



Human Interactions with Sharks, Rays & Skates

An Annotated Bibliography

Chantal D. Pagel
Michael Lück



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TABLE OF CONTENTS

1. Introduction	4
2. Reference Bibliography	5
3. Annotated Bibliography	23
4. About the Editors	133



Shark cage diving

1. INTRODUCTION

This is the third of a series of annotated bibliographies, published by Dotterel Publishing. The aim of this series is to provide a comprehensive overview of the literature pertaining to specific touristic and leisure activities, in particular (but not limited to) wildlife viewing activities. These annotated bibliographies will aid researchers and other interested persons and organisations locate relevant literature.

Interactions with elasmobranchs (sharks, rays and skates) have increased significantly over the past two decades, and so has the academic attention to these. As with many human interactions with wildlife there is a growing concern about the consequences of these activities, which is reflected by a large number of the works in this bibliography.

The main part of this document is divided into two sections: The first section is a *reference bibliography*, listing works in alphabetical order. The second section is an *annotated bibliography*, adding abstracts/summaries to most of the works listed in the first section, again in alphabetical order.

We have included references from a variety of sources, mostly from academic journals, books, theses and dissertations, conference proceedings and technical reports. While the majority of sources relate directly to elasmobranchs and tourism, we have also included some works on general tourism and recreational activities and the effects these may have on sharks, rays and skates. A selection of references about shark conservation and “management”, as well as medical studies were also included, because these are indirectly linked to recreational interactions with elasmobranchs. We acknowledge that there are also numerous non-academic books and websites on elasmobranchs and tourism activities; however, these would be virtually impossible to include in a systematic manner due to the sheer volume of these.

While this is an extensive bibliography, we do not claim it to be complete. In fact, we aim to regularly update this bibliography, and gratefully accept any suggestions for inclusion. Please email suggestions with publication details to dotterelpublishing@gmail.com

We would like to thank Uli Kunz for the permission to use some of his wonderful photographs!



Scuba diving with Mobulids

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Scuba diving with a whale shark (*Rhincodon typus*)

3. ANNOTATED BIBLIOGRAPHY

A

Authors: Abrantes, K. G., Brunnschweiler, J. M., and Barnett, A.

Year: 2018

Title: You are what you eat: Examining the effects of provisioning tourism on shark diets

Journal: Biological Conservation

Volume: 224

Issue: -

Pages: 300-308

Abstract: Wildlife tourism is a growing industry, with significant conservation and socio-economic benefits. Concerns have however been raised about the possible impacts of this industry on the long-term behaviour, health and fitness of the animal species tourists come to see (the target species), particularly when those species are regularly fed to improve the tourism experience. Information on the contribution of food rewards to the diet of the target species at feeding sites is critical to assess the dependency on handouts and to identify possible health/fitness problems that might be associated, if handouts become the main part of animals' diets. Here, Abrantes and colleagues use stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) to evaluate the importance of handouts for a marine predator, the bull shark (*Carcharhinus leucas*), at a feeding site (Fiji) where shark feeds occur five days/week and sharks (up to 75 individuals/dive) are fed ~200 kg of tuna heads/day. There was no evidence of incorporation of food provided, even for individuals that regularly consume food rewards. Results, when combined with those from previous studies on bull shark movements and feeding rates at our study site, show that current levels of provisioning likely have no long-term impacts on bull shark diet or behaviour. This study also demonstrates the applicability of stable isotope analysis to assess and monitor the contribution of food rewards to wildlife, and highlights the benefits of using multi-sources of information to gain a holistic understanding of the effects of provisioning predators.

Authors: Acuña-Marrero, D., de la Cruz-Modino, R., Smith, A. N. H., Salinas-de-Léon, P., Pawley, M. D. M., and Anderson, M. J.

Year: 2018

Title: Understanding human attitudes towards sharks to promote sustainable coexistence

Journal: Marine Policy

Volume: 91

Issue: -

Pages: 122-128

Abstract: Better understanding of human attitudes towards sharks is essential to foster support for shark conservation. Here, a quantitative multivariate approach was used to analyse data from questionnaire-based surveys of public attitudes towards sharks in the Galapagos Marine Reserve to identify some of the most influential socio-economic factors, emotions and beliefs that shape those attitudes. The aesthetic value of sharks, their environmental role, and their perceived dangerousness had the greatest influence on attitudes. However, attitudes also varied according to the gender, occupation, and residency status of respondents. Knowledge and experience with sharks had a moderate influence on attitudes, while behavioural responses, such as tolerance and support for the protection of sharks, showed strong correlations with attitudes. Therefore, it is recommended that efforts to promote positive attitudes and behaviours towards sharks should use strategies that encourage support for shark conservation policies by targeting the most influential emotions and beliefs held by the public.

Authors: Afonso, A. S., Niella, Y. V., and Hazin, F. H.

Year: 2017

Title: Inferring trends and linkages between shark abundance and shark bites on humans for shark-hazard mitigation

Journal: Marine and Freshwater Research

Volume: 68

Issue: 7

Pages: 1354-1365

Abstract: Afonso et al.'s study aims at inferring linkages between the abundance of potentially dangerous sharks (PDSs) and shark hazard, so as to derive information about the underlying processes of shark peril off Recife, Brazil. Fishery-independent longline and drumline data collected from May 2004 through December 2014 for *Carcharhinus leucas* and *Galeocerdo cuvier* measuring ≥ 109 cm were considered for analysis. Generalised additive models showed that the frequency of shark bites was directly proportional to and followed the same seasonal trends as PDS abundance, meeting the hypothesis that higher shark abundance may result in an increased chance of a shark bite. However, the species-specific seasonality of bull and tiger sharks seemed to follow distinct patterns. This method was helpful in comparing the abundance dynamics of the PDSs caught by the local shark hazard-mitigation program with the distribution of shark bites, so as to infer whether the species involved in the incidents were being effectively captured. Also, it provided some information about each species' contribution to the overall dynamics in local shark hazard. However, despite being a potentially useful risk-management tool, its predictive efficacy for shark-peril mitigation may depend on the availability of abundant data spanning across wide temporal ranges.

Author: Alajandro Sibaja-Cordero, J.

Year: 2008

Title: Spatial-temporal tendencies of marine faunal observations in touristic dives (Isla del Coco, Costa Rica)

Journal: Revista de Biología Tropical

Volume: 56

Issue: 2

Pages: 113-132

Abstract: Data on several marine species collected over 15 years (1991 to 2007), by dive-masters of the diving company Undersea Hunter, at 27 sites around Isla del Coco (Cocos Island), Pacific Costa Rica, were analysed. The goal was to create a base line of the pelagic species that live in the waters of the Island based on reports of their activity during tourist dives. A data matrix was generated and multivariate methods used to determine the patterns of temporal and spatial variation. Variability in the occurrence of several species was high between sites. All sites presented a change in the assemblages during the 1991-92 and 1997-98 El Nino events. However, some sites had more influence by this climatic oscillation. El Nino event had stronger repercussion on the abundance and occurrence of particular species. Elasmobranchs such as the scalloped hammerhead sharks (*Sphyrna lewini*) and the marbled ray (*Taeniura meyeni*) showed a negative association with anomalous sea surface temperatures. Starting in 2000 there is a decrease in the average abundances and in the presence of the pelagic species, especially for economically important sharks. These variables reach similar values compared to those of El Nino years. A possible explanation is the increase of illegal fishing that took place around the Island or immediate waters. Some of these are species with great mobility. Nevertheless, some species had a small recovery in recent years. A collaborative programme between the Government of Costa Rica and MarViva (a non-governmental organisation) in recent years has resulted in an improvement in the conservation of the marine fauna of Isla del Coco.

Author: Altobelli, R. D.

Year: 2011

Title: The experience of shark diving in Pacific Harbour, Fiji: Who goes and how important is education and interpretation?

Academic Department: School of Hospitality and Tourism

University: Auckland University of Technology

Thesis Type: Doctoral

Abstract: The idea of interacting with predatory sharks in their natural environment may have caused a great deal of apprehension twenty years ago. Recent changes in perceptions towards predatory sharks, especially among the scuba diving community, along with increasing worldwide accessibility enabling interaction with these animals, have led to a growing popularity in the activity of shark diving.

There are many destinations around the globe, ranging from the United States (US), South Africa and Australia to, more recently, Fiji, where paying clients can participate in tours that take them beneath the surface of the sea to view a variety of shark species. The emergence of shark diving has also attracted the attention of academic researchers in tourism. Studies have begun addressing some issues surrounding this activity but few have focused on the concepts of education and interpretation or on gaining greater knowledge about the participants on shark diving tours.

This study set out to achieve two main aims. The first aim was to gain insights into individuals participating in the activity of shark diving in Beqa Lagoon, Fiji and on a live-aboard ship operating out of Lautoka, Fiji. An overview of the study's respondents is developed by exploring a variety of demographic and psychographic characteristics. The second aim was to examine the role of education and interpretation within the context of shark diving by measuring various aspects such as respondents' overall satisfaction with on-tour interpretation, the importance of learning, and visitors' recommendations for improving the educational efforts of the operators. Particular attention is paid in this thesis to the Theory of Mindfulness and Orams' Interpretation Model, and their relevance within the context of shark diving.

The main data-collection tools used in this study were a review of relevant literature, and on-tour (paper and pen) and follow-up (on-line) questionnaires. Interviews with shark dive operators, and conversations with and observations of divers and operators were also used, but to a lesser extent. The on-tour questionnaires were administered during the period from 29 February 2008 to 11 October 2008. Follow-up on-line questionnaires were administered three months after respondents completed their on-tour questionnaire. The follow-up phase ran from 1 July 2008 to 27 February 2009.

The majority of respondents in this study were young, well-educated professionals and above-average earners; they came from a variety of countries around the world. The respondents valued learning highly and felt strongly about having on-tour educational information provided to them, which was available on-site but not always being effectively communicated by the operators. Being exposed to sharks in their natural environment had a profound impact on these divers, especially on their learning. The survey results, however, indicated that developing a formally structured educational programme, although important, is not absolutely critical to this type of wildlife tourism. Even so, the respondents indicated that they would like more educational information from the operators. By ensuring a shark diving environment which is educational and conducive to learning, operators increase the likelihood of divers having the best possible shark diving experience, which potentially translates into benefits for operators, divers and sharks.

This thesis contributes to the small but growing body of literature on shark tourism as well as to the larger body of literature on wildlife tourism. The first main contribution of this thesis is combining Orams' Interpretation Model with the Theory of Mindfulness within the context of

shark diving, and the newly adapted Interpretation Model for Shark Diving demonstrates how these two constructs fit together. The second main contribution is the methodological technique of surveying the same respondents twice: first on tour, immediately following their shark diving trip, and then three months post tour. The third main contribution of this thesis is the development of the Shark Diving Experience Model which illustrates the impact of being exposed to sharks in their natural environment.

Authors: Amin, R., Ritter, E., and Kennedy, P.

Year: 2012

Title: A geospatial analysis of shark attack rates for the east coast of Florida: 1994–2009

Journal: Marine and Freshwater Behaviour and Physiology

Volume: 45

Issue: 3

Pages: 185-198

Abstract: Shark attacks have historically been studied from a viewpoint of encounter number per region and so limited to the areas in which the attacks occurred. In this exploratory modelling study, the goal was to examine whether an area-specific cluster analysis algorithm undertaken with a modern cluster analysis tool (SaTScan™ 9.1.0) could enhance our spatial and spatio-temporal understanding of attack patterns. The data used were from Florida's east coast between 1994 and 2009. The programme suggests several high- and low-risk areas for shark attacks. The results are discussed from a quantitative rather than qualitative perspective.

Authors: Anderson, D. J., Kobryn, H. T., Norman, B. M., Bejder, L., Tyne, J. A., and Loneragan, N. R.

Year: 2014

Title: Spatial and temporal patterns of nature-based tourism interactions with whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia

Journal: Estuarine, Coastal and Shelf Science

Volume: 148

Issue: -

Pages: 109-119

Abstract: As with other nature-based tourism ventures, whale shark tourism is expanding rapidly worldwide, which highlights the need to understand more about the nature of these activities. Records of interactions between tour operators and whale sharks at Ningaloo Reef, Western Australia (22.5°S, 113.5°E) were obtained from the Western Australian Department of Parks and Wildlife from 2006 to 2010 and evaluated to determine the scale of the tourism operations and the spatial and temporal distribution of interactions. The number of whale shark tours at Ningaloo increased by approx. 70% (520–886 tours per year) and the number of interactions with whale sharks by 370% between 2006 (694) and 2010 (3254). The locations of whale shark interactions recorded in logbooks (2006–2009) and electronic monitoring systems (2009 and 2010) were used to plot the smoothed densities of tour operator interactions with whale sharks. Generalised linear models were used to investigate how the presence/absence and number of whale shark interactions at North and South Ningaloo were influenced by the distance to the reef crest, the distance to passages and their interaction terms for the aggregated five-year data set. Over the five years, distance to the reef crest was the best predictor of the presence/absence of whale shark interactions at both North (interactions concentrated within 3 km of the reef crest) and South Ningaloo (interactions within 6 km of the reef crest) followed by distance to passages. The reef passages are very significant areas for tourism interactions with whale sharks at Ningaloo. The distribution of interactions at North and South Ningaloo varied from year to year, particularly in the strong La Niña year of 2010, when average sea

surface temperatures remained above 24 °C and whale sharks were observed much later in the year than previously (late August). This study demonstrates the value of the data collected by the tour operators at Ningaloo Reef and managed by a government agency for the conservation of whale sharks and sustainable whale shark tourism.

Authors: Anderson, J., Johnson, R., Bester, M., Swanson, S., and Gennari, E.

Year of Conference: 2012

Title: Impact of small scale chumming activities on the movement patterns of white sharks (*Carcharodon carcharias*) in Mossel Bay, South Africa

Conference Name: World Congress of Herpetology

Conference Location: Vancouver, Canada

Page: 16

Abstract: Shark cage diving has become both a popular and controversial activity at numerous locations around the world. Such activities are widely argued to have economic and educational values with minimal impacts upon a natural resource. Critics of the cage diving industry claim increased risks for public safety, as well as environmental and ecological impacts. In South Africa, the cage diving industry is largely focused on the white shark (*Carcharodon carcharias*) at three main centres; Mossel Bay, Gansbaai and False Bay. It is documented that at least 15% of the white shark population in these areas move between these sites, whilst Mossel Bay supports a semi-resident population of female white sharks, that may stay in the area for upwards of six months. Movements of white sharks (n=15) in Mossel Bay were analysed in relation to the activity of the sole cage diving operator between 2005 and 2009. Sharks were tracked over several days both with and without concurrent cage boat activity. Putative behavioural change was observed in individual sharks both in relation to the activity of the cage boat and as a function of experience. The study demonstrates natural behavioural patterns of sharks may be altered by methods employed by cage dive vessels (chumming), but such behavioural changes may be short term and reversible. No reliable evidence was gained to either support or refute that such behavioural change conveys increased risks for public safety, or may have long term ecological impacts.

Author: Anderson, R. C.

Year: 2002

Title Elasmobranchs as a recreational resource

Editors: S. Fowler, T. Reid and F. A. Dipper

Book Title: Elasmobranch biodiversity, conservation and management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997

City: Gland, Switzerland

Publisher: The World Conservation Union (IUCN).

Pages: 46-51

Abstract: Changing patterns of recreation over the last decade have brought changes in attitudes towards elasmobranchs. In particular there is a growing realisation that there are powerful incentives for sustainable (and often non-extractive) recreational utilisation of many elasmobranch resources. There are three large groups of recreational users: 1. Recreational divers. The growth of recreational diving in recent years has been little short of explosive. Divers like to see sharks and rays in their natural habitats and are willing to pay large sums of money to do so. Revenue from shark and ray diving internationally runs into hundreds of millions of dollars annually, as a result of which divers have become a powerful force for shark and ray conservation. 2. Recreational fishers. Fishing is one of the most popular leisure activities worldwide. There is a growing trend among elasmobranch fishers to release catches

alive, often after tagging. As a result, mortality in some stocks has been reduced while at the same time information of value to resource managers has increased. 3. Aquarists. Recent improvements in aquarium technology have led to a boom in the display of live elasmobranchs both in big new public aquariums and in domestic tanks. As a result there has been a great increase in awareness of the importance and vulnerability of elasmobranch resources.

Authors: Anderson, R. C., Adam, M. S., Kitchen-Wheeler, A-M., and Stevens, G.

Year: 2010

Title: Extent and economic value of manta ray watching in Maldives

Journal: Tourism in Marine Environments

Volume: 7

Issue: 1

Pages: 15-27

Abstract: Manta rays, *Manta alfredi*, are a major attraction for tourist divers and snorkelers in the Republic of Maldives (central Indian Ocean). The aims of this study were to assess the extent and economic value of manta ray watching in the Maldives, by surveys of tourist numbers at manta diving sites, and from interviews with experienced divers. Ninety-one manta dive sites were identified, where tourists made an estimated 143,000 dives and over 14,000 snorkels annually during 2006–2008. This was estimated to be worth about US\$8.1 million per year in direct revenue. The growth of manta ray watching has provided support for both research and conservation in the Maldives. However, there are indications that at the most popular manta dive sites the large numbers of visiting divers and snorkelers may be having a negative impact on manta numbers. There is a need for improved tourist education, and perhaps for regulation of diver numbers at some sites.

Authors: Anna, Z., and Saputra, D. S.

Year: 2017

Title: Economic valuation of whale shark tourism in Cenderawasih Bay National Park, Papua, Indonesia

Journal: Biodiversitas Journal of Biological Diversity

Volume: 18

Issue: 3

Pages: 1026-1034

Abstract: The whale sharks' aggregation in the waters of Cenderawasih Bay has an impact on improving the marine tourism industry in the region. On the other hands, Whale Shark is one of the species listed in the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN), the vulnerable status, means that a whale shark populations have been reduced by 20% to 50% within 10 years or three generations. The decline numbers of whale sharks caused by human activities that damage the fish and the habitat, such as fishing and tourism activities. This is due to the lack of public awareness about the function and value of these resources and its habitat. The whale shark has inherent value as marine resources, and has an environmental services value, in relation to tourism activities. This paper measures the economic value and environmental services of the whale shark and its habitat. The method of Travel Cost is used to calculate the value of expenditures incurred by both foreign and local tourists. The study also measured the value obtained by tourist operators, the value of fishing activities, and the value of the habitat, through the people's Willingness to Pay (WTP), using Contingent Valuation Method (CVM). From the result of the overall economic valuation can be determined the estimated value of whale shark tourism, as well as Cenderawasih Bay National Park area, amounted to IDR 35.5 trillion. The policy implication of this research is the need for appreciation of the whale sharks' value, as well as its habitat, by managing and

developing conservation areas, and community capacity building on the understanding of the importance of whale sharks and its conservation.

Author: Antoniou, A.

Year of Conference: 2000

Title: Aggregations of whale sharks (*Rhincodon typus*) occur each year off South Africa (Indian Ocean) and in the waters surrounding Utila, Bay Islands Honduras (Caribbean Sea) where they form the basis of an ecotourism industry

Conference Name: American Elasmobranch Society 16th Annual Meeting

Conference Location: La Paz, Mexico

Page: -

Abstract: In 1998 and 1999 the Shark Research Institute deployed satellite tags on five whale sharks in an effort to gather information on their long term and short term movements. Problems were encountered with the attachment of the tags to the sharks. Satellite tags were attached to the sharks by divers and various tag-anchors were utilised with varying degrees of success. Tethered tags were attached by divers and a variety of tag-anchors were utilised. Data received so far are encouraging, which will enable the author to draw a picture of the day to day life of a whale shark.

Author: Apps, K.

Year: 2018

Title: More than an adrenaline rush: A study of white shark cage-dive participants in Australia and the potential to encourage a conservation ethic

Academic Department: School of Environment, Science and Engineering

University: Southern Cross University

Thesis type: Bachelor of Science and Management (Honours I)

Abstract: Wildlife tourism is often promoted by government and industry as an activity which supports conservation by enhancing participant environmental knowledge, attitudes and behaviour. Despite speculation as to the conservation potential of wildlife tourism, empirical evidence to support such claims is limited. Globally, many shark species are facing significant population declines, yet conservation programs are often hampered by negative public perceptions. Sharks are one group of marine species which could benefit from the conservation potential of tourism. However, despite the rising popularity of shark-based tourism over the past two decades, little academic attention has focused on the human dimension of the experience. To address this gap in knowledge the aim of this thesis is to explore the human dimension of shark tourism, and to investigate the conservation potential of the activity.

A case study approach was adopted using white shark cage-dive tourism at the Neptune Islands, South Australia. As the only white shark cage-dive site in Australia and one of only five sites worldwide, this study is the first to investigate the participant experience at the Neptune Islands. Mixed-method research was used to collect qualitative and quantitative responses from participants on-board the three cage-dive operations between March 2014 and July 2016. Data was collected during four phases: 1) an application of the theory of planned behaviour to determine participants beliefs related to the cage-dive experience (n=86), 2) an exploration of the role of on-tour education and interpretation (n=607), 3) an investigation of the social value of the tourism site (n=675), and 4) an examination of participants attitude and behaviour towards shark conservation post-tour (n=136).

Results demonstrated that cage-dive participants valued the tourism activity and site as an educational opportunity, with demand for additional information focused on shark biology, habits and conservation. Post-tour responses identified a positive shift in participants attitudes

and concern for sharks, and increased participation in conservation-related behaviour. A synthesis of findings from the four research phases reveals the significance of education/interpretation and an emotional engagement in the experience, as key themes contributing to the conservation potential of white shark cage-dive tourism. This research concludes that in order for wildlife tourism to build a motivated constituency of people who support conservation, it is necessary for operators to combine the emotional response of viewing wildlife with the educational benefits of a specifically designed interpretation programme.

Authors: Apps, K., Dimmock, K, and Huveneers, C.

Year: 2018

Title: Turning wildlife experiences into conservation action: Can white shark cage-dive tourism influence conservation behaviour?

Journal: Marine Policy

Volume: 88

Issue: -

Pages: 108-115

Abstract: Wildlife tourism is often promoted as an activity which supports conservation by enhancing environmental knowledge, attitudes, and behaviour through interpretative messaging and personal experiences with wildlife. Despite these potential linkages, evidence to support such claims is limited. In order for wildlife tourism operators to build a motivated constituency supporting conservation, elements of the tour which contribute to positive attitudes and environmental behaviour must be identified. This study investigated the attitudes and environmental behaviour of 136 wildlife tourists following a white shark cage-dive experience in South Australia. Responses to an online survey revealed a significant increase in participation for seven of the eight conservation-related behaviours explored, and a positive shift in participants' understanding, awareness, attitudes, and concern for sharks following the tour. Results suggest that emotional engagement during the tour is associated with enhancing participants' knowledge and attitude towards sharks. Recommendations for complementing the emotional response to viewing wildlife, with interpretative communication, are discussed.

Authors: Apps, K., Dimmock, K, Lloyd, D. J., and Huveneers, C.

Year: 2016

Title: In the water with white sharks (*Carcharodon carcharias*): Participants' beliefs toward cage-diving in Australia

Journal: Anthrozoös

Volume: 29

Issue: 2

Pages: 231-245

Abstract: White shark (*Carcharodon carcharias*) cage-diving tourism is a controversial activity that provokes emotional and often opposing points of view. With increasing demand for shark tourism since the 1990s, the underlying determinants driving this growth in participation remain unclear. This paper adopts a qualitative approach to investigate beliefs underlying tourists' choice to observe white sharks while cage-diving at the Neptune Islands, South Australia. Elicitation surveys gathered responses from a sample ($n = 86$) of cage-diving participants. Content analysis of the responses revealed the decision to cage-dive with white sharks is driven by factors including education and the perceived naturalness of the experience. The findings of this study indicate an opportunity for cage-dive operators to provide in situ education and interpretation with potential for increased tourist satisfaction and shark conservation outcomes.

Authors: Apps, K., Dimmock, K, Lloyd, D. J., and Huveneers, C.

Year: 2017

Title: Is there a place for education and interpretation in shark-based tourism?

Journal: Tourism Recreation Research

Volume: 20

Issue: 1

Pages: 24-45

Abstract: Interpretive encounters are a major component of many wildlife tourism experiences and can make significant contributions to tourist satisfaction and pro-conservation attitudes. The growth of shark-based tourism has provided numerous opportunities to contribute to conservation by exposing tourists to sharks in their natural habitat, provide them with education and interpretation programmes that dispel myths, and draw attention to the threats facing shark populations. However, little research has focused on the motivations and expectations of marine tourists in relation to on-tour interpretation, particularly within industries linked to adrenaline rush. The present study explored the role of on-tour education and interpretation during a white shark cage-dive tour in South Australia. Participant surveys sought to answer the questions, do cage dive tourists want to be educated and what do they want to learn? Results support the demand for additional on-tour information focused on shark biology, habits, and conservation, suggesting participants want more than an adrenalin rush. The findings contribute to understanding the importance of education in shark-based tourism as the cage-dive participant experience and conservation potential of the tour can be enhanced with the addition of a structured interpretation programme.

Authors: Apps, K., Lloyd, D., and Dimmock, K.

Year of Conference: 2014

Title: Human dimensions of shark-based tourism

Conference Name: Shark International

Conference Location: Durban, South Africa

Page: 16

Abstract: Shark conservation can be described as an environmental and social dilemma. That is, sharks are an essential factor in balancing marine ecosystems, however public perception of sharks often dictates less than positive attitudes toward support for shark conservation. Shark-based tourism has the potential to generate significant education and conservation opportunities by enhancing participant knowledge and appreciation of sharks, and stimulating public support for shark conservation. As the popularity of shark diving develops globally, research and management strategies have started addressing some of the issues surrounding shark dive activities (e.g. impacts to shark behaviour, economic value of shark tourism), however, an understanding of the human dimension of the activity is largely absent. This study invokes the theory of planned behaviour (TPB) as a diagnostic tool to provide preliminary insights into the beliefs of participants at two shark-based tourism operations in Australia. A TPB based questionnaire was used to elicit participants' salient beliefs pertinent to scuba diving with *Carcharias taurus* in NSW, and shark cage diving with *Carcharodon carcharias* in South Australia. A content analysis of participant responses revealed beliefs that may underpin future persuasive communication strategies aiming to stimulate shark conservation attitudes and behaviours. This study demonstrates how the application of a well-established psychological theory can improve understanding of shark-based tourists, and build on the body of knowledge aiming to benefit the management of developing global shark tourism, and the conservation of shark species.

Authors: Apps, K., Lloyd, D. and Dimmock, K.

Year: 2014

Title: Scuba diving with the grey nurse shark (*Carcharias taurus*): an application of the theory of planned behaviour to identify divers beliefs

Journal: Aquatic Conservation: Marine and Freshwater Ecosystems

Volume: 25

Issue: 2

Pages: 201-211

Abstract: Scuba diving with the critically endangered grey nurse shark (*Carcharias taurus*) is a popular attraction for divers on the east coast of Australia. As the popularity of shark diving develops globally, research is required to evaluate how diving with sharks affects the behaviour and ecology of the species. Understanding participant's behaviour when diving with *C. taurus* can provide valuable information for researchers and policy makers trying to conserve this species. An elicitation procedure based on the theory of planned behaviour was applied to determine divers' beliefs pertinent to approaching *C. taurus* when scuba diving at two sites on Australia's east coast. A content analysis of responses revealed preliminary insights into the salient beliefs of divers. This initial step is an essential foundation for subsequent phases of research and communication aimed at improving shark and diver interactions and experiences.

Authors: Araujo, G., Lucey, A., Labaja, J., So, C. L., Snow, S. J., and Ponzo, A.

Year: 2014

Title: Population structure and residency patterns of whale sharks, *Rhinocodon typus*, at a provisioning site in Cebu, Philippines

Journal: PeerJ

Volume: 2

Issue: -

Pages: e543

Abstract: This study represents the first description of whale sharks, *Rhinocodon typus*, occurring at a provisioning site in Oslob, Cebu, Philippines. Frequent observations of sharks are often difficult, even at tourism sites, giving rise to provisioning activities to attract them. The present study provides repeated longitudinal data at a site where daily provisioning activities took place, and whale sharks were present every day. A total of 158 individual whale sharks were photographically identified between March 2012 and December 2013, with 129 males (82%), 19 females (12%) and 10 (6%) of undetermined sex. Mean estimated total length was 5.5 m (± 1.3 m S.D.). Twenty individuals were measured with laser photogrammetry to validate researchers' estimated sizes, yielding a good correlation ($r^2 = 0.83$). Fifty-four (34%) individuals were observed being hand-fed by local fishermen (provisioned), through in-water behavioural observations. Maximum likelihood methods were used to model mean residency time of 44.9 days (± 20.6 days S.E.) for provisioned *R. typus* contrasting with 22.4 days (± 8.9 days S.E.) for non-provisioned individuals. Propeller scars were observed in 47% of the animals. A mean of 12.7 (± 4.3 S.D.) *R. typus* were present in the survey area daily, with a maximum of 26 individuals (August 10, 2013) and a minimum of two (December 6, 2012). Twelve (8%) individuals were seen on at least 50% of survey days ($n = 621$), with a maximum residency of 572 days for one individual (P-396). Twenty-four individuals were photographically identified across regional hotspots, highlighting the species' migratory nature and distribution. Extended residency and differences in lagged identification rates suggest behavioural modification on provisioned individuals, underlying the necessity for proper management of this tourism activity.

Authors: Araujo, G., Lucey, A., So, C. L., Labaja, J., Snow, S. J., and Ponzo, A.

Year of Conference: 2014

Title: Describing the population structure and residency of whale sharks visiting the waters of Oslob, Cebu, Philippines, during the provisioning hours, between March 31st 2012 and December 31st 2013

Conference Name: Shark International

Conference Location: Durban, South Africa

Page: 17

Abstract: Prior to this study, the aggregation of *Rhincodon typus* occurring in the waters of Tan-Awan, Oslob had not been described. Provisioning activities started in late 2011, bringing in approximately 100,000 tourists every year. Daily photographic identification of individuals was used as a non-invasive means to describe the population. A total of 158 individual *R. typus* were identified. A significant juvenile male bias was found, with 129 males (81.65%), 19 female (12.03%) and 10 of unknown sex (6.33%).

Authors: Araujo, G., Ponzo, A., Geary, D., Craven, S., Snow, S. J., and Lucey, A. R.

Year: 2017

Title: Describing the population structure of *Rhincodon typus* occurring in the waters of Oslob– Cebu, Philippines– between March 2012 and June 2013, during the provisioning interaction hours

Journal: PeerJ

Volume: 1

Issue: -

Pages: e70v1

Abstract: Prior to this study, the aggregation of whale sharks in the waters of Oslob had never been described. Provisioning (Orams, 2002) activities started in late 2011, and systematic data collection in March 2012, attracting over 100,000 tourists in the first year, and is currently the most reliable aggregation of *R. typus* in the Philippines. Daily in-water photographic identification was used as a non-invasive means to describe the population throughout the study period. A total of 135 sharks were identified, and IDs were independently matched by three researchers to minimise error. Photogrammetry (Rohner, 2011) was adopted to complement population description. Daily sightings ranged from two to 23 different animals in the interaction area (mean=11.14). A total of 109 males, 15 females and 11 *R. typus* of undetermined sex were described. The size was estimated for 73.3% of the population, with an average of 5.36m \pm 1.3m. Photogrammetry posed a mean of 5.63m \pm 0.59m on 14 sharks, 6.75% >than researchers' estimates. Resighting (>1d) was observed in 66.7% of the population. Five individuals were present for >300d (n=443) in the interaction area, with a maximum of 420d. Nine individuals were successfully matched across regional hotspots including Donsol and Southern Leyte. Despite the presence of animals in Oslob year round and the influence of the provisioning, there appears to be a seasonal influx of animals, with a maximum of 46 different animals present in the month of June 2012 and again in May 2013, contrasting with a monthly average of 28.9. It appears these waters are important to the species and it is paramount to fully investigate the impact of the provisioning on the population of *R. typus* in the Philippines.

Authors: Araujo, G., Vivier, F., Labaja, J. J., Hartley, D., and Ponzo, A.

Year: 2017

Title: Assessing the impacts of tourism on the world's largest fish *Rhincodon typus* at Panaon Island, Southern Leyte, Philippines

Journal: Aquatic Conservation: Marine and Freshwater Ecosystems

Volume: 27

Issue: 5

Pages: 986-994

Abstract: Shark-based tourism is a rapidly growing industry, particularly with whale sharks, as new hotspots are identified worldwide. Understanding any impacts of tourism is essential to minimise any potential detrimental effects on the target species and habitat. In-water behavioural observations of whale sharks were used to understand any impacts of tourism at a small site in Panaon Island, Southern Leyte, Philippines. A generalised linear mixed model was fitted to test anthropogenic and environmental variables, with interaction duration as the response variable, to assess any disturbance to the animals by the tourism activities. Whale sharks were observed between the months of November and June between 2013 and 2016, with highly variable seasons. In total, 527 tourist-whale shark interactions were recorded during 359 trips identifying 104 individual whale sharks, most of which were juvenile males (85%, measuring c. 5.5m total length). Proximity of motorised vessels and interactions in deeper waters were found to significantly shorten interactions. Short-term behavioural changes were observed in response to human events (e.g. touching). Interactions when whale sharks were feeding were significantly longer than when they were not. Individual behavioural variability was observed. Impacts could be mitigated with small managerial changes and increased enforcement, such as limiting the number of motorised vessels and the number of people around the whale sharks. Although no long-term impacts were recorded during this study, it is difficult to ascertain this in a long-lived, wide-ranging species. This knowledge gap highlights the need to build long-term monitoring programmes, and to apply the precautionary principle for the sustainable use of this endangered species.

B

Authors: Babcock, E. A., and Nakano, H.

Year: 2009

Title: Sharks of the open ocean: Biology, fisheries and conservation

Editors: M. D. Camhi, E. K. Pikitch, and E. A. Babcock

Book Title: Recreational fishing for pelagic sharks worldwide

City: Oxford, UK

Publisher: Blackwell Publishing

Pages: 193-204

Abstract: While government fisheries agencies have not documented the recreational fisheries for, pelagic sharks in most countries, information exists in the records of fishing clubs, cooperative, tagging programmes, and the International Game Fish Association. Countries with significant pelagic shark recreational fisheries include Australia, New Zealand, the United States, and the United Kingdom. Some recreational pelagic shark fishing also occurs in Ireland, Italy, the Azores, Mauritius, South Africa, the Caribbean, and Mexico. Most pelagic shark, game fishing is now catch-and-release, and the total mortality caused by recreational fisheries, has been declining since the 1980s. The most commonly caught pelagic sharks are, blue (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), porbeagle (*Lamna nasus*), and, thresher sharks (*Alopias spp.*).

Author: Baldrige, H. D.

