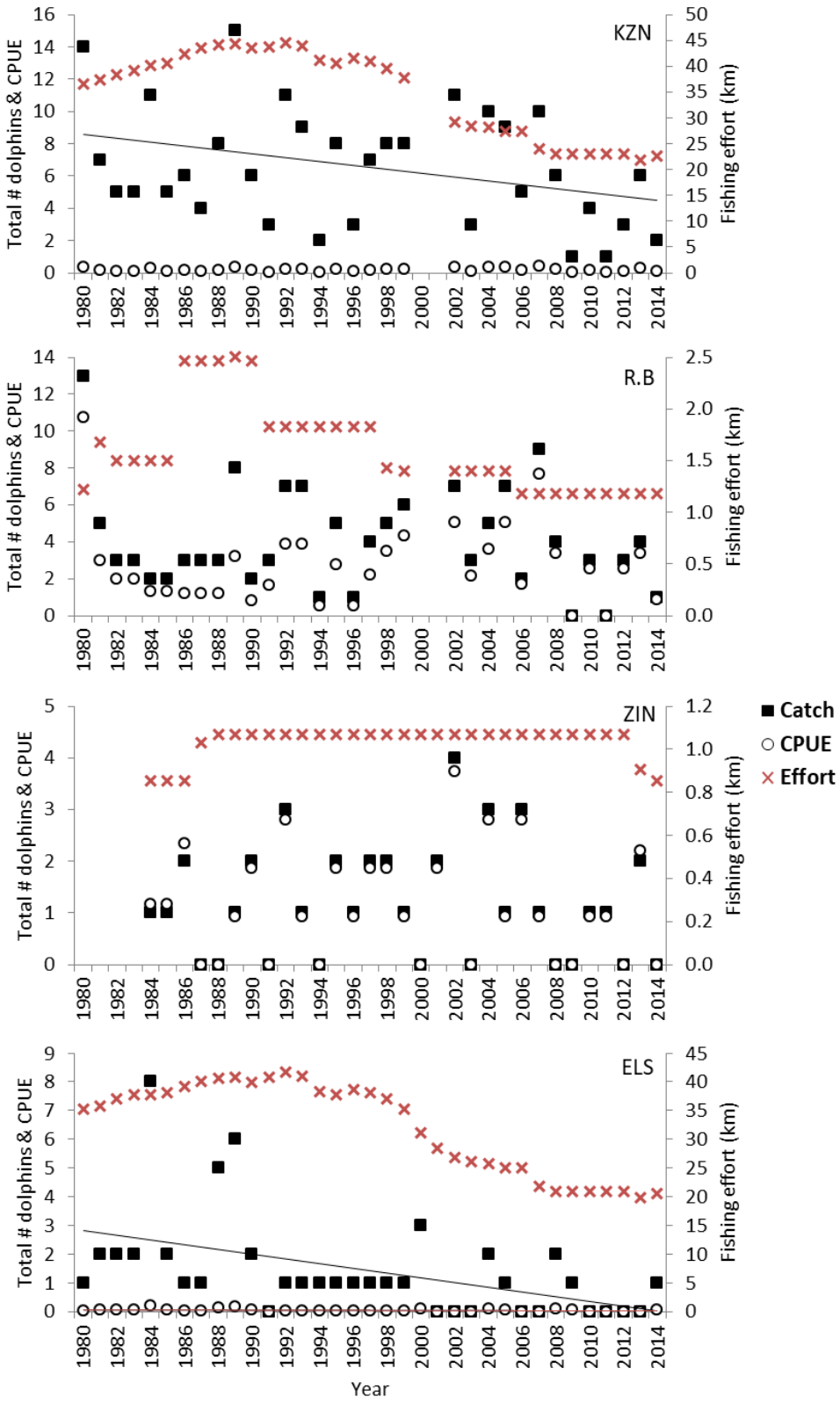

Fig. 2. Annual total catch, effort (km of net/year) and catch per unit effort (CPUE; dolphins/km of net/year) for humpback dolphins from 1980–2014 in KwaZulu-Natal (KZN) and constituent areas: Richards Bay (R.B), Zinkwazi (ZIN) and the 44 other beaches with nets, Elsewhere (ELS). Due to underreporting at Richards Bay, data from 2000 and 2001 have been omitted from the Richards Bay and KwaZulu-Natal series.

Spatial analysis

Between 1991 and 2004 net 5 caught the most humpback dolphins, followed by nets 4 and 99 (Figure 6). The catch in net 5 was significantly reduced by a third when the net size was halved, from an annual average of 1.55 ± 0.35 SE to 0.50± 0.25 SE. It was obvious that the catch in net 4 has also been lower since 2005, 0.92 ± 0.20 SE to 0.20 ± 0.13 SE. Catch in net 99, and the 3 other nets, did not change (table 2). Overall at Richards Bay the annual catch rate in these 6 nets decreased (non-significantly) from 4.82 ± 0.71 SE dolphins to 2.90± 0.69 SE.

