

ROV camera.

The video footage was generally good with high resolution and clear visibility up to approximately 10m. The ROV was able to investigate areas not accessible by the towed camera system. Viewing of the footage at the time of recording and subsequent playback revealed that although Dive Site 10 appeared to be suitable habitat for Grey Nurse Shark no individuals were observed on the day surveyed.

4. DISCUSSION

4.1 Distribution of Grey Nurse Shark off WA

Examination of fishery and research records in combination with detailed interviews of commercial fishers, professional dive operators and members of dive clubs etc revealed that Grey Nurse Sharks appear to be widely distributed along the WA coast between Augusta and Exmouth (Figure 6). This distribution corresponds to the previously recognized range for this species (Last and Stevens, 1994). This species is thought to occur all the way around the Australian mainland (Last and Stevens, 1994) but is rare in the Northern Territory and through the southern extent of its range.

A project that examined movements of few Grey Nurse Sharks using Pop-up archival transmitting tags found that the juveniles move hundreds of kilometres along the WA mid-west coast between Perth and Kalbarri (McAuley, 2004), indicating that individual Grey Nurse Sharks are not restricted to particular localities or habitats. The east coast Grey Nurse Shark population is known to have a complex (i.e. sex and age segregated) seasonal migration pattern (Pollard et al. 1996; Otway and Parker, 2000), while Compagno (1984) suggests this species is migratory throughout much of its distribution. Additionally, movements of tagged Grey Nurse Shark in WA between depths of 20 and 140 m also indicated broad use of the continental shelf (McAuley, 2004). It is clear that Grey Nurse Sharks off the WA coast therefore occur across much of the continental shelf, as has previously been reported by Last and Stevens (1994) for the Australian population as a whole.

This study failed to locate any Grey Nurse Shark aggregations off the western Australian coast. The limited field program precluded any definite conclusions on the occurrence or locations of aggregations. Thus, the lack of verified Grey Nurse Shark aggregation sites in WA from this current study does not indicate that such sites do not exist. Whilst Grey Nurse Sharks in eastern Australia are known to aggregate in depths suitable for recreational diving, it is not known if such aggregations occur at greater depths (e.g. <50 m water) on either the east or west coasts. Furthermore, aggregating behaviour on the east coast does not imply it occurs on the west coast. Nonetheless, there is a possibility that west coast Grey Nurse Sharks may aggregate, but not to a degree (i.e. numbers, locations, durations) which would result in this behaviour being consistently detectable. Either of these alternatives is possible because the one-off observations employed in this study may have been unsuitable for assessing the presence or lack thereof of Grey Nurse Shark aggregations. However, considering that commercial fishing is the main potential source of incidental mortality of Grey Nurse Shark in WA, and given that the commercial fishing effort over this species' range in WA is decreasing, the status of the stocks previously reported to IUCN (i.e. strong and stable) is likely to still hold. Therefore, the failure to detect any Grey Nurse Shark aggregation sites off Western Australia is unlikely to be the result of a seriously overexploited stock. Indeed, although the east coast population of Grey Nurse Shark is listed as Critically Endangered, aggregations are still observed. If the east and west coast populations behaved similarly, then not only would recreational divers off WA have recorded at least a few consistent aggregations, but any such aggregations should still be evident.

In summary, Grey Nurse Shark off western Australia may not

- aggregate to the same degree as in eastern Australia,
- aggregate in depths or areas suitable for recreational SCUBA diving,
- aggregate with sufficient regularity in locations frequented by recreational divers.

4.2 Survey methods to identify Grey Nurse Shark aggregations

Although no Grey Nurse Shark aggregation sites were verified, the study can provide guidelines for potential future surveys.

4.2.1 Tagging

The infrequent occurrence of Grey Nurse Shark captures in commercial fishing gear and general lack of knowledge of where Grey Nurse Shark can reliably be found precludes the use of some tagging methods as a means of contributing data that may assist in the identification of aggregation sites. While the archival tags used by McAuley (2004) successfully showed migratory patterns, only a small number of sharks were tagged, making this type of tagging an expensive option for identifying aggregation sites. The approach proposed in this study, which was to visually survey suitable habitats in areas close to where Grey Nurse Shark had previously been observed, appears to be the only practical, low-cost technique.

4.2.2 ROV

ROV surveys appear suitable for surveying limited areas of potential aggregation sites. The towed camera was opportunistically trialled and while it did have some operational advantages over the ROV, the inability to check under ledges or in reef-gutters precludes this method for Grey Nurse Shark visual surveys.