Year: 1974

Book Title: Shark attack: A program of data reduction and analysis. Contributions from the Mote Marine Laboratory (Volume 1, Number 2)

City: Sarasota, FL

Publisher: Mote Marine Laboratory

Abstract: Data from 1165 case histories of shark attack against man were reduced to a form handleable by automatic data retrieval systems. Numerous probes by computer were made to (a) provide statistical significance to the existence or absence of common factors associated with known instances of predaceous shark behaviour, and (b) evaluate the present approach to gathering meaningful data on shark attack and thereby determine requirements for maintaining such an effort in the future. Although information was carefully screened for correlations between occurrence of shark attack and a number of environmental and behavioural parameters, it was considered of greater importance that patterns or relationships be identified that distinguished victims from non-victims among exposed populations. Points of interest were examined in the light of previously accepted correlations and popular beliefs. Wound characteristics and other considerations suggested that perhaps 50-75% of shark attacks on humans have no direct relationship to feeding. A number of popular concepts linking shark attack to environmental parameters, including water temperature, appear to be casual relationships having to do more with determining bathing pressure at beaches. Contrary to current ideas, divers appear attack prone, with a strong relationship to spearfishing. Trends indicate that, in the 1970's, attacks upon divers will average at least one-third of all reported cases. Yet, divers show fewer, less damaging injuries than swimmers and enjoy a far lower mortality rate. Effectiveness of a variety of weapons and diversionary actions were examined. Updated advisories were developed for bathers and swimmers, divers, and attack victims. The question of shark motivation in human attack was examined. A case was made strongly favouring continuation and expansion of the Shark Attack File.

Author: Baldrige, H. D.

Year: 1988

Title: Shark aggression against man: Beginnings of an understanding

Journal: California Fish and Game

Volume: 74

Issue: 4

Pages: 208-217

Abstract: Over four decades of multidisciplinary studies provide an enlightened approach to understanding unprovoked shark aggression against man, particularly that against swimmers, divers, surfers, and fishermen in relatively shallow coastal waters. Incidence of attack is surprisingly low, and resulting injuries are most often survived. Attackers represent the full-size range of predatory sharks. Any shark having both opportunity and physical capacity for injuring humans is considered dangerous. Attacks occur anywhere and anytime men encounter sharks, having higher probabilities related, but not necessarily causatively, to conditions favouring man's recreational use of the sea. The shark's limited arsenal for doing violence includes teeth for grasping and cutting, scaled hide for abrading, and momentum for forcing. Shark behaviour and wound characteristics in totality convincingly suggest a high percentage of strikes against man are not determined efforts to devour humans as a prey of choice, being instead perhaps responses to motivations other than feeding. Such nonforaging aggressions have been observed in the field and lend themselves to credible explanation. To be effective, repellents and other antishark measures must cope with a multiplicity of shark motivations. New testing procedures need to be devised, giving full consideration to forces for aggression other than the feeding

drive. Captured attackers should be carefully examined for anatomical, physiological, and biochemical anomalies.

Author: Baldrige, H. D.

Year: 1996

Title: Comments on means for avoidance or deterrence of white shark attacks on humans

Editors: A. P. Klimley, and D. Ainley

Book Title: Great white sharks: The biology of *Carcharodon carcharias*

City: San Diego, CA, USA

Publisher: Academic Press

Pages: 477-479

Abstract: White sharks *Carcharodon carcharias* have attacked humans engaged in the full range of marine recreational and occupational activities. Bathers have been attacked at beaches; surfers and kayakers, farther off-shore; and all forms of divers and spear fishermen, both on the surface and at depth.

Authors: Baldrige Jr., H. D., and Williams, J.

Year: 1969

Title: Shark attack: Feeding or fighting?

Journal: Military Medicine

Volume: 134

Issue: 2

Pages: 130-133

Abstract: In the development of anti-shark measures, one very basic question has never been adequately answered. Why do sharks attack human beings? The answer is not as obvious as it may seem to some, and there is little doubt that we must understand more clearly the cause or causes of shark aggressions before we can ever hope to significantly alter their often disastrous effects. Evidence further suggests that hunger or the feeding drive may not be as important in shark attack as heretofore believed.

Authors: Bargnesi, F., Lucrezi, S., and Ferretti, F.

Year: 2020

Title: Opportunities from citizen science for shark conservation, with a focus on the Mediterranean Sea

Journal: The European Zoological Journal

Volume: 87

Issue: 1

Pages: 20-34

Abstract: The Mediterranean Sea is a hotspot for shark conservation. A decline in large pelagic shark populations has been observed in this vast region over the last 50 years and a lack of data on the local population status of various species has been pointed out. Throughout history, the relation between people and sharks has been revolving around a mixture of mystery, fear, and attraction. Recently, however, a remunerative ecotourism industry has been growing in areas of shark aggregation globally. This growth has been accompanied by the establishment of a citizen science (CS) movement aimed to engage and recruit ecotourists in data collection for shark research. Several CS projects have generated interesting results in terms of scientific findings and public engagement. In the Mediterranean Sea, shark aggregations are not as relevant to support locally-focused CS actions on shark diving sites as in other parts of the world. However, a series of other initiatives are taking place and CS could offer an excellent opportunity for shark conservation in the Mediterranean Sea. The dramatic decline of shark populations shown

in the region calls for alternative ways to collect data on species distributions and abundance. Obtaining such data to set proper conservation and management plans for sharks in the Mediterranean Sea will be possible if existing CS initiatives collaborate and coordinate, and CS is widely acknowledged and deployed as a valuable tool for public education, engagement, and scientific discovery. After providing an overview of multiple facets of the relationship between humans and sharks, the authors focus on the possibility of exploiting new technologies and attitudes toward sharks among some groups of ocean users to boost participatory research. CS is a great opportunity for shark science, especially for areas such as the Mediterranean Sea and for large pelagic sharks whose populations are highly impacted.

Author: Barkai, A.

Year: 2017

Title: Olrac Observer: An interactive citizen science, data collection platform with applications for ecotourism

Conference Name: The 9th International Congress on Coastal and Marine Tourism: Global challenges – local solutions

Conference Location: Gothenburg, Sweden

Page: 25

Abstract: Every day, countless vessels, from cruise ships, sightseeing tours to recreational fishing vessels roam the oceans. Collectively, these vessels are exposed to a myriad of environmental conditions, pollution events and observe enormous amounts of marine life. The collective data-gathering potential of these vessels is tremendous. The author's vision is that each one of these vessels could become a data collection platform, relying predominantly on localised observation data collected at a ground-roots level and with a strong focus on spatial and temporal distributions. The author and his team of programmers have developed such a data collection platform that can transform this vision into reality, the Olrac Dynamic Marine Observer (OlracDMO). OlracDMO is made of two components, a vessel unit for real time recording of observations while at sea and a web-server for the management of observations from numerous vessels. These units have the capacity to gather, store and manage a variety of observational data types, in many forms and formats, on one integrated platform. OlracDMO is a highly interactive tool, which assists casual observers (no technical skills are needed) in describing and identifying a variety of observations such as marine species, sea birds, pollution, debris, other vessels and more.

OlracDMO allows users to capture images of the observations they made during their tour, store them on their own computer, send them to the central website for public viewing as well as giving them the ability to create a trip diary in the form of a printed or digital multimedia booklet. This software encourages tourists to learn and explore the environment they have come to experience while contributing to the public's general knowledge of the ocean and marine conservation efforts. OlracDMO is currently designed to allow users to record and identify sightings of 89 mammal species, 359 birds, 35 sharks and rays, seven turtles, four pollution types, 51 other vessels, eight ghost fishing devices and more.

OlracDMO has been designed to enhance the experience of eco-tourists and contribute with vital observations toward marine conservation. However, it also has the potential to assist tour operators who can use OlracDMO collection of observations (website, trip booklets) to create awareness of their operations and to use them as part of marketing campaigns to attract marine eco-tourists. This information can also be used by tour operators to optimise their trips by identifying marine sighting hotspots that maximise experiences of marine life at sea.

Authors: Barker, S. M., Peddemors, V. M., and Williamson, J. E.

Year:2011

Title: A video and photographic study of aggregation, swimming and respiratory behaviour changes in the grey nurse shark (*Carcharias taurus*) in response to the presence of SCUBA divers

Journal: Marine and Freshwater Behaviour and Physiology

Volume: 44

Issue: 2

Pages: 75-92

Abstract: The grey nurse shark (*Carcharias taurus*) is a popular attraction for shark eco-tourism using SCUBA. The species is also 'globally Vulnerable' (IUCN 2008. List of Threatened Species. www.iucnredlist.org/). Magic Point (off Maroubra) in Sydney is favoured by recreational SCUBA divers wishing to observe these sharks. The objective of this study was to experimentally test the level of the activities of recreational SCUBA divers on shark behaviour. This study assessed the shark responses to diver group size (4, 8 and 12), time of day (am, noon and pm) and diver distance from the sharks (3m and 6 m). The study found that diver activity does affect the aggregation, swimming and respiratory behaviour of sharks at this site, albeit at short-term levels. Diver group size had no significant effect on shark aggregation, but the proximity of divers to the sharks was crucial. Shark distribution in the cave changed significantly in the presence of divers at 3m distance from the cave, but stayed unchanged at 6m. This was particularly apparent in the presence of large groups of 12 divers at 3m distance when sharks increased their swim speed and ventilation mechanism from 'active' to 'RAM' ventilation. Such change coincided with a sudden decrease in ventilation frequency. The research suggests that these effects are short-term and that sharks resume their behaviour once the divers retreat. If divers abide by the current code of practice for diving at this site, it is unlikely that their activities will substantially impact grey nurse sharks in the long term.

Authors: Barker, S. M., Peddemors, V. M., and Williamson, J. E.

Year:2011

Title: Recreational SCUBA diver interactions with the critically endangered grey nurse shark (*Carcharias taurus*)

Journal: Pacific Conservation Biology

Volume: 16

Issue: 4

Pages: 261-269

Abstract: Grey nurse sharks *Carcharias taurus* are listed as “Critically Endangered” along the east coast of Australia. Magic Point (off Maroubra) in Sydney is favoured by recreational SCUBA divers wishing to observe these sharks. This study was conducted to answer the question: do current recreational SCUBA diving practices at Magic Point have a significant impact on the aggregation behaviour of *C. taurus*? The study found that diver activity does temporarily affect the behaviour of *C. taurus* at this site, with a significant difference in the number of sharks and their distribution within the preferred area of occupation inside the cave between diver and non-diver treatments. Small dive groups (= four divers) approached the cave closer than large groups, resulting in a greater impact on sharks than large groups positioned further back from the cave. Shark behaviour rapidly returned to pre-diver exposure levels once divers left the area. This study is the first to (a) monitor recreational SCUBA diver activities at a critical habitat site and (b) use a non-invasive behavioural technique to study the behavioural responses of *C. taurus* towards SCUBA divers in southern NSW. It contributes to improving *C. taurus* conservation measures along the east coast of Australia by highlighting current diver behaviour and its impact on grey nurse sharks at this site. Results suggest that changes in the

current code of practice regarding SCUBA diving at recognised and protected grey nurse shark critical habitat sites should be considered by relevant management agencies.

Authors: Barnett, A., Payne, N. L., Semmens, J. M., and Fitzpatrick, R.

Year: 2016

Title: Ecotourism increases the field metabolic rate of whitetip reef sharks

Journal: Biological Conservation

Volume: 199

Issue: -

Pages: 132-136

Abstract: Wildlife tourism has been shown to cause behavioural changes to numerous species. Yet, there is still little understanding if behavioural changes have consequences for health and fitness. The current study combined accelerometry and respirometry to show that provisioning whitetip reef sharks (*Triaenodon obesus*) for tourism increases their daily energy expenditure by elevating activity levels during periods when they normally rest. Field metabolic rate increased by 6.37% on provisioning days compared to non-provisioning days. Since metabolism is a key parameter influencing most biological and ecological processes, this represents some of the clearest evidence to date that ecotourism can impact critical biological functions in wild animals.

Authors: Barreiros, J. P., Gadig, O. B. F., and Haddad Jr., V.

Year: 2014

Title: An unprovoked attack by a blue shark *Prionace glauca* (*Chondrichthyes: Carcharhinidae*) on a spear fisherman in Terceira Island, Azores, Northeast Atlantic

Journal: Wilderness & Environmental Medicine

Volume: 25

Issue: 3

Pages: 371-372

Abstract: The blue shark, *Prionace glauca* (Linnaeus, 1758), is a large predatory oceanic-epipelagic species with worldwide distribution that is usually harmless to humans. However, its inquisitive behaviour when facing divers in open waters and a moderately powerful set of jaws and teeth can inflict severe injuries; reasons for this shark to be regarded with caution in some shark-human interaction scenarios. There are at least 13 recorded unprovoked attacks imputed to this species to date (e.g. <http://www.flmnh.ufl.edu/fish/sharks/statistics/species3.htm>).

Authors: Becerril-García, E. E., Hoyos-Padilla, E. M., Micarelli, P., Galván-Magaña, F., and Sperone, E.

Year: 2019

Title: The surface behaviour of white sharks during ecotourism: A baseline for monitoring this threatened species around Guadalupe Island, Mexico

Journal: Aquatic Conservation: Marine and Freshwater Ecosystems

Volume: 29

Issue: 5

Pages: 773-782

Abstract: Cage diving is the most important activity for the sustainable use of white sharks (*Carcharodon carcharias*). However, information related to their behaviour during ecotourism is scarce. This study provides useful information for monitoring *C. carcharias* during cage-diving activities around Guadalupe Island, Mexico. Surface behaviour of 106 white sharks was recorded for 87 days on-board six cage-diving boats in 2012, 2013, and 2014. Of the observed sharks, 63% were immature specimens ($n = 67$) and 37% were considered mature ($n = 39$).

Seventy-one per cent were males ($n = 75$) and 29% were females ($n = 31$). Interactions were classified into one of the 11 behaviours: parading, close inspection, horizontal attack, vertical attack, bait catching, feeding, not feeding, buoy catching, encounter, escape, and staying. Parading, close inspections, and horizontal attacks were performed more often by mature males, whereas immature females performed more vertical attacks, with no differences between mature and immature males. A total of 1,542 ethograms were registered. Each ethogram consisted on average of 6.3 ± 5.6 behaviours with a significant transitional pattern from horizontal attacks to parading and close inspections, and from vertical and horizontal attacks to bait being caught. A pattern related to feeding in a simple stimulus response reflex was observed. The shark's length seems to play an important role in the efficiency of the attacks, presumably resulting from the experience of mature individuals. Intentional feeding should be avoided to prevent negative effects related to ecotourism. This study constitutes a baseline for future research on white shark behaviour. It can be applied in other regions regardless of environmental conditions, quantity and size of the boats, and types of bait. Using this standard method could improve the monitoring, management, and conservation of this vulnerable species.

Authors: Bentz, J., Dearden, P., Ritter, E., and Calado, H.

Year: 2014

Title: Shark diving in the Azores: challenge and opportunity

Journal: Tourism in Marine Environments

Volume: 10

Issue: 1/2

Pages: 71-83

Abstract: Many shark species are highly endangered. The main cause of mortality is fishing. Shark tourism is growing worldwide and has the potential to provide incentive-based conservation for some shark species but fishing remains a major challenge. In the Azores, sharks are still relatively abundant and a shark tourism industry has developed over the last few years. This article reports on the current status of shark diving, conflicts with fishing, dive industry management, and the potential future sustain-ability of shark diving in the Azores. Interviews with industry stakeholders show a rapidly emerging conflict with fisheries that threatens the future sustainability of the shark-diving industry. To facilitate the sustainable development of shark watching, partnerships among operators, local fishers, and the government are essential.

Authors: Bluemel, J. K., French, G. C., and Rowat, D.

Year: 2013

Title: An aerial view: Insights into the effects of ecotourism on the behavior of whale sharks (*Rhincodon typus*) in Seychelles

Journal: PeerJ

Volume: 1

Issue: -

Pages: e103v1

Abstract: Worldwide, whale shark encounters are a highly sought ecotourism activity. Encounter Codes are implemented to help reduce anthropogenic disturbances. To assess their design and effectiveness, aerial behavioural surveys provide an excellent platform to identify behaviours with little or no observer induced bias. Five-minute focal-animal behavioural surveys were conducted during micro-light aerial surveys of whale sharks in Seychelles, both in the absence ($n=26$) and presence ($n=24$) of Marine Conservation Society, Seychelles research/ecotourism boats and in-water swimmers (following boat and in-water Encounter Codes). Whale shark behaviours with no anthropogenic influences were identified from encounters without boats and recorded as the percentage of survey time. Ordinal logistic

regression (OLR) was used to determine whether the proportion of time sharks spent on the surface was dependent upon environmental, morphometric and/or anthropogenic predictors. Differences between the surface swimming time before and after arrival of a boat were also assessed using a paired t-test. The altitude of the aircraft was not found to influence whale shark behaviour, neither did environmental factors. There was a significant probability of whale sharks spending shorter periods of time swimming on the surface when in the presence of boats and in-water swimmers (OLR p-value<0.001, paired t-test p-value<0.001). Smaller-sized sharks spent considerably longer periods of time on the surface than larger sharks (p-value<0.05), which was more evident in the absence of anthropogenic influences. Aerial survey methods permit monitoring of behaviour without observer induced bias, enabling critical evaluation of encounter management. Boat presence and in-water swimmers did affect the behaviour of sharks suggesting that experimental examination of encounter regulations can help determine optimal restrictions to minimise the disturbance to this protected species.

Authors: Boissonneault, M. F., Gladstone, W., Scott, P., and Cushing, N.

Year: 2005

Title: Grey nurse shark human interactions and portrayals: A study of newspaper portrayals of the grey nurse shark from 1969–2003

Journal: Electronic Green Journal

Volume: 1

Issue: 22

Pages: -

Abstract: The general lack of knowledge in dominant society pertaining to the different shark species has led to the depletion of the more placid species such as the grey nurse shark (*Carcharias taurus*). This study consisted of a content analysis of 41 Australian newspaper articles pertaining specifically to the grey nurse shark and serves to deconstruct the explicit messages that they attempt to convey to their readers. The data generated by this study exemplify the perceptions of *C. taurus* as represented by major Australian newspapers between the years 1969 and 2003. The majority of the opinion or editorial pieces concerning the grey nurse shark examined in this study were positive, whereas the majority of the news articles examined fell within a more neutral range. The findings of this study imply that the level of interest in the plight of *C. taurus* has increased as *C. taurus*'s circumstances have become more critical.

Authors: Bradford, R., and Robbins, R. L.

Year: 2013

Title: A rapid assessment technique to assist management of the white shark (*Carcharodon carcharias*) cage dive industry, South Australia

Journal: The Open Fish Science Journal

Volume: 1

Issue: 6

Pages: 13-18

Abstract: Port Lincoln, South Australia is the departure port for the only white shark, *Carcharodon carcharias*, cage dive industry in Australia. Established in the early 1960's as a niche tourism venture, the industry has recently undergone a rapid expansion to accommodate greater passenger numbers, more tourism operators, and additional infrastructure aimed at capturing a greater proportion of the tourist dollar. However, to date, there has been no assessment of growth in the industry. Bradford and Robbins have used the operator logbook system, introduced in 2000, as the basis for a rapid assessment of the maturity as well as a conservative estimate of the economic value of the industry, with a focus on 2011. From the

logbook system the number of days on-site has increased from an average of 67 days per year prior to 2007 to 287 days on-site in 2011. In 2011 the industry accommodated approximately 5,200 passengers with a direct domestic expenditure estimated to be in excess of 6 million AUD. Changes in shark behaviour have been observed following the increase in days on-site. The white shark cage dive industry has reached a stage in its development where increased management is required in order to ensure a viable industry into the future. The rapid assessment technique described herein will allow managers to track changes in cage dive participation rates and quickly respond to changes in the industry.

Authors: Bradley, D., Papastamatiou, Y. P., and Caselle, J. E.

Year: 2017

Title: No persistent behavioural effects of SCUBA diving on reef sharks

Journal: Marine Ecology Progress Series

Volume: 567

Issue: -

Pages: 173-184

Abstract: Despite rapid growth in the marine tourism sector, the impacts of recreation on the marine environment are generally not well understood. Most existing studies of marine recreation ecology have focused on behavioural changes resulting from direct interactions between humans and wildlife including provisioning. However, non-consumptive, non-provisioning human impacts may also result in persistent behavioural impacts to shark populations. In this study, Bradley and colleagues examined differences in residency, abundance, and behaviour of reef sharks at Palmyra Atoll in response to long-term SCUBA diving activity, using a combination of survey techniques including baited remote underwater video systems and multi-year passive acoustic monitoring. In most locations with recreational diving operations, some level of human impact is pervasive, but on Palmyra, extractive fishing is prohibited, and scientific diving activities are concentrated on just a few sites that house long-term monitoring projects. These sites experience relatively intensive diving, while the majority of the island is entirely undived. Evidence from elsewhere has shown that sharks behaviourally respond to people in the water over short time scales, but our results indicate that this response may not persist. The authors did not detect differences in reef shark abundance or behaviour between heavily dived and undived locations, nor were there differences in shark residency patterns at dived and undived sites in a year with substantial diving activity and a year without any diving. The results suggest that humans can interact with reef sharks without persistent behavioural impacts, and that well-regulated shark diving tourism can be accomplished without undermining conservation goals.

Authors: Bray, R., Wesley, R., and Zimmerman, D.

Year of Conference: 1994

Title: Are electric rays (*Torpedo spp.*) a health hazard to divers?

Conference Name: American Elasmobranch Society 10th Annual Meeting

Conference Location: Los Angeles, CA, USA

Pages: -

Abstract: Electric rays of the genus *Torpedo* are known to produce powerful electric discharges used to kill fish prey and deter predators. Pacific electric rays (*Torpedo californica*) are found in shallow water along the Pacific coast, where they are frequently encountered by scuba divers. There have been over 40 unexplained scuba diving fatalities off Los Angeles County attributed to "accidental drowning"; electric rays have never been considered as the primary cause of death. The discharges produced by electric rays resemble the discharge pattern known to reliably induce ventricular fibrillation in large mammals. Until more is known about the

discharges produced by electric rays and the electrical characteristics of divers in seawater, the authors urge that divers be cautious of electric rays. These rays may pose the greatest hazard at night, during which they appear to be actively hunting prey.

Authors: Brena, P. F., Mourier, J., Planes, S., and Clua, E.

Year: 2015

Title: Shark and ray provisioning: functional insights into behavioural, ecological and physiological responses across multiple scales

Journal: Marine Ecology Progress Series

Volume: 538

Issue: -

Pages: 273-283

Abstract: The use of olfactory stimuli and the provision of food are a common practice to prompt artificial aggregations of emblematic wild species and ensure the economic viability of the wildlife-watching industry. Several elasmobranch species have been targeted by such operations in a variety of locations for over four decades. A recent review succinctly addressed the potential effects of shark diving tourism, including shark provisioning, on shark individual behaviour and ecology, but the paucity of data on the ecology of elasmobranchs precluded general statements. By using a functional framework, the authors reviewed the findings of the 22 available studies that investigated the behavioural, physiological, and ecological response of 14 shark and three ray species targeted by artificial provisioning. Focusing on the underlying processes that rule the response of targeted elasmobranch species, it is reported that further effects acting beyond the individual scale. The authors suggest that the most commonly described alterations of individual movement patterns have cascading effects through the group and community scales, ultimately resulting in altered health condition and individual behaviour toward humans. It is concluded that by stressing the potential for provisioning activities to support the investigation of complex ecological and behavioural processes in elasmobranchs.

Authors: Bruce, B. D., and Bradford, R. W.

Year: 2013

Title: The effects of shark cage-diving operations on the behaviour and movements of white sharks, *Carcharodon carcharias*, at the Neptune Islands, South Australia

Journal: Marine Biology

Volume: 160

Issue: 4

Pages: 889-907

Abstract: The attraction or provisioning of sharks for the purpose of tourism is a lucrative and popular industry that remains controversial regarding its possible risks to target species and impacts on local ecosystems. The long-term impacts of such activities on the behaviour and movement patterns of sharks have typically been difficult to establish as most studies investigate contemporary behaviour concurrent with existing operations and thus have no comparative base from which to compare effects. Bruce and Bradford compared patterns of residency and behaviour of acoustic-tagged white sharks at the Neptune Islands in South Australia between periods before and after an abrupt and sustained doubling of cage-diving effort that occurred in 2007. The number of sharks reported by cage-dive operators significantly increased after 2007. Comparisons also revealed there were significant increases in sharks' periods of residency, the periods spent within areas where shark cage-diving operations occur and changes in sharks' diel pattern of habitat use. Changes were site-specific with no significant differences in shark behaviour revealed over the same period at an island group 12 km from regular shark cage-dive sites. The results suggest that cage-diving operations can lead to long-term changes in the site-

specific behaviour of a highly vagile shark species which may need to be considered in the context of their conservation and in managing the impacts of the industry.

Author: Bruce, B.

Year: 2015

Title: A review of cage diving impacts on white shark behaviour and recommendations for research and the industry's management in New Zealand

City: Hobart, Tasmania

Institution: CSIRO Marine and Atmospheric Research for Department of Conservation, New Zealand

Abstract: White shark cage diving is a relatively new industry in New Zealand waters and some aspects of its management falls under the jurisdiction of the Department of Conservation (DOC). Although initially un-regulated, the industry in New Zealand has recently seen the introduction, in 2013, of a Code of Practice by DOC followed by the introduction of permits to operate in 2014. Furthermore, DOC committed to review the Code of Practice in 2016 to ensure that managing the New Zealand industry into the future was guided by experiences from other jurisdictions and the latest scientific knowledge on white sharks. This paper contributes to that process by providing a summary of white shark cage dive industries and their management world-wide, followed by a review of scientific literature of the impact of cage diving operations on white shark behaviour.

Author: Brunnschweiler, J. M.

Year: 2010

Title: The Shark Reef Marine Reserve: a marine tourism project in Fiji involving local communities

Journal: Journal of Sustainable Tourism

Volume: 18

Issue: 1

Pages: 29-42

Abstract: The Shark Reef Marine Reserve in Fiji is an ecotourism project designed to protect a small reef patch and its fauna while preserving the livelihood of local communities. It involves the local communities by using a participatory business planning approach to Marine Protected Area management, generating income through diver user fees, distributed to the local villages that have exchanged their traditional fishing rights in the marine reserve for this new source of income. The Shark Reef Marine Reserve is a self-sustaining and profitable project, and is an example of a privately initiated, bottom-up approach, which includes all relevant stakeholders in an area where marine rights are finely subdivided into small units.

Authors: Brunnschweiler, J. M., Abrantes, K. G., and Barnett, A.

Year: 2014

Title: Long-term changes in species composition and relative abundances of sharks at a provisioning site

Journal: PLoS ONE

Volume: 9

Issue: 1

Pages: e86682

Abstract: Diving with sharks, often in combination with food baiting/provisioning, has become an important product of today's recreational dive industry. Whereas the effects baiting/provisioning has on the behaviour and abundance of individual shark species are starting to become known, there is an almost complete lack of equivalent data from multi-species shark

diving sites. In this study, changes in species composition and relative abundances were determined at the Shark Reef Marine Reserve, a multi-species shark feeding site in Fiji. Using direct observation sampling methods, eight species of sharks (bull shark *Carcharhinus leucas*, grey reef shark *Carcharhinus amblyrhynchos*, whitetip reef shark *Triaenodon obesus*, blacktip reef shark *Carcharhinus melanopterus*, tawny nurse shark *Nebrius ferrugineus*, silvertip shark *Carcharhinus albimarginatus*, sicklefin lemon shark *Negaprion acutidens*, and tiger shark *Galeocerdo cuvier*) displayed inter-annual site fidelity between 2003 and 2012. Encounter rates and/or relative abundances of some species changed over time, overall resulting in more individuals (mostly *C. leucas*) of fewer species being encountered on average on shark feeding dives at the end of the study period. Differences in shark community composition between the years 2004–2006 and 2007–2012 were evident, mostly because *N. ferrugineus*, *C. albimarginatus* and *N. acutidens* were much more abundant in 2004–2006 and very rare in the period of 2007–2012. Two explanations are offered for the observed changes in relative abundances over time, namely inter-specific interactions and operator-specific feeding protocols. Both, possibly in combination, are suggested to be important determinants of species composition and encounter rates, and relative abundances at this shark provisioning site in Fiji. This study, which includes the most species from a spatially confined shark provisioning site to date, suggests that long-term provisioning may result in competitive exclusion among shark species.

Authors: Brunnschweiler, J. M., and Baensch, H.

Year: 2011

Title: Seasonal and long-term changes in relative abundance of bull sharks from a tourist shark feeding site in Fiji

Journal: PLoS ONE

Volume: 6

Issue: 1

Pages: e16597

Abstract: Shark tourism has become increasingly popular, but remains controversial because of major concerns originating from the need of tour operators to use bait or chum to reliably attract sharks. Brunnschweiler and Baensch used direct underwater sampling to document changes in bull shark *Carcharhinus leucas* relative abundance at the Shark Reef Marine Reserve, a shark feeding site in Fiji, and the reproductive cycle of the species in Fijian waters. Between 2003 and 2009, the total number of *C. leucas* counted on each day ranged from zero to 40. Whereas the number of *C. leucas* counted at the feeding site increased over the years, shark numbers decreased over the course of a calendar year with fewest animals counted in November. Externally visible reproductive status information indicates that the species' seasonal departure from the feeding site may be related to reproductive activity.

Authors: Brunnschweiler, J. M., and Barnett, A.

Year: 2013

Title: Opportunistic visitors: long-term behavioural response of bull sharks to food provisioning in Fiji

Journal: PLoS ONE

Volume: 8

Issue: 3

Pages: e58522

Abstract: Shark-based tourism that uses bait to reliably attract certain species to specific sites so that divers can view them is a growing industry globally, but remains a controversial issue. Brunnschweiler and Barnett evaluate multi-year (2004–2011) underwater visual (n = 48

individuals) and acoustic tracking data ($n = 82$ transmitters; array of up to 16 receivers) of bull sharks (*Carcharhinus leucas*) from a long-term shark feeding site at the Shark Reef Marine Reserve and reefs along the Beqa Channel on the southern coast of Viti Levu, Fiji. Individual *C. leucas* showed varying degrees of site fidelity. Determined from acoustic tagging, the majority of *C. leucas* had site fidelity indexes .0.5 for the marine reserve (including the feeding site) and neighbouring reefs. However, during the time of the day (09:00–12:00) when feeding takes place, sharks mainly had site fidelity indexes ,0.5 for the feeding site, regardless of feeding or non-feeding days. Site fidelity indexes determined by direct diver observation of sharks at the feeding site were lower compared to such values determined by acoustic tagging. The overall pattern for *C. leucas* is that, if present in the area, they are attracted to the feeding site regardless of whether feeding or non-feeding days, but they remain for longer periods of time (consecutive hours) on feeding days. The overall diel patterns in movement are for *C. leucas* to use the area around the feeding site in the morning before spreading out over Shark Reef throughout the day and dispersing over the entire array at night. Both focal observation and acoustic monitoring show that *C. leucas* intermittently leave the area for a few consecutive days throughout the year, and for longer time periods (weeks to months) at the end of the calendar year before returning to the feeding site.

Authors: Brunnschweiler, J. M., and McKenzie, A.

Year: 2010

Title: Baiting sharks for marine tourism: Comment on Clua et al. (2010)

Journal: Marine Ecology Progress Series

Volume: 120

Issue: -

Pages: 283-284

Abstract: A recent study by Clua et al. (2010; Marine Ecology Progress Series, 414, 257-266) that looks at the behavioural response of sicklefin lemon sharks *Negaprion acutidens* to underwater feeding for ecotourism purposes has a number of methodological and semantic problems that complicate the evaluation of the results and raise questions about the conclusions. Main issues are the lack of a control, the use of non-defined terms to characterise observed behaviours, and statements not supported by data. Unwarranted conclusions include the notion that behavioural changes were caused by the human interference, the link between intraspecific aggression and the feeding process, and the loss of genetic variability as a consequence of the aggregating effect of shark feeding.

Authors: Brunnschweiler, J. M., Payne, N.L., and Barnett, A.

Year: 2018

Title: Hand feeding can periodically fuel a major portion of bull shark energy requirements at a provisioning site in Fiji

Journal: Animal Conservation

Volume: 21

Issue: 1

Pages: 31-35

Abstract: Wildlife tourism is often extolled for its contribution to conservation. However, understanding the effects of tourism activities on the health of target animals is required to fully assess conservation benefits. Shark tourism operators often use food rewards to attract sharks in close proximity to tourists, but nothing is known about the contribution of these food rewards to the energetic requirements of target species. In this study, hand feeding of bull sharks *Carcharhinus leucas* was directly observed on 36 commercial shark watching dives in the Shark Reef Marine Reserve (SRMR), Fiji. Mean number of tuna heads consumed per dive by focal

individuals ranged from 1.3 to 3.7. Monitored bull sharks consumed an average of ~0.74 heads per provisioning day, and bioenergetics modelling suggests that some sharks might periodically be meeting their full energy requirement from provisioning at the SRMR. Knowing how much individual sharks consume at provisioning sites and how this relates to their energy requirements is crucial in order to better understand the effects of wildlife tourism and its contribution to conservation.

Authors: Buckley, K. A., Crook, D. A., Pillans, R. D., Smith, L., and Kyne, P. M.

Year: 2018

Title: Sustainability of threatened species displayed in public aquaria, with a case study of Australian sharks and rays

Journal: Reviews in Fish Biology and Fisheries

Volume: 28

Issue: 1

Pages: 137-151

Abstract: Zoos and public aquaria exhibit numerous threatened species globally, and in the modern context of these institutions as conservation hubs, it is crucial that displays are ecologically sustainable. Elasmobranchs (sharks and rays) are of particular conservation concern and a higher proportion of threatened species are exhibited than any other assessed vertebrate group. Many of these lack sustainable captive populations, so comprehensive assessments of sustainability may be needed to support the management of future harvests and safeguard wild populations. Buckley and colleagues propose an approach to identify species that require an assessment of sustainability. Species at risk of extinction in the wild were considered to be those assessed as threatened (CR, EN or VU) on the IUCN Red List of Threatened Species, or data deficient species that may be at an elevated risk of extinction due to life history traits and habitat associations. The authors defined sustainable captive populations as self-maintaining, or from a source population that can sustain harvest levels without risk of population declines below sustainable levels. The captive breeding and wild harvest records of at risk species displayed by Australian aquaria were examined as a case study. Two species, largemouth sawfish *Pristis pristis* and grey nurse shark *Carcharias taurus*, were found to have unsustainable captive populations and were identified as high priorities for comprehensive sustainability assessments. This review highlights the need for changes in permitting practices and zoo and aquarium record management systems to improve conservation outcomes for captive elasmobranchs.

Authors: Burgin, S., and Hardiman, N.

Year: 2015

Title: Effects of non-consumptive wildlife-oriented tourism on marine species and prospects for their sustainable management

Journal: Journal of Environmental Management

Volume: 151

Issue: -

Pages: 210-220

Abstract: Marine non-consumptive wildlife-oriented tourism, whereby tourists observe and/or interact closely with animals, without purposely having a detrimental effect on them, has been growing globally in recent decades. Human-mediated feeding (provisioning) is widely used by tour operators to attract target species, facilitate viewing and interaction with tourists. Although potential effects of such provisioning on terrestrial fauna have been given moderate scientific research attention, equivalent research in the marine environment is limited. Effects of provisioning marine wildlife may include direct habituation, behavioural change, and/or dietary

impacts among individuals and species. There may also be disruption to the species associated assemblage. It was found that the literature on the effects of non-consumptive wildlife tourism is fragmented and results from different areas and taxa are frequently contradictory. Most studies appeared to be of a few years' duration, at most. This reflects the relative immaturity of the industry and many enterprises studied typically commenced within the 1990s. Studies (other than fish) tended to focus on a focal species with few addressing the wider implications for the associated assemblage. Supplementary feeding may also have impacts on the health and wellbeing of provisioned animals. It is concluded that such nature tourism is often not benign e focal species and their assemblage are often disrupted. The authors conclude that funding to better understand the impacts and thus address them is imperative. To supplement funding for the research and monitoring required, an additional charge could be incorporated into the fee charged to those engaging in marine wildlife tourism.