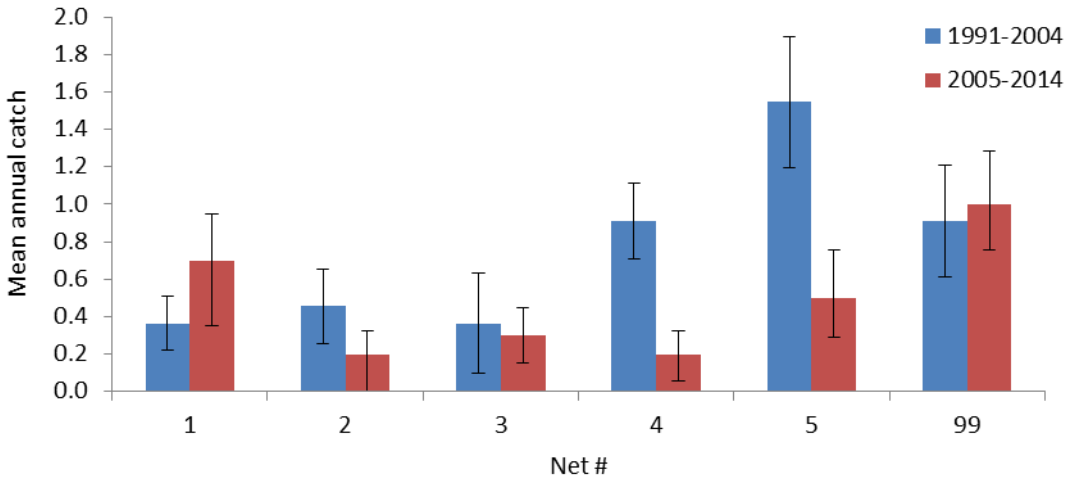

Fig. 3. Mean (+SE) annual catch rate in R.B shark nets, before and after reducing net 5 by half and net 99 by a third.

	T Stat	p
Net 1	-1.29	0.211
Net 2	0.89	0.386
Net 3	0.11	0.917
Net 4	2.93	0.008*
Net 5	2.25	0.036*
Net 99	-0.39	0.699
All 6 nets	1.66	0.112

Table 2. Statistical results of Student's t-test for each net before (n=13) and after (n=10) April 2005 when net 5 and net 99 were reduced in size.

DISCUSSION

Looking at the temporal trends across the province, the annual catch rate fluctuated at high-catch beaches, Richards Bay and Zinkwazi, but decreased slightly at the other beaches (combined). Focussing on the spatial distribution of the humpback dolphin bycatch at Richards Bay and reducing the size of the net with the highest bycatch significantly reduced the annual catch rate in that net. Overall, the humpback dolphin bycatch in all the Richards Bay nets tended to reduce following the mitigation action in 2005.

Catch in KwaZulu-Natal has decreased very slightly since 1980 but there has been no trend in the catch per unit effort in the province. At Richards Bay and Zinkwazi, catches fluctuate from year to

year. However, catches at other beaches have become much rarer, while the catch per unit effort has stablised. Between 1980 and 2014, both catch, and catch per unit effort at KZN beaches other than Richards Bay and Zinkwazi were very low, an average of 1.43±0.24 SE humpback dolphins per year at the 44 other beaches (on average, 0.04 dolphins per year per km of netting). The number of beaches that have shark nets and the number of nets per beach, have decreased over this period. For example, the average annual fishing effort In KwaZulu-Natal in the first 10 years of the study (1980-1989) was 38.2 km of netting per year. In the last 10 years (2005-2014), the annual average fishing effort was 21.6km per year. In 1998, the KwaZulu-Natal Sharks Board reduced effort by 25% province-wide and in 2007, many of the shark nets in the southern part of KZN were replaced with baited hooks (Cliff and Dudley, 2011). This has led to a predictably low catch per unit effort at most of the beaches.

Although there has not been a significant linear decrease in catch over time at Richards Bay, looking at discrete periods before and after a mitigation change suggests that there has been a recent decrease in catch. Removing the southern half of net 5 has had the desired effect of mitigating the humpback dolphin bycatch at Richards Bay by one dolphin each year. In this small population, this is a significant number. It should be noted though that the size of net 4 was not changed and it too caught fewer dolphins in the past 10 years. This might be due to a concurrent shift in the position of the southern end of the installation about 100m to the east, away from the breakwater. The dolphins are attracted to the breakwaters and spend time feeding in the area (Atkins et al., 2004; Keith et al., 2013) and moving the nets away, even a small distance, may have reduced the risk of entanglement. Unfortunately, reducing the size of net 99 did not appear to make any difference. Net 99 is currently the highest catch net in KwaZulu-Natal and should be the focus of future mitigation strategies.

CONCLUSION

A reduction of humpback dolphin bycatch in KwaZulu-Natal as a whole over the past 35 years may be due to a reduction in effort (and gear change to baited hooks). At Richards Bay, a change of gear and the repositioning of gillnets in a spatially-strategic area has been an effective way to reduce bycatch. A similar gear change (using baited hooks or non-lethal methods of repelling sharks) could be a good mitigation strategy to reduce humpback dolphin bycatch in other high-catch shark nets.

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