The small ROV system used in this study had the advantage that it could be deployed from relatively small vessels and could be handled without the need for lifting gear (e.g. deck winch). The limitation to working in wind strengths <18 knots could be managed through careful observation of weather forecasts during the planning phase for a trip. However, the limitation imposed by current strengths >1.5 knots could not be managed because there is no system in place to predict currents. These unfavourable environmental conditions could be compensated for by factoring in or planning several more field days at each site (each potential site would require several trips, each of several days). In terms of planning a sampling strategy, the use of the small ROV therefore poses a risk because days spent at sea can result in no

deployment of the ROV but still incur substantial costs. The best way to manage this risk would be to determine which times of the year are likely to have the weakest currents in the depth ranges to be surveyed by ROV.

4.2.3 SCUBA

SCUBA has been used successfully on the east coast to survey Grey Nurse Shark aggregation sites (Otway and Parker, 2000; Otway et al., 2003). There is no doubt that this method works, helped by the relatively inactive nature of Grey Nurse Sharks at particular reefs when divers follow set protocols to minimise shark disturbance. However, SCUBA is not an appropriate method for surveying waters deeper than 30 m. This is particularly the case when volunteers are used in a survey program because the majority of recreational divers will not have the training required for deep-water diving.

4.2.4 *Sampling Protocols and Experimental Design*

Single observations at potential sites are an ineffective means of searching for Grey Nurse Shark aggregation sites. Even if one Grey Nurse Shark had been observed at some of the surveyed sites, this would not have been sufficient evidence to indicate the presence of an aggregation site. Each site selected for survey in this current study was ranked according to the number of sightings/captures and the suitability of the benthic habitat. An aggregation is considered to be five or more Grey Nurse Sharks present at the same site at the same time (Otway and Parker 2000). The identification of key aggregation sites off eastern Australia was based on knowledge gained over many years (decades) by the recreational diving community. There are undoubtedly reefs off eastern Australia at which Grey Nurse Shark occurs but that would not constitute an aggregation site. Indeed, a comprehensive visual (SCUBA) survey of ~60 sites over nearly two and half year off NSW and southern QLD found that nearly 90% of observed Grey Nurse Shark occurred at only 14 sites (Otway et al., 2003).

A more appropriate strategy to search for aggregation sites off WA would be to survey a reduced number of sites over a greater temporal and spatial scale. However, given the substantial spatial and temporal variability along the entire NSW coast and

the concomitant patchiness of key aggregation sites (Otway et al, 2003), selection of Western Australian sites to survey over longer periods remains problematic because of the lack of any means of prioritizing sites beyond that which was undertaken in this project. Even in NSW there has been no clear determination why some habitats are used for aggregation and other apparently suitable habitats are not.

4.2.5 Fixed underwater camera

An alternative visual method of undertaking longer-term sampling might be to use underwater cameras fixed in place for a set period of time (e.g. weeks). The technology is now available to place cameras *in situ* and take images at predetermined intervals. Baited underwater cameras could initially be used to detect sites that are at least visited by Grey Nurse Shark, while a time series of images (from unbaited cameras to avoid biasing retention of Grey Nurse Shark in an area) would permit quantification of the frequency at which Grey Nurse Shark visit a site.

4.2.6 Community-based survey program

A program of visual surveys by the diving community (dive shops, charter boats, dive clubs, individuals) in eastern Australia was able to undertake 10 surveys over a period of ~2.5 years, with an average of 57 sites sampled on each survey (Otway et al., 2003). This more extensive survey recorded several hundred Grey Nurse Sharks. A geographically wide sampling program would be less likely to succeed in WA for two reasons. Firstly, the sites surveyed off eastern Australia were those at which Grey Nurse Sharks were known to aggregate; the aim was to map the sites as well as determine the abundance of Grey Nurse Shark. Grey Nurse Sharks are known to aggregate in very specific locations at particular reefs, whereas in this west coast study such precise spatial information would not be available. Secondly, the much lower human population along much of the WA coast would struggle to provide a similar level of diver coverage to that undertaken off eastern Australia. However, recreational divers could carry out longer term monitoring of a few select shallow-water sites off WA. Such a program would require ongoing management (e.g. training, co-ordination, data entry etc) but would nonetheless be a relatively cost-effective method of extending the search for Grey Nurse Shark aggregation sites.

This may particularly apply to the Perth and Exmouth regions where there are many divers and many reported sightings of Grey Nurse Shark.