C

Authors: Cagua, E. F., Collins, N., Hancock, J., and Rees, R.

Year: 2014

Title: Whale shark economics: A valuation of wildlife tourism in South Ari Atoll, Maldives

Journal: PeerJ

Volume: 2

Issue: -

Pages: e515

Abstract: Whale sharks attract large numbers of tourists, divers and snorkelers each year to South Ari Atoll in the Republic of Maldives. Yet without information regarding the use and economic extent of the attraction, it is difficult to prioritise conservation or implement effective management plans. Cagua and colleagues used empirical recreational data and generalised mixed statistical models to conduct the first economic valuation (with direct spend as the primary proxy) of whale shark tourism in Maldives. They estimated that direct expenditures for whale shark focused tourism in the South Ari Marine Protected Area for 2012 and 2013 accounted for US\$7.6 and \$9.4 million respectively. These expenditures are based on an estimate of 72,000–78,000 tourists who are involved in whale shark excursions annually. That substantial amount of income to resort owners and operators, and tourism businesses in a relatively small area highlights the need to implement regulations and management that safeguard the sustainability of the industry through ensuring guest satisfaction and whale shark conservation.

Authors: Cains, J. E., and Dobson, J.

Year: 2008

Chapter Title: Shark

Book Title: The encyclopedia of tourism and recreation in marine environments

Editor: M. Lück

Pages: 429-430

City: Wallingford, United Kingdom

Publisher: CABI

Abstract: The term shark refers to members of the elasmobranch group, comprising the skates, rays and sharks. Elasmobranchs are present in every sea or ocean on the planet, and utilise all layers of the water column, with some specialised for bottom-dwelling, others mid-water hunting and yet others inhabiting the darkest and deepest extents of the oceans. Some are filter-feeders – for example, the whale shark, which is the largest fish in the sea. Alternatively, the large open-water predators like the great white and mako sharks have powerful jaws and are

stealthy predators that hunt fish, sharks, and marine mammals. Many shark populations are under threat from human activities. It is estimated that 100 million sharks are killed each year, both by targeted fisheries and as by-catch. The tourism industry can also pose a threat to sharks through sport fishing, the use of shark nets to protect beaches and through the sale of teeth as souvenir. Despite the growing range of threats to sharks and the vulnerable conservation status of many species, protection is limited. Sharks are becoming popular marine wildlife attractions through the growth in shark-diving. This is being seen as a way to help conserve sharks as it helps ensure that they can be worth more alive, as tourist attractions, than dead.

Authors: Cains, J. E., and Dobson, J.

Year: 2008

Chapter Title: Shark-diving

Book Title: The encyclopedia of tourism and recreation in marine environments

Editor: M. Lück

Pages: 430-432

City: Wallingford, United Kingdom

Publisher: CABI

Abstract: Diving with sharks, be it baited or un-baited, caged or free-diving, has become a fast-growing industry. Previously considered only for ‘extreme adventure’ tourists, shark experiences have become accessible to all. The best shark-diving experiences generally incorporate close-up, but no-touch, observation of the animal. Beginners and even non-qualified divers can dive with sharks in some aquaria and snorkel with surface-feeding whale and basking sharks and with a variety of rays and smaller sharks that inhabit inshore areas and coral reefs. Non-divers can also undertake surface cage dives such as those with great white sharks in South Africa and with sandbar and Galapagos sharks in Hawaii. More experienced divers can enjoy shark encounters in areas such as the Bahamas where a variety of large species such as tiger, bull, grey reef and hammerhead sharks can be encountered in relatively calm water with good visibility. Shark-based tourism can be used as a tool to aid shark conservation efforts through the generation of economic benefits and educating tourists about sharks. The word shark often conjures images of Jaws and other negative stereotypes in people’s minds. Sharks are apex predators, and therefore tend to be sparsely distributed and can be difficult to find. In order to increase the likelihood of seeing sharks, some tour operators attract them to dive sites using a technique known as ‘bait and chum’. Critics suggest that chumming distracts sharks from their natural behaviour patterns and that chumming and feeding teaches sharks to associate humans with food, which may increase the potential of shark attacks on humans. However, no link between chumming and/or feeding of sharks and shark attacks as yet been found.

Authors: Caldicott, D. G. E., Mahajani, R., and Kuhn, M.

Year: 2001

Title: The anatomy of a shark attack: a case report and review of the literature.

Journal: International Journal of the Care of the Injured (Injury)

Volume: 32

Issue: -

Pages: 445-453

Abstract: Shark attacks are rare but are associated with a high morbidity and significant mortality. The authors report the case of a patient’s survival from a shark attack and their subsequent emergency medical and surgical management. Using data from the International Shark Attack File, Caldicott and colleagues review the worldwide distribution and incidence of shark attack. A review of the world literature examines the features which make shark attacks unique pathological processes. The authors offer suggestions for strategies of management of

shark attack, and techniques for avoiding adverse outcomes in human encounters with these endangered creatures.

Author: Cater, C.

Year: 2010

Title: Any closer and you'd be lunch! Interspecies interactions as nature tourism at marine aquaria

Journal: Journal of Ecotourism

Volume: 9

Issue: 2

Pages: 133-148

Abstract: Marine aquaria continue to be popular tourist attractions, and while not ecotourism per se, they are clearly nature-based, and fulfil parallel tourist needs for interaction with animals. In recent years, some of these facilities have recognised that visitors desire an experience that goes beyond the visual and entertainment encounters that categorise the majority of their offerings, for example, the 'Animal Adventures' programme at Sea World on Australia's Gold Coast. However, these interactions open up a whole new realm of performance management for these organisations, coordinating a range of actors from tourists, wildlife trainers, and the animals themselves. This paper examines why tourists are seeking such encounters, and shows how these interactions are contextualised and given meaning in tourist narratives, situated within an emerging social science discourse on embodiment. Observations suggest that society's over-anthropomorphising of the animals in question brings particular opportunity for dissonance. The broader significance of animal-human relations is explored through this interface, as are the implications for sustainable nature tourism in the future. There is potential here for a more enlightened approach to animal tourism, and a more nuanced categorisation of these activities in the literature.

Authors: Catlin, J., Hughes, M., Jones, T., Jones, R., and Campbell, R.

Year: 2013

Title: Valuing individual animals through tourism: science or speculation?

Journal: Biological Conservation

Volume: 157

Issue: -

Pages: 93-98

Abstract: Non-consumptive wildlife tourism plays an important role both in raising conservation issues and in providing economic support for conservation initiatives. Although the direct value of wildlife has been historically associated with its consumption, tourism is increasingly being used to value wildlife for its economic and environmental qualities. There are various methods by which these values can be assessed. In particular, there is a recent trend towards ascribing tourism values to individual animals. Such approaches enable direct comparisons with the extractive of use animals. These calculations can depict clear contrasts in value in tourism's favour which can then be publicised to a wider audience. Whilst this method may appear desirable, this paper demonstrates that valuations made at the scale of single animal are frequently based on assumptions that may not withstand critique. In turn it is argued, that given the flaws in this method, instead of enhancing arguments for conservation it has the potential to weaken its case. It is contended that using tourism to value wildlife should be conducted at a destination or higher level where the arguments have a firmer scientific basis and thus more impact and relevance.

Authors: Catlin, J., Hughes, M., Jones, T., and Jones, R.

Year: 2014

Title: White sharks in Western Australia: Threat or opportunity?

Journal: Journal of Ecotourism

Volume: 13

Issue: 2/3

Pages: 159-169

Abstract: This paper explores the Western Australian Government's decision to disallow white shark tourism operations within the State. This policy was made during a time of an unprecedented number of shark bite fatalities in the region. Catlin and colleagues argue that the Government's verdict was reactive due to this abnormality and did not take a balanced and considered approach. White sharks are an important key stone species with a high conservation value, but a particularly negative popular image. Therefore, the authors contend that dismissing the prospect of tourism also dismissed the prospect of creating a more realistic representation of the species. In addition, economic benefits to a regional area and research opportunities on the species were also lost.

Authors: Catlin, J., and Jones, R.

Year: 2010

Title: Whale shark tourism at Ningaloo Marine Park: a longitudinal study of wildlife tourism

Journal: Tourism Management

Volume: 31

Issue: 3

Pages: 386-394

Abstract: This article demonstrates the changes that occur due to the maturation of a wildlife tourism industry through the application of a Wildlife Tourism Framework. Specifically, in 2005 survey data was collect from participants of whale shark tourism at Ningaloo Marine Park in Western Australia, facilitating a direct comparison with a study conducted a decade earlier. The results conformed with predictions by the Framework, in particular, a shift in the industry towards the mainstream from the periphery. In comparison with the past, whale shark tourism at Ningaloo now attracts more generalist tourists who place different preferences on the whale shark tourism experience. There is now a greater distribution of age groups; less skilled individuals; a higher tolerance to crowding; and a larger focus on the non-wildlife components of the experience. Furthermore, this article, discusses the pertinent management implications associated with this shift.

Authors: Catlin, J., Jones, T., and Jones, R.

Year: 2012

Title: Balancing commercial and environmental needs: licensing as a means of managing whale shark tourism on Ningaloo reef

Journal: Journal of Sustainable Tourism

Volume: 20

Issue: 2

Pages: 163-178

Abstract: This paper explores the creation, significance and progression of the licensing systems employed to regulate whale shark tourism at Ningaloo Marine Park. Since 1993 mandatory whale shark tour operator licences have been offered through an evolving competitive tender process. A content analysis of the evolution of licence requirements revealed a progression from a minimalist approach to one covering a full range of detailed and audited sustainability indicators. A tour operators' opinion survey was undertaken to understand

industry issues and the impacts of the regulatory licensing system. Operators cited the need for business planning and offering a quality experience as their main challenges. Issues included cost pressures from local and global competitors. Few saw their own activities as being an environmental issue, and few saw regulation procedures as an issue. It is argued that further refinement of the licensing system is required to put its operations into a transparent, science-based context, and to offer incentives for improvements to rise above basic compliance. An explicit consideration of the balance between environmental regulation and commercial sustainability is needed to create a situation of perpetual improvement and provide best outcomes for all stakeholders, including operators, the local economy, the environment and guests.

Authors: Catlin, J., Jones, T., Norman, B., and Wood, D.

Year: 2010

Title: Consolidation in a wildlife tourism industry: the changing impact of whale shark tourist expenditure in the Ningaloo coast region

Journal: International Journal of Tourism Research

Volume: 12

Issue: 2

Pages: 134-148

Abstract: In this paper, Catlin and colleagues examine the expenditure of whale shark tour participants at Ningaloo Marine Park, Western Australia; the location of the world's first whale shark tourism industry, established in 1989. They demonstrate that in 2006, participants' expenditure in the region was \$894 per trip, total expenditure was \$6.0 million (all figures are in Australian dollars), and between \$2.4 and \$4.6 million would have been lost to the region if whale shark tourism did not exist. Their measure of participants' expenditure is substantially lower than the calculation of \$2370 per participant from a previous study of whale shark tourists using data collected in 1995. The authors argue that this is consistent with a change in the types of wildlife tourists that participate in an activity as the industry reaches the point of consolidation. The results also suggest that using old data to forecast wildlife tourists' expenditure needs to take into account the industry's stage of development.

Authors: Chapman, B. K., and McPhee, D.

Year: 2016

Title: Global shark attack hotspots: Identifying underlying factors behind increased unprovoked shark bite incidence

Journal: Ocean & Coastal Management

Volume: 133

Issue: -

Pages: 72-84

Abstract: Unprovoked shark bite remains a rare, unlikely occurrence; however, shark bite incidence is increasing world-wide. In an effort to understand why shark bite incidence is increasing, Chapman and McPhee examine recent trends in unprovoked shark bite statistics and other media from the six global shark bite “hotspots”, the United States, South Africa, Australia, Brazil, Reunion Island and the Bahamas, and review recent literature that identifies potential causative factors that may contribute to rising shark bite incidence. Increases in shark bite incidence are likely attributable to rises in human population, as well as other causative factors, including habitat destruction/modification, water quality, climate change and anomalous weather patterns and the distribution/abundance of prey. Chapman and McPhee’s analysis shows that increases are likely the result of a set of conditions that disrupts the natural balance

of an area at a local or regional level and increases the probability of shark-human interaction. The authors also present recommendations for future management of shark-human interaction.

Authors: Cisneros-Montemayor, A. M., Barnes-Mauthe, M., Al-Abdulrazzak, D., Navarro-Holm, E., and Sumaila, U. R.

Year: 2013

Title: Global economic value of shark ecotourism: implications for conservation

Journal: Oryx

Volume: 47

Issue: 3

Pages: 381-388

Abstract: Amid declining shark populations because of overfishing, a burgeoning shark watching industry, already well established in some locations, generates benefits from shark protection. The authors compile reported economic benefits at shark watching locations and use a meta-analytical approach to estimate benefits at sites without available data. Results suggest that, globally, 590.000 shark watchers expend > USD 314 million per year, directly supporting 10.000 jobs. By comparison, the landed value of global shark fisheries is currently c. USD 630 million and has been in decline for most of the past decade. Based on current observed trends, numbers of shark watchers could more than double within the next 20 years, generating > USD 780 million in tourist expenditures around the world. This supports optimistic projections at new sites, including those in an increasing number of shark sanctuaries established primarily for shark conservation and enacted in recognition of the ecological and economic importance of living sharks.

Authors: Clua, E. E., and Torrente, F.

Year: 2015

Title: Determining the role of hand feeding practices in accidental shark bites on scuba divers

Journal: Journal of Forensic Science & Criminology

Volume: 3

Issue: 5

Pages: hal-01238771

Abstract: Shark-based ecotourism is significantly developing around the world, often without appropriate management of risk. This activity involves a risk of accidental bites on divers that can be quite severe or even fatal. To determine if ecotourism companies' liability can be engaged in the context of bites on scuba divers in presence of hand-feeding practices, supporting the legitimacy of financial compensation for the victims. Clua and Torrente analysed the development from the mid-eighties to 2010 of shark-based ecotourism through artificial provisioning practices in Moorea Island (French Polynesia) and more specifically the features and motivation of two bites on divers by Sicklefin Lemon sharks. The specific practice of hand-feeding can be considered as a facilitating factor for accidental bites on divers, potentially involving the diving operator's responsibility. The authors contend that their findings should support the technical work of experts that might be called in such cases.

Authors: Coghlan, A., Fox, K. R., Prideaux, B., and Lück, M.

Year: 2017

Title: Successful interpretation in Great Barrier Reef tourism: Dive in or keep out of it?

Conference Name: The 6th International Congress on Coastal and Marine Tourism: The spirit of Ubuntu: Connecting continents, places and people

Conference Location: Port Elizabeth, South Africa

Pages: 47-60

Abstract: Marine wildlife tourism has become one of the fastest growing tourism sectors. In the context of the Great Barrier Reef, it focuses on five types of activities: (i) “swim-with” programs, (ii) surface watching activities (whales and dolphins); (iii) diving (corals, sharks, etc), (iv) reef snorkelling trips and (v) glass bottom boat tours. It is proposed that management, product design and experience, and outcome will be different for each of these and not all findings within marine wildlife tourism are transferable between tourism types.

This paper looks at patterns of activities on the Great Barrier Reef (GBR), using visitor surveys (N=3407) collected in a four year study of GBR tourism. Results suggest that the most popular activity is snorkelling (75.5%), followed by swimming (46.2%) and glass bottom boat tours (43.6%). Divers made up a total of 25% of the sample. There were significant differences in the travel experiences and reef tour satisfaction ratings between respondents participating in different types of activities. Non-divers were less likely to have been to other reefs before, less motivated to visit the region to see the GBR, staff had a greater influence on their satisfaction, and they were more likely to say that interpretation during their experience changed their appreciation of the reef and their behaviour. Interpretation had the greatest influence on the behaviour and attitudes of respondents who had participated in a combination of activities, and these respondents also rated their satisfaction with the tour higher than other groups. The implications of the findings are discussed.

Author: Colangelo, J.

Year: 2015

Title: Diving beneath the surface: A phenomenological exploration of shark ecotourism and environmental interpretation from the perspective of tourists

Academic Department: Department of Communication

University: University of Ottawa

Thesis Type: Master of Arts

Abstract: Wildlife ecotourism is becoming a well-established industry due to its ability to contribute to local economies and the growing tourist demand for opportunities to observe endangered or rare species. Wildlife ecotourism is also recognised for its ability to provide free choice-learning settings for visitors, through the use of environmental interpretation programmes. The process of environmental interpretation is a communication phenomenon thought to hold the potential to contribute to conservation by educating and raising awareness amongst tourists about environmental issues. Using a qualitative phenomenological research design, this research examined the environmental interpretation programmes of great white shark ecotourism operators in Gansbaai, South Africa, from the perspective of tourists. Findings indicated that while tourists did not primarily choose to embark on shark tourism excursions to learn more about the species, many participants became slightly more informed about great whites and the surrounding environment after their experience. It was also found that most participants did not experience nervousness or fear when in the water with great whites, but instead felt an emotional connection and appreciation for the animal, causing a shift towards proconservation attitudes.

Authors: Corcoran, M. J., Wetherbee, B. M., Shivji, M. S., Potenski, M. D., Chapman, D. D., and Harvey, G. M

Year: 2013

Title: Supplemental feeding for ecotourism reverses diel activity and alters movement patterns and spatial distribution of the southern stingray, *Dasyatis americana*.

Journal: PLoS ONE

Volume: 8

Issue: 3

Pages: e59235

Abstract: Southern stingrays, *Dasyatis americana*, have been provided supplemental food in ecotourism operations at Stingray City Sandbar (SCS), Grand Cayman since 1986, with this site becoming one of the world's most famous and heavily visited marine wildlife interaction venues. Given expansion of marine wildlife interactive tourism worldwide, there are questions about the effects of such activities on the focal species and their ecosystems. The authors used a combination of acoustic telemetry and tag-recapture efforts to test the hypothesis that human-sourced supplemental feeding has altered stingray activity patterns and habitat use at SCS relative to wild animals at control sites. Secondly, they also qualitatively estimated the population size of stingrays supporting this major ecotourism venue. Tag-recapture data indicated that a population of at least 164 stingrays, over 80% female, utilised the small area at SCS for prolonged periods of time. Examination of comparative movements of mature female stingrays at SCS and control sites revealed strong differences between the two groups: The fed animals demonstrated a notable inversion of diel activity, being constantly active during the day with little movement at night compared to the nocturnally active wild stingrays; The fed stingrays utilised significantly ($p < 0.05$) smaller 24 hour activity spaces compared to wild conspecifics, staying in close proximity to the ecotourism site; Fed stingrays showed a high degree of overlap in their core activity spaces compared to wild stingrays which were largely solitary in the spaces utilised (72% vs. 3% overlap respectively). Supplemental feeding has strikingly altered movement behaviour and spatial distribution of the stingrays, and generated an atypically high density of animals at SCS which could have downstream fitness costs for individuals and potentially broader ecosystem effects. These findings should help environmental managers plan mitigating measures for existing operations, and develop precautionary policies regarding proposed feeding sites.

D

Author: Davis, D.

Year: 1998

Title: Whale shark tourism in Ningaloo Marine Park, Australia

Journal: Anthrozoös

Volume: 11

Issue: 1

Pages: 5-11

Abstract: Interactions between tourists and marine animals have become increasingly popular in recent years. Since 1993 a new tourism industry, based on swimming with whale sharks, has developed in Ningaloo Marine Park, off the coast of Western Australia. This is the only known, accessible place in the world where whale sharks congregate in significant numbers. Certain results from surveys of participants in the 'whale shark experience,' undertaken in 1995 and 1996, are reported, with a focus on management questions relating to human-to-shark separation distances, swimmers making contact with sharks, satisfaction with the experience, and the

numbers of swimmers in the water. While the rules on separation distances were changed between the years, statistical analyses indicate that satisfaction with the experience did not change ($F_{(1,671)}=1.25$, $p>0.05$). Resulting from the rule changes, swimmers did not get so close to sharks in 1996 ($F_{(1,671)}=273.41$, $p<0.05$), nor were they as concerned about the number of other people in the water ($F_{(1,671)}=16.10$, $p<0.05$). It is concluded that a simple change to the regulation on separation distances resulted in improved human experiences and potentially less interference with the animals.

Authors: Davis, D., Banks, S., Birtles, A., Valentine, P., and Cuthill, M.

Year: 1997

Title: Whale sharks in Ningaloo Marine Park: managing tourism in an Australian marine protected area

Journal: Tourism Management

Volume: 18

Issue: 5

Pages: 259–271

Abstract: The whale shark is the largest fish in the ocean. A tourism industry based on interacting with whale sharks has developed recently in Ningaloo Marine Park, off the coast of Western Australia. This is the only known, accessible place in the world where whale sharks congregate in significant numbers. Results from surveys of participants in the ‘whale shark experience’ are reported, with the experience found to be extremely satisfying for most consumers. Yet management questions relating to diver-to-shark separation distances, the appropriate number of operators, and the use of regulation, self-regulation and economic instruments, remain. The nexus between experiential aspects of the whale shark attraction and such management concerns is examined, and the usefulness of appropriate research in resolving management questions established. It is concluded that a judicious combination of management approaches is required to ensure the sustainable development of the whale shark tourism industry.

Authors: Davis, D., and Tisdell, C. A.

Year: 1999

Title: Tourist levies and willingness to pay for a whale shark experience

Journal: Tourism Economics

Volume: 5

Issue: 2

Pages: 161-174

Abstract: Swimming with whale sharks has become popular in the waters of Ningaloo Marine Park, Western Australia, since 1993. The Park is one of very few known and accessible places in the world where whale sharks congregate on a regular and predictable basis. Consumers' willingness to pay (WTP) to participate in the whale shark experience, and their willingness to contribute financially to the management of the resource might be important to the long-term sustainability of the industry. The Western Australian Department of Conservation and Land Management levies tourist operators A one dollar per passenger per day, and uses the funds collected for research, management and education about whale sharks. Surveys were undertaken to determine the willingness of participants to pay for their whale shark experience and to pay the levy. WTP for the experience was slightly below the amounts actually paid, while Japanese tourists indicated a lower WTP than did other tourists. Respondents indicated WTP a significantly higher levy than is presently charged ($t=-10.99$, $P < (1,0S)$). In a log lineal analysis the only significant effect on WTP the levy was ethnicity (Pearson chi-square =16.2473, $P < 0.0S$), with Japanese tourists again signalling lower WTP than other groups. It is concluded

that tourists are willing, via the payment of a transparent 'access fee', to contribute to the costs of sustainable management of the whale shark experience.

Authors: Dearden, P., Ziegler, J., and Rollins, R.

Year: 2017

Title: Perspectives on crowding at a provisioned whale shark site

Conference Name: The 9th International Congress on Coastal and Marine Tourism: Global challenges – local solutions

Conference Location: Gothenburg, Sweden

Pages: 41

Abstract: Perceived crowding is an important indicator of the social impacts of a given tourism activity and can be used to assess social carrying capacity for a site. Understanding why tourists are crowded is important for effective management, as it allows for targeted interventions. Research of perceived crowding in the marine environment has identified a number of variables that may affect tourists' levels of perceived crowding including number of other swimmers and boats, proximity of swimmers, level of experience, gender, and nationality. The goal of this study was to understand the relative importance of these factors in influencing perceived crowding at a 'swim-with' whale shark tourism site in the Philippines in order to inform management of this site.

A total of 295 surveys were distributed to whale shark tour participants in Oslob, Philippines, from April to June 2016, in order to assess perceived crowding at the site. Perceived crowding was assessed in terms of the number of other swimmers per shark, the number of boats per shark, and the number of boats total in the viewing area. Results were coded and analysed in SPSS version 21.

The social carrying capacity of this site ranged from overcapacity to greatly overcapacity, depending on the measure of perceived crowding used. Respondents who reported feeling crowded were significantly more likely to report that the number of swimmers, divers and boats reduced their enjoyment, as well as perceive problems with all snorkeler behaviours compared to those who did not feel crowded. Both nationality and specialisation were important factors in understanding crowding, while gender was not. Foreign tourists and specialists were significantly more likely to feel crowded than national tourists and generalists, respectively. Crowding played an important role in influencing tour experience. Tourists who felt crowded rated the tour significantly lower and were significantly less likely to recommend the tour. They were also significantly more likely to perceive tourism activities in Oslob as having negative impacts on the local community and whale sharks and be more supportive of management interventions compared to those who did not feel crowded.

Crowding is a serious problem in Oslob requiring immediate management intervention through limits on the number of people and boats allowed per shark. Special attention is needed for managing the experience of foreign tourists, who pay more for the whale shark experience and represent a growing tourist segment at this site, if sustainability is to be achieved.

Authors: Dearden, P., Topelko, K. N., and Ziegler, J.

Year: 2008

Title: Tourist interactions with sharks

Editors: J. Higham and M. Lück

Book Title: Marine wildlife and tourism management: Insights from the natural and social

City: Wallingford, United Kingdom

Publisher: CABI

Pages: 66-90

Abstract: The last 20 years have witnessed a remarkable change in attitudes towards sharks amongst those that are the most exposed to them, divers. From a conservation viewpoint, this has been very beneficial in that many locations around the world have now enacted shark conservation regulations in order to protect the subjects of the shark-watching industry. This rapid growth is well-demonstrated with the whale shark, where watching now occurs in some 18, mostly under-developed, countries where the income is sorely needed. However, in terms of management, the challenges are just beginning.

Author: Dicken, M. L.

Year: 2014

Title: Socio-economic aspects of the Sodwana Bay SCUBA diving industry, with a specific focus on sharks

Journal: African Journal of Marine Science

Volume: 36

Issue: 1

Pages: 39-47

Abstract: Understanding socio-economic aspects of the diving industry at Sodwana Bay, including data on participant motivation and expenditure, is crucial for the effective management of the St Lucia and Maputaland marine protected areas, South Africa. Between July 2011 and July 2012 a total of 59,553 dives were conducted by 15,780 divers (95% CI = 15,295–16,277). Data were collected by means of the administration of a semi-structured survey questionnaire to 750 dive participants. Participant responses indicated that the direct value of diving to the iSimangaliso Wetland Park was R75,484,784 (95% CI = R73,071,709–R78,682,514). A total of 1,000 Monte Carlo simulations were used to estimate confidence intervals. The majority of dives at Sodwana were on coral-covered sandstone reefs (95.2%), with shark diving accounting for only 4.8% of dives. Although sharks were not the primary attraction for divers to visit Sodwana, 84.2% of respondents stated that they were interested in shark diving and that more opportunities to dive with sharks would encourage them to revisit Sodwana more often. Attaching an economic value to sharks as a dive attraction to Sodwana and highlighting their potential for the growth of the dive industry may act as leverage for their protection against fishing within iSimangaliso.

Authors: Dicken, M. L. and Hosking, S. G.

Year: 2009

Title: Socio-economic aspects of the tiger shark diving industry within the Aliwal Shoal Marine Protected Area, South Africa

Journal: African Journal of Marine Science

Volume: 31

Issue: 2

Pages: 227-232

Abstract: Understanding socio-economic aspects of the tiger shark *Galeocerdo cuvier* diving industry, including information on participant expectations, experiences and expenditure, is

necessary for the effective management of the Aliwal Shoal Marine Protected Area on the east coast of South Africa. Between January and December 2007, a total of 2 133 tiger shark dives was conducted by 1 065 divers (95% CI = 946–1 198). Data were collected by means of the administration of a semi-structured survey questionnaire to 197 (18.6%) dive participants. Respondents indicated that the direct value of tiger shark diving to the Aliwal Shoal region was R12 405 274 (95% CI = R10 777 324–14 228 541). A total of 1 000 Monte Carlo simulations was used to estimate confidence intervals. On a ranking from one (poor) to five (excellent), the average participant response to overall quality of dive and standard of dive operator was 4.6 and 4.7 respectively. The majority of divers (98.0%) observed a tiger shark, at an average of four per dive. Although tiger sharks approached to an average distance of 1.6 m from divers, the majority (95.9%) felt safe and enjoyed the experience. The majority of interviewees (88.5%) supported the use of chumming for a closer ‘tiger shark experience’.

Author: Dobson, J.

Year: 2006

Title: Sharks, wildlife tourism, and state regulation

Journal: Tourism in Marine Environments

Volume: 3

Issue: 1

Pages: 15-23

Abstract: Research on the development of marine wildlife tourism has tended to focus on the growth and economic importance of the whale-watching industry and its management via self-regulation. However, a number of other species are also utilised as attractions by the marine wildlife tourism industry. There has been increased targeting of a range of, potentially aggressive, shark species as attractions. Areas, such as South Africa [the Great White Shark (*Carcharodon carcharias*)], Florida and the Caribbean [Tiger sharks (*Galeocerdo cuvier*), Bull sharks (*Carcharhinus leucas*), and Caribbean reef sharks (*Carcharhinus perezii*)] have developed shark-based tourism. This has raised numerous ethical objections, both anthropocentric and biocentric in nature, leading to the intervention by the state in the form of various regulatory frameworks. This article utilises a case study approach to assess the issues that surround the introduction of state regulation in South Africa and Florida in order to manage the shark-based tourism located there. The article highlights the complex issues facing those tasked with implementing state regulatory frameworks. It concludes that the difficult task of attempting to integrate issues of stakeholder involvement, enforcement, and the balancing of anthropocentric and biocentric concerns results in any framework only being able to be seen as a “best fit” solution for managing shark-based tourism.

Author: Dobson, J.

Year: 2008

Chapter Title: Shark! A new frontier in tourist demand for marine wildlife

Book Title: Marine wildlife and tourism management: Insights from the natural and social sciences

Editors: J. Higham, and M. Lück

Pages: 49-65

City: Wallingford, United Kingdom

Publisher: CAB International

Abstract: Shark! A word that can strike fear into the hearts of many people is synonymous with unseen monsters from the deep, crushing jaws and violent death. Yet it is also a word that is increasingly becoming associated with the marine wildlife tourism industry. Research into the development, impact and management of shark-based tourism has been limited and is certainly

not as well developed as that of research focusing on cetacean watching. This chapter will attempt to outline some of the key features of shark-based tourism, especially in terms of its potential management challenges and areas in need of further research.

Author: Dobson, J.

Year: 2011

Title: Towards a utilitarian ethic for marine wildlife tourism

Journal: Tourism in Marine Environments

Volume: 7

Issue: 3/4

Pages: 213-222

Abstract: Ethical issues in wildlife tourism have been the subject of increasing academic interest in recent years. This article begins by examining the issues that arise from extending moral consideration to animals through an exploration of the boundaries that can be drawn in order for a being to be considered part of the moral community. Issues of animal suffering during wildlife tours are then explored using catch and release sport fishing and aquaria as examples. Utilitarianism (with its emphasis on consequentialism, welfare, and ensuring the greatest good for interested parties) is then introduced and its potential to act as an ethical framework for marine wildlife tourism is considered and evaluated. The article concludes that although utilitarianism has certain weaknesses as an ethical philosophy, its consequentialist focus and its requirement that the interests of both human and animals involved in wildlife tourism interactions are given equal consideration, can help ensure that more balanced decisions are made regarding the distribution of benefits and costs that result from marine wildlife tours.

Author: Dudley, S. F. J.

Year: 1997

Title: A comparison of the shark control programs of New South Wales and Queensland (Australia) and KwaZulu-Natal (South Africa)

Journal: Ocean and Coastal Management

Volume: 34

Issue: 1

Pages: 1-27

Abstract: The shark control programmes of New South Wales (NSW), Queensland and KwaZulu-Natal (KZN) are compared in an attempt to determine whether the fishing effort applied in the KZN program could be reduced. The stated mechanism in all three programmes is to reduce shark numbers, and thereby the probability of an encounter between a shark and a bather. Large-mesh (50–60 cm stretched) gill nets are used in each programme, and in Queensland these are supplemented by baited drumlines. The number of standard (100 m net) net-days per protected (meshed) bathing area per month is about 26 in NSW, 57 in Queensland and 192 in KZN. There is a four-month closed season (i.e. no control measures) in winter in NSW, a six-week closed season at some Queensland beaches and no closed season in KZN. Despite these differences, the apparent successes of the programmes in reducing the total number of shark attacks recorded at meshed beaches are impressive and comparable. The same shark species are believed to have been responsible for most of the attacks in the three regions, these being the great white shark (*Carcharodon carcharias*), the bull shark (*Carcharhinus leucas*) and the tiger shark (*Galeocerdo cuvier*). After comparing factors such as the nearshore physical environment and trends in shark catch and catch rate, it is concluded that there is a case for reducing the number of nets in KZN.

Authors: Du Preez, M., Dicken, M., and Hosking, S. G.

Year: 2012

Title: The value of tiger shark diving within the Aliwal shoal marine protected area: a travel cost analysis

Journal: South African Journal of Economics

Volume: 80

Issue: 3

Pages: 387-399

Abstract: Using on-site survey data collected via the administration of a questionnaire to 197 respondents during the period stretching from January 2007 to December 2007 from the Aliwal Shoal Marine Protected Area, this study estimates and compares an ordinary least squares and two Poisson count data models of recreational tiger shark diving demand. The Poisson model corrected for endogenous stratification and truncation provided the best results. It was concluded that in 2007, the consumer surplus per person per tiger shark dive was R1,136, and the total consumer surplus per annum was R2,080,925.

F

Author: Farr, M., Stoeckl, N., and Beg, R. A.

Year: 2014

Title: The non-consumptive (tourism) 'value' of marine species in the Northern section of the Great Barrier Reef

Journal: Marine Policy

Volume: 43

Issue: -

Pages: 89-103

Abstract: This paper uses the Kristrom (logit) spike model to analyse contingent valuation (payment card) data from a study of 2180 domestic and international visitors taking reef trips to the Northern section of the Great Barrier Reef. It investigates: (a) their willingness to pay for a "100% guaranteed sighting" of several different marine species; and (b) the sensitivity of final estimates to various methodological issues. It finds that final estimates are particularly sensitive to questionnaire design, but that the ranking of species (from most to least 'valued') is robust across a range of methodological specifications. The most valued groups of species were (in order): whales and dolphins; sharks and rays; 'variety'; marine turtles; and finally large fish. Evidently, whale watching is not the only potentially lucrative source of tourism revenue; other marine species may be similarly appealing. These potential revenues need to be considered when making decisions about whether or not to conserve marine species.

Authors: Ferretti, F., Jorgensen, S., Chapple, T. K., De Leo, G., and Micheli, F.

