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REPLY COMMENT

Criticism is unfounded: reply to Middleton et al. (2007)

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MODELLING CHOICES DO NOT LEAD TO OVERESTIMATION

Middleton et al. (2007) argue that some of the modelling choices in my analysis of Hector's dolphin *Cephalorhynchus hectori* bycatch (Slooten 2007) lead to an overestimation of the impact of fishing on this species and of the potential for population recovery if fishing mortality were reduced to zero. This reply explains the rationale behind the model choices in more detail and shows that they do not influence the results in the way that Middleton et al. (2007) claim. One of the clearest demonstrations of this comes from a model (Davies et al. 2007) that became available after Slooten (2007) was published. Davies et al. (2007) is co-authored by 2 of the authors of Middleton et al. (2007) and it follows virtually all of Middleton et al.'s (2007) suggestions regarding catch rate, analysis of fishing effort and other aspects of model structure. I estimated that by the year 2050 populations would decline to 5475 ind. (coefficient of variation, CV = 0.20) if current management continues, and recover to 15 411 ind. (CV = 0.16) if fisheries mortalities are reduced to zero. The corresponding estimates from Davies et al. (2007) are 5688 and 14 799 ind. Putting Middleton et al.'s (2007) comments into perspective, we are essentially arguing over differences of a few hundred individuals over a 50 yr projection. Nevertheless, I will respond to their comments in detail below.

Middleton et al.'s (2007) criticism of the way that fishing effort was dealt with is surprising, as the New Zealand Seafood Industry Council (SeaFIC) were consulted on this issue. After seeking advice from SeaFIC and the New Zealand Ministry of Fisheries (Mfish), I deliberately modelled fishing effort in a simple, straightforward manner to match the scale and quality of the data available. Effort data for gillnet fisheries are collected only to the scale of the 16 areas used in the model. Fishers are not required to provide data on distance offshore, water depth or detailed location information. More detailed treatment of fishing effort (spatially and temporally) would have been a highly subjective exercise involving many assumptions and arbitrary decisions based on anecdotal information from fishermen, voluntary logbook programmes etc. For example, Middleton et al.'s (2007) suggestions about inferring gillnet effort from the reported catch of 2 species (rig *Mustelus lenticulatus* and school shark *Galeorhinus galeus*) depend crucially on effort for those 2 species being representative of the fishery as a whole and on catch per unit effort remaining constant over time. In addition, such treatment ignores the fact that the rig fishery started as a trawl fishery (see Francis & Smith 1988). Gillnetting increased as trawling decreased, and both of these fisheries have an impact on Hector's dolphin.

A more complex approach was taken by Davies et al. (2007), filtering fishing effort data to exclude effort targeting species usually caught in shallow water (e.g. flatfish, mullet) and relatively deep water (e.g. hapuku, bass). For example, just under half the gillnet effort in Area 12 was removed, as these species were deemed not to overlap with Hector's dolphin. This is plainly inconsistent with the fact that Hector's dolphin eat flatfish and mullet (Slooten & Dawson 1994, Anonymous 2007a) and have been caught in gillnets set for several of the excluded species. Regardless of the likely bias introduced by excluding some fish species, such arbitrary decisions go well beyond the data available, relying heavily on anecdotal information and guesswork.

Middleton et al. (2007) are incorrect in assuming that the way I have dealt with fishing effort would lead to overestimation of historical bycatch and carrying capacity (K). This would only be the case if there were substantially more overlap between gillnets and dolphins in Canterbury (where the observer programme was carried out) than in other areas. This is unlikely, for 2 reasons. Firstly, commercial gillnetting has been

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banned since 1988 in the 1170 km^2 Banks Peninsula Marine Mammal Sanctuary, which contains the majority of the dolphins found in the Canterbury area (Dawson et al. 2004). Secondly, the predominantly shallow bathymetry to the north and south of Banks Peninsula gives a far greater area of shallow water, suitable for gillnetting, than exists on the more steeply shelving South Island west coast. There, the relatively abundant dolphin population and the gillnetting effort are restricted to a much narrower zone. This would increase overlap, not decrease it.

VOLUNTARY REPORTS ARE THE TIP OF THE ICEBERG

Middleton et al. (2007) criticise the bycatch estimate used and the fact that it was treated as invariant. The catch rate in Slooten (2007) came from a 1997–1998 observer programme in Canterbury (Area 12 in Slooten 2007). The official estimate for the number of dolphins caught in commercial gillnets in Canterbury that fishing season was 18 ind. (Baird & Bradford 2000, Starr & Langley 2000, Anonymous 2007b). There are several higher estimates of catch rate based on different analyses of the same observer data, including 23 to 26 ind. (E. R. Secchi unpubl. thesis) and 29 ind. (Davies et al. 2007). I used the lowest estimate (18 ind.) as it was published and non-controversial. This estimate was treated as invariant because there were too few data to assume anything else.