4.3 Management of Grey Nurse Shark in WA

The main source of mortality of Grey Nurse Sharks in WA is assumed to have been through commercial gillnet fishing. However, Grey Nurse Shark is not a targeted species. Over the eight years prior to 1997, analysis of catch rate data for WA Grey Nurse Sharks suggests a relatively large and stable population (Pollard et al., 2003). Since 1997, there have been effort reductions in the shark fisheries in response to sustainability concerns for other shark species (*Furgaleus macki*, *Carcharhinus obscurus*). These reductions should benefit western Grey Nurse Shark by reducing their incidental capture. Future management of these fisheries is likely to include an effort ceiling of between 20-50% of the fisheries peak effort levels. Reduction in effort should translate into reduced mortality. This current study identified large unfished areas within the geographic boundaries of the demersal gillnet fishery, which combined with the area closed to shark fishing between NW Cape and Steep Point since 1993 and the recent (2005) 80% reduction in fishing area in the WA North Coast Shark Fishery, potentially offers significant refugia to Grey Nurse Shark in WA.

In response to the increased demand for shark fin and the resultant increased targeting of large shark species, WA now has regulations to prohibit landing of fins without trunks. DNA techniques are also now available as a means of identifying Grey Nurse Shark body parts (McAuley et al., 2005). These measures should help quantify the levels of unrecorded fishing mortality of Grey Nurse Shark.

The level of Grey Nurse Shark mortality from recreational fishing has not been quantified, but this sector is not known to specifically target sharks, preferring scalefish. Anecdotal evidence indicates however that Grey Nurse Sharks are caught and occasionally landed by recreational fishers. Incorrect species identification and the lack of knowledge on the protected status of Grey Nurse Sharks are thought to account for this source of mortality. Although shown in relevant recreational fishing brochures, identification guides and government websites as a protected species, an

increased educational program to ensure correct identification of Grey Nurse Sharks and promote in the release should reduce recreational fishing related mortality of this species.

4.4 Conclusion

In consideration of the stability of the population reported prior to 1997 and the subsequent decreases in effort in the shark fisheries since 1997, the current status of the western population of Grey Nurse Shark is likely to be similar to or better than that of 1997.

Despite this study being unable to confirm the presence of any Grey Nurse Shark aggregations off WA, available information suggests that Grey Nurse Sharks are still widely distributed along the WA coast and are still regularly encountered, albeit with little or indeterminate frequency. There is a possibility that Grey Nurse Sharks do not aggregate to the same degree or in the same areas/habitat types as off the east coast. If the west coast population aggregates in deeper waters or in habitat not suitable for setting gillnets, their vulnerability to commercial fishing is unlikely to change, hence the population should remain stable or be able to increase from its level prior to effort reductions in the temperate gillnet fishery. Given the ongoing increased level of management for all WA commercial fisheries, which in most cases equates to reductions in fishing effort (both for line and net fisheries), it is likely that fishing related mortality of Grey Nurse Sharks will decline further. As such, knowledge of whether Grey Nurse Shark aggregation sites exist off WA does not currently appear to provide any potential additional benefits to how this species is currently managed in WA. Thus, there may be little value in continuing to search for aggregation sites given the status of the stock, particularly when more pressing issues relevant to the sustainability of other elasmobranchs have been identified. The commercially exploited elasmobranchs of current concern in WA waters are dusky, sandbar and whiskery sharks (Gaughan and Chidlow, 2005). It was concern for the status of these key commercial species that has driven the ongoing effort reductions in the shark fishery. Other non-targeted elasmobranchs that require more data to clarify their status include sawfish (Family Pristidae) and *Glyphis* sp. A and *Glyphis* sp. C. Outside of Western Australia, the Critically Endangered status for the east coast Grey

Nurse Shark indicates that this population be given a significantly higher research priority than western Grey Nurse Shark.

Although the western Grey Nurse Shark population appears to be reasonable stable, the inherent vulnerability of this strongly k-selected species (late maturity, low fecundity and slow growth) warrants that the population status be regularly reviewed. The approach taken here has proven to be risky in terms of obtaining clear results; the project was thus unable to determine whether western Grey Nurse Sharks aggregate or not. As such, considerably more investment in visual surveys would likely be required before this technique could be expected to result in data of sufficient robustness to be confidently used to assess the status of the population.

The most cost-effective long-term method of undertaking regular population assessments would appear to be through careful review of the catch rate data from the commercial fisheries. Because fishers no longer report Grey Nurse Shark catches, this approach is not currently possible. Investment in an education program on the reporting requirements may help to overcome this deficiency in reporting.

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