Year: 2015

Title: Reconciling predator conservation with public safety

Journal: Frontiers in Ecology and the Environment

Volume: 13

Issue: 8

Pages: 412-417

Abstract: Global loss of predators calls for increased conservation of these crucial ecosystem components. However, large predators can also threaten public safety and adversely affect economic activities, creating conflicts between different public interests. In the ocean, although many shark species are facing worldwide declines, recorded instances of unprovoked attacks

by sharks on humans have been increasing, stirring public concern and generating radical policies such as culling. Ferretti and colleagues show that despite increasing records of white shark (*Carcharodon carcharias*) attacks in California, the individual attack risk for ocean users has decreased by >91% over a 63-year period (1950 to 2013). The decrease in risk could be explained by an undetected long-term shark population decline and/or changes in behaviour and spatial distribution of people and sharks, the latter possibly associated with the recovery of pinniped (*Phocidae* and *Otariidae*) populations. Promoting safer behaviours among human ocean users could prove orders of magnitude more effective than culling, while meeting the dual goal of improving public safety and conserving endangered marine predators.

Authors: Fetterplace, L. C., Gibbs, L. M., and Rees, M.

Year: 2018

Title: Data from: Shark meshing (bather protection) program, NSW, Australia: Catch and effort data 1950–2017

Publisher: *figshare*

Abstract: This downloadable dataset contains the total shark catch; catch of great white shark, tiger shark and whaler sharks; estimates of netting effort; and catch per unit effort (number of sharks per 100 net days) in the *Shark Meshing (Bather Protection) Program*, NSW, Australia for netting seasons 1950–2017.

Authors: Fitzpatrick, Abrantes, K. G., Seymour, J., and Barnett, A.

Year: 2011

Title: Variation in depth of whitetip reef sharks: does provisioning ecotourism change their behaviour?

Journal: Coral Reefs

Volume: 30

Issue: -

Pages: 569-577

Abstract: In the dive tourism industry, shark provisioning has become increasingly popular in many places around the world. It is therefore important to determine the impacts that provisioning may have on shark behaviour. In this study, eight adult whitetip reef sharks *Triaenodon obesus* were tagged with time-depth recorders at Osprey Reef in the Coral Sea, Australia. Tags collected time and depth data every 30 s. The absolute change in depth over 5-min blocks was considered as a proxy for vertical activity level. Daily variations in vertical activity levels were analysed to determine the effects of time of day on whitetip reef shark behaviour. This was done for days when dive boats were absent from the area, and for days when dive boats were present, conducting shark provisioning. Vertical activity levels varied between day and night, and with the presence of boats. In natural conditions (no boats present), sharks remained at more constant depths during the day, while at night animals continuously moved up and down the water column, showing that whitetip reef sharks are nocturnally active. When boats were present, however, there were also long periods of vertical activity during the day. If resting periods during the day are important for energy budgets, then shark provisioning may affect their health. So, if this behaviour alteration occurs frequently, e.g., daily, this has the potential to have significant negative effects on the animals' metabolic rates, net energy gain and overall health, reproduction and fitness.

G

Authors: Gallagher, A. J., and Hammerschlag, N.

Year: 2011

Title: Global shark currency: The distribution, frequency, and economic value of shark ecotourism

Journal: Current Issues in Tourism

Volume: 14

Issue: 8

Pages: 797-812

Abstract: Ecotourism represents a highly popularised activity which has exhibited global growth in recent years. In the present paper, Gallagher and Hammerschlag examine the distribution, frequency, and economic value of shark-based ecotourism operations worldwide. A total of 376 shark ecotour operations across 83 locations and eight geographic regions were identified. The authors describe the global and regional scope of the industry; determine the species utilised in shark ecotourism activities; and examine the recreational usage values of sharks. Further, they conducted a case study of a shark tourism operation based in South Africa by analysing 12 years of demographical and economical data, revealing increasing trends in the total number of customers served and cost per trip over the sampling period. The authors also compare consumptive and non-consumptive values of shark resources and discuss the potential research and conservation implications of the industry to sharks worldwide.

Authors: Gallagher, A. J., Vianna, G. M. S., Papastamatiou, Y. P., Macdonald, C., Guttridge, T. L., and Hammerschlag, N.

Year: 2015

Title: Biological effects, conservation potential, and research priorities of shark diving tourism

Journal: Biological Conservation

Volume: 184

Issue: -

Pages: 365-379

Abstract: Shark diving tourism is a burgeoning, global industry. The growing perception that sharks can be worth more alive for tourism than dead in a fish market has become one of the leading contemporary arguments for shark conservation. However, there still exists concern that many aspects of shark-related tourism (e.g., provisioning) may alter natural behaviours and foraging areas, as well as pose a threat to humans by associating people with food. These concerns are largely driven by the previously limited scientific knowledge regarding the effects of shark diving tourism on shark biology, the marine environment and human interactions. Here Gallagher and colleagues review and summarise previous research in these areas and evaluate the potential effects of dive tourism on shark behaviour, ecology and subsequent human dimensions. To assist the development of future research, they provide a set of research questions. Taken together, they authors conclude that under the right conditions and if done in a precautionary, responsible manner, shark diving can provide a net conservation benefit (i.e., garnering of protective measures, raising awareness, instilling a conservation ethic) for a handful of species.

Authors: Gallagher, A. J. and Huveneers, C. P M.

Year: 2018

Title: Emerging challenges to shark-diving tourism

Journal: Marine Policy

Volume: 96

Issue: -

Pages: 9-12

Abstract: Shark-diving tourism has become a global phenomenon and is widely promoted to contribute to pro-conservation attitudes by dispelling myths and exposing tourists to sharks in their natural habitat. It has also resulted in a stimulating scientific literature identifying pros and cons of practices, elucidating potential biological effects on associated species, and evaluating social implications. With the worldwide popularisation of shark tourism in recent years, a set of new challenges facing shark-diving tourism is starting to emerge. Gallagher and Huveneers offer their thoughts on four topics that have developed into challenges for shark-related wildlife tourism: animal welfare, ecological interactions, fitness and bioenergetics, and public safety. Their discussion primarily involves perspectives on white shark operations, and, to a lesser extent, whale shark tourism. The authors contend that their opinions do not necessarily reflect the most important issues to shark-diving tourism; instead, they suggest that they are timely and that this paper should be considered an ‘open letter’ to researchers and policy-makers. Consideration of emerging challenges to any field are important for adaptive management and as such will be of interest to operators and resource managers tasked with ensuring sustainable practices.

Authors: Gaspar, C., Chateau, O., and Galzin, R.

Year: 2008

Title: Feeding sites frequentation by the pink whipray *Himantura fai* in Moorea (French Polynesia) as determined by acoustic telemetry

Journal: Cybium

Volume: 32

Issue: 2

Pages: 153-164

Abstract: This study examines the frequentation of feeding sites by the pink whipray (*Himantura fai*) in the lagoon of Moorea (French Polynesia) from April 2005 to March 2006. Six multidirectional hydrophones (VEMCO VR 2) were deployed at 1.5-3 m depth in the North-western area of the Moorea lagoon in which two ray feeding sites were set up for tourism purposes in 1995 and 1999. The study area (1.9 km²) is part of a marine reserve created by the French Polynesian government in October 2004. Fourteen individuals (six males, eight females; disc width DW: 73-114 cm) were surgically implanted with individually coded ultrasonic transmitters (VEMCO V8-SC and V13-1H) and presence/absence data were collected for up to 340 days. One ray was never detected. Of the other 13 animals, seven (four males, three females) showed a maximum presence time on one feeding site (Sand bank) and four (one male, three females) favoured the other one (Motu); two rays (one male, one female) were detected less than 10% of their total detection time at either of the feeding sites. Both receivers located on the feeding sites detected all 12 individuals during the data collection period and detected a fish an average of 89% of the time daily, whereas the mean daily detection time of the other four receivers - located outside of any feeding area ranged from 27 to 60%. Only one ray was detected by all six receivers in the same day. The authors observed different frequentation patterns between individuals at each feeding site. Daily bimodal pattern related to feeding time is shown but with no correlation with tourist or feeding numbers. Rays show anticipation on feeding times (one or two hours before feeding hours) but they are conditioned and come on

sites with or without feeding activity occurring on the selected day. Even if the study suggests that site fidelity exists for 11 individuals out of 13, the long-term impact of feeding on ray behaviour, reproduction and health still needs to be explored.

Authors: Geldenhuys, L-L., van der Merwe, P., and Saayman, M.

Year: 2017

Title: Travel behaviour of shark cage diving and whale watching marine adventure participants

Conference Name: The 9th International Congress on Coastal and Marine Tourism: Global challenges – local solutions

Conference Location: Gothenburg, Sweden

Pages: 35

Abstract: Viewing and interacting with wildlife in their natural habitat has become an important component of the tourism industry. Marine animals are becoming an increasingly popular tourist attraction, especially sharks and whales. Humans are fascinated with these animals and want to have a close-up experience. The literature clearly indicates an increase in the interest of tourists towards marine adventure activities. What the literature is not clear about is the behaviour of these participants, referring specifically to travel motives, reasons for participation, and experiences when participating in marine adventure activities. If these concepts are known, marketing can be done more effectively. Gaining an understanding of why these participants partake in marine adventure activities, the industry can manage effectively and efficiently. Therefore, the aim of this research is to determine the travel behaviour of marine adventure activity participants in terms of shark cage diving and whale watching.

This study follows a quantitative, descriptive research approach. Quantitative methods are employed in the form of a survey, where questionnaires are administered to participants of shark cage diving and whale watching. This research is a work in progress. The results will be analysed using a factor analysis to determine the behaviour of participants, their travel motives, reasons for participation, and experiences. The profile of these tourists is anticipated to be mostly international who have never participated in similar activities before. The travel motives of tourists are expected to indicate that being educated about the marine wildlife is important, feeling of success gained through the activity and being close to marine wildlife. The research also revealed that majority of participants are willing to contribute to the conservation of marine wildlife (sharks and whales).

The results obtained from this research will be useful to improve the understanding of the marine adventure tourism market, development of marine adventure tourism participation guidelines, and best practices.

Authors: Geldenhuys, L-L., van der Merwe, P., and Saayman, M.

Year: 2019

Title: Determining the market for marine wildlife tourism in South Africa

Journal: African Journal of Hospitality, Tourism and Leisure

Volume: 8

Issue: 4

Pages: -

Abstract: Viewing and interacting with wildlife in their natural habitat has become an important component of the tourism industry. Shark cage diving and whale watching are two prominent activities in South Africa and are becoming an increasingly popular tourist attraction. Humans are fascinated with these animals and want to have a close-up experience. The literature clearly indicates an increase in the interest of tourists towards marine wildlife activities. The behaviour of these participants, referring specifically to the profile, reasons for participation, and experiences when participating in marine wildlife activities, needs clarification. If these

behaviours are known, marketing can be done more effectively. Gaining an understanding of why these participants join in marine wildlife activities, the industry can hopefully be managed more effectively and efficiently. Therefore, the purpose of this research is to determine the market of marine wildlife tourists in terms of shark cage diving and whale watching. Quantitative, descriptive methods are employed in the form of a survey, where questionnaires were administered to participants of shark cage diving and whale watching. The profile of these tourists is indicative of mostly international participants who have never participated in similar activities before, between the ages of 35 and 40 years. The motives of tourists to participate indicate that an experience, being educated about marine wildlife, the feeling of success gained through the activity and being close to marine wildlife are all important motivations for certain tourists. Six market segments have been identified, namely thrill seekers, thalassophiles (from the Greek ‘friends of the sea’), risk takers, adrenaline seekers, consorts and experience seekers (T2RACE). The results obtained from this research are hopefully going to be very useful for improving the understanding of the marine wildlife tourism market, development of marine wildlife tourism participation guidelines, and in enhancing quality of offerings and best practices.

Authors: Gibbs, L., Fetterplace, L., Rees, M., and Hanich, Q.

Year: 2019

Title: Effects and effectiveness of lethal shark hazard management: The *Shark Meshing (Bather Protection) Program*, NSW, Australia

Journal: People and Nature

Volume: 2019

Issue: -

Pages: 1-15

Abstract: ‘Shark attack’ presents a considerable social-environmental challenge. Each year a small number of people are injured or killed by shark bite. Concurrently, sharks and other marine life are subject to unprecedented anthropogenic pressures. Shark hazard management varies globally, but lethal strategies are common, with negative consequences for species and environments. Of particular concern are the effects for threatened species. Lethal strategies have recently come under criticism, based on the negative effects for marine life, effectiveness for human safety and inconsistency with contemporary values. Moves to improve both safety and conservation can be hindered by polarised debate. Gibbs and colleagues present a case study of the world’s longest-running lethal shark hazard management programme, the *Shark Meshing (Bather Protection) Program*, New South Wales, Australia. They take an interdisciplinary approach to bring into conversation factors that contribute to safety and conservation outcomes. To date, most research focuses on one or other of these areas. The authors seek to synthesise the factors that are not previously considered in relation to each other. The aims were to: (a) identify and critique the diverse factors that determine the outcomes of the programme; (b) assess the negative effects of the program for sharks and other marine life; and (c) assess the effectiveness of the programme for reducing threat of shark interactions. Gibbs and colleagues found that: (a) multiple social and environmental factors contribute to programme outcomes; (b) total shark numbers and populations of key target species – white shark (*Carcharodon carcharias*), tiger shark (*Galeocerdo cuvier*) and bull shark (*Carcharhinus leucas*) – have declined over the programme’s 80 years, as have a number of non-target species; (c) incidence of shark bite has declined since the programme’s introduction, but two external points warrant attention. First, key factors influencing the shark bite incidence are frequently overlooked, namely changing cultures of beach- and ocean-use, advances in beach patrol, and emergency and medical response. Second, the proportion of bites leading to fatality has decreased significantly in recent decades. Beach patrol and emergency response contribute to human

safety and well-being without the negative consequences of lethal strategies. As such, they offer a focus for future shark hazard management and research.

Authors: Gibbs, L., and Warren, A.

Year: 2015

Title: Transforming shark hazard policy: Learning from ocean-users and shark encounter in Western Australia

Journal: Marine Policy

Volume: 58

Issue: -

Pages: 116-124

Abstract: Killing sharks is a popular strategy for reducing risk for beach-goers and ocean-users. But the effectiveness of kill-based strategies is debated and the ecological and economic costs are high. In Western Australia the state government introduced new policy in 2012 in response to shark-related fatalities, to track, catch and destroy sharks deemed to pose an ‘imminent threat’ to beach-goers. This paper reports on a survey of Western Australia-based ocean-users, and pursues two aims: to develop an understanding of the experiences of ocean-users in encountering sharks; and to learn about the attitudes of ocean-users towards shark hazard management. The research finds that people encounter sharks often, without harm, and that most ocean-users adapt their practices in order to reduce personal risk. The majority of ocean-users oppose the kill-based elements of the new policy, and kill-based shark hazard management strategies more broadly. Rather, ocean-users strongly support further research and education focusing on shark behaviour and shark deterrents, and approaches that enable people to understand and accept risks associated with ocean use. These findings present opportunity to refocus debates about shark hazard management on non-lethal strategies in concert with better educating publics so they can make informed decisions about their ocean-based activities.

Authors: Gilbert, J., and Edney, J.

Year: 2017

Title: Shark Watch NSW: A local solution with global application

Conference Name: The 9th International Congress on Coastal and Marine Tourism: Global challenges – local solutions

Conference Location: Gothenburg, Sweden

Pages: 42

Abstract: Byron Bay, on the New South Wales (NSW) far north coast (Australia), is a popular tourist destination for both international and domestic visitors, and tourism is the main driver of the local economy. Almost three-quarters of visitors to Byron Bay list natural marine areas as one of the main reasons they visit, and more than three-quarters visit to go to the beach. As a meeting place for temperate and subtropical currents the area also attracts a huge diversity of marine wildlife throughout the year. Consistent with worldwide statistics, there has been a recent spike in human–shark interactions in the Byron Bay area. These interactions have been primarily attributed to juvenile/subadult white sharks, *Carcharodon carcharias*, which migrate north during the Austral winter into northern NSW and southern Queensland waters. This spike in interactions led to a climate of fear in sections of the community with some predicting a decline in tourism, and questions of how (or if) the problem should be ‘managed’ have divided the community.

In response, a community-initiated, volunteer organisation, Shark Watch NSW Inc, was established as an evidence-based, non-lethal alternative to current methods of mitigating human–shark interactions. The primary aim of Shark Watch is to provide a real-time warning system to alert ocean users to the presence of sharks. It is observer-based, and combines human

spotters and Unmanned Aerial Vehicles to detect shark activity in the vicinity of swimmers and surfers. The Shark Watch model was developed to capitalise on the positive aspects of human and drone surveillance, and overcome the respective limitations of each method by combining them.

Shark Watch is also a citizen science programme. Trained volunteers collect data on all marine wildlife activity, environmental conditions, and numbers and types of ocean users. This data assists in identifying factors that may contribute to increased shark activity. Shark Watch also has an educational component that aims to raise community awareness about shark biology, ecology and behaviour, and the local marine environment generally. This allows the community to make better-informed decisions about their use of local beaches. Byron Shire Council provided funding for the first Shark Watch crew. Shark Watch was chosen as Council's preferred mitigation strategy because it is a sustainable, cost-effective method. Shark Watch was developed for the community, by the community, and involves the community. It also allows the community to take ownership of the solution to this challenge. It is a successful model, and interest has grown for the programme to commence operations at a number of other locations.

The Shark Watch model was designed to operate at any location in Australia and internationally. As such, it provides a local solution to a global issue, and a local solution with global application.

Authors: Gore, M. L., Muter, B. A., Lapinski, M. K., Neuberger, L., and Van der Heide, B.

Year: 2011

Title: Risk frames on shark diving websites: Implications for global shark conservation

Journal: Aquatic Conservation Marine and Freshwater Ecosystems

Volume: 21

Issue: -

Pages: 165-172

Abstract: Decision-makers can leverage understanding about the human dimensions (HD) of shark conservation to inform more effective conservation action. Characterising risk frames on shark diving websites can provide insight about the HD of shark conservation and deepen understanding of the role of risk in influencing human relationships with wildlife. The objectives of the current study were to: (1) describe risk frames (e.g. victim, perpetrator) found on shark diving websites; (2) explore themes among and between risk frames; and (3) synthesise implications for conservation. Content among 53 websites was analysed in December 2008; 15% used only a perpetrator frame, 21% used only a victim frame, 36% used both frames and 28% used neither frame. Websites with a conservation link were more likely to use a victim frame ($T_{50.283}$, $P_{0.05}$). The occurrence of both frames on study websites speaks to the relevancy of applying risk-related thinking to shark conservation. This research highlights how risk frames are contextualised on selected shark diving websites. Integrated with understanding of the ecological processes surrounding sharks and their conservation, HD information such as that presented here can contribute to more effective shark conservation.

Author: Graham, R. T.

Year: 2003

Title: Behaviour and conservation of whale sharks on the Belize Barrier Reef

Academic Department: Environment Department

University: University of York

Thesis Type: Doctoral

Abstract: Populations of large pelagic migratory fish have declined steeply in the past two decades due to overexploitation. Efforts to manage or protect these species have been

constrained by their cryptic nature and a paucity of knowledge of their biology and behaviour. Conservation of migratory animals requires understanding of the movements of individual animals, populations and species. Whale sharks (*Rhincodon typus*), the main subject of this thesis, are large, planktivorous, highly mobile and pantropical, and their life history traits of late maturity, longevity and low fecundity make them vulnerable to overexploitation but little is known of their behaviour.

A five-year study of their behaviour in an unexploited population was undertaken on the Belize Barrier Reef between 1998 and 2003, in relation to a spatio-temporally predictable food source, in order to improve management and conservation. Whale sharks displayed strong diel, intra- and inter-seasonal fidelity to Gladden Spit, a particular site that hosts large seasonal aggregations of spawning snappers. The population of whale sharks at Gladden Spit is transient and composed primarily of juvenile males. Individuals measured a mean total length of 6.3 m \pm SD 1.7 m (range: 3.0 m to 12.7 m; error of \pm 0.50 m). Satellite pop-off tags revealed that the whale sharks were physiologically robust, being able to dive over 1000 m and withstand temperatures under 5°C possibly for orientation or to locate abundant sources of food. Diving behaviour displayed a strong circadian and circalunar component.

After feeding on cubera and dog snapper (*Lutjanus cyanopterus* and *L. jocu*) spawn at Gladden, sharks dispersed throughout the Belize Barrier Reef with directed movements of over 550 km recorded to the tip of the Yucatan Peninsula and east of the Bay Islands in Honduras. Whale sharks did not appear to aggregate at any of seven other documented fish spawning aggregation sites on the Belize Barrier Reef.

The mutton snapper (*L. analis*) fishery based at Gladden Spit experienced significant declines in catch per unit effort and size of fish caught between 2000 and 2002. Declines occurred despite a drop in the number of fishers fishing the spawning aggregation since the inception of the fishery. Whale sharks did not appear to prey on mutton snapper spawn and were unlikely contributors to the mutton snappers' decline. In 2002, whale shark encounter tourism brought US\$ 1.35 million to the Gladden Spit and Silk Cayes Marine Reserve communities, offering an economic alternative to the mutton snapper fishery. Patterns of whale shark movement and feeding behaviour indicated that the marine reserve boundaries encompassed the main spawning aggregation and whale shark feeding zones. Increased visitor and boat numbers to the marine reserve coincided with alterations in the spawning behaviour of aggregating snappers and consequently the visitation of whale sharks at Gladden Spit. Strong management directives and enforcement are needed at the marine reserve to check unregulated growth of tourism and thus minimise its impacts on the fish spawning aggregations and visiting whale sharks.

Authors: Gray, G. M. E., and Gray, C. A.

Year: 2017

Title: Beach-user attitudes to shark bite mitigation strategies on coastal beaches; Sydney, Australia

Journal: Human Dimensions of Wildlife

Volume: 22

Issue: 3

Pages: 282-290

Abstract: Common strategies to protect swimmers from unprovoked shark bite incidents on coastal beaches are controversial. Gray and Gray surveyed beach users on two Sydney beaches to gauge their knowledge and attitudes to current and topical shark bite mitigation strategies. Most interviewees (>55%) were aware that shark nets were deployed on each beach, and gave relatively strong (>60%) support for their use. In contrast, beach users were overwhelming against (>80%) the general culling of sharks, and also opposed (>70%) the strategy of catching and killing sharks following a shark bite incident. There was little difference between genders

in their attitudes to each strategy, but the oldest age category (51+) surveyed was generally most supportive of the lethal strategies. The results demonstrated the dichotomies in public attitudes to the different mitigation strategies, particularly passive versus active culling, and highlighted the need for greater public education for the development of socially acceptable solutions to shark hazards.

H

Authors: Hammerschlag, N., Gallagher, A. J., Wester, J., Luo, J., and Ault, J. S.

Year: 2012

Title: Don't bite the hand that feeds: assessing ecological impacts of provisioning ecotourism on an apex marine predator

Journal: Functional Ecology

Volume: 26

Issue: 3

Pages: 567-576

Abstract: There has been considerable debate over the past decade with respect to wildlife provisioning, especially resultant behavioural changes that may impact the ecological function of an apex predator. The controversy is exemplified by the shark diving industry, where major criticisms based on inference, anecdote and opinion stem from concerns of potential behaviourally mediated ecosystem effects because of ecotourism provisioning (aka 'chumming' or feeding). There is a general lack of empirical evidence to refute or support associated claims. The few studies that have investigated the behavioural impacts of shark provisioning ecotourism have generated conflicting conclusions, where the confidence in such results may suffer from a narrow spatial and temporal focus given the highly mobile nature of these predators. There is need for studies that examine the potential behavioural consequences of provisioning over ecologically relevant spatial and temporal scales. To advance this debate, Hammerschlag and colleagues conducted the first satellite telemetry study and movement analysis to explicitly examine the long-range migrations and habitat utilisation of tiger sharks (*Galeocerdo cuvier*) originating in the Bahamas and Florida, two areas that differ significantly with regards to the presence / absence of provisioning ecotourism. Satellite telemetry data rejected the behaviourally mediated effects of provisioning ecotourism at large spatial and temporal scales. In contrast, to the restricted activity space and movement that were hypothesised, geolocation data evidenced previously unknown long-distance migrations and habitat use for both tiger shark populations closely associated with areas of high biological productivity in the Gulf Stream and subtropical western Atlantic Ocean. The authors speculate that these areas are likely critically important for *G. cuvier* feeding forays and parturition. They concluded that, in the light of potential conservation and public awareness benefits of ecotourism provisioning, this practice should not be dismissed out of hand by managers. Given the pressing need for improved understanding of the functional ecology of apex predators relative to human disturbance, empirical studies of different species sensitivities to disturbance should be used to guide best-practice ecotourism policies that maximise conservation goals.

Authors: Hani, M. S., Jompa, J., Nessa, M. N., and White, A. T.

Year of Conference: 2019

Title: Behavioural analysis of manta ray tourists in Eastern Indonesia

Conference Name: IOP Conference Series: Earth and Environmental Science

Pages: 1-5

Abstract: Indonesia has several manta ray aggregation sites, including Nusa Penida, Komodo, and Raja Ampat. The popularity of manta ray watching tourism has attracted tourists to

Indonesia from around the world. Understanding tourist behaviour is vital in order to develop operational approaches and strategies for species protection and tourist satisfaction. The objectives of this study were to analyse tourist motivation, attitudes, preferences, and perceptions before, during, and after manta ray watching. Questionnaires were distributed during May-June 2018, involving 20 local operators and 43 respondents. The traveling patterns of manta tourists indicate that they rarely travel alone, most prefer one to three companions; they generally spent several days in the destination area, used a variety of lodging options, and selected nature as the primary reason for their visit. In Nusa Penida and Komodo, most tourists decided to go manta ray watching after arriving at their destination, in contrast to Raja Ampat. They spent a minimum of \$500 and up to more than \$1000 (excluding airfares). The Likert scale analysis shows three main factors affecting tourists' decision to go manta ray watching: to see manta rays in their habitat; to view an endangered species; and to interact with the fish. Specific attitudes and behaviours of manta ray tourists included: viewing manta rays from a distance; diving, and snorkelling encounters; visiting several manta locations; willingness to pay extra for species conservation; revisiting specific locations; following procedures/code of conduct. Favourite aspects enjoyed by tourists were manta ray morphology and swimming behaviour.

Authors: Haskell, P. J., McGowan, A., Westling, A., Mendez-Jimenez, A., Rohner, C. A., Collins, K., Rosero-Caicedo, M., Salmond, J., Monadjem, A., Marshall, A. D., and Pierce, S. J.
Year: 2015

Title: Monitoring the effects of tourism on whale shark *Rhincodon typus* behaviour in Mozambique

Journal: Oryx

Volume: 49

Issue: 3

Pages: 492-499

Abstract: The whale shark *Rhincodon typus* is a popular focal species in the marine tourism industry. The authors analysed 689 encounters with at least 142 individual sharks during 2008–2010 to assess their behaviour in the presence of swimmers at Tofo Beach, Mozambique. Sharks varied in size (estimated 3.0 – 9.5m total length) and the majority (74%) were males. The sharks displayed avoidance behaviours during 64.7% of encounters. Encounter duration decreased significantly, from 12 minutes 37s with undisturbed sharks to 8 minutes 25s when sharks expressed avoidance behaviours, indicating that interactions with tourists affected the sharks' short-term behaviour. However, during the 2.5-year study period the authors found no trend in the mean encounter duration, the overall expression of avoidance behaviour or the likelihood of an individual shark exhibiting avoidance behaviours. Potential effects of tourism may be mitigated by the non-breeding status and transient behaviour of sharks at this aggregation site

Authors: Hazin, F. H. V., and Afonso, A. S.

Year: 2014

Title: A green strategy for shark attack mitigation off Recife, Brazil

Journal: Animal Conservation

Volume: 17

Issue: 4

Pages: 287-296

Abstract: Shark attacks on humans have prompted the implementation of shark control programmes aiming at reducing local populations of potentially aggressive species using mostly gillnets. However, shark meshing produces ecological disturbances by inflicting severe mortality not only to sharks but also to several harmless, frequently endangered taxa, including

cetaceans, sirenians and chelonids. A different methodological approach to mitigate shark peril off Recife combines bottom longlining and drumlines with comparably better results. This region has been experiencing an abnormally high shark attack rate since 1992, but the protective fishing strategy was developed in 2004 only. Unlike traditional shark control programmes, the Shark Monitoring Program of Recife (SMPR) aims at removing dangerous sharks not from their populations but from the hazardous area instead, which is achieved by capturing, transporting and releasing sharks offshore. During eight years, the SMPR caught fish and turtles only and showed high selectivity for sharks compared with shark meshing. Target species comprised *carcharhinids* and *sphyrnids* and accounted for 7% of total catch. The fishing mortality of abundant taxa was generally low except for *Carcharhinus acronotus* and *Gymnothorax* spp., and protected species had ~100% survival. The shark attack rate diminished about 97% while fishing operations were being conducted ($W = 1108.5$, $P < 0.001$), whereas no-fishing periods and the period prior to the implementation of the SMPR had similar shark attack rates. Overall, the SMPR seems to be less detrimental than shark meshing strategies while clearly contributing for enhancing bather safety; thus, it may provide an effective, ecologically balanced tool for assisting in shark attack mitigation.

Authors: Hazin, F. H. V., Burgess, G. H., and Carvalho, F. C.

Year: 2008

Title: A shark attack outbreak off Recife, Pernambuco, Brazil: 1992-2006

Journal: Bulletin of Marine Science

Volume: 82

Issue: 2

Pages: 199-212

Abstract: An unprecedented series of shark attacks on humans off Recife, Pernambuco, Brazil within a 14-yr period from September 1992 to September 2006 resulted in 47 incidents, including 17 fatalities. A suite of biotic and abiotic factors was examined to determine commonality in the attacks. Surfers and body boarders were the group most affected with a majority of victims being young (< 20 yrs old) males. Attacks occurred predominantly in shallow water, close to shore at beaches lying on a narrow channel bordered by an adjacent reef. Attacks transpired year-round with peaks in July and were distributed daily from Thursday to Tuesday, with peak on Sundays and no attacks recorded on Wednesdays. The construction and growth of the Suape Port, located just to the south of Recife, has resulted in major environmental degradation and is likely to have played a role in the recent onset of shark attacks. Individuals of the species most often implicated in the attacks, the bull shark, *Carcharhinus leucas* (Müller and Henle, 1839), may have been displaced from preferred estuarine/ inshore habitats to the nearby Jaboatão River and the adjacent lagoon resulting in increased interaction with humans.

Authors: Huvneers, C., Rogers, P. J., Beckmann, C., Semmens, J. M., Bruce, B. D., and Seuront, L.

Year: 2013

Title: The effects of cage-diving activities on the fine-scale swimming behaviour and space use of white sharks

Journal: Marine Biology

Volume: 160

Issue: -

Pages: 2863–2875

Abstract: Wildlife tourism has become increasingly popular and is one of the fastest growing sectors of the tourism industry. A radio-acoustic positioning system was deployed to monitor the fine-scale movements of 21 white sharks (*Carcharodon carcharias*) and investigate the

effects of shark cage-diving activities on their swimming behaviour and space use. This study contributes towards improving our understanding of the complex relationship between wildlife tourism and its effects on sharks, and assesses how tourism targeting sharks affects behaviour at a finer spatial scale than previously investigated. This study demonstrated that shark cage-diving operators (SCDO) influenced the fine-scale three-dimensional spatial distribution and the rate of movement of white sharks at the Neptune Islands. White sharks stayed more than 30 m away from the SCDO on 21 % of the days detected, but spent a significant amount of time in close proximity to the SCDO on the remaining days. Individual variation was detected, with some sharks behaviourally responding to SCDO more than others. The degree of variation between individual sharks and the different levels of interaction (e.g. presence, proximity to SCDO, and consumption of tethered bait) highlights the complexity of the relationships between SCDO and the effects on sharks. To improve our understanding of these relationships, future monitoring of shark cage-diving operations requires proximity to SCDO to be recorded in addition to the presence within the area. Further work is needed to assess whether the observed behavioural changes would affect individual fitness and ultimately population viability, which are critical information to unambiguously assess the potential impacts of wildlife tourism targeting sharks.

Authors: Huveneers, C., Rogers, P. J., Semmens, J. M., Beckmann, C., Kock, A. A., Page, B., and Goldsworthy, S. D.

Year: 2013

Title: Effects of an electric field on white sharks: *In situ* testing of an electric deterrent

Journal: PLoS ONE

Volume: 8

Issue: 5

Pages: e62730

Abstract: Elasmobranchs can detect minute electromagnetic fields, $<1 \text{ nVcm}^{-1}$, using their ampullae of Lorenzini. Behavioural responses to electric fields have been investigated in various species, sometimes with the aim to develop shark deterrents to improve human safety. The present study tested the effects of the Shark Shield Freedom7™ electric deterrent on (1) the behaviour of 18 white sharks (*Carcharodon carcharias*) near a static bait, and (2) the rates of attacks on a towed seal decoy. In the first experiment, 116 trials using a static bait were performed at the Neptune Islands, South Australia. The proportion of baits taken during static bait trials was not affected by the electric field. The electric field, however, increased the time it took them to consume the bait, the number of interactions per approach, and decreased the proportion of interactions within two metres of the field source. The effect of the electric field was not uniform across all sharks. In the second experiment, 189 tows using a seal decoy were conducted near Seal Island, South Africa. No breaches and only two surface interactions were observed during the tows when the electric field was activated, compared with 16 breaches and 27 surface interactions without the electric field. The present study suggests that the behavioural response of white sharks and the level of risk reduction resulting from the electric field is contextually specific, and depends on the motivational state of sharks.

Authors: Huveneers, C., Meekan, M. G., Apps, K., Ferreira, L. C., Pannell, D., and Vianna, G. M.

Year: 2017

Title: The economic value of shark-diving tourism in Australia

Journal: Reviews in Fish Biology and Fisheries

Volume: 27

Issue: 3

Pages: 665-680

Abstract: Shark-diving is part of a rapidly growing industry focused on marine wildlife tourism. This study aimed to provide an estimate of the economic value of shark-diving tourism across Australia by comprehensively surveying the whale shark (*Rhincodon typus*), white shark (*Carcharodon carcharias*), grey nurse shark (*Carcharias taurus*), and reef shark (mostly *Carcharhinus amblyrhynchos* and *Triaenodon obesus*) diving industries using a standardised approach. A socio-economic survey targeted tourist divers between March 2013 and June 2014 and collected information on expenditures related to diving, accommodation, transport, living costs, and other related activities during divers' trips. A total of 711 tourist surveys were completed across the four industries, with the total annual direct expenditure by shark divers in Australia estimated conservatively at \$25.5 M. Additional expenditure provided by the white-shark and whale shark-diving industries totalled \$8.1 and \$12.5 M for the Port Lincoln and Ningaloo Reef regions respectively. International tourists diving with white sharks also expended another \$0.9 M in airfares and other activities while in Australia. These additional revenues show that the economic value of this type of tourism do not flow solely to the industry, but are also spread across the region where it is hosted. This highlights the need to ensure a sustainable dive-tourism industry through adequate management of both shark-diver interactions and biological management of the species on which it is based. This study also provides standardised estimates which allow for future comparison of the scale of other wildlife tourism industries (not limited to sharks) within or among countries.

I

Author: Indab, A. L.