Middleton et al. (2007) argue that my bycatch estimates are inconsistent with voluntarily reports of catches. The bycatch record for Canterbury clearly demonstrates the fallacy of this comparison. Voluntary reports from fishers and reports from fisheries observers in the early 1970s were the first indication of Hector's dolphin mortalities in gillnet fisheries (e.g. Cawthorn 1988, Taylor 1992). Interviews with fishers indicated that 230 dolphins were caught during 1984 to 1988 (Dawson 1991). Recent analyses based on observer data indicate that catches during 1984 to 1988 were much higher, averaging 100 ind. yr^{-1} (Davies et al. 2007). Despite the creation of a protected area, estimated catches still average 28 dolphins yr^{-1} (2000 to 2006) with an estimated 35 dolphins taken in 2006 (Davies et al. 2007). Taking into account that a large proportion of the local dolphin population is protected by the sanctuary, the catch rate from the observer programme is much higher than voluntary reports or reports by fishers in interviews. For example, during 1995 to 2005 an average of 2 dolphins yr^{-1} were voluntarily reported. Clearly, the number of voluntary reports and gillnet-caught dolphins that end up beachcast, found and reported to the Department of Conservation (DOC) are the tip of the iceberg. This mirrors national and international experience, which shows that observer programmes are required to obtain reliable data on bycatch (e.g. see Young et al. 1993). Typically, only a very small proportion of bycatch is reported voluntarily. Another clear illustration of the fact that voluntary reports underestimate bycatch is that all the gillnet bycatch reported in the 1997–1998 observer programme was from boats with observers. Based on voluntary reports, unobserved vessels apparently caught no dolphins. The probability of this being the case was about 1 in 10 000.

Middleton et al.'s (2007) criticism that the catch rate estimate from the Canterbury observer programme is used for all other areas, applies to all risk analyses for Hector's dolphin to date. For more than 2 decades, scientists and conservation groups have encouraged government to carry out a nationwide observer programme for gillnet and trawl fisheries to estimate the number of dolphins caught. In the absence of this information, researchers have had no option but to use the data available. By using the lowest available estimate of dolphin catch in commercial gillnets (18 ind. yr^{-1}), and not including any catches in recreational gillnets or trawl fisheries, Slooten (2007) substantially underestimates the impact of fishing on Hector's dolphin. In this context, Middleton et al's (2007) argument as to whether the 2 dolphins released 'alive' should have been excluded from the analysis seems somewhat moot, especially as there is no indication they survived beyond their release. Davies et al. (2007) also use all catches from the observer programme, regardless of whether they were reported as dead or alive. Their attempts at fitting a model that included only the dead dolphins failed, due to lack of convergence.

GENETIC DATA AND POPULATION SURVEYS

Middleton et al. (2007) argue that the decline of the South Island west coast population is not consistent with the fact that Pichler (2002) did not detect genetic evidence for a decline. In fact, there is no genetic evidence of a decline because sample sizes were insufficient to test for one. Pichler & Baker (2000) used the same set of genetic data to examine loss of genetic diversity, but could not do the test for the South Island west coast because there were only 4 historical samples to compare with 47 recent ones. First, they found significant loss of genetic variability in the 2 populations for which the sample size was sufficient to carry out a statistical test. Second, even if Pichler & Baker (2002) had done the test but failed to find a difference, this does not mean that no difference exists. It is not legitimate to argue from a non-significant result with-out considering statistical power. Absence of evidence is not the same as evidence of absence.

Population size estimates certainly do not provide evidence of a population increase. The first estimates for the species (3000 to 4000 ind.) were based on strip transect surveys using a 4 m inflatable boat and 2 observers (Dawson & Slooten 1988), or extrapolation from research in part of the species' range (Baker 1978). A recent series of population surveys was much better funded and used a team of 4 observers, line-transect methodology, a 15 m research vessel, high-wing aircraft and was fully corrected for visibility and availability bias. As a result, the population estimate has been updated to 7270 ind. (CV = 0.16) for the South Island and 111 ind. (CV = 0.44) for the North Island population, also known as Maui's dolphin (Dawson et al. 2004, Slooten et al. 2004, 2006). This certainly does not indicate that populations are increasing. The only area for which the latest estimate was significantly higher is the west coast of the South Island, where prevailing southwest swell, even on a calm day, restricts the view of observers in a small inflatable. This is one reason why subsequent surveys were done from an elevated platform (6 m eyeheight) on a 15 m boat, or using aircraft. It would be irresponsible to infer population trend from a comparison of these 2 surveys, given the very different methods used.