Year: 2016

Title: Willingness to pay for whale shark conservation in Sorsogon, Philippines

Editors: N. Olewiler, H. A. Francisco, and A. J. G. Ferrer

Book Title: Marine and coastal ecosystem valuation, institutions, and policy in Southeast Asia

City: Singapore, Indonesia

Publisher: Springer

Pages: 93-128

Abstract: Societies continually make choices among various options that affect their welfare. Trade-offs are typically difficult to make especially in a developing country context where even the basic needs are sometimes hard to finance. It then becomes an empirical question whether people from a developing country perceive any benefit from what can be considered as a non-essential good like the preservation of certain endangered species and would therefore be willing to sacrifice certain things for it. Using contingent valuation methodology (CVM), this chapter sets out to determine if such benefit for whale shark preservation exists for developing country citizens, or if they are too poor to pay for conservation. The study was carried out in Sorsogon province where whale sharks are popularly known; the area is touted worldwide as having the largest congregation of the species during peak season. Various multivariate logit regression analyses were done to generate sensitivity analysis of the estimates prior to the

welfare value calculation. Sensitivity to payment designs was also tested through hypothesis testing. Survey results show that the people are aware and concerned about environmental issues, including the precarious condition of whale sharks in Sorsogon. They are not, however, able or willing to pay for the implementation of the Conservation Program because poverty, employment, and other economic concerns take precedence over environmental issues. Detailed observance of the entire CV exercise generated zero or close to zero welfare value. It is interesting to note that after an elaborate preparation, implementation, and analysis of CV data, results show zero or close to zero welfare values. The message is clear that with meagre available resources, people in a developing country like the Philippines are not willing to pay for the conservation of wildlife. Government, as it stands now, has limited budget to support basic services in supporting human life, hence, funding for species conservation is expectedly low. Financing of conservation programs, therefore, necessitates assistance from the international community. But be that as it may, there is also a lot at stake for the Philippines in ensuring the continuous existence of whale sharks and the country will do well to proactively explore alternative financing options for conservation.

J

Authors: Johnson, R. H., and Nelson, D. R.

Year: 1973

Title: Agonistic display in the gray reef shark, *Carcharhinus menisorrah*, and its relationship to attacks on man

Journal: Copeia

Volume: 1973

Issue: 1

Pages: 76-84

Abstract: An agonistic display directed primarily toward divers was observed on 23 occasions in *Carcharhinus menisorrah* at Eniwetok Atoll, Marshall Islands, during January 1971. This display was filmed in normal speed and slow motion and found to consist of two locomotor elements: [1] laterally exaggerated swimming, and [2] rolling and/or spiral looping, and four postural elements: [1] lifting of the snout, [2] dropping of the pectoral fins, [3] arching of the back and [4] lateral bending of the body. This behaviour was found to occur under approach-withdrawal conflict situations, and rapid diver approach was shown to be a releasing stimulus. It was a graded phenomenon with the most intense displays occurring when there was maximum escape-route restriction and when diver aggression was initiated while the shark was approaching rather than lateral or departing. Under the circumstances in which it was observed, this display probably expressed defensive threat. It appeared ritualised in nature and is likely to be of value in normal social encounters. This display has been related to attacks on man and may indicate a motivational basis other than feeding for such attacks.

Authors: Johnson, R. L. and Kock, A.

Year: 2006

Title: South Africa's White Shark cage-diving industry - is their cause for concern?

Journal: WWF South Africa Report Series

Volume: 2006/Marine/001

Issue: -

Pages: -

Abstract: This paper presents a review on recent research examining the white shark cage diving industry in South Africa. In particular Johnson and Kock cover the controversial

'conditioning' debate and whether humans face an increased danger due to the industry's operation protocol. Key findings of this review include: White sharks travel between cage diving sites at Mossel Bay, Gansbaai and False Bay. Therefore, concerns regarding the impacts cage diving may have on white shark/human interactions should be assessed at a 'South African', rather than 'region specific' level. Conditioning can only arise if white sharks gain significant and predictable food rewards. Thus, conditioning will only arise if operators intentionally and wilfully contravene current permit regulations prohibiting intentional feeding of sharks. On rare occasions, indications of positive conditioning have been observed at Mossel Bay (four sharks). Evidence exists that adherence to permit regulations and infrequent or no feeding of sharks does not promote conditioning, and may in fact cause sharks to temporally ignore chumming vessels. It is highly improbable that the 'conditioning of sharks' to a cage diving vessel would increase danger to human water users such as swimmers, surfers, scuba divers and kayakers. This is due to visual and olfactory dissimilarity of these humans to the conditioned neutral stimulus (i.e. the cage diving vessel and associated structures). However, even if the public perceive an 'increase in danger', this will have a negative effect on the (1) conservation status of white sharks in South Africa, (2) the perceived safety of beaches in the Western Cape, and (3) the long term viability of the cage diving industry. Conditioning controversy remains relevant due to some operators contravening permit conditions and intentionally feeding sharks. This state has arisen due to operators working in a consequent free environment where client expectation is high. The failure of DEAT to timely issue permits has exacerbated the non-compliant environment. Recent action by DEAT with regard to extreme contraventions of regulations (e.g. chumming adjacent to swimming beaches), must be extended to include all breaches of permit conditions, including the intentional feeding of sharks.

Authors: Jones, T. Wood, D., Catlin, J., and Norman, B.

Year: 2009

Title: Expenditure and ecotourism: Predictors of expenditure for whale shark tour participants

Journal: Journal of Ecotourism

Volume: 8

Issue: 1

Pages: 32-50

Abstract: Whale shark tourism is an icon industry in Western Australia and a prominent example of successful ecotourism. In 2006, whale shark tour participants spent \$6.0 million in the Ningaloo Coast region of Western Australia and added between \$2.4 million and \$4.6 million to the regional economy in direct expenditure. However, to date no research has been conducted on the predictors of whale shark tour participants' expenditure. In this article, Jones and colleagues assess the importance of visitor expenditure for ecotourism, assess the predictors of the expenditure of whale shark tour participants and discuss how this information can contribute towards ecotourism goals. The data analysed here were collected through a survey distributed to participants between April and June 2006. The authors assess a range of variables for their relationship to individual expenditure per trip and determine that the duration of stay, household income, age, staying in a hotel, trip motivation and being from North America or Southeast Asia positively correlate with individual expenditure per trip. Group size and originating from Germany or the United Kingdom and Ireland negatively correlate with expenditure. In addition to identifying future steps, Jones and colleagues also discuss the relevance of their finding that more motivated participants have a higher expenditure for ecotourism.

K

Authors: Kelly, C., Glegg, G. A., and Speedie, C. D.

Year: 2004

Title: Management of marine wildlife disturbance

Journal: Ocean & Coastal Management

Volume: 47

Issue: 1-2

Pages: 1-19

Abstract: In recent years, concerns have been raised about the health and status of a range of marine species in UK waters, including the bottlenose dolphin (*Tursiops truncatus*) and basking shark (*Cetorhinus maximus*). Disturbance and harassment from increasing inshore leisure traffic and a fascinated public have been identified as potential threats to these large marine species. This concern is coupled with a legislative framework that is perceived to be less effective in protecting key species than it could be, and difficult to enforce. This study examined the extent of anthropogenic disturbance to a range of marine wildlife in inshore waters around the South West peninsula and investigated people's knowledge of existing legislation and its perceived suitability. The results revealed a low level of reported incidents and a lack of awareness of marine protection legislation amongst all sectors. Confusion over the reporting process, roles and responsibilities was also identified. This study therefore recommends widespread promotion of the provisions of existing legislation, coupled with a more integrated approach between organisations involved in the management of the marine environment. It also highlights the availability of a range of management options including education and codes of practice.

L

Authors: Lagabrielle, E., Allibert, A., Kiszka, J. J., Loiseau, N., Kilfoil, J. P., and Lemahieu, A.

Year: 2018

Title: Environmental and anthropogenic factors affecting the increasing occurrence of shark-human interactions around a fast-developing Indian Ocean island

Journal: Scientific Reports

Volume: 8

Issue: 3676

Pages: -

Abstract: Understanding the environmental drivers of interactions between predators and humans is critical for public safety and management purposes. In the marine environment, this issue is exemplified by shark-human interactions. The annual shark bite incidence rate (SBIR) in La Réunion (Indian Ocean) is among the highest in the world (up to one event per 24,000 hours of surfing) and has experienced a 23-fold increase over the 2005–2016 period. Since 1988, 86% of shark bite events on surfers involved ocean-users off the leeward coast, where 96% of surfing activities took place. Lagabrielle and colleagues modelled the SBIR as a function of environmental variables, including benthic substrate, sea temperature and period of day. The SBIR peaked in winter, during the afternoon and dramatically increased on coral substrate since the mid-2000s. Seasonal patterns of increasing SBIR followed similar fluctuations of large coastal shark occurrences (particularly the bull shark *Carcharhinus leucas*), consistent with the hypothesis that higher shark presence may result in an increasing likelihood of shark bite events. Potential contributing factors and adaptation of ocean-users to

the increasing shark bite hazard are discussed. This interdisciplinary research contributes to a better understanding of shark-human interactions. The modelling method is relevant for wildlife hazard management in general.

Authors: Lapinski, M., Neuberger, L., Gore, M. L., Muter, B. A. and Van Der Heide, B.

Year: 2013

Title: Shark bytes: message sensation value and emotional appeals in shark diving websites

Journal: Journal of Risk Research

Volume: 16

Issue: 6

Pages: 733-751

Abstract: Websites designed to promote risky activities provide a novel context for studying the role of emotional appeals and message sensation value (MSV) in risk messages in order to ultimately understand the type of messages that motivate people to engage in risk behaviours. Framed in theories of message design and emotion, this study investigates representations of threat, efficacy, and the extent to which risk messages appeal to a range of positive and negative emotions through the examination of 53 shark diving websites using content analysis and computer-generated linguistic analysis. Results indicate that few websites provide explicit threat information (i.e. severity and susceptibility) but many do present implicit threats. Efficacy-related messages were present on all websites. Positive emotion was more common than negative emotion and there is little representation of the traditional components of MSV. Implications for theory development and communication about risk-seeking are addressed.

Authors: Laroche, R. K., Kock, A. A., Dill, L. M., and Oosthuizen, W. H.

Year: 2007

Title: Effects of provisioning ecotourism activity on the behaviour of white sharks, *Carcharodon carcharias*

Journal: Marine Ecology Progress Series

Volume: 338

Issue: -

Pages: 199-209

Abstract: Ecotourism operations which provide food to large predators have the potential to negatively affect their target species, by conditioning them to associate humans with food, or by generally altering their behavioural patterns. This latter effect could have potentially detrimental consequences for the ecosystem inhabited by the predator, because any behavioural changes could affect the species with which they interact. Laroche and colleagues present the results of an experimental study conducted from June to October 2004, which examined the effects of provisioning ecotourism on the behaviour of white sharks around a seal colony on a small island in South Africa. Although ecotourism activity had an effect on the behaviour of some sharks, this was relatively minor, and the majority of sharks showed little interest in the food rewards on offer. It is unlikely that conditioning would occur from the amount of ecotourism activity tested, because even those sharks identified supplying most of the data presented here (which may be more strongly predisposed towards conditioning, as their persistence around the boat is what allowed them to be identified) showed a nearly ubiquitous trend of decreasing response with time. Furthermore, even the sharks frequently acquiring food rewards typically stopped responding after several interactions. Consequently, moderate levels of ecotourism probably have only a minor impact on the behaviour of white sharks, and are therefore unlikely to create behavioural effects at the ecosystem level.

Authors: Lemahieu, A., Blaison, A., Crochelet, E., Bertrand, G., Pennober, G., and Soria, M.

Year: 2017

Title: Human-shark interactions: The case study of Reunion island in the south-west Indian Ocean

Journal: Ocean & Coastal Management

Volume: 136

Issue: -

Pages: 73-82

Abstract: An uncommon series of shark attacks, mostly involving surfers, occurred on the West coast of Reunion Island between 2011 and 2013, causing eight deaths. Following these events, which resulted in social, economic and political upheaval, and referred to as the "shark crisis", a scientific program with the aim of understanding shark behaviour and ecology in Reunion Island was launched in 2012. It integrated spatial and temporal monitoring protocol of coastal uses allowing for the study of shark attack repercussions on the dynamics of 15 types of uses. In this paper, Lemahieu and colleagues bring shark and users observations together in order to assess human-shark interactions. Firstly, they assess the impacts that shark attacks have triggered in terms of users spatiotemporal distribution between 2011 and 2013. Secondly, the authors explore human-shark interactions in 2013 using cross-mapping techniques. Results show that three areas (*Saint-Gilles, Trois-Bassins, Etang-Salé*) have high levels of potential interaction and should be of high interest for the local authorities and stakeholders for further mitigation policies. Although further studies are needed to better understand the link between shark presence and shark attack, this study provides a first insight into human-shark interactions in Reunion Island.

Authors: Lester, E., Speed, C., Rob, D., Barnes, P., Waples, K., and Raudino, H.

Year: 2019

Title: Using an electronic monitoring system and photo identification to understand effects of tourism encounters on whale sharks in Ningaloo Marine Park

Journal: Tourism in Marine Environments

Volume: 14

Issue: 3

Pages: 121–131

Abstract: In-water shark-based tourism is growing worldwide and whale sharks (*Rhincodon typus*) are one of the most popular targets of this industry. It is important to monitor tourism industries to minimise any potential impacts on target species. At Ningaloo, Western Australia, Electronic Monitoring Systems (EMS) have been installed on licensed tour vessels to collect information on encounters between snorkelers and whale sharks. This study combined data from the EMS with whale shark identification photographs, to assess the impact of in-water tourism on the encounter duration for individual sharks. During 2011 and 2012, 948 encounters with 229 individual sharks were recorded using EMS. Encounter durations between whale sharks and tourism vessels ranged between 1 and 59 min (mean = 11 min 42 s, $SD \pm 11$ min 19 s). The authors found no evidence for a decline in encounter duration after repeated tourist encounters with individual sharks. Encounter duration varied among tourism operator vessels and were shorter when the sex of the whale shark could not be identified. Given that individual sharks were swum with on average 2.4 times per day ($\pm SD$ 2.08), and up to 16 times over the course of the study, our results suggest that there is no evidence of long-term impacts of tourism on the whale sharks at Ningaloo. However, the inclusion of well-defined categories of whale shark behaviours and information regarding how interactions between tourists and whale sharks end will complement the data already collected by the EMS. This preliminary investigation

demonstrates the potential for the EMS as a data resource to better understand and monitor the impacts of tourism interactions on whale sharks.

Authors: Lewis, A., and Newsome, D.

Year: 2003

Title: Planning for stingray tourism a Hamelin Bay, Western Australia: The importance of stakeholder perspectives

Journal: International Journal of Tourism Research

Volume: 5

Issue: -

Pages: 331-346

Abstract: Stingray tourism continues to be developed at various locations around the world with the concept being marketed on television travel programmes, documentaries, internet sites and travel brochures. Food provisioned stingray tourism, for example, now attracts some 100,000 visitors a year to ‘stingray city’ in the Cayman Islands. At Hamelin Bay in southwest Western Australia, up to 16 large stingrays (*Dasyatis brevicaudata* and *Dasyatis thetidis*) and numerous eagle rays (*Myliobatis australis*) are fed by visitors from the water’s edge. This study reports on stakeholder perspectives relating to tourism development and potential management of the Hamelin Bay site. From the results of this study it is clear that there is sufficient interest in stingray tourism (by all the stakeholders surveyed) to develop Hamelin Bay as a permanent feeding site. Visitors on average gave their experience with the rays a satisfaction value of 8.9 out of 10. Twentyfive per cent of visitors surveyed did not want commercialisation, tour groups or excessive visitor numbers. Their main concern was that the health and safety of the rays may deteriorate with an increase of visitors if the situation is not managed correctly. Visitors desire to be educated about the rays, and how to best interact with them safely. Visitors also acknowledged that the site needs management through more signs, information and a management plan. Management for the site is therefore likely to be best implemented through the application of signage, development of guidelines/codes of conduct, protection of the rays and zoning the beach according to specific recreational purposes. Management regimes should also use various indicators to monitor the impacts of stingray tourism at Hamelin Bay.

Author: Lobel, P. S.

Year of Conference: 2008

Title: Diver eco-tourism and the behavior of reef sharks and rays – an overview

Conference name: The American Academy of Underwater Sciences 27th Symposium: Diving for Science 2008

Conference Location: Dauphin Island, AL, USA

Pages: -

Abstract: This paper addresses the issue of the expanding tourist dive industry that is focused on seeing sharks and other elasmobranchs. The two competing approaches involve baiting and feeding sharks and rays verses natural observations without feeding. In terms of shark feeding dive operations, there are two main questions: 1) How safe are divers on tourist operations that attract sharks and rays using bait? 2) How is the fish's behaviour and ecology being affected by this interaction? The broader issue is: what is the best practice in terms of conservation and ecology? The author offers some observations on shark behaviour and suggestions for future scientific research.

Authors: Lowe, J., and Tejada, J. F. C.

Year: 2019

Title: The role of livelihoods in collective engagement in sustainable integrated coastal management: Oslob Whale Sharks

Journal: Ocean & Coastal Management

Volume: 170

Issue: -

Pages: 80-92

Abstract: Livelihoods are a crucial factor in sustainable integrated coastal management and can bring big payoffs for people and coral reef resources but their role in encouraging collective engagement in management is not well understood. Dive tourism is often cited for its capacity to provide livelihoods to reduce reliance on coral reef resources, however, there is little evidence of its ability to achieve this goal. Lowe and Tejada use key stakeholder interviews with artisanal fishers, their community, local government and politicians and the sustainable livelihoods framework to study Oslob Whale Sharks, the most financially successful and controversial community-based dive tourism site in the world. Oslob Whale Sharks has generated income from ticket sales of approximately US\$18.4 m over five years. The authors found that Oslob Whale Sharks has created alternate livelihoods for 177 fishers, and diversified livelihoods throughout the community, reducing fishing effort and changing livelihood strategies away from reliance on coral reef resources. Livelihoods from Oslob Whale Sharks increase food security for fishers and their families and improve the wellbeing of their community. Livelihoods have galvanised fishers and their community to change behaviour and collectively engage in management. The findings indicate connection between livelihoods and the provision of finance to protect whale sharks and manage five marine reserves, indicating that fishers and local government are protecting the whale sharks and coral reef resources their livelihoods depend on.

Authors: Lowe, J., Tejada, J. F. C., and Meekan, M. G.

Year: 2019

Title: Linking livelihoods to improved biodiversity conservation through sustainable integrated coastal management and community based tourism: Oslob Whale Sharks

Journal: Marine Policy

Volume: 108

Issue: -

Pages: 103630

Abstract: Alternative livelihood projects are criticised as having minimal effect on biodiversity conservation. Studies are rare and where success is claimed, outcomes and reasons why projects work, have not been documented. Livelihoods are an essential element of sustainable integrated coastal management, an accepted framework for conserving coral reefs and marine resources in the tropics. It is not known whether alternative livelihood projects contribute to the goal of improving biodiversity conservation through sustainable integrated coastal management. Here, Lowe and colleagues examine Oslob Whale Sharks, an alternate livelihoods project in the Philippines built on provisioning whale sharks for community-based dive tourism. They investigate how Oslob Whale Sharks contributes to sustainable integrated coastal management and whether it has any effect on biodiversity conservation. Using key stakeholder interviews with artisanal fishers, their community, local politicians and government, the authors found that Oslob Whale Sharks contributes to all nine factors required for sustainable integrated coastal management. Fishers and local authorities report their perception that whale sharks are protected from poaching and finning and destructive fishing has decreased, while fish abundance, pelagic fish species and catch have increased. The findings further suggest that as

there is little evidence that this type of tourism has any negative impacts on the biology or behaviour of whale sharks, Oslob Whale Sharks provides sustainable livelihoods and a delivery mechanism for sustainable integrated coastal management.

Authors: Lucrezi, S., Bargnesi, F., and Burman, F.

Year: 2020

Title: “I would die to see one”: a study to evaluate safety knowledge, attitude and behaviour among shark scuba divers

Journal: Tourism in Marine Environments

Volume: Advance online publication

Issue: Advance online publication

Pages:

Abstract: Shark diving tourism is an activity that can contribute significantly to coastal economies, while also offering tremendous help to shark conservation efforts. Nevertheless, like any form of wildlife-based tourism, shark diving poses management challenges revolving around ethical and safety considerations. Safety in shark diving normally focuses on operational self-efficacy and adherence to shark diving codes of conduct to prevent incidents such as shark bites and minimise ecological harm. However, safety issues in shark diving can arise from personal choices to exceed standard certification limits. Any detrimental results are capable of casting doubts on the sustainability of shark diving, thus jeopardising its future as well as shark conservation. This study addressed compliance with shark diving codes of conduct and standard diving safety by examining the knowledge, attitude and behaviour of people who engage in free scuba diving with predatory sharks. The research made use of mixed methods of data collection, including interviews with shark divers at two popular shark diving destinations in Southeast Africa (n = 86) and an online questionnaire survey amongst shark divers (n = 89). The results showed that divers had positive attitudes towards sharks and shark diving. However, a notable proportion declared that they had exceeded certification limits and broken codes of conduct during shark diving. In particular, diving experience and being a professional diver were correlated significantly with poor safety attitudes and behaviour. The results highlight the need to create an understanding among scuba divers of the connection between shark diving safety and conservation, including the negative implications of safety breaches, whether big or small, for the future of shark diving tourism and of sharks.

Authors: Lucrezi, S., Gennari, E., and Ellis, S.

Year: 2019

Title: A test of causative and moderator effects in human perceptions of sharks, their control and framing

Journal: Marine Policy

Volume: 109

Issue: -

Article Number: 103687

Abstract: Sharks have historically suffered from a negative image, which has been indirectly fuelling public fear and government decisions to kill sharks, as part of bather protection programmes in various countries. Scientists are arguing, however, that the public opinion of sharks is increasingly positive, and that opposition to lethal shark control and to negative shark framing is growing. Positive attitudes and behaviour towards sharks tend to be influenced by an array of factors, which ought to be considered in studies aimed at effectively steering shark conservation actions. This study used a questionnaire survey of 1138 beach visitors in South Africa, together with structural equation modelling, to investigate human perceptions of sharks, and their influence on outcome variables including attitudes and behaviour towards shark

hazard mitigation and shark framing. The results show that basic knowledge and attitudes towards sharks have a significant effect on the outcome variables. Additionally, attitudes towards sharks moderate the effect of perceived risk from sharks on the outcome variables. The results support arguments of public concern for sharks, and provide guidance for strategies aimed at garnering more support for shark conservation.

M

Authors: Macdonald, C., Gallagher, A. J., Barnett, A., Brunnschweiler, J., Shiffman, D. S., and Hammerschlag, N.

Year: 2017

Title: Conservation potential of apex predator tourism

Journal: Biological Conservation

Volume: 215

Issue: -

Pages: 132-141

Abstract: In recent decades, public interest in apex predators has led to the creation and expansion of predator-focused wildlife tourism. As wildlife tourism has become an increasing topic of study for both social and biological scientists, researchers have debated whether these activities serve conservation goals by providing non-consumptive values for wildlife. Discussion of predator tourism requires additional recognition of predator-specific biological and ecological characteristics, consideration of human safety concerns, and mitigation of human-wildlife conflict. By reviewing tourism activities centred on both aquatic and terrestrial predators from diverse taxa (sharks, crocodiles, and big cats), Macdonald and colleagues evaluate the potential benefits and conservation challenges associated with predator tourism. Their review suggests that positive conservation outcomes are possible, but not assured given historical, cultural, and ecological complexities. The authors explore some of the factors which determine whether tourism contributes to conservation outcomes, including (1) effective protection of animals and habitats, (2) avoidance and mitigation of human-wildlife conflict, (3) quality of associated educational interpretation and outreach, (4) collaboration with local stakeholders, and (5) use of generated funds to advance conservation goals. Their findings suggest tourism is most likely to support predator conservation and/or recovery when the industry has both public and political support and under conditions of effective regulation focused on management, monitoring and enforcement by local, national, and international bodies.

Authors: Maillaud, C., and Van Grevelinghe, G.

Year: 2005

Title: Attaques et morsures de requins en Polynésie française: Shark attacks and bites in French Polynesia

Journal: Journal Européen des Urgences/European Journal of Emergency Medicine

Volume: 18

Issue: 1

Pages: 37-41

Abstract: Maillaud and Van Grevelinghe report several shark attacks and bites which occurred in French Polynesia. This kind of accident seems to be more common in this country than in other French Indo-Pacific islands. In most of the cases the authors recorded, injuries were not major, and no death occurred. Sharks involved in these accidents were small or medium-sized fisheaters. Fish blood or flesh close to the victim while performing scuba diving with shark

feeding or spearfishing appears to have worked as a stimulus on sharks, and according to the data should be considered as a major factor of such accidents.

Authors: Maljković, A., and Côté, I. M.

Year: 2011

Title: Effects of tourism-related provisioning on the trophic signatures and movement patterns of an apex predator, the Caribbean reef shark

Journal: Biological Conservation

Volume: 144

Issue: 2

Pages: 859-865

Abstract: Wildlife provisioning, i.e. the provision of bait to generate aggregations of charismatic megafauna as tourist attractions, occurs around the world. This practice is often promoted as an economic incentive to conserve the focal species, yet has stimulated debate based on the potential for risks to human safety and perceptions of behavioural shifts in provisioned populations. The authors studied a population of Caribbean reef sharks (*Carcharhinus perezii*) in the Bahamas that has been subject to regular provisioning for >20 years. They used a combination of focal observations of sharks during feeding events, remote acoustic telemetry and stable isotope analysis of shark muscle tissue to determine the impacts of provisioning on the trophic signatures and ranging behaviour of sharks in this population. A small number of large sharks monopolised more than 50% of the bait on offer. These 'fed' individuals showed significant ^{15}N enrichment in their tissues compared to conspecifics of the same size that failed to obtain bait at the feeding site, and un-provisioned sharks from a control site. Despite the disparity in trophic signatures, fed, unfed and control sharks exhibited similar degrees of residency at their respective home receiver sites, and travelled similar daily minimum distances. Thus, despite long-term provisioning of this Caribbean reef shark population, there is no evidence for shifts in the behaviours considered which might affect the ecological role of these sharks. However, further research is required to examine potential indirect effects of shark provisioning on sympatric fauna and habitat before this activity can be placed within a sustainable marine conservation framework

Author: Martin, R. A.

Year: 2006

Title: A review of shark agonistic displays: Comparison of display features and implications for shark-human interactions

Journal: Marine and Freshwater Behaviour and Physiology

Volume: 40

Issue: 1

Pages: 3-34

Abstract: Agonistic displays in 23 species of sharks of six families are described and illustrated. These displays are reviewed in terms of ethological concepts and shark hydrodynamic models. Shark agonistic displays feature many common elements rendering them readily distinguishable from normal swimming and pseudodisplays caused by sharksucker irritation. Shark agonistic displays are most readily elicited by rapid, direct diver approach when food is absent and potential escape routes restricted. Such displays appear to be motivated by defence of self or the immediately surrounding space rather than defence of territory or resources. Costs and benefits of display versus attack in shark–shark and shark–diver contests are evaluated using payoff matrices and optimal strategies are identified. Shark–human interactions are modelled in terms of a system of nested critical approach distances. For divers faced with a displaying

shark, responses which may decrease the likelihood of defensive attack are suggested. Recommendations for future work on shark agonistic behaviour are offered.

Author: Mau, R.

Year: 2008

Title: Managing for conservation and recreation: The Ningaloo whale shark experience

Journal: Journal of Ecotourism

Volume: 7

Issue: 2/3

Pages: 213-225

Abstract: The Western Australian Department of Environment and Conservation has statutory responsibility for conservation, and commercial and recreational aspects of the Ningaloo Whale Shark Experience. The whale shark experience participation rate had grown by 150% since 1995. In this paper, the ability of the existing management programme to balance ecological, social and economic factors is reviewed. The Department has established a statutory Code of Conduct which applied equally to commercial and recreational users when interacting with whale sharks. The Code of Conduct for Whale Shark Interaction was developed to provide for an acceptable impact on the wildlife and a safe visitor experience. A restricted licensing regime was applied. Studies conducted to date indicate that any significant impact on the whale shark population is unlikely as a result of the tourism interactions at Ningaloo. Social surveys indicate a high level of satisfaction with all aspects of the whale shark experience. An education programme was implemented to cater for industry needs and a local, national and international audience. At this time, the Ningaloo Whale Shark experience may effectively be described as an ecologically sustainable wildlife tourism industry managed by a government conservation department based on non-consumptive use of wildlife.

Authors: McCagh, C., Sneddon, J., and Blanche, D.

Year: 2015

Title: Killing sharks: The media's role in public and political response to fatal human-shark interactions

Journal: Marine Policy

Volume: 62

Issue: -

Pages: 271-278

Abstract: In 2013–14 the Western Australian Government deployed drum lines to catch and kill sharks perceived to be a threat to public safety. This policy decision sparked considerable controversy and debate which played out in the media. There have been limited studies examining the role of media discourses in the development of shark management policies. This study shows that media reporting reflected the unidirectional correlation between the public and policy makers; while there appeared to be a correlation between public pressure and the decision to deploy drum lines, there was no association between the culling program and public support. The reflective role the media played in the drum line debate was evident in their use of prescriptive and emotive language about human–shark incidents, and the use of two opposing frames; anthropocentric and conservation. Combined, these results suggest that the public policy makers need to rethink their approach to developing shark hazard mitigation programs through ongoing, meaningful engagement with the general public, scientists and stake holders, if they wish to garner public support.

Author: McKay, T.

Year: 2020

Title: Locating great white shark tourism in Gansbaai, South Africa within the global shark tourism economy

Editors: J. M. Rogerson and G. Visser

Book Title: New directions in South African Tourism geographies

City: Basel, Switzerland

Publisher: Springer Nature

Pages: 283-297

Abstract: Great white shark (*Carcharodon carcharias*) tourism is a highly controversial, iconic niche form of shark tourism that forms part of the nature-based adventure tourism or wildlife tourism market. As such it straddles hard adventure, nature-based adventure as well as marine ecotourism. Great white shark cage diving tourism in South Africa started in the early 1990s and has expanded tremendously. The chance for people to observe and appreciate Great Whites, combined with opportunities to support local communities, along with focused educational initiatives means that this alternative to consumptive uses of wildlife could assist with the long-term preservation of sharks. In addition, it may have a positive impact on the attitudes, knowledge and behaviour of the public with respect to sharks. However, this type of ‘up close and personal’ wildlife tourism which involves ‘close encounters’ with wild animals and marketed as a type of ‘enhanced client experience’ is not unproblematic. The negative impacts on animals in general range from physiological stress; behavioural changes, as well as overall declines in health status, birth rates and even mortality. Thus, this type of wildlife tourism is highly controversial and cannot be left unmanaged. This chapter provides an overview of great white shark tourism around the world. It explores the geographical location of in-water great white shark tourism, and then locates the Gansbaai, South Africa industry within the international one. It concludes that South Africa offers a product that is significantly cheaper than any other location. It also hosts many more tourists. Nevertheless, the South African industry is a highly vulnerable one, with the loss of regular great white sightings between 2016 and 2018 taking a heavy toll on the industry.

Author: McPhee, D.

Year: 2014

Title: Unprovoked shark bites: Are they becoming more prevalent?

Journal: Coastal Management

Volume: 42

Issue: 5

Pages: 478-492

Abstract: An unprovoked shark bite is an extremely infrequent, but highly disturbing hazard for water sport participants in many parts of the world. Information was analysed on the total number of unprovoked shark bites between 1982 and 2011. In this period, unprovoked shark bites were recorded from 56 countries with 27 recording fatalities; however 84.5% occurred in only six countries - United States, Australia, South Africa, Brazil, Bahamas and Reunion Island. The three shark species commonly responsible for unprovoked bites are the white shark (*Carcharodon carcharias*), the tiger shark (*Galeocerdo cuvier*), and the bull shark (*Carcharhinus leucas*). Over the period examined, the total number of unprovoked shark bites and the number that were fatal increased in frequency. However, fatalities from unprovoked fatal shark bite still represented an infrequent hazard to people utilising the coastal zone for water-based leisure activities. The increase in unprovoked shark bites could not be explained entirely by increases in human population, and this article also concluded that changes in the population of relevant shark species were also unlikely to explain the increase. The paper

concluded that both natural and anthropogenic factors may change the amount of spatial overlap between relevant shark species and areas of human use.

Authors: McPhee, D. P., and Blount, C.

Year: 2014

Title: Unprovoked shark bites: Are they becoming more prevalent?

City/State: St Leonards, NSW, Australia

Institution: NSW Department of Primary Industries

Date: October

Abstract: While shark bite incidents are rare, they are extremely traumatic. To reduce the risk of shark bite incidents and fatalities, the New South Wales (NSW) government provides a suite of bather protection measures including:

- A shark meshing programme along 51 beaches between Wollongong and Stockton;
- The public awareness programme ‘SharkSmart’, designed to inform and educate water sports enthusiasts about ways to reduce the risk of a shark bite incident;
- A Shark Incident Response Plan, which provides a coordinated government response to shark related incidents;
- Grants to assist the construction of observation towers and provide associated shark-spotting equipment; and
- Research to investigate better ways to use aerial surveillance to provide additional bather protection during the peak beach activity season.

The NSW government is committed to a comprehensive approach to bather protection and is currently investigating emerging technologies for potential use off some ocean beaches in NSW, Australia to further reduce the chances of a shark bite incident. Cardno was commissioned by the NSW Department of Primary Industries (DPI) to undertake the first part of this process: an independent review of technologies currently available. This report presents the findings of the desktop review which was presented at a stakeholder workshop where a ‘short list’ of feasible technologies was discussed for possible trial off some NSW ocean beaches.

Authors: Meekan, M., and Lowe, J.

Year: 2019

Title: Does provisioning for tourism harm whale sharks at Oslob? A review of the evidence and reply to Ziegler et al. (2018)

Journal: Tourism Management

Volume: 75

Issue: -

Pages: 626-629

Abstract: Provisioning of whale sharks (*Rhincodon typus*) for tourism at Oslob in the Philippines is a controversial issue. Recent studies that claim negative impacts of this industry on the ecology of whale sharks are characterised by a lack of baselines, limited methodological approaches and poor interpretation of results. They do not provide robust evidence for management or for advocacy that seeks to prevent provisioning. Furthermore, these studies cannot be used to draw conclusions about the ethics of tourists visiting Oslob or the motivations of the local people running the tourism operation.

Authors: Meyer, C. G., Dale, J. J., Papastamatiou, Y. P., Whitney, N. M., and Holland, K. N.

Year: 2009

Title: Seasonal cycles and long-term trends in abundance and species composition of sharks associated with cage diving ecotourism activities in Hawaii

Journal: Environmental Conservation

Volume: 36

Issue: 2

Pages: 104-111

Abstract: Shark cage diving is both popular and controversial, with proponents citing educational value and nonextractive use of natural resources and opponents raising concerns about public safety and ecological impacts. Logbook data collected 2004–2008 from two Oahu (Hawaii) shark cage diving operations were analysed to determine whether such voluntary records provide useful insights into shark ecology or ecotourism impacts. Operators correctly identified common shark species and documented gross seasonal cycles and long-term trends in abundance of Galapagos (*Carcharhinus galapagensis*), sandbar (*Carcharhinus plumbeus*) and tiger sharks (*Galeorcerdo cuvier*). Annual cycles in shark abundance may indicate seasonal migrations, whereas long-term trends suggest gradual exclusion of smaller sandbar sharks from cage diving sites. Numerically dominant (>98%) Galapagos and sandbar sharks are rarely implicated in attacks on humans. Negligible impact on public safety is supported by other factors such as: (1) remoteness of the sites, (2) conditioning stimuli that are specific to the tour operations and different from inshore recreational stimuli and (3) no increase in shark attacks on the north coast of Oahu since cage diving started. Tracking studies are required to validate logbook data and to determine whether sharks associated with offshore cage diving travel into inshore areas used for in-water recreation.

Authors: Meyer, L., Pethybridge, H., Beckmann, C., Bruce, B., and Huveneers, C.

Year: 2019

Title: The impact of wildlife tourism on the foraging ecology and nutritional condition of an apex predator

Journal: Tourism Management

Volume: 75

Issue: -

Pages: 206-215

Abstract: Shark and ray tourism is growing in popularity and often necessitates attractants like bait and chum to encourage close encounters. Such practices remain contentious amongst stakeholders as they may affect the species they target. Meyer and colleagues used lipid and fatty acid profiles to investigate the effects of South Australia's cage-diving industry on the diet and nutritional condition of white sharks *Carcharodon carcharias* (n = 75). They found no evidence of dietary shifts or reduced nutritional condition after a >3 week period of tourism-exposed residency at the Neptune Islands where the cage-diving industry operates. White sharks fed on a variety of prey groups, similar to other populations around Southern Australia that are not exposed to ecotourism provisioning. These findings indicate that current cage-diving operations in South Australia do not alter white shark diet and nutritional condition where prey resources are abundant.

Authors: Murray, A., Garrud, E., Ender, I., Lee-Brooks, K., Atkins, R., Lynam, R., Arnold, K. Roberts, C. M., Hawkins, J., and Stevens, G.

Year: 2019

Title: Protecting the million-dollar mantas; creating an evidence-based code of conduct for manta ray tourism interactions

Journal: Journal of Ecotourism

Volume: Advance online publication

Issue: Advance online publication

Pages: Manta ray tourism is estimated to contribute US\$ 140 million annually to the global economy. The multitudes of tourists potentially disturb the animals, yet the effect of human behaviour on feeding manta rays has not been quantified. Using videos collected at feeding sites in the Maldives, Murray and colleagues found that only 44% of observed human-manta interactions complied with existing guidelines. Human behaviours; accidental obstruction, diving too near/in front, chasing, and approaching from the front, all had a statistically significant negative effect on behaviour, resulting in feeding cessation, while passive interactions resulted in significantly less disturbance and cessation reactions. Interactions within three metres caused significantly increased avoidance behaviours. These findings support the guidelines provided by the Manta Trusts' code of conduct, which aims to develop legislation to minimise disturbance by tourism. The authors' key recommendations aim to ensure that the manta ray tourism industry remains sustainable and non-detrimental to the animals' natural behaviour. Visit <https://swimwithmantas.org/> for video abstract.

Authors: Muter, B. A., Gore, M. L., Gledhill, K. S., Lamont, C., and Huveneers, C.

Year: 2013

Title: Australian and U.S. news media portrayal of sharks and their conservation

Journal: Conservation Biology

Volume: 27

Issue: -

Pages: 187-196

Abstract: Investigation of the social framing of human–shark interactions may provide useful strategies for integrating social, biological, and ecological knowledge into national and international policy discussions about shark conservation. One way to investigate social opinion and forces related to sharks and their conservation is through the media's coverage of sharks. Muter and colleagues conducted a content analysis of 300 shark-related articles published in 20 major Australian and U.S. newspapers from 2000 to 2010. Shark attacks were the emphasis of over half the articles analysed, and shark conservation was the primary topic of 11% of articles. U.S. 47%) and shark conservation issues ($\chi^2 = 6.856$; Australian 15% vs. U.S. 11%) as the primary article topic. Significantly more Australian articles than U.S. articles treated shark attacks ($\chi^2 = 3.862$; Australian 58% vs. U.S. 11%) and used politicians as the primary risk messenger (i.e., primary person or authority sourced in the article) discussed sharks as entertainment (e.g., subjects in movies, books, and television; $\chi^2 = 15.130$; U.S. 6% vs. Australian 8% vs. U.S. 1%). However, significantly more U.S. articles than Australian articles (15%) discussed sharks as entertainment. Despite evidence that many shark species are at risk of extinction, the authors found that most media coverage (Australian 1%) and used scientists as the primary risk messenger ($\chi^2 = 5.333$; U.S. 25% vs. Australian 1%). Australian emphasised the risks sharks pose to people. To the extent that media reflects social opinion, our results highlight problems for shark conservation. The authors suggest that conservation professionals purposefully and frequently engage with the media to highlight the rarity of shark attacks, discuss preventative measures water users can take to reduce their vulnerability to shark encounters, and discuss conservation issues related to local and threatened

species of sharks. When integrated with biological and ecological data, social-science data may help generate a more comprehensive perspective and inform conservation practice.

N

Authors: Needham, M. D., Szuster, B. W., Mora, C., Lesar, L. and Anders, E.

Year: 2017

Title: Manta ray tourism: interpersonal and social values conflicts, sanctions, and management

Journal: Journal of Sustainable Tourism

Volume: 25

Issue: 10

Pages: 1367-1384

Abstract: Scuba diving and snorkelling with manta rays (*M. birostris*, *M. alfredi*) at sites in Hawaii, USA, have become popular, with upward of 30 tour boats and 300 participants daily. This article examined whether conflicts are occurring within and between these activities and if so, what types of conflict are prevalent and how would participants respond (support restrictions, sanction others). Data from surveys of 444 participants following evening trips to view manta rays showed that 79% of snorkelers experienced in-group conflict with other snorkelers, and 53% of scuba divers reported conflict with other divers. Most conflicts were interpersonal (physical interactions among individuals interfering with experiences). Conflict behaviours included bumping into people (up to 92%), not being aware (up to 73%), and blinding people with underwater flashlights (up to 56%). There were fewer out-group conflicts between different activities (snorkelers vs. scuba divers) and minimal social values conflicts (negative preconceptions, no physical interactions among individuals). Participants supported limiting numbers of snorkelers, scuba divers, and boats, and providing education on how to behave with others. Those experiencing conflicts were more supportive of these strategies and more likely to directly sanction participants causing conflicts, but were not more likely to indirectly sanction managers and operators.

Authors: Needham, M. D., Szuster, B. W., Lesar, L., Mora, C. and Knecht, D. P.

Year: 2018

Title: Snorkelling and scuba diving with manta rays: encounters, norms, crowding, satisfaction, and displacement

Journal: Human Dimensions of Wildlife

Volume: 23

Issue: 5

Pages: 461-473

Abstract: This research note examined encounters, norms, crowding, satisfaction, and displacement among people snorkelling and scuba diving with manta rays at sites in Hawaii. These sites are popular with up to 30 tour boats and 300 participants each day. Data from a survey of 444 participants showed that 82% felt crowded by snorkelers, 78% felt crowded by boats, and 69% felt crowded by scuba divers when viewing manta rays. In reporting their norms, participants stated they would accept seeing an average of no more than 52 snorkelers, 32 scuba divers, and 11 boats at one time. However, 77% of respondents encountered more snorkelers than their norm for seeing snorkelers, 67% saw more scuba divers than they would accept, and 68% encountered more boats than their norm. These participants were more crowded, less satisfied, and more likely to become displaced (not visit again) compared to those who encountered fewer than their norms.

Author: Neff, C.

Year: 2012

Title: Australian beach safety and the politics of shark attacks

Journal: Coastal Management

Volume: 40

Issue: 1

Pages: 88-106

Abstract: There are no simple government solutions when sharks bite people. These rare and sometimes fatal incidents are fraught with uncertainties and command a disproportionate amount of psychological space in the minds of the public, as well as a large degree of policy space and funding from many governments. Responses to mitigate shark bite incidents involve public policies that contend with the needs of public safety as well as the responsibility to protect endangered predators. Little study to date has been done examining the politics of shark attacks, yet these events are among the most geographically dispersed human–wildlife conflicts in the world. Neff examines the underlying concerns that drive this policy process by asking how problem definition framing by policy entrepreneurs affects government responses following shark bite incidents. Through a case study of shark bite incidents in Sydney, Australia in 1929, 1934, and 2009, he identifies three competing problem definitions: behavioural, psychological, and conservation. The psychological definition, building confidence in the minds of the public, is shown to be the most successful. Building on previous research, Neff argues that policy entrepreneurship is a central feature in the strength of problem definitions. He concludes by suggesting lessons for the balanced coastal management of human–marine life conflicts including the selection of trusted spokespeople, prioritising measures to relieve short-term public anxiety, reframing beach ecosystems as “the wild,” and connecting public safety education to personal behaviour.

Author: Neff, C.

Year: 2014

Title: Human perceptions and attitudes towards sharks

Editors: E. J. Techera and N. Klein

Book Title: Sharks: Conservation, governance and management

City: London, United Kingdom

Publisher: Taylor & Francis

Pages: 107-131

Abstract: The meaning given to the human-shark relationship has had a profound impact on shark management and governance for centuries. This chapter addresses the way perceptions about sharks and shark bites can impact shark conservation and improve management. A test of how much animals matter to humans is how we treat them following human-wildlife conflicts. How are conservation values located in the political dialogue regarding dangerous, threatening and predatory animals? The presented case studies affirm the impact of public policies dedicated to shark bite prevention on shark conservation. If sharks are framed in policy terms as an enemy that needs to be killed, this undermines shark conservation by reducing public support for sharks and weakening the political capital of organisations that advocate on their behalf.

Authors: Neff, C., and Hueter, R.

Year: 2013

Title: Science, policy, and the public discourse of shark “attack”: a proposal for reclassifying human–shark interactions

Journal: Journal of Environmental Studies and Sciences

Volume: 3

Issue: 1

Pages: 65-73

Abstract: There are few phrases in the Western world that evoke as much emotion or as powerful an image as the words “shark” and “attack.” However, not all “shark attacks” are created equal. Under current labels, listings of shark attacks may even include instances where there is no physical contact between shark and human. The dominant perception of intent-laden shark “attacks” with fatal outcomes is outdated as a generic term and misleading to the public. Neff and Hueter propose new descriptive labels based on the different outcomes associated with human–shark interactions, including sightings, encounters, bites, and the rare cases of fatal bites. They argue two central points: first, that a review of the scientific literature shows that humans are “not on the menu” as typical shark prey. Second, the authors argue that the adoption of a more prescriptive code of reporting by scientists, the media, and policy makers will serve the public interest by clarifying the true risk posed by sharks and informing better policy making. Finally, Neff and Hueter apply these new categories to the 2009 New South Wales Shark Meshing Report in Australia and the history of shark incidents in Florida to illustrate how these changes in terminology can alter the narratives of human–shark interactions.

Authors: Neff, C., and Yang, J.

Year: 2013

Title: Shark bites and public attitudes: Policy implications from the first before and after shark bite survey

Journal: Marine Policy

Volume: 38

Issue: C

Pages: 545-547

Abstract: Public feelings toward sharks are expected to grow negatively following shark bites on humans. Media and government responses are often predicated on this presumptive emotional response; however, there have been no published data on attitudes toward sharks following shark bite incidents. This study shows that levels of “pride” in white shark populations in the absence of an incident remained steady after a shark bite occurred. This was consistent across response areas regarding other marine life and “confidence” in beach safety programmes. Results are based on a pilot survey conducted in the Cape Town beach suburbs of Fish Hoek and Muizenberg before and after a shark bite at Fish Hoek beach. The study found no statistical significance between survey responses and the occurrence of the shark bite incident. The results indicate a previously undocumented level of public sophistication following these events. These data challenge the underlying basis of policy responses to shark bites and suggest that new considerations of public knowledge, endemic value and causal narratives should be incorporated into decision making.

Authors: Newman, H. E., and Medcraft, A. J.

Year: 2002

Title: Whale shark tagging and ecotourism

Editors: S. Fowler, T. Reid and F. A. Dipper

Book Title: Elasmobranch biodiversity, conservation and management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997

City: Gland, Switzerland

Publisher: The World Conservation Union (IUCN).

Pages: 230-235

Abstract: Whale sharks are becoming increasingly important to the growing dive tourism industry in South East Asia and Western Australia. Seasonal aggregations of whale sharks in specific areas in Asian countries have been recorded by dive operators, who actively promote diving and snorkel trips with these sharks. Whale sharks are also being harvested, apparently on an increasing scale, in the Philippines, Taiwan and Indonesia for their meat, fins, oil and cartilage. At present little is known about their population numbers, migratory habits and behaviour. This paper describes a proposal to use ecotourism operations as a basis for a South East Asia regional effort to assess whale shark populations and exploitation, in conjunction with other studies in South Africa, Mozambique, the Seychelles and Western Australia.

Authors: Newsome, D., Lewis, A., and Moncrieff, D.

Year: 2004

Title: Impacts and risks associated with developing, but unsupervised, stingray tourism at Hamelin Bay, Western Australia.

Journal: International Journal of Tourism Research

Volume: 6

Issue: 5

Pages: 305-323

Abstract: Interacting with stingrays at Hamelin Bay, in the south-west of Western Australia, appears to be substantially growing in popularity. Promotion of the rays is increasing through websites and brochures and larger tourism productions, such as the 'Getaway' television programme, have shown interest in the Hamelin Bay site. Yet there is still very little known about the impacts on rays (both behavioural and physical), risks to humans, or indeed the issues that provisioning stingrays can present. Although Shackley (1998) conducted an impact study of stingray provisioning in the Cayman Islands, provisioning activities at Hamelin Bay, and other areas in the southwest are unique because they are shore-based. As part of developing a profile of conditions at the Hamelin Bay provisioning site the authors investigated stingray numbers and their distribution in the area. They also collected data on the type and amount of provisioned food, investigated stingray behaviour and observed how tourists interacted with stingrays. It was shown through site profile data that rays are attracted to the site principally by food provisioning and secondarily by boats due to learned association with food. They are most common at the provisioning site in the middle of the day, as are peak visitor numbers. Behavioural impacts on rays were found to be attraction to humans, resulting in aggression and hierarchy towards one another. Attraction to humans at the provisioning site reflected that the rays may be partially habituated. However, rays were also seen foraging naturally for food, indicating that they are not yet dependent on humans. Other potential impacts to rays include boat damage from pleasure craft, overfeeding, being fed the wrong food, damage from fishing hooks and risk of disease from foul water. Lesions on skin and permanent shoaling behaviour, as witnessed at other stingray provisioning sites, were not observed at Hamelin Bay. Management actions are recommended to reduce impacts on the rays, eliminate risks to visitors and increase visitor satisfaction.

Author: Norman, B. M.

Year: 1999

Title: Aspects of the biology and ecotourism industry of the whale shark *Rhincodon typus* in north-western Australia

Academic Department: School of Biological Sciences and Biotechnology

University: Murdoch University

Thesis Type: Masters by Research

Abstract: The conservation status of the widely-distributed whale shark *Rhincodon typus* is presently listed as 'Indeterminate - Data Deficient'. One of the main hindrances to obtaining biological data on whale sharks that is relevant to determining its 'conservation status' is that this species has rarely been recorded as occurring in sufficient numbers to obtain quantitative data. However, *R. typus* does form aggregations at Ningaloo Marine Park (NMP), Western Australia, annually between March and June. This has enabled studies to be made of aspects of the biology of *R. typus* and of the possible impacts of the ecotourism industry on this species. Using a position provided on vessels involved with the whale shark ecotourism industry at NMP, *R. typus* was observed on 360 separate occasions in 1995, 1996 and 1997, and it was possible to sex 90.3% of these sharks. The majority of the sexed sharks (84.6%) were male and ranged in length from 4 to 12 m, with a mean of 7.4 m, while the females ranged in length from 4.5 to 8.5 m, with a mean of 6.2 m. The size and degree of abrasion of the claspers was used as an indicator of whether or not a male shark had mated. Using such criteria, it was estimated that male whale sharks start to mature at ca 8 m and that ca 50% are mature by the time they reach 8.6m.

Observations suggested that *R. typus* feeds by using both suction and flow-through mechanisms. The prey that were observed being ingested included coral spawn, tropical krill, mysids and small jellyfish. The contents of a faecal sample contained parts of the exoskeleton of copepods and the scales of small fishes. The degree of mouth distension, which is assumed to be related to feeding activity, was low during most observation periods.

Photographs of the scars and natural patterning on the skin of individual sharks were used to construct a photographic library for subsequent identification of these sharks. The features used for identifying individual sharks were chosen because they were considered likely to remain for a protracted period. The Whale Shark Photo-identification Library that was produced provides details on the characteristic features of 52 *R. typus* that were present at NMP. Six individuals were recorded at NMP in both 1995 and 1996, four in both 1996 and 1997, and one in both 1995 and 1997. No identified whale sharks were recorded in all three years.

Rhincodon typus was distributed widely throughout NMP, with most boat and aerial sightings lying within 1 - 2 lsm of the reef crest between Tantabiddi and Turquoise Bay. *Rhincodon typus* was typically sighted in water depths of 10 to 30 m. The sharks were predominantly travelling parallel to Ningaloo Reef, with significantly more moving in a northward than southward direction. Acoustic tracking of *R. typus* in 1997 suggested that this species remains within NMP for extended periods and is at the surface for ca 17% of daylight hours.

The number and species of fauna observed to be associated with *R. typus* were recorded, and a new species of copepod, *Pandarus sp. nov.*, which lives on the skin of *R. typus* has been described. Golden trevally (*Gnathanodon speciosus*), miscellaneous trevally (*Carangid sp.*), remora (*Remora sp.*) and slender suckerfish (*Echeneis naucrates*) were common. The prevalence of *Pandarus sp. nov.* was inversely proportional to the number of *Remora sp.* and *E. mucrates* in 1996, while the opposite was true in 1997, suggesting that *Pandarus sp. nov.* were preyed on by these diskfish.

Rhincodon typus is the basis of the ecotourism industry that operates within NMP each year. While there was considerable variation in the number of tour vessels searching for whale sharks at NMP each year, the greatest mean number of vessels operating per week in successive whale

shark seasons were 6.7 during Week 8 (April 19 - 25) of 1995, 6.1 during Week 7 (April 12 - 18) of 1996 and 6.9 during Week 8 (April 19 - 25) of 1997. The greatest mean numbers of whale sharks sighted per week in each year were 5.1 during Week 14 (May 31 - June 6) of 1995, 4.2 during Week 6 (April 5 - 11) of 1996 and 4.1 during Week 8 (April 19 - 25) of 1997.

Tourists, who were permitted to swim alongside *R. typus*, interacted with sharks for a mean period of 19.3 min in 1995, 14.2 min in 1996 and 9.5 min in 1997. The reduction in the duration of interaction in three successive years suggests that, over time, *R. typus* may have become slightly less tolerant of the ecotourism industry at NMP. The mean minimum distance between vessel and shark during each interaction was 20.7 m in 1995, 21.3 m in 1996 and 31.0 m in 1997. The mean minimum distance between tourist and shark during each interaction was 1.5 m in 1995, 2.05 m in 1996, and 2.1 m in 1997. The mean minimum distance of vessel and tourist from *R. typus* during each individual interaction decreased as the duration of the interaction increased. Therefore, both *R. typus* and this industry must be carefully monitored to ensure that the impacts of humans are kept to a minimum and thereby ensure that whale sharks return to NMP each year.

An ethology of whale shark behaviours, which included banking, porpoising, diving and eye-rolling, was produced in an attempt to determine whether there is evidence that the ecotourism industry has a negative impact on *R. opus* at NMP. The frequency of behavioural change was greatest in the first 0 - 5 min of an observation. Eye-rolling by *R. typus* was recorded as a reaction to flash-photography, while banking was often recorded when SCUBA was used and/or tourists swam beneath the head of the shark. The swimming speed of *R. typus* at NMP was rarely too fast for tourists to maintain proximity to the sharks.

Several sharks possessed both recent and healed scars, which were probably inflicted by vessel contact. The recent wounds indicate that vessels had caused injuries to *R. typus* within NMP. These individuals tended to display a higher frequency of avoidance behaviours and reduced interaction times.

Recommendations are provided to the Western Australian Department of Conservation and Land Management which are aimed at reducing the potential deleterious effects of the ecotourism industry on the whale sharks at NMP.

Authors: Nosal, A. P., Keenan, E. A., Hastings, P. A. and Gneezy, A.

Year: 2016

Title: The effect of background music in shark documentaries on viewers' perceptions of sharks.

Journal: *PLoS ONE*

Volume: 11

Issue: 8

Pages: e0159279

Abstract: Despite the ongoing need for shark conservation and management, prevailing negative sentiments marginalise these animals and legitimise permissive exploitation. These negative attitudes arise from an instinctive, yet exaggerated fear, which is validated and reinforced by disproportionate and sensationalistic news coverage of shark 'attacks' and by highlighting shark-on-human violence in popular movies and documentaries. In this study, the authors investigate another subtler, yet powerful factor that contributes to this fear: the ominous background music that often accompanies shark footage in documentaries. Using three experiments, they show that participants rated sharks more negatively and less positively after viewing a 60-second video clip of swimming sharks set to ominous background music, compared to participants who watched the same video clip set to uplifting background music, or silence. This finding was not an artefact of soundtrack alone because attitudes toward sharks did not differ among participants assigned to audio-only control treatments. This is the first study to demonstrate empirically that the connotative attributes of background music

accompanying shark footage affect viewers' attitudes toward sharks. Given that nature documentaries are often regarded as objective and authoritative sources of information, it is critical that documentary filmmakers and viewers are aware of how the soundtrack can affect the interpretation of the educational content.

O

Authors: O'Connell, C. P., Andreotti, S., Rutzen, M., Mejer, M., Matthee, C. A., and He, P.

Year: 2014

Title: Effects of the Sharksafe barrier on white shark (*Carcharodon carcharias*) behavior and its implications for future conservation technologies

Journal: Journal of Experimental Marine Biology and Ecology

Volume: 460

Issue: -

Pages: 37-46

Abstract: The white shark (*Carcharodon carcharias*) is an apex predator and is a protected species that suffers from several sources of anthropogenic mortality, such as shark nets. Shark nets are devices used to minimise the interaction between beachgoers and potentially dangerous sharks; however, these nets have negatively impacted local and migratory shark populations, in addition to killing substantial quantities of other marine organisms. To address this issue, the present study developed and examined the effects of an alternative technology (the "Sharksafe" barrier) composed of two stimuli: (1) visual-artificial-kelp and (2) electrosensory-magnets, on *C. carcharias* behaviour. Generalised linear mixed effect models were used to test hypotheses pertaining to the effects of treatment type, exposure quantity (i.e. habituation), conspecific density, and water visibility on shark behaviour. Analyses based on 49, one-hour trials illustrate that the swim patterns of all 63 individual *C. carcharias* was altered in the presence of the artificial kelp-the procedural control region, and the magnetic kelp-the magnetic region of the barrier (i.e. procedural control and magnetic regions reduced entrance frequency and increased avoidance and pass around frequency). Also, preliminary observations illustrated that the barrier had no observable impact on Cape fur seal (*Arctocephalus pusillus pusillus*) behaviour. The *C. carcharias*-specific repellency associated with the Sharksafe barrier and the ability of the barrier to withstand harsh environmental conditions warrant future experiments to assess its exclusion capabilities on predatory sharks and possible application to replace shark nets.

Authors: O'Connell, C. P., Stroud, E. M., and He, P.

Year: 2014

Title: The emerging field of electrosensory and semiochemical shark repellents: Mechanisms of detection, overview of past studies, and future directions

Journal: Ocean and Coastal Management

Volume: 97

Issue: -

Pages: 2-11

Abstract: Since the sinking of the USS Indianapolis (CA-35) and associated shark attacks in 1945, the quest to find an effective shark repellent has been endless. Early efforts were focused on finding a shark repellent which would minimise the probability of a shark attack. However, studies illustrate that shark populations are drastically declining which has led to calls for effective management policies and practices to reduce both directed catch and bycatch of various shark species. With increased need for shark conservation, the focus has shifted to protecting sharks from harmful anthropogenic pressures, such as fishing gear and beach nets. Current shark repellent technologies which aim to minimise elasmobranch mortality in fishing

gears include: permanent magnets, electropositive metal (EPM) alloys, and semiochemicals. This paper reviews present electrosensory and semiochemical shark repellents, the mechanisms of elasmobranch (e.g. shark, skate and ray) detection and repellency, species-specificity in elasmobranch response to the stimuli, and environmental and biological conditions which may influence repellent success. Future research to enhance our knowledge on electrosensory repellents and to improve the success of repellent implementation and application are discussed.

Authors: O'Malley, M. P., Lee-Brooks, K., and Medd, H. B.

Year: 2013

Title: The global economic impact of manta ray watching tourism

Journal: PLoS ONE

Volume: 8

Issue: 5

Pages: -

Abstract: As manta rays face increased threats from targeted and bycatch fisheries, manta ray watching tourism, if managed properly, may present an attractive economic alternative to consumptive use of these species. Both species in the genus *Manta* (*Manta alfredi* and *Manta birostris*) are classified by the International Union for the Conservation of Nature Red List as species Vulnerable to extinction in the wild, and are considered unsustainable as fisheries resources due to their conservative life history characteristics, which considerably reduce their ability to recover population numbers when depleted. Utilising dive operator surveys, Internet research, and a literature review, this study provides the first global estimate of the direct economic impact of manta ray watching tourism and examines the potential socio-economic benefits of non-consumptive manta ray watching operations relative to consumptive use of manta rays as a fishery resource. In the 23 countries in which manta ray watching operations meeting our criteria were identified, the authors estimated direct revenue to dive operators from manta ray dives and snorkels at over US\$73 million annually and direct economic impact, including associated tourism expenditures, of US\$140 million annually. Ten countries account for almost 93% of the global revenue estimate, specifically Japan, Indonesia, the Maldives, Mozambique, Thailand, Australia, Mexico, United States, Federated States of Micronesia and Palau. In many of the areas where directed fisheries for manta rays are known to occur, these activities overlap with manta ray tourism sites or the migratory range of the mantas on which these sites depend, and are likely to be unsustainable and detrimental to manta ray watching tourism.

Author: Oyarzun, F.

Year: 2017

Title: Exploring the prospects for adaptive co-management of wildlife tourism: The case of shark cage diving on Stewart Island, New Zealand

Academic Department: Department of Tourism

University: University of Otago

Thesis Type: Doctoral

Abstract: Wildlife tourism consists of people viewing and/or encountering wildlife. These often close encounters with wildlife tourism can produce direct and significant negative impacts on wildlife, their habitat, and adjacent communities. With this in mind, it is important to ensure that wildlife tourism developments are undertaken following sustainable principles, to avoid or at least minimise potential negative impacts. In a similar way to many other activities based on the utilisation of natural resources, wildlife tourism faces a range of challenges to the way that it has been practiced, with calls for new and innovative approaches. The utilitarian anthropocentric paradigm of 'dominion over nature' and the use of reductionist approaches to

deal with complex problems are considered to be increasingly less applicable in contemporary natural resource management. There has been a call for a shift from conventional reductionist approaches, to new nonlinear complex adaptive system approaches. These ideas also challenge the paradigm of sustainability, from its focus on achieving and maintaining stability to a focus on enhancing resilience to disturbance, based on the understanding that the world is constantly changing and evolving and therefore, characterised by uncertainty. The management of natural resources, including activities such as nature-based tourism, requires a better understanding of the relationship between human and natural systems, and a better knowledge of methods to address complex social-ecological systems. In this context, the adaptive co-management framework, which combines the ideas of collaboration amongst stakeholders and learning-by-doing, presents itself as a useful interdisciplinary approach. The overall experience to date with ACM suggests it may be a useful framework for addressing uncertainty and complexity in the management of natural resources such as forestry, fishery, farming and the management of protected areas. Since tourism systems are described as Complex Adaptive Tourism Systems (CATS) and tourist destinations can be regarded as social-ecological systems, the prospects for adaptive co-management in tourism seem are strong. This thesis aims to critically examine prospects for the sustainable management of wildlife tourism using adaptive co-management. Given that the object of study falls into the domain, critical realism was chosen as research paradigm, since it provides an adequate philosophical ontology for the study of complexity. The research takes a qualitative approach, conducted through an instrumental case study that examines the wildlife tourism activity of shark cage diving near Stewart Island, New Zealand. Shark cage diving consists of close encounters with sharks in their own habitat carried out by divers submerged in a shark-proof cage built of steel. This wildlife tourism activity is carried out to see great white sharks in several places around the world, including Stewart Island, New Zealand. There are contentious issues concerning the use of food to attract the sharks to the cage due to the possible Pavlovian conditioning of the sharks to the sound of boat motors, which may in turn generate an aggressive behaviour toward divers and other marine users, endangering their livelihoods. On Stewart Island, several members of the community are concerned about the possibility of sharks being conditioned by the use of food during shark cage diving, due to its possible negative effects. They fear that their safety and livelihoods can be put in jeopardy if the sharks become more aggressive. Social issues are the fear and social tension that the shark cage diving operations have produced within the community; ecological issues are the potential changes in the behaviour and safety of wildlife. As can be noted, this case was chosen because it presents a particularly interesting situation characterised by some contentious issues regarding the management of wildlife and the effects –actual and potentials– that it is producing on the local community. The complexity of the situation and the wide variety of stakeholders involved generate interesting prospects for the application of an adaptive co-management framework. Three methods of data collection were used: semi-structured in-depth interviews, archival research, and participant observation. The subsequent interpretation of the data collected was conducted using a process of ‘thematic analysis’ which consisted of the coding of the qualitative information based on patterns. These patterns arise from the identification of the key elements of the ACM framework, and the roles of the stakeholders identified in the Integrated Conceptual Model of Adaptive co-management of Wildlife Tourism proposed in this thesis. The analysis included the study of the role, relevance and involvement of each stakeholder, the presence of the core components of adaptive co-management in the case study, and the analysis of the roles that the stakeholders play, and the relations among them in the context of the shark cage diving operations. The analysis aims to identify the favourable conditions and constraints for the implementation of an ACM framework. The analysis reveals that prospects for an ACM approach to wildlife tourism, in general, are strong, with ACM presenting itself as a useful framework to address issues in which conventional resources management frameworks are

failing to address, such as multi-stakeholders conflicts and the management of common-pool resources. Critical factors were identified in relation to the potential implementation of an adaptive co-management framework for the case study and arguably wildlife tourism in general. Issues related to communication channels, the need for community engagement, the need for leadership, the involvement of tourists and the tourism industry, the representation of wildlife in adaptive co-management, and the need for flexible adaptive frameworks, offer several challenges for the implementation of adaptive co-management. However, other facilitating factors regarding rich social capital and evidence of successful co-management in related natural resource management provide evidence for optimism that the implementation of adaptive co-management may be fruitful in such settings.

P

Authors: Pagel, C. D., Lück, M., and Orams, M. B.

Year of Conference: 2017

Title: The careless fish will be eaten by the shark: The risk, the motivation and the role of social media within close encounters with marine wildlife in Polynesia

Conference Name: The 9th International Congress on Coastal & Marine Tourism (CMT)

Conference Location: Gothenburg, Sweden

Page: 40

Abstract: With its diverse range of marine megafauna including cetaceans, sirenians, chelonids as well as many elasmobranch species, Polynesia has a distinctive advantage for marine wildlife tourism and great potential to become a leading destination in the future. Over the past decades wildlife watching has grown and changed from a rare experience to a mainstream tourism activity with tourists demanding greater opportunities to see and interact with animals in their natural environment. Swim-with programmes (SWPs) experience a steady growth in popularity, in which participants interact with marine wildlife in open-water environments, posing a potential hazard to tourist health and safety. Risk perception is a crucial aspect in adventure and wildlife-focused tourism but while threats to animals involved in tourism activities are widely discussed in literature, potential impacts of wildlife on tourist safety (including being bitten, stung, hit or charged) remain understudied. The basis of this research will deal with motivations as well as an in-depth assessment of tour participants' awareness of potential risks associated with SWPs in the region of Polynesia. Further, the involvement of key stakeholders, such as tour operators, will deliver new insights to the nature of risk factors and the experiences with the management of incidents. In this context, a special focus will be given to the understanding of the function of social media platforms and consumer generated content (CGC) in this particular wildlife tourism segment.

The implementation will be based on a case study approach on three selected sites in Polynesia offering SWPs (humpback whales (*Megaptera novaeangliae*) in Niue, New Zealand fur seals (*Arctocephalus forsteri*) in New Zealand, as well as Galapagos- (*Carcharinus galapagensis*), tiger- (*Galeocerdo cuvier*) and sandbar sharks (*Carcharinus plumbeus*) in Hawai'i) incorporating on-site questionnaire-based surveys of tour participants as well as interviews with stakeholders of SWPs in the region. The identification of risk factors in the context of close interactions with marine wildlife in Polynesia as well as the proactive involvement of the key stakeholders such as tour participants, operators and policy makers are vital components to formulate and discuss custom-tailored risk management strategies, such as the development of effective wildlife interpretation programmes, which will facilitate the promotion of safety in commercial operations.

Authors: Pagel, C. D., Lück, M., and Orams, M. B.

Year of Conference: 2020

Title: Getting the shot: Photographer's behaviour during commercial swim-with-wildlife tours

Conference Name: 30th Annual Council for Australasian Tourism and Hospitality Education Conference

Conference Location: Auckland, New Zealand

Page: -

Abstract: Capturing images through photographs and videos has long been recognised as playing an influential role in wildlife tourism experiences. In the 21st century, with the ubiquity of Web 2.0 in people's everyday lives, images can now be shared instantaneously via social media platforms to the screens of an online audience. The quest for 'photo-trophies' that can be liked, shared and reproduced may influence how tour participants behave around wildlife. This paper reports on qualitative research on tour providers who offer in-water encounters with marine wildlife and their experiences of the influence of social media on their clients' behaviour when in the water with three different animal species. Semi-structured in-depth interviews with operators at three different sites revealed a consistent theme of 'pushy' behaviour displayed by skilled wildlife photographers and social media influencers when seeking close encounters with whales, seals and sharks. Such behaviour fosters the potential for wildlife harassment and may provoke animal behaviour that could pose safety risks for people. The operators interviewed identified that serious wildlife photographers were the most likely to ignore safety instructions and guidelines communicated by the operator. The findings illustrate that investigating operator-client relationships from the perspective of the operator can provide important insights into tourist behaviour. Inappropriate or ignorant conduct can then be targeted through specific communication and management strategies.

Authors: Pagel, C. D., Orams, M. B., and Lück, M.