There are no direct estimates of the number of dolphins caught off the west coast. Therefore, all of the risk analyses carried out so far (including Davies et al. 2007 and Slooten 2007) use the catch rate from the Canterbury observer programme (per km of gillnet, per km^2 area, per dolphin in the population). Therefore, the proportion of the population caught and the rate of population decline remain the same, regardless of current population size. The only aspect of risk that is reduced is the risk that comes from very small population size.

WHY EFFECTS OF FISHING ARE UNDERESTIMATED

Middleton et al. (2007) focussed on reasons why the effects of fishing might have been overestimated. However, there are compelling reasons why the impact has been underestimated, including:

- Commercial gillnet bycatch is the only impact for which enough data are available to include it in risk analyses. Other human impacts such as bycatch in trawling, gillnetting in North Island harbours, recreational gillnetting, pollution and marine mining are not included.
- Population size and recovery predictions for management options that involve reducing commercial gillnet bycatch are unrealistically optimistic, because they effectively assume that all other impacts combined have zero impact on the population.
- All above analyses assume that management would result in complete removal of fishing effort from specified areas and seasons. By contrast, the existing protected areas have displaced fishing effort north, south and offshore, with bycatch decreasing in one area but increasing in others.
- Protected areas are assumed to be 100 % effective, although illegal fishing and continued bycatch have been reported in the existing protected areas.
- None of the models described above are individual-based or include an Allee effect.
- Slooten (2007) used the lowest available estimate of catch rate.

SIMILAR PREDICTIONS FROM OTHER RISK ANALYSES

One of the strongest indications that Middleton et al.'s (2007) concerns are unjustified comes from comparisons with other analyses. Martien et al. (1999), Burkhart & Slooten (2003) and Slooten (2007) all draw very similar conclusions. So do 2 very different models, including an age-structured model based on estimates of mortality rates — including natural and bycatch mortality (Slooten et al. 2000). The latter analysis does not include density dependence, maximum population growth rate or catch rate estimates. It concluded that the Banks Peninsula population is declining and likely to continue declining under current management (Slooten et al. 2000). Another, very different analysis also draws similar conclusions (Davies & Gilbert 2003, Davies et al. 2007). There are concerns about model structure and some of the inputs and results[1]. However, this complex Bayesian model produces an estimate of K (21 169) on the same order as mine (29 316, CV = 0.16). More importantly, their lower estimate of K makes very little difference to the overall results. I estimated that by 2050 populations would decline to 5475 ind. (CV = 0.20) if current management continues, and recover to 15 411 ind. (CV = 0.16) if fisheries

[1]For example, Davies et al.'s (2007) estimates of K are very sensitive to the priors. When less influential priors were used, their model produced better fits for survival rates, lower estimates of maximum population growth and higher estimates for K than those above (Davies et al. 2007). This may be driven by model structure, as a very similar model used for New Zealand sea lion (also developed jointly by the National Institute of Water & Atmospheric Research, NIWA, and the fishing industry) is similarly sensitive to priors and penalties external to the prior in its estimates of K and maximum population growth (Breen & Kim 2005).

mortalities are reduced to zero. The corresponding estimates from Davies et al. (2007) are very similar at 5688 and 14 799 ind. Likewise, Davies et al.'s (2007) estimate of current population depletion compared to 1970 population size (34%) is very similar to Slooten's (2007) estimate (27%). Both analyses clearly indicate Hector's dolphin is 'Endangered' (reduction to <50% over 3 generations, 39 yr for Hector's dolphin, IUCN 2001, 2007).

SCIENCE AND POLITICS

As highlighted in a recent article in *Nature* (Rosenberg 2007), research on unsustainable fishing practices is usually challenged by fishing industry representatives. Rosenberg's (2007, p. 989) description of a typical response 'the science was wrong, the rules wouldn't work and everyone would go out of business' accurately describes public statements by the New Zealand Seafood Industry Council, which repeat many of Middleton et al.'s (2007) claims. To enable science-based decision making in such adversarial situations, Rosenberg (2007) recommends asking questions like 'what do we know' and 'what does that mean we should do'. In this case, we know that Hector's dolphin populations have been seriously depleted since the early 1970s due to mortalities in gillnet fisheries and that trawling poses an additional risk. All risk analyses carried out for the species (by scientists from universities, government, the fishing industry and consulting companies like the National Institute of Water & Atmospheric Research, NIWA) predict continued population declines under current management; and recovery from <8000 now to around 15 000 ind. in 50 years' time if fishing impacts are removed. Looking past the minutiae at the big picture, there is a great deal of scientific agreement and very little disagreement.

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