Year: 2020

Title: #BiteMe: Considering the potential influence of social media on in-water encounters with marine wildlife

Journal: Tourism in Marine Environments

Volume: 15

Issue: Advance online publication

Pages: Advance online publication

Abstract: Over the past three decades, interacting with wildlife as a tourism activity has grown significantly and has transformed from a relatively rare experience into a mainstream tourism product. Tourism opportunities to watch, photograph and otherwise interact with animals in their natural environment have grown to include a range of species and settings, including in the sea. Close encounters with marine wildlife are facilitated by a wide range of commercial operators, and many include and promote a strong adventure component. This paper provides a consideration of the issues of risk and the emerging role of the use of social media in marine wildlife tourism experiences. While the concept of ecotourism has been widely explored in wildlife tourism research, the inherited risk involved in these activities has received little attention. This is particularly the case regarding interactions with potentially dangerous wildlife in open-water environments. This aspect warrants exploration in the context of the growth of wildlife photography/videography and sharing via social media platforms, which frequently display close encounters with animals in dangerous scenarios for both people and wildlife involved.

Authors: Patroni, J., Simpson, G., and Newsome, D.

Year: 2018

Title: Feeding wild fish for tourism—A systematic quantitative literature review of impacts and management

Journal: International Journal of Tourism Research

Volume: 20

Issue: 3

Pages: 286-298

Abstract: Feeding wildlife for the purpose of tourism is a contentious issue with for and against arguments being raised by tour operators, non-governmental organisations, researchers, and managers. Despite this situation, there is a growing trend in the feeding of marine wildlife to guarantee visitors an exciting up-close experience. This review investigates the scope and key findings of research conducted on the impacts and social aspects of tourism related wild fish feeding. This systematic quantitative literature review identified 58 peer-reviewed articles on feeding wild fish for tourism. Of those articles, 35 (60%) reported on ecological impacts on the fish. Only 14 articles explored fish feeding tourism from a social perspective, and of those only 9 (15%) investigated the perspectives of visitors. This review highlights that the impacts and management of complex human-wildlife interactions, such as feeding wild fish, are case and species specific. The impacts of feeding wild fish for tourism include changes in species distribution and behaviour, negative health effects, increased predation of some fish species, and risk of injury to tourists. There is less research on social aspects such as visitor attitudes and satisfaction with fish feeding operations. Further studies are required on visitor demand and interests, and the ecological implications of provisioning to ensure the scenarios in which fish feeding occur are sustainable, maximising the tourism experience while minimizing negative impacts on fish populations. It is important that progress is made towards developing appropriate codes of conduct and nationally and internationally accredited standards of practice.

Author: Pauly, D.

Year: 2002

Title: Growth and mortality of the basking shark *Cetorhinus maximus* and their implications for management of whale sharks *Rhincodon typus*

Editors: S. Fowler, T. Reid and F. A. Dipper

Book Title: Elasmobranch biodiversity, conservation and management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997

City: Gland, Switzerland

Publisher: The World Conservation Union (IUCN).

Pages: 199-208

Abstract: New methods were used to reanalyse previously published length-frequency data on basking shark *Cetorhinus maximus* and thereby resolve an earlier controversy about the growth rate of this fish. These methods confirm earlier suggestions of a slow growth (von Bertalanffy $K > 0.06/\text{year}$, for an asymptotic length of 10m), and correspondingly low natural mortality ($M > 0.07/\text{year}$), as appropriate for a fish with a record length of 9.7m. Given what is known of the inverse relationship between asymptotic length and K in hundreds of fish species (including sharks), the above results imply that whale sharks *Rhincodon typus* should exhibit, for an asymptotic length of 14m, K and M values of about 0.03 and 0.05/year, respectively. Such slow growth and the high longevity this implies should make whale sharks even more sensitive than basking sharks to human-induced mortality, thus arguing against exploitation by fisheries. Also, ecotourism schemes will have to be careful to avoid becoming a source of indirect mortality.

Authors: Pepin-Neff, C., and Wynter, T.

Year: 2018

Title: Shark bites and shark conservation: An analysis of human attitudes following shark bite incidents in two locations in Australia

Journal: Conservation Letters

Volume: 11

Issue: 2

Pages: -

Abstract: This article reports on the first comparative surveys in two separate locations to measure public attitudes toward sharks following shark bite incidents. This study focuses directly on the communities affected by the shark bites, both in Australia - the town of Ballina in the State of New South Wales ($N = 500$) and the city of Perth in Western Australia ($N = 600$) - and reports on their attitudes and policy preferences relating to sharks immediately after serious shark bite incidents in 2015 and 2016. In both communities the authors found that a large majority of respondents prefer nonlethal policies; most respondents believe shark bite incidents to be accidental rather than intentional; while fear of sharks correlates with support for lethal policies, this association is powerfully mediated by perceptions of intentionality. These findings have implications for international wildlife management, particularly regarding predator species in need of conservation. Conservation is based on the public acceptability of a species and if intentionality can mediate fear effects and promote policies that protect the species this is a step forward for conservation management globally.

Authors: Pierce, S. J., Mendez-Jimenez, A., Collins, K., Rosero-Caicedo, M., and Monadjem, A.

Year: 2010

Title: Developing a Code of Conduct for whale shark interactions in Mozambique

Journal: Aquatic Conservation: Marine and Freshwater Ecosystems

Volume: 20

Issue: 7

Pages: 782-788

Abstract: The whale shark (*Rhincodon typus*) is a popular focal species within the global marine tourism industry. Although this has contributed to increased protection being granted to the species in several countries, tourism itself can be detrimental to the sharks in the absence of appropriate management. Potential impacts can be mitigated, at least in the short term, by adherence to well-designed interaction guidelines. A burgeoning marine tourism industry based on swimming with whale sharks has developed at Tofo Beach in Mozambique. However, no formal management is currently in place at this site. The behaviour of whale sharks during interactions with boats and swimmers were recorded during 137 commercial snorkelling trips run from Tofo Beach over a 20 months period. Whale sharks were encountered on 87% of trips, which operated year-round. Boat proximity and shark size were significant predictors of avoidance behaviour. No avoidance responses were recorded at 420 m boat distance. The mean in-water interaction time between sharks and swimmers was 8 min 48 s overall. There was a significant decrease in interaction times during encounters where sharks expressed avoidance behaviours, and also in cases where sharks had expressed boat avoidance behaviour before swimmers entered the water. It is suggested that mean encounter times can be extended through adherence to a basic Code of Conduct for operators and swimmers that enforces minimum distances between the sharks, boats and swimmers. Using encounter time as a measure of the 'success' of interactions holds promise, as longer encounters appear to be indicative of lower impacts on sharks while also providing higher customer satisfaction for swimmers.

Authors: Pini-Fitzsimmons, J., Knott, N.A., and Brown, C.

Year: 2018

Title: Effects of provisioning on site in the short-tail stingray *Bathytoshia brevicaudata*

Journal: Marine Ecology Progress Series

Volume: 600

Issue: -

Pages: 99-110

Abstract: Food provisioning can have significant effects on marine wildlife. It is common practice for recreational anglers to discard fish waste back into waterways, yet the effects of incidental provisioning as a result of recreational fish cleaning on marine wildlife have not been assessed and are likely not being considered in fisheries management. At the Woollamia boat ramp in Jervis Bay, Australia, local anglers have been incidentally provisioning short-tail stingrays *Bathytoshia brevicaudata* through fish-cleaning activities for >30 yr. This provided an opportunity to investigate the influence of provisioning on a small scale. Pini-Fitzsimmons and colleagues used behavioural observations to assess stingray site use patterns against provisioning intensity to determine if provisioning can cause changes to the movements and behaviour of this large, marine mesopredator. Twelve female short-tail stingrays were found to use the site during observation periods for this study. Their presence was significantly correlated with the intensity of provisioning events (cumulative duration per observation session), which occurred most often in the afternoons. Significantly more stingrays visited during provisioning than pre-provisioning in simulated provisioning trials at sites where stingrays are not normally provisioned. Additionally, stingrays were considered to be exhibiting anticipatory behaviour as evidenced by increased visitation in the afternoon, irrespective of whether the fish-cleaning table was in use. These data indicate an influence of provisioning on the stingrays' movements and use of the site and has implications with respect to accepted practices for discarding fish waste.

Authors: Popa, D., and Van Hoesen, K

Year: 2016

Title: A "shark encounter": Delayed primary closure and prophylactic antibiotic treatment of a Great White shark bite

Journal: The Journal of Emergency Medicine

Volume: 51

Issue: 5

Pages: 552-556

Abstract: Shark bites are rare but sensational injuries that are covered in the lay press but are not well described in the medical literature. Popa and Van Hoesen present the case of a 50-year-old man who sustained two deep puncture wounds to his thigh from a great white shark in the waters surrounding Isla de Guadalupe off the coast of Baja California, Mexico, during a caged SCUBA dive. They discuss a strategy of closing the wounds in a delayed primary fashion 24 hours after injury, our antibiotic choices, and the patient's course and review marine pathogens and appropriate antibiotic coverage.

Author: Quiros, A. L.

Year: 2005

Title: Whale shark "ecotourism" in the Philippines and Belize: evaluating conservation and community benefits.

Journal: Tropical Resources: Bulletin of the Yale Tropical Resources Institute

Volume: 24

Issue: -

Pages: 42-48

Abstract: This paper presents the qualitative results of research, conducted between January and August 2004, on the impacts of whale-shark "ecotourism" in the Philippines and Belize. Impacts to the whale sharks as well as impacts to the communities involved, in terms of social and cultural changes, are discussed. It is shown that one alternative for creating a more sustainable whale-shark tourism product is to institutionalise ecotourism by changing rules and regulations, properly financing tourism management, and monitoring tourism impacts.

Author: Quiros, A. L.

Year: 2007

Title: Tourist compliance to a Code of Conduct and the resulting effects on whale shark (*Rhincodon typus*) behaviour in Donsol, Philippines

Journal: Fisheries Research

Volume: 84

Issue:

Pages: 102-108

Abstract: This study examines tourist compliance to the Code of Conduct for whale shark (*Rhincodon typus*) interactions and assesses impacts of tourists on whale sharks in Donsol, Philippines. Whale sharks feed in Donsol's nutrient rich waters between November and June, drawing up to 7100 visitors annually. Tourist, tour operator, and whale shark behaviour were examined during human-whale shark interactions ($n = 777$) on 117 boat trips (March, April and May) in 2004, and on 76 boat trips in 2005 ($n = 620$). Average compliance to Code of Conduct regulations in 2004 and 2005 was 44% for the minimum distance kept; 82% for no touching, no path obstruction and a maximum of six swimmers per whale shark; 89% for a maximum of one boat per shark, 99% for no flash photography and no SCUBA, scooters, and jet-skis. Significant predictors of whale shark's directional changes were path obstruction and proximity of swimmer to whale shark, while for whale shark's dive response it was first-time sighting and whale shark feeding. The significant predictor of a violent shudder behaviour was touching. Generalised linear modelling evaluated change indirection, dive response and violent shuddering variables, and found that touching, flash photography, and swimmer diving towards the whale shark significantly affected the magnitude of disturbance. Tourism impacts on whale sharks can be minimised through adaptive management that monitors tourism and alters interaction regulations to reflect tourist and tour operator actions that have detrimental effects on whale sharks.

R

Authors: Raudino, H., Rob, D., Barnes, P., Mau, R., Wilson, E., Gardner, S., and Waples, K.

Year: 2016

Title: Whale shark behavioural responses to tourism interactions in Ningaloo Marine Park and implications for future management

Journal: Conservation Science Western Australia

Volume: 10

Issue: 2

Pages: -

Abstract: This study examined whale shark behaviour using fixed-wing aerial surveys in Ningaloo Marine Park between 2007 and 2009. The aims of the project were to develop and trial a method to test for impacts of tourism vessels and swimmers on whale shark behaviour. Whale sharks made significantly more directional changes when vessels were present, with approximately twice as many changes in direction observed per scan when a vessel was present. Whale sharks also maintained neutral behaviours, such as surface swimming, swimming at depth, resurfacing, or no reaction during interactions and, notably, more of these were recorded when a vessel was present. This suggests that, while behaviours were maintained regardless of the presence of vessels, whale sharks may have still responded to vessels by changing direction more frequently. The aerial observations were effective in detecting an increase in directional changes but further behavioural studies are required to improve our understanding of natural diving and surfacing behaviour in whale sharks. Alternative research platforms and technologies may be necessary to investigate whale shark behaviour in more detail and to further evaluate potential impacts of tourism interactions on whale sharks.

Authors: Richards, K., O’Leary, B. C., Roberts, C. M., Ormond, R., Gore, M., and Hawkins, J. P.

Year: 2015

Title: Sharks and people: Insight into the global practices of tourism operators and their attitudes to shark behaviour

Journal: Marine Pollution Bulletin

Volume: 91

Issue: -

Pages: 200–210

Abstract: Shark tourism is a popular but controversial activity. Richards and colleagues obtained insights into this industry via a global e-mailed questionnaire completed by 45 diving/snorkelling operators who advertised shark experiences (shark operators) and 49 who did not (non-shark operators). 42% of shark operators used an attractant to lure sharks and 93% stated they had a formal code of conduct which 86% enforced “very strictly”. While sharks were reported to normally ignore people, nine operators had experienced troublesome behaviour from them. Whilst this research corroborates previous studies indicating minimal risk to humans from most shark encounters, a precautionary approach to provisioning is required to avoid potential ecological and societal effects of shark tourism. Codes of conduct should always stipulate acceptable diver behaviour and appropriate diver numbers and shark operators should have a moral responsibility to educate their customers about the need for shark conservation.

Authors: Rodger, K., Smith, A., Davis, C., Newsome, D. and Patterson, P.

Year: 2010

Title: A framework to guide the sustainability of wildlife tourism operators: Examples of marine wildlife tourism in Western Australia

City/State: Gold Coast, QLD, Australia

Institution: CRC for Sustainable Tourism

Date: 2010

Abstract: Growth in the wildlife tourism industry has been significant in recent years with an increasing focus on tourism centred on free-ranging wildlife. In Australia tourism based in the marine environment, including observing and interacting with coastal and marine wildlife, is increasing in popularity. The future potential for increased growth in marine tourism is dependent upon the abundance and diversity of Australia's marine wildlife. Negative impacts of tourism on marine wildlife are difficult to assess as in many cases little is known about the animals or their environment. With the rapid growth in marine tourism the potential for both biophysical and social impacts needs to be recognised. Given the potential impacts and the variable nature of wildlife tourism operations the need arises for a formal auditing and monitoring framework that can identify potential or actual problems and the need for management. This report will examine the opportunities and the barriers in producing a simple, yet reliable framework to assess knowledge available on visitor satisfaction and expectations, identify key areas of product/service improvement, gauge the quality of interpretation programmes, evaluate the effectiveness of impact mitigation strategies and also evaluate the application of key performance indicators for monitoring systems for marine wildlife tourism.

Authors: Rodger, K., Smith, A., Newsome, D., and Moore, S. A.

Year: 2011

Title: Developing and testing an assessment framework to guide the sustainability of the marine wildlife tourism industry

Journal: Journal of Ecotourism

Volume: 10

Issue: 2

Pages: 149-162

Abstract: Growth in the marine wildlife tourism industry has been accompanied by concerns regarding its sustainability. This paper develops and tests a generic framework for assessing the sustainability of such ventures. The framework aims to guide the collection and collation of existing information and then use this information to identify current sustainability issues and information gaps. Development relied on a literature review and expert opinion. Testing was undertaken on whale shark tourism at Ningaloo Marine Park in north-western Australia. Evaluation of the framework suggests it has applicability (i.e. it is simple to use) and is useful, where usefulness refers to the ability to contribute to sustainable tourism management. Its reproducibility (i.e. providing consistent responses irrespective of the context) could only be determined through application to multiple case studies, a recommendation flowing from this study. The framework has at least three applications: improving existing marine wildlife tourism operations through reviewing their sustainability; developing an auditing mechanism as part of the licensing provisions for such tourism; and helping to determine the likely sustainability of proposed ventures. Overall, this framework provides an important opportunity to further develop the professionalism of the wildlife tourism sector through enhancing good practice.

Authors: Rowat, D., and Engelhardt, U.

Year: 2007

Title: Seychelles: A case study of community involvement in the development of whale shark ecotourism and its socioeconomic impact

Journal: Fisheries Research

Volume: 84

Issue: 1

Pages: 109-113

Abstract: Whale sharks (*Rhincodon typus*) have long been known to the local community of Seychelles, especially the fishers, but the sharks have never been exploited there as a food resource. The growing interest in the species by visitors to the islands prompted a more proactive management approach in response to an initial pilot monitoring programme. The stakeholder driven process involving dive and boat operators, conservation organisations and governmental agencies that instigated a nationwide monitoring network is described and the feedback to the public and stakeholders is illustrated. The development and adoption of a code of conduct for whale shark encounters to enable the sustainable use of whale sharks as an ecotourism resource is described. Published estimates of the worth of whale sharks as an ecotourism resource in Seychelles forecast a potential value of up to US\$4.99m for a 14-week season; these are reviewed and compared to actual revenues realised by the fledgling whale shark ecotourism activities. The direct links and spin-offs of these commercial activities to the on-going research programme and the mutual benefits are discussed.

Authors: Rtshiladze, M. A., Andersen, S. P., Nguyen, D. Q. A., Grabs, A., and Ho, K.

Year: 2011

Title: The 2009 Sydney shark attacks: Case series and literature review

Journal: ANZ Journal of Surgery

Volume: 81

Issue: 5

Pages: 345-351

Abstract: There were 59 unprovoked shark attacks worldwide in 2008. Twelve of these occurred in Australia, ranking it as second only to the USA. In February 2009, two attacks occurred within 72h in Sydney, Australia. The two patients involved survived severe limb trauma. Case one suffered bite trauma to the lower limb and hand and underwent staged debridement and early amputation. Case two presented with a hand severed at the level of the wrist that was initially replanted. However, it would succumb to progressive necrosis after 12 days. The authors discuss the aspects of these cases that contributed to the patients' survival and ultimately good functional outcomes. New paradigms for the management of major trauma patients have emerged over the last decade. Rtshiladze and colleagues consider recent advances in the understanding of pre-hospital tourniquet use, rapid transit to the operating suite and damage control surgery, and examine how they impacted on the management of our patients. Very little is known about the microbiology of shark bites. Organisms from sea water, the patient's skin and the shark's mouth must all be considered when selecting appropriate antimicrobial prophylaxis. The planning of definitive surgery in severe limb trauma is dependent on the interactions of a number of factors including physical, psychological and social issues. The decision to ultimately replant or amputate the effected limb is best made in union with the patient and their family.

Authors: Sanzogni, R. L., Meekan, M. G., and Meeuwig, J. J.

Year: 2015

Title: Multi-year impacts of ecotourism on whale shark (*Rhincodon typus*) visitation at Ningaloo reef, Western Australia.

Journal: PloS ONE

Volume: 10

Issue: 9

Pages: e0127345

Abstract: In-water viewing of sharks by tourists has become a popular and lucrative industry. There is some concern that interactions with tourists with ecotourism operations might harm sharks through disruption of behaviours. Here, the authors analysed five years of whale shark (*Rhincodon typus*) encounter data by an ecotourism industry at Ningaloo Reef, Western Australia, to assess the impact of ecotourism interactions on shark visitation, within the context of the biological and physical oceanography of the region. Their data base consisted of 2823 encounter records for 951 individual whale sharks collected by ecotourism operators between 2007 and 2011. They found that total encounters per whale shark and encounters per boat trip increased through time. On average, whale sharks re-encountered in subsequent years were encountered earlier, stayed longer and tended to be encountered more often within a season than sharks that were only encountered in a single year. Sequential comparisons between years did not show any patterns consistent with disturbance and the rate of departure of whale sharks from the aggregation was negatively correlated to the number of operator trips. Overall, their analysis of this multi-year data base found no evidence that interactions with tourists affected the likelihood of whale shark re-encounters and that instead, physical and biological environmental factors had a far greater influence on whale shark visitation rates. This approach provides a template for assessing the effects of ecotourism interactions and environmental factors on the visitation patterns of marine megafauna over multiple years.

Authors: Schleimer, A., Araujo, G., Penketh, L., Heath, A., McCoy, E., Labaja, J., Lucey, A. and Ponzio, A.

Year: 2015

Title: Learning from a provisioning site: code of conduct compliance and behaviour of whale sharks in Oslob, Cebu, Philippines

Journal: PeerJ

Volume: 3

Issue: -

Pages: e1452

Abstract: While shark-based tourism is a rapidly growing global industry, there is ongoing controversy about the effects of provisioning on the target species. This study investigated the effect of feeding on whale sharks (*Rhincodon typus*) at a provisioning site in Oslob, Cebu, in terms of arrival time, avoidance and feeding behaviour using photo-identification and focal follows. Additionally, compliance to the code of conduct in place was monitored to assess tourism pressure on the whale sharks. Newly identified sharks gradually arrived earlier to the provisioning site after their initial sighting, indicating that the animals learn to associate the site with food rewards. Whale sharks with a long resighting history showed anticipatory behaviour and were recorded at the site on average 5 min after the arrival of feeder boats. Results from a generalised linear mixed model indicated that animals with a longer resighting history were less likely to show avoidance behaviour to touches or boat contact. Similarly, sequential data on feeding behaviour was modelled using a generalised estimating equations approach, which

suggested that experienced whale sharks were more likely to display vertical feeding behaviour. It was proposed that the continuous source of food provides a strong incentive for the modification of behaviours, i.e., learning, through conditioning. Whale sharks are large opportunistic filter feeders in a mainly oligotrophic environment, where the ability to use novel food sources by modifying their behaviour could be of great advantage. Non-compliance to the code of conduct in terms of minimum distance to the shark (2 m) increased from 79% in 2012 to 97% in 2014, suggesting a high tourism pressure on the whale sharks in Oslob. The long-term effects of the observed behavioural modifications along with the high tourism pressure remain unknown. However, management plans are traditionally based on the precautionary principle, which aims to take preventive actions even if data on cause and effect are still inconclusive. Hence, an improved enforcement of the code of conduct coupled with a reduction in the conditioning of the whale sharks through provisioning were proposed to minimise the impacts on whale sharks in Oslob.

Authors: Semeniuk, C. A., Bourgeon, S., Smith, S. L., and Rothley, K. D.

Year: 2009

Title: Hematological differences between stingrays at tourist and non-visited sites suggest physiological costs of wildlife tourism

Journal: Biological Conservation

Volume: 142

Issue: 8

Pages: 1818-1829

Abstract: Wildlife tourism alters the environmental conditions in which the focal animal lives, and it is therefore necessary to assess the ability of the animal to adjust to and persist in these novel conditions if the industry is to be sustainable. Here, Semeniuk and colleagues report on the physiological responses of southern stingrays (*Dasyatis americana*) which are the focus of intense marine provisioning-tourism in the Cayman Islands. Using stingrays from non-tourist sites about Grand Cayman as a basis for comparison, they show in this natural experiment that tourist-exposed stingrays exhibit hematological changes indicative of physiological costs of wildlife tourism. The novel conditions with which the stingrays must interact include non-natural food, higher injury rates (from boats, conspecifics and predators), and higher parasite loads (from crowding conditions). As a result of this year-round environment, stingrays display sub-optimal health: lower hematocrit, total serum protein concentrations, and oxidative stress (i.e., lower total antioxidant capacity combined with higher total oxidative status). Moreover, they show evidence of attenuation of the defense system: for tourist stingrays only, animals possessing both injuries and high parasite loads also exhibit lowest leukocrit, serum proteins and antioxidant potential, as well as differing proportions of differential leukocytes indicative of suppression (lymphocytes and heterophils) and down-regulation (eosinophils), thus suggesting that the physiological changes of tourist stingrays are in partial response to these stressors. While survival- and reproduction- quantification was not possible in this long-lived marine species, the physiological measures, situated within ecological context, indicate that the long-term health and survival of tourist stingrays have a significant probability of being affected. Consequently, management of the tourism attraction is essential. The indicators chosen in this study reflect general health indices and defense capabilities used across taxa, and represent a trade-off between ease of collection/analysis and interpretation so that managers can continue the research for monitoring purposes.

Authors: Semeniuk, C. A. D., Haider, W., Cooper, A., and Rothley, K. D.

Year: 2010

Title: A linked model of animal ecology and human behaviour for the management of wildlife tourism

Journal: Ecological Modelling

Volume: 221

Issue: 22

Pages: 2699-2713

Abstract: Wildlife tourism attractions are characterised as having intricately coupled human–wildlife interactions. Accordingly, the ability to mitigate negative impacts of tourism on wildlife necessitates research into the ecology of the system and of the human dimensions, since plans aimed at optimizing wildlife fitness must also be acceptable to tourists. Semeniuk and colleagues developed an integrated systems dynamics model for the management of tourist–stingray interactions at ‘Stingray City Sandbar’ (SCS), Cayman Islands. The model predicts the state of the tourism attraction over time in relation to stingray population size, stingray life expectancy, and tourist visitation under various management scenarios. Stingray population data in the model comprised growth rates and survival estimates (from mark-and-recapture data) and mortality estimates. Inputted changes in their respective rates under different management scenarios were informed by previous research. Original research on the demand of heterogeneous tourist segments for management regulations via a stated choice model was used to calculate changes in the tourist population growth rate from data supplied by the Caymanian government. The management attributes to which tourists were responsive also have anticipated effects on stingray ecology (migration and mortality), and vice versa, thus linking the two components. The authors found that the model’s predictions over a 25-year time span were sensitive to the stingray population growth rate and alternate management options. Under certain management scenarios, it was possible to maximise both the tourist segment in favour of no management and stingray numbers while reducing stingray health. However, the most effective relative strategy included a reduction in visitor density, restricted stingray interactions, and an imposition of a small fee. Over time, although fewer stingrays were predicted to remain at SCS, they would live longer and experience fewer stochastic disease events, and the desirable tourist segment was predicted to predominate. By understanding how management will affect tourist activities and their subsequent impacts on both wildlife health and visitor satisfaction, one can explore the management alternatives that would optimise both

Authors: Semeniuk, C. A. D., and Rothley, K. D.

Year: 2008

Title: Costs of group-living for a normally solitary forager: effects of provisioning tourism on southern stingrays *Dasyatis americana*

Journal: Marine Ecology Progress Series

Volume: 357

Issue: -

Pages: 271-282

Abstract: Animals can perceive tourists as predators and will incur fitness costs should their predator-avoidance behaviours result in forgone resource acquisition. Not all wildlife, however, treat tourists as predators; animals can respond positively to tourists, especially when food is used as an attractant. Semeniuk and Rothley investigate the costs posed by novel grouping over a tourism-provisioned food resource in a normally solitary forager, the southern stingray *Dasyatis americana*, in Grand Cayman. Specifically, they test the hypotheses that group-living stingrays in a new environment—which includes both the presence of tourists and quickly renewing food patches—will be exposed to increased injuries, ecto-dermal parasites and

aggressive interference competition that result from the unusual grouping behaviour. The authors found that, in comparison to stingrays from non-tourist sites, tourist-fed stingrays are more likely to have lower body condition, be injured by boats and predators, be susceptible to ecto-dermal parasites, and be engaged in intense interference competition (in the form of conspecific bite marks). Stingrays from tourist sites also have significantly higher mean numbers of injuries, parasites, and median bite marks. By exploring alternative hypotheses to explain the pattern of our findings (e.g. natural causes/behaviour), Semeniuk and Rothley unequivocally show that the impacts incurred by the stingrays stem from the effects of tourism. These findings suggest that novel grouping poses costs to the stingrays; the tourist site represents a riskier habitat with regards to injury and predation; and there may be long-term fitness consequences. From a management perspective, measures should be taken to alleviate the crowded conditions at tourist sites, in terms of both boat and stingray density.

Authors: Semeniuk, C. A. D., Speers-Roesch, B., and Rothley, K. D.

Year: 2007

Title: Using fatty-acid profile analysis as an ecologic indicator in the management of tourist impacts on marine wildlife: a case of stingray-feeding in the Caribbean

Journal: Environmental Management

Volume: 40

Issue: 4

Pages: 665-677

Abstract: Feeding marine wildlife as a tourism experience has become a popular means by which to attract both people and wildlife, although management efforts are still in their infancy. “Stingray City Sandbar” in the Cayman Islands, where visitors can hand feed free-ranging Southern Stingrays (*Dasyatis americana*), is a world-famous attraction currently undergoing visitor and wildlife management. One plan is to decrease the amount of non-natural food provided by tourists with the intention of decreasing stingray habituation to the artificial food source and promoting stingray health. However, the effectiveness of this action is uncertain given that neither the extent of squid composition in the stingray diet nor the degree of nutrient similarity between the fed and natural diets is unknown. Semeniuk and colleagues used fatty acid (FA) profile analysis to address these questions by assessing the serum non-esterified FA composition of fed and unfed stingrays around the island and compared them with FA profiles of (1) the provisioned food source (squid) and (2) other warm- and cold-water elasmobranchs (sharks and rays). The results indicated that fed stingrays were distinct. The FA profiles of the fed stingray population were expressly different from those of the unfed populations and showed a remarkable similarity to the FA composition of squid, suggesting that squid is the main food source. The tropical fed stingrays also exhibited essential FA ratios, specific to both species and habitat, comparable with those of elasmobranchs and squid from cold-water environs, implying that the provisioned food does not provide a similar nutritional lipid composition to that eaten in the wild. The results suggest that FA profiles are a valuable indicator for the management and monitoring of fed Southern Stingrays because they can be used to assess differences in diet composition and provide an index of nutritional similarity. The findings are currently being used by Caymanian stakeholders in designing practical management actions for their wildlife attraction.

Authors: Simpfendorfer, C. A., Heupel, M. R., White, W. T., and Dulv, N. K.

Year: 2011

Title: The importance of research and public opinion to conservation management of sharks and rays: A synthesis

Journal: Marine and Freshwater Research

Volume: 62

Issue: 6

Pages: 518-527

Abstract: Growing concern for the world's shark and ray populations is driving the need for greater research to inform conservation management. A change in public perception, from one that we need to protect humans from sharks to one where we must protect sharks from humans, has added to calls for better management. The present paper examines the growing need for research for conservation management of sharks and rays by synthesising information presented in a Special Issue from the 2010 Sharks International Conference and by identifying future research needs, including topics such as taxonomy, life history, population status, spatial ecology, environmental effects, ecosystem role and human impacts. However, this biological and ecological research agenda will not be sufficient to fully secure conservation management. There is also a need for research to inform social and economic sustainability. Effective conservation management will be achieved by setting clear priorities for research with the aid of stakeholders, implementing well designed research projects, building the capacity for research, and clearly communicating the results to stakeholders. If this can be achieved, it will assure a future for this iconic group, the ecosystems in which they occur and the human communities that rely on them.

Authors: Skubel, R. A., Shriver-Rice, M., and Maranto, G. M.

Year: 2019

Title: Introducing recreational values as a tool for shark conservation, science and management

Journal: Frontiers in Marine Science

Volume: 6

Issue: -

Pages: Article 53

Abstract: Relational values (RV) are values that arise from a relationship with nature, encompassing a sense of place, feelings of well-being (mental and physical health), and cultural, community, or personal identities. With sharks, such values are formed by diverse groups that interact with these animals and their ecosystems, either physically or virtually, whether a scientist, student, fisher, or media-viewer. Further, these user groups may overlap or come into conflict over management plans, media portrayals of sharks, and their conservation status. Although scientists have not explicitly aimed to assess RV through sharks, qualitative studies of shark fishers, tourism operators, tourists, and the public, as well as historical and archeological accounts, can be interpreted through an analytical lens to reveal values which can also be defined as relational. To this end, this review considers studies capturing RV alongside those of economic value (increasingly, the value of a shark is appraised by their financial value in shark tourism) and the social and cultural roles of sharks. Based on these studies and the broader RV literature, Skubel and colleagues then outline a workflow for how RV can be leveraged in scientific inquiry, equitable resource management, and education. They conclude that via collaborative assessments of RV, with implicit inclusion of multiple values of sharks and by acknowledging their importance to all parties involved in user conflicts, the RV framework can lead to a constructive dialog on polarising conservation and management issues. By illuminating shared values, and/or revealing dichotomies of values ascribed toward certain areas or objects, this framework can provide inroads to mediation, seeking to conserve or even

restore relationships with nature, and their derived values as much as is possible. This approach can yield unexpected knowledge, solutions, and compromises in an increasingly complex conservation landscape.

Authors: Smith, K., Scarr, M., and Scarpaci, C.

Year: 2010

Title: Grey nurse shark (*Carcharias taurus*) diving tourism: Tourist compliance and shark behaviour at Fish Rock, Australia.

Journal: Environmental Management

Volume: 46

Issue: -

Pages: 699-710

Abstract: Humans can dive with critically endangered grey nurse sharks (*Carcharias taurus*) along the east coast of Australia. This study investigated both compliance of tourist divers to a code of conduct and legislation and the behaviour of grey nurse sharks in the presence of divers. A total of 25 data collection dives were conducted from December 2008 to January 2009. Grey nurse shark and diver behaviour were documented using 2-min scan samples and continuous observation. The proportion of time spent observing human–shark interactions was 9.4% of total field time and mean human–shark interaction time was 15.0 min. Results were used to gauge the effectiveness of current management practices for the grey nurse shark dive industry at Fish Rock in New South Wales, Australia. Grey nurse shark dive tourists were compliant to stipulations in the code of conduct and legislation (compliance ranged from 88 to 100%). The research detailed factors that may promote compliance in wildlife tourism operations such as the clarity of the stipulations, locality of the target species and diver perceptions of sharks. Results indicated that grey nurse sharks spent the majority of their time milling (85%) followed by active swimming (15%). Milling behaviour significantly decreased in the presence of more than six divers. Distance between sharks and divers, interaction time and number of sharks were not significantly correlated with grey nurse shark school behaviour. Jaw gaping, rapid withdrawal and stiff or jerky movement were the specific behaviours of grey nurse sharks that occurred most frequently and were associated with distance between divers and sharks and the presence of six or more divers. Revision of the number of divers allowed per interaction with a school of grey nurse sharks and further research on the potential impacts that shark-diving tourism may pose to grey nurse sharks is recommended.

Authors: Smith, K. R., Scarpaci, C., and Otway, N. M.

Year: 2016

Title: Scuba-diving impacts and environmental influences on the patrolling behaviour of grey nurse sharks (*Carcharias taurus*): a preliminary assessment using acoustic telemetry at Fish Rock, Australia

Journal: Tourism in Marine Environments

Volume: 12

Issue: 1

Pages: 17-34

Abstract: The patrolling behaviour of the critically endangered grey nurse shark (*Carcharias taurus*) comprising the occupation of, and movements between, two locations at Fish Rock (off eastern Australia) was documented using passive acoustic telemetry. Sharks occupied the locations symmetrically, asymmetrically, randomly, and nonrandomly. Passive acoustic telemetry was also used to provide a preliminary assessment of the impacts of scuba diving tourism on patrolling behaviour. Maintaining natural behaviours unaffected by anthropogenic disturbances including scuba diving tourism is essential for the recovery and long-term

conservation of this critically endangered species. The patrolling behaviour of replicate sharks on any given day was similar but varied subtly and sometimes markedly in the periods before, during, and after scuba diving typically occurs. In contrast, patrolling behaviour varied substantially among days with and without scuba diving; however, this was not statistically significant. Scuba diving did not impact the occupation of, or movements between, the locations by grey nurse sharks. Instead it is likely that the sharks responded to oceanographic features, localised currents, and prevailing sea conditions by adopting a range of swimming behaviours to conserve energy, and this accounted for the variation in patrolling behaviour among days. Future research at other aggregation sites, during different lunar phases and with sharks at various life history stages should be done to confirm the findings of this first assessment and to enhance the generality of the results to grey nurse sharks elsewhere. Regular monitoring of grey nurse shark scuba diving tourism should be done to ensure that any anthropogenic disturbances are identified so that mitigation can be implemented.

Authors: Smith, K., Scarpaci, C., Scarr, M. J. and Otway, N. M.

Year: 2014

Title: Scuba diving tourism with critically endangered grey nurse sharks (*Carcharias taurus*) off eastern Australia: Tourist demographics, shark behaviour and diver compliance

Journal: Tourism Management

Volume: 45

Issue: -

Pages: 211-225

Abstract: Guidelines and a national code of conduct were implemented to manage scuba diving tourism with the critically endangered grey nurse shark (*Carcharias taurus*) along the Australian east coast. The demographics of diving tourists, swimming behaviour of grey nurse sharks at various life-history stages and compliance of divers to the guidelines/code of conduct were simultaneously assessed during diver-shark interactions at four sites from March 2011 to February 2012. Milling was the most frequent swimming behaviour observed and no significant changes occurred with the number of divers or distance to sharks. Divers exhibited 100% compliance with all guidelines investigated. Satisfactory compliance may have been attributable to guideline clarity, the ease of establishing diver-shark interactions, stakeholder involvement in management processes and diver perceptions of sharks. Similar sampling of group and individual shark behaviour should be done to further enhance the understanding of the beneficial and adverse impacts of this marine wildlife tourism sector.

T

Authors: Techera, E., and Klein, N.

Year: 2014

Book Title: Sharks: Conservation, governance and management

City: London, UK

Publisher: Taylor & Francis

Abstract: *Sharks: Conservation, Governance and Management* surveys the current knowledge and the status of the law and science in relation to sharks, with a particular focus on improving frameworks for their conservation and management. Recent trends are analysed including shark finning bans that have been put in place in several countries, the widening number of nations establishing shark sanctuaries and the growth of shark-based tourism. The efficacy of current listing processes for endangered species, spatial measures and fisheries regulations is also examined. Tourism is explored as an alternative to fishing and the risks and impacts associated with this industry are analysed.

Authors: Techera, E., and Klein, N.

Year: 2013

Title: The role of law in shark-based eco-tourism: Lessons from Australia

Journal: Marine Policy

Volume: 39

Issue: -

Pages: 21-28

Abstract: Marine-based tourism offers opportunities for economic, educational and environmental benefits but is not without risks to people, animals and the environment. If the benefits of this sector are to be harnessed it will require an increasing focus upon law and policy governing the industry. This is particularly the case for shark eco-tourism, which can be an important conservation tool for these species. Australia has a longstanding history of tourism involving whale sharks and great white sharks and an examination of Australian law and policy in shark eco-tourism provides a powerful case study. This article identifies lessons that may be learnt from Australian shark eco-tourism as a first step towards identification of best practice legal strategies that both support the industry and ensure environmental integrity.

Authors: Theberge, M. M., and Dearden, P.

Year: 2006

Title: Detecting a decline in whale shark *Rhincodon typus* sightings in the Andaman Sea, Thailand, using ecotourist operator-collected data

Journal: Oryx

Volume: 40

Issue: 3

Pages: 337-342

Abstract: In this paper, the authors analyse long-term whale shark *Rhincodon typus* sightings collected by ecotourist operators and evaluate the validity of conclusions drawn from the data for scientific and conservation purposes. To date information about the basic ecology and movements of whale sharks is sparse, and only recently has the species received global conservation attention. A dive company in Phuket, Thailand, documented whale shark sightings in the Andaman Sea for 10 years along 300 km of coastline. Whale shark sightings, corrected for effort, dropped by 96% between 1998 and 2001. Combining the seasons from 1992 to 1998, the number of whale shark sightings increased significantly from October to May. The size of sharks observed suggest that the majority were juveniles. The authors discuss the limitations of using ecotourist operators as non-specialist volunteers for data collection but conclude that their use can be beneficial for long-term, broad geographic studies such as this.

Authors: Thomson, J. A., Araujo, G., Labaja, J., McCoy, E., Murray, R., and Ponzo, A.

Year: 2017

Title: Feeding the world's largest fish: highly variable whale shark residency patterns at a provisioning site in the Philippines

Journal: Royal Society Open Science

Volume: 4

Issue: 9

Pages: 170394

Abstract: Provisioning wildlife for tourism is a controversial yet widespread practice. Thomson and colleagues analysed the residency patterns of juvenile whale sharks (*Rhincodon typus*) in Oslob, Philippines, where provisioning has facilitated a large shark-watching operation since 2011. The authors identified 208 individual sharks over three years, with an average of 18.6 (s.d.=7.8, range=6-43) individuals sighted per week. Weekly shark abundance varied

seasonally and peak-season abundance (approx. May–November) increased across years. Whale sharks displayed diverse individual site visitation patterns ranging from a single visit to sporadic visits, seasonal residency and year-round residency. Nine individuals became year-round residents, which represents a clear response to provisioning. The timing of the seasonal peak at Oslob did not align with known non-provisioned seasonal aggregations elsewhere in the Philippines, which could suggest that seasonal residents at Oslob exploit this food source when prey availability at alternative sites is low. Since prolonged residency equates to less time foraging naturally, provisioning could influence foraging success, alter distributions and lead to dependency in later life stages. Such impacts must be carefully weighed against the benefits of provisioning (i.e. tourism revenue in a remote community) to facilitate informed management decisions.

Authors: Topelko, K. N., and Dearden, P.

Year: 2005

Title: The shark watching industry and its potential contribution to shark conservation

Journal: Journal of Ecotourism

Volume: 4

Issue: 2

Pages: 108-128

Abstract: Over 100 million sharks are killed annually, putting enormous pressure on shark populations worldwide. Sharks have traditionally been considered a detriment to coastal tourism, but since the early 1990s, shifts in attitudes amongst divers have led to growth in the popularity of shark watching as a tourist activity. An estimated 500,000 divers a year find, photograph, feed and swim with sharks, contributing millions of dollars to local and regional economies. This paper examines whether the economic value attached to shark watching can provide enough incentive to reduce consumptive exploitation levels. Although the economic value attached to shark watching has led to greater protection of sharks in some locations, analysis of available data suggests that incentives do not appear large enough to encourage a significant reduction in fishing pressure appropriate to the scale of threat facing sharks. Growth of the shark watching industry is constrained by a number of factors including perceived risks and benefits, declining shark populations, and government regulations. However, conservation strategies for sharks involving tourism can be envisaged, involving varying levels of non-consumptive and consumptive uses of sharks. Three kinds interaction between the non-consumptive and consumptive use of sharks are outlined along with implications for shark conservation.

U

Authors: UNEP/CMS

Year: 2017

Title: Sustainable boat-based wildlife watching

City/Country: Bonn, Germany

Institution: United Nations Environment Programme/Convention on the Conservation of Migratory Species of Wild Animals

Issue: COP12/Doc.24.4.5

Abstract: The aim of this document is to provide general best practice guidelines to assist CMS Parties interested in adopting appropriate measures to ensure the sustainability of any boat-based wildlife-watching activities in their area of jurisdiction.

The guidelines provided here aim at ensuring that boat-based wildlife-watching activities do not have negative effects on the long-term survival of populations and habitats and have minimal impact on the behaviour of watched and associated animals.

These guidelines address boat-based wildlife watching only and do not include measures to reduce the impact of other activities such as ‘swim-with’ or ‘dive-with’ that might occur at the same time. When more activities occur at the same time, specific guidelines and limitations shall be included to ensure the safety of marine wildlife and all participants.

V

Author: Venables, S.

Year: 2013

Title: Short-term behavioural responses of manta rays, *Manta alfredi*, to tourism interactions in Coral Bay, Western Australia

Academic Department: School of Veterinary and Life Sciences

University: Murdoch University

Thesis Type: Bachelor of Science

Abstract: Over the past two decades snorkelling or diving with manta rays has become a highly sought after experience for tourists worldwide. The Coral Bay manta ray interaction industry has experienced significant growth since its inception in the early 1990s, and concerns have been raised in recent years regarding disturbance to the manta ray population, and behavioural changes due to tourist interactions. This study was a preliminary assessment of the effect of tourism interactions on *Manta alfredi* behaviour in Coral Bay, Western Australia. In order to identify behavioural responses or changes, the natural behaviours exhibited by manta rays in the waters of Coral Bay were identified and described, and in doing so this study was the first to describe in detail four distinct foraging behaviours that are yet to be explained in the published literature.

A total of 91 manta ray interactions were observed over a four months period to determine the frequency, form and influencing factors of short-term behavioural responses to three separate elements of the tourist interactions: the interaction with the swim group, the tour vessel and the attempt at capturing an identification photo. Behavioural responses were exhibited by manta rays during 34.1 % of interactions with swim groups (n = 91), 15.5 % of interactions with tour vessels (n = 98), and 48.1 % of manta rays exhibited a response to photo identification attempts (n = 77). Several factors were found to influence the occurrence of a behavioural response including the initial behavioural state and age class of the manta ray, the amount of surface splash, the approach strategy of the tour operator or photographer, the duration of the interaction and whether or not it was the manta ray’s first interaction that day. Forms of behavioural responses ranged from immediate avoidance responses to changes in behavioural state, including the termination of feeding behaviours and departure from cleaning stations. Such responses have the potential to lead to biologically significant impacts on the population, including declines in abundance and habitat displacement. Further study is necessary to confirm these links; however as the manta ray tourism industry continues to expand, precautionary management intervention is recommended.

Authors: Venables, S., Winstanley, G., Bowles, L., and Marshall, A. D.

Year: 2016

Title: A giant opportunity: The economic impact of manta rays on the Mozambican tourism industry — an incentive for increased management and protection

Journal: Tourism in Marine Environments

Volume: 12

Issue: 1

Pages: 51-68

Abstract: Manta rays are internationally threatened species and population declines have been reported in various locations worldwide. As iconic megafauna species, they are also major drawcards for wildlife tourism industries. Economic valuation of these industries can provide an incentive for the protection of species and natural habitats through the creation of marine protected areas (MPAs) and the restriction of harvesting or trade. Site-specific estimates are essential, particularly in developing countries, to promote the non-consumptive use of resources and develop appropriate management strategies. This study represents the first localised estimate of the economic benefits of manta ray tourism in Mozambique. Data from 478 tourist expenditure surveys, 15 stakeholder surveys, and yearly diver numbers provided by coastal tour operators were used to estimate the economic impact of manta ray tourism in the Inhambane Province. Manta ray-focused tours were estimated to be worth US\$10.9 million per year in direct revenue to dive operators in the Inhambane Province, with an estimated direct economic impact (including associated tourism expenditures) of US\$34.0 million annually. In the absence of manta ray tourism, between \$16.1 million and \$25.7 million would be lost to the region each year. Tourist and stakeholder survey responses emphasised the importance of manta rays to Mozambican coastal tourism. Both parties highlighted the need for increased protection of marine species and their environment and showed strong support for the implementation of MPAs along the Inhambane coast.

Author: Vianna, G. M. S.

Year: 2015

Title: Conservation of reef sharks in the Palau Shark Sanctuary: Implications of spatial ecology, socio-economic value and anthropogenic impacts

Journal: Marine & Freshwater Research

Academic Department: School of Animal Biology

University: The University of Western Australia

Thesis Type: Doctoral

Abstract: Despite growing awareness of the widespread depletion of shark populations, conservation arguments based on the ecological importance of sharks for marine ecosystems have been insufficient to prevent or reduce ongoing declines. This suggests that there is a need for holistic conservation strategies that integrate ecological information with a better understanding of relationships between sharks and humans. While negative anthropogenic impacts on sharks (such as fishing) have been relatively well-documented, there is an emerging realisation that not all interactions between humans and sharks are necessarily harmful, and in some cases may even be beneficial for both parties. In 2009, Palau declared the world's first shark sanctuary, an action that recognised the importance of sharks to the national economy and health of the country's marine ecosystems. At the time, the sanctuary was assumed to be an effective strategy to ensure the conservation of sharks. However, it was declared with very little baseline knowledge about the ecology and population status of reef sharks, or with any appraisal of their interactions with humans. This thesis addressed this issue using a multi-disciplinary approach, combining ecological and socio-economic data with citizen science to improve our understanding of the ecology of reef sharks. Through this approach, Vianna explored the effects

of interactions between shark and human populations and the potential of these interactions in assisting in the resolution of some of the challenges of shark conservation faced by developing nations.

Using acoustic telemetry, Vianna showed that grey reef sharks (*Carcharhinus amblyrhynchos*) have strong residency at aggregation sites, displaying complex patterns of vertical movement driven by environmental factors. At the same aggregations, the comparison of telemetry data from tagged sharks with counts of sharks collected by professional dive guides revealed a strong correlation between the two datasets, suggesting that citizen science programs can provide reliable and low-cost data to assist long-term monitoring of shark populations. Through a survey study, Vianna estimated the socio-economic value of sharks as a non-consumptive tourism resource in Palau. She showed that shark diving was a major contributor to the national economy, accounting for 8% of the gross domestic product of the country with distribution of revenues benefiting several sectors of society, while promoting shark conservation from community to national levels. Finally, her assessment of the conservation status of reef shark populations of Palau showed very large differences in shark abundances across the sanctuary with low abundance strongly correlated with indicators of illegal, unreported and unregulated fishing in the remote and unvisited reefs of the sanctuary.

Vianna's thesis shows that patterns of shark abundance within the Palau Shark Sanctuary are complex and show evidence of the effects of human impacts. Although the behaviour of humans is generally thought to affect shark populations negatively, the research shows that an alternative scenario, where populations of sharks and humans can both benefit from interactions, is also possible. While a tourism-based conservation strategy may represent an economically attractive scenario for decision-makers, Vianna's research also highlights that any broad-scale conservation benefits will be dependent on management strategies that ensure effective enforcement and surveillance over broad spatial scales (100-1000s of km), instead of just at individual tourism sites. In summary, the thesis presents a framework for assessing the effectiveness of shark sanctuaries highlighting the potential benefits of a tourism-based conservation strategy. This ecological and socio-economic framework can contribute to effective conservation of shark populations, while promoting economic development and assisting the livelihood of local communities in developing countries where marine tourism is viable.

Authors: Vianna, G. M. S., Meeuwig, J. J., Pannell, D., and Meekan, M. G.

Year: 2011

Title: The socio-economic value of the shark-diving industry in Fiji

City/State: Perth, WA, Australia

Institution: Australian Institute of Marine Science, University of Western Australia

Date: November 2011

Abstract: Vianna and colleagues quantified the economic revenues generated by shark diving and the distribution of these revenues to the principal local stakeholders involved with the industry, including businesses, government and local community. Shark-diving contributed US \$42.2 million to the economy of Fiji, a sum composed of revenues generated by the industry combined with the taxes paid by shark-divers to the government. This estimate was based on self-administered questionnaires designed to collect information on the costs and benefit of the shark-diving industry. The authors conducted the study in August/September 2011 and distributed questionnaires on the islands of Viti Levu (including the islands of Nananu-i-Ra and Beqa), Vanua Levu, Taveuni and Kadavu, the Yasawa and Mamanuca groups. Questionnaires were answered by 289 divers, 18 dive operators, six resort managers (surveyed at Pacific Harbour and Coral Coast only), 14 dive guides and nine local subsistence fishers from villages

that regularly received payment from shark-diving operators for the use of the reef of which they are the traditional owners.

The authors took a conservative approach to all calculations in order to reduce the risk of over-estimating the value of shark-diving to the Fijian economy. They calculated the economic revenue of shark-diving to Fiji based on three key pieces of information:

- (1) Total number of divers visiting the country and the proportion of tourists engaged in dive activities from the Fiji International Visitor Survey 2009
- (2) All expenditures of the divers visiting Fiji primarily to engage in shark-diving activities (“dedicated shark-divers”) as revealed by our surveys;
- (3) The expenditures of divers who visited Fiji for reasons other than diving with sharks, but chose to engage in shark-diving while in the country (“casual shark-divers”) as revealed by our surveys. Expenditures of these divers were allocated as the proportion of their trip spent shark diving, rather than for their entire visit.

In 2010 Vianna and colleagues estimated that approximately 49,000 divers were engaged in shark-diving activities in Fiji accounting for 78% of the 63,000 divers visiting the country. Dedicated and casual shark-divers accounted for 24% and 54% of all divers interviewed respectively. The shark-diving industry contributed US \$17.5 million in taxes to the government, a sum composed of corporate taxes from shark-diving (US \$11.6 million) and the direct taxes from shark-divers (US \$5.9 million). A minimum of US \$4 million was generated annually by shark-diving for local communities. This revenue consisted of salaries paid by the industry to employees (US \$3.9 million annually) and community levies paid by dive operators to traditional owners in villages for access to reefs (US \$124,200 annually). Employees of the dive industry were predominantly Fijian (13 of 14 dive guides who responded to surveys).

Community levies from shark-diving have played a significant role in promoting the conservation of reefs through systems of traditional ownership. Viti Levu hosted the largest number of dedicated and casual shark-divers (17,000) with Pacific Harbour accounting for around 50% of the shark-divers, or approximately 8,600 tourists. The Mamanuca/Yasawa group also hosted a large number of shark-divers (11,000) while Vanua Levu/Taveuni hosted approximately 3,600. Kadavu had only 17% of divers identified as casual sharkdivers and no dedicated shark-divers interviewed during our survey. Shark-diving generated approximately US \$10.2 million on Viti Levu (63% of business revenues from diving) and US \$3.2 million (40% of the business revenues) in the Mamanuca/Yasawa groups.

Authors: Vianna, G. M. S., Meekan, M. G., Pannell, D. J., Marsh, S. P., and Meeuwig, J. J.

Year: 2012

Title: Socio-economic value and community benefits from shark-diving tourism in Palau: a sustainable use of reef shark populations

Journal: Biological Conservation

Volume: 145

Issue: 1

Pages: 267-277

Abstract: Arguments for conservation of sharks based on their role in the maintenance of healthy marine ecosystems have failed to halt the worldwide decline in populations. Instead, the value of sharks as a fishery commodity has severely reduced the abundance of these animals. Conservation may be assisted by the development of an alternative approach that emphasises the economic value of sharks as a non-har-vested resource. This study quantifies the value of a tourism industry based on shark diving. Using data collected from surveys, as well as government statistics, Vianna and colleagues show that shark diving is a major contributor to the economy of Palau, generating US\$18 million per year and accounting for approximately 8% of the gross domestic product of the country. Annually, shark diving was responsible for

the disbursement of US\$1.2 million in salaries to the local community and generated US\$1.5 million in taxes to the government. If the population of approximately 100 sharks that interact with tourists at popular dive sites was harvested by fishers, their economic value would be at most US\$10 800, a fraction of the worth of these animals as a non-consumptive resource. Fishers earn more selling fish for consumption by shark divers than they would gain by catching sharks. Shark diving provides an attractive economic alternative to shark fishing, with distribution of revenues benefiting several sectors of the economy, stimulating the development and generating high revenues to the government, while ensuring the ecological sustainability of shark populations.

Authors: Vianna, G. M. S., Meekan, M. G., Rogers, A. A., Kragt, M. E., Alion, J. M., and Zimmerhackel, J. S.

Year: 2018

Title: Shark-diving tourism as a financing mechanism for shark conservation strategies in Malaysia

Journal: Marine Policy

Volume: 94

Issue: -

Pages: 220-226

Abstract: This study estimated the economic value of the shark-diving industry in Semporna, the most popular diving destination of Malaysia, by surveying the expenditures of diving tourists and dive operators through the region. A willingness-to-pay survey was also used to estimate the potential of the industry as a financing mechanism for enforcement and management of a hypothetical Marine Protected Area (MPA) to conserve shark populations. The study showed that in 2012, shark-diving tourism provided direct revenues in excess of USD 9.8 million to the Semporna region. These economic benefits had a flow-on effect, generating more than USD 2 million in direct taxes to the government and USD 1.4 million in salaries to the community. A contingent valuation analysis indicated that implementation of a fee paid by divers could generate over USD 2 million for management and enforcement of the MPA each year. These findings suggest that shark diving is an important contributor to the economy of the Semporna region that could be used as a mechanism to assist financial resourcing for management and conservation strategies.

Authors: Vignon, M., Sasal, P., Johnson, R. L., and Galzin, R.

Year: 2010

Title: Impact of shark-feeding tourism on surrounding fish populations off Moorea Island (French Polynesia)

Journal: Marine & Freshwater Research

Volume: 61

Issue: 2

Pages: 163-169

Abstract: Shark feeding is widespread throughout tropical, subtropical and temperate marine ecosystems and gives rise to controversy because there is little consensus regarding its management. There are few comprehensive reports that consider how shark feeding with bait might impact local fishes, despite the development of this practice during the last few decades. Although shark feeding might theoretically have parasitological effects on local non-target fish species in the vicinity of feeding areas, this aspect has never been investigated. During an extensive parasitological survey conducted between 2005 and 2007, a total of 1117 fish belonging to six common grouper and snapper species were sampled throughout the entire north coast of Moorea Island (French Polynesia), encompassing three localities where feeding has

occurred frequently since the 1990s. Parasites exhibited no spatial patterns except for the infections on the blacktip grouper (*Epinephelus fasciatus*). On this species, the prevalence of larval cestodes that parasitise sharks as adults and the intensity of their infestation were significantly higher around shark-feeding localities compared with non-shark-feeding localities. The results of this study suggest for the first time that although long-term shark feeding has parasitological implications, the impacts appear limited, only involve cestode larvae from one host species and do not seem to affect the health of the studied fish.

W

Author: Walker, T.

Year: 2002

Title Review of fisheries and processes impacting shark populations of the world

Editors: S. Fowler, T. Reid, and F. A. Dipper

Book Title: Elasmobranch biodiversity, conservation and management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997

City: Gland, Switzerland

Publisher: The World Conservation Union (IUCN).

Pages: 220-229

Abstract: Populations of many species of shark around the world are being affected by harvesting and habitat change. Widespread stock reductions have occurred for targeted and bycatch species of shark in certain industrial fisheries. More localised reductions have occurred closer to shore from the effects of industrial, artisanal, recreational and, possibly, traditional fisheries. Beach protection programmes, designed to reduce the risk of shark attack on humans at bathing beaches, have also reduced numbers. Several countries are beginning to manage usage of their shark resources rationally, but most are not. Whilst stocks of some species are being harvested sustainably, stocks of other species have been reduced to levels where they now require total protection. Other factors impacting shark populations are more difficult to quantify. Industrial, domestic and agricultural development in coastal and catchment areas are affecting inshore nursery areas. Aquaculture, ecotourism, spread of exotic organisms, pollution and environmental disturbance by fishing gear, and, in the long-term, global warming and ozone thinning are probably having more subtle impacts. These anthropogenic non-harvesting influences together are likely to be impacting first on those species of shark reliant on inshore areas for their nurseries; certain migratory species are likely to be impacted in the long-term.

Author: Ward-Paige, C. A.

Year: 2014

Title: The role of the tourism industry

Editors: E. J. Techera and N. Klein

Book Title: Sharks: Conservation, governance and management

City: London, United Kingdom

Publisher: Taylor & Francis

Pages: 157-175

Abstract: The marine tourism industry consists of a variety of stakeholders that depend on abundant and diverse natural resources. The trend towards improved monitoring, conservation and management is particularly evident in the industry of shark and ray tourism which is demonstrated by a growing number of research projects that are facilitated by the tourism industry, and associated operational and policy changes advocated for by the tourism industry. This chapter outlines the role of the tourism industry in shark conservation, governance and management, including recreational fishers, divers, snorkellers and vessel-based operations.

Authors: Ward-Paige, C. A. and Lotze, H. K.

Year: 2011

Title: Assessing the value of recreational divers for censusing elasmobranchs

Journal: PLoS ONE

Volume: 6

Issue: 10

Pages: -

Abstract: Around the world, researchers are using the observations and experiences of citizens to describe patterns in animal populations. This data is often collected via ongoing sampling or by synthesising past experiences. Since elasmobranchs are relatively rare, obtaining data for broad-scale trend analysis requires high sampling effort. Elasmobranchs are also relatively large and conspicuous and therefore it may be possible to enlist recreational divers to collect data on their occurrence and relative abundance from daily dive activities. For this, however, a good understanding of the value of data collected by recreational divers is essential. Here, the authors explored the value of recreational divers for censusing elasmobranchs using a diverse set of data sources. First, they used a simulation experiment to explore detection rates of the roving diver technique, used by recreational divers, across a range of fish densities and speeds. Next, using a field survey, they showed that inexperienced recreational divers detect and count elasmobranchs as well as experienced recreational divers. Finally, semi-structured interviews of recreational dive instructors were used to demonstrate the value of their recollections in terms of effort and their descriptions of spatial and temporal distributions of sharks in Thailand. Overall, this study provides initial ground-work for using recreational divers for monitoring elasmobranch populations. If used appropriately, citizen-collected data may provide additional information that can be used to complement more standardised surveys and to describe population trends across a range of spatial and temporal scales. Due to the non-extractive nature of this data, recreational divers may also provide important insight into the success of conservation initiatives, such as shark sanctuaries and no-take zones.

Author: West, J. G.

Year: 2011

Title: Changing patterns of shark attacks in Australian waters

Journal: Marine and Freshwater Research

Volume: 62

Issue: 6

Pages: 744-754

Abstract: Although infrequent, shark attacks attract a high level of public and media interest, and often have serious consequences for those attacked. Data from the Australian Shark Attack File were examined to determine trends in unprovoked shark attacks since 1900, particularly over the past two decades. The way people use the ocean has changed over time. The rise in Australian shark attacks, from an average of 6.5 incidents per year in 1990–2000, to 15 incidents per year over the past decade, coincides with an increasing human population, more people visiting beaches, a rise in the popularity of water-based fitness and recreational activities and people accessing previously isolated coastal areas. There is no evidence of increasing shark numbers that would influence the rise of attacks in Australian waters. The risk of a fatality from shark attack in Australia remains low, with an average of 1.1 fatalities year⁻¹ over the past 20 years. The increase in shark attacks over the past two decades is consistent with international statistics of shark attacks increasing annually because of the greater numbers of people in the water.

Authors: Wetherbee, B. M., Lowe, C. G., and Crow, G. L.

Year: 1994

Title: A review of shark control in Hawaii with recommendations for future research

Journal: Pacific Science

Volume: 48

Issue: 2

Pages: 95-115

Abstract: In an attempt to allay public fears and to reduce the risk of shark attack, the state government of Hawaii spent over \$300,000 on shark control programmes between 1959 and 1976. Six control programmes of various intensity resulted in the killing of 4,668 sharks at an average cost of \$182 per shark. The programmes furnished information on diet, reproduction, and distribution of sharks in Hawaii, but research efforts of the programmes had a number of shortcomings. Analysis of the biological data gathered was not directed toward the tiger shark, *Galeocerdo cuvier* (Peron & LeSueur), which is responsible for most attacks in Hawaii. Reliable estimates of shark populations in Hawaii cannot be made based on catch data from control programmes because of sampling biases. Most of the information gained from the control programmes was not published in reviewed journals and is not readily available to the scientific community. The ability of the control programmes to reduce shark populations and to remove large sharks from coastal waters appears to have been stated with more confidence than is warranted, considering seasonal changes observed in shark abundance and variable fishing effort. Shark control programmes do not appear to have had measurable effects on the rate of shark attacks in Hawaiian waters. Implementation of large-scale control programmes in the future in Hawaii may not be appropriate. Increased understanding of the behaviour and biology of target species is necessary for evaluation of the effectiveness of small-scale control efforts, such as selective fishing after an attack. Acoustic telemetry, conventional tagging, and studies on population dynamics concentrating primarily on the tiger shark may be used to obtain data about activity patterns, distribution, and population parameters, providing information useful for reducing the risk of shark attack in Hawaii and elsewhere.

Authors: Whatmough, S., Van Putten, I., and Chin, A.

Year: 2011

Title: From hunters to nature observers: a record of 53 years of diver attitudes towards sharks and rays and marine protected areas

Journal: Marine and Freshwater Research

Volume: 62

Issue: 6

Pages: 755-763

Abstract: Human values, perceptions, attitudes and interactions with the natural environment have been found to change over time, with social and economic information used to inform management decisions and actions. Content analysis is applied here to a 53-year long collection of the popular dive magazine, *Sport Diving*, to identify recreational divers' experiences with regard to sharks and rays, the Great Barrier Reef (GBR) and marine protected areas (MPAs). This analysis suggests there has been a diversification of diver activities with the emergence of passive-observational activities such as SCUBA diving. Attitudes towards sharks and rays have changed significantly, with recreational divers changing from a group that could be described as adventure-seeking hunters to a group that can be described as nature-appreciating observers, suggesting an increase in conservation awareness. The GBR continues to be a highly regarded dive destination, with divers perceiving positive effects of protection within MPAs. However, declines in the abundance of large fish and sharks and rays were occasionally reported throughout the 53 year period. Collectively, these types of data can show changes in resource-

use patterns, perceptions and attitudes and provide information that supplements scientific monitoring data. These data may be valuable where scientific data is scarce, historical records difficult to obtain, and where attitudinal change can significantly affect future resource use.

Author: White, L.

Year: 2008

Title: Sea the value: Quantifying the value of marine life to divers

Academic Department: Nicholas School of the Environment

University: Duke University

Type of Thesis: Master of Environmental Management

Abstract: Contemporary wildlife conservation is often promoted through market-mechanisms. The logic behind this approach is that wildlife must 'pay its way' if it is to be conserved. While this approach can be critiqued from a variety of perspectives, considerable investment has been made in finding ways to create markets for wildlife conservation. From a methods perspective, assessments of willingness to pay, using contingent valuation surveys, have become widely used to determine whether or not various values for wildlife can be translated into market values, and thus into economic arguments for their conservation. This study assesses respondent views of the role of divers in marine conservation and examines willingness to pay among certified U.S. scuba divers for particular wildlife encounters while diving.

Authors: Wong, C. W. M., Conti-Jerpe, I., Raymundo, L. J., Dingle, C., Araujo, G., Ponzo, A., and Baker, D. M.

Year: 2019

Title: Whale shark tourism: Impacts on coral reefs in the Philippines

Journal: Environmental Management

Volume: 63

Issue: 2

Pages: 282-291

Abstract: Reef-based tourism has been developing rapidly in recent decades yet its impacts on reef ecosystems are often overlooked. In Tan-awan, Oslob, Philippines, whale sharks are attracted to the shallow reefs where they are provisioned up to 50 tons y^{-1} of feed and this phenomenon in turn attracts $>300,000 y^{-1}$ visitors. Given the intensive provisioning and concentrating tourism activities, Wong and colleagues hypothesised that the whale shark tourism-impacted site (IS) will have greater impacts on reef degradation and higher anthropogenic nitrogen pollution level compared to its reference site (RS). Ecological surveys revealed that relative to the RS, the IS had 36% higher relative abundance of *Pocillopora* and *Porites* coral over other genera, >2.5 -fold lower coral density, and 20% higher macroalgal cover, which the authors concluded are signs of reef degradation. Also, they conducted stable nitrogen isotope analysis on gorgonian skeletons to trace nitrogen sources at both sites through time. Although an average 1‰ isotope enrichment found in the IS relative to the RS could indicate anthropogenic nitrogen inputs in the IS, this enrichment was consistent over time and existed before the tourism developed. Despite that, Wong and colleagues cautioned against the imminent threat of local eutrophication caused by the continued inputs of nitrogen derived from provisioning and tourism activities. In summary, this study provided the first documentation of the impacts of provisioned whale shark tourism on the local reefs in Tan-awan and established an ecological baseline for future comparisons. Such assessments can offer important information on reef health, coastal development, and tourism management.

Authors: Wood, P. and Rumney, J.

Year: 2017

Title: Key stakeholder views of marine research tourism in Australia

Conference Name: The 6th International Congress on Coastal & Marine Tourism: The spirit of Ubuntu: Connecting continents, places and people

Conference Location: Port Elizabeth, South Africa

Pages: 97-119

Abstract: Marine research tourism (MRT) is defined as marine ecotourism where marine research is an important part of the tourism attraction. The aim of this study was to further understand the supply side views of Australian MRT stakeholders towards the present and any potential development of MRT in Australia. An online survey of 49 key stakeholders views and subsequent analysis was undertaken. Stakeholders were asked 19 questions about their views on; the benefits of, driving forces, issues, and opportunities for, and the role of private industry and government in MRT in Australia.

This study identified three likely benefits of MRT that can be considered to be a core competitive advantage for MRT when compared with many marine tourism or ecotourism ventures. The potential for increased opportunities and benefits of MRT to indigenous Australians is also identified. Survey respondents also identified a range of potential coordination and service provision roles for Australian indigenous groups, environmental conservation organisations and marine education societies in any coordinated development of MRT in Australia. Academic publications and the involvement of marine research agencies with MRT were identified as important or essential to MRT.

Overall, conservation organisations, marine education societies, marine research students, tour organisations, and MRT operators had positive views about MRT in Australia. However, many marine managers, researchers and tour operators appeared to have a reticence towards MRT. This reticence is partly due to MRT related concerns that have not previously been identified in the literature. They are; possible independent influence from other MRT stakeholders on established marine research agendas, possible competition by MRT for traditional research funding, and the possibility of popular MRT science competing with less popular but important marine research priorities. To address such concerns, this paper recommends a range of strategies for any coordinated strategic plan to develop MRT in Australia.

Z

Authors: Zemah Shamir, Z., Zemah Shamir, S., Becker, N., Scheinin, A., and Tchernov, D.

Year: 2019

Title: Evidence of the impacts of emerging shark tourism in the Mediterranean

Journal: Ocean & Coastal Management

Volume: 178

Issue: 1

Pages: 104847

Abstract: Shark tourism is a new concept that has not yet been recognised in Israel. While the principles and regulation of shark tourism in particular and wildlife tourism in general are developing rapidly worldwide, and Israel is only at the very beginning of this process. The aggregations of sharks near the power plant in Hadera (in the middle-northern part of the Israeli coast) are a source of interest and attraction for many people, including swimmers, divers, and kayakers. The desire of tourists, and therefore of local businesses as well, to take part in this amazing and profitable phenomenon poses certain risks, in view of the lack of regulation in the area. In this study the authors analyse the ecological-socioeconomic consequences of shark

tourism as well as the risks of visitor pressure for the environment. The authors' observations suggest that human divers might disturb the sharks and influence behavioural changes. They call on decision makers to regulate the area have least ecological damage so that the sharks can live with minimum disturbance while allowing some reasonable amount of wildlife tourism.

Author: Ziegler, J.

Year: 2010

Title: Assessing the sustainability of whale shark tourism: a case study of Isla Holbox, Mexico

Academic Department: Department of Geography

University: University of Victoria (BC)

Thesis type: Master of Science

Abstract: Sharks are among the most threatened taxonomic groups worldwide. Shark tourism is viewed as a potential means of protecting threatened species, while also providing a sustainable livelihood for local communities. Whale sharks are one such species. Whale shark tourism has grown rapidly in the last twenty years. It is worth an estimated US\$66 million and is available in over 15 countries worldwide. However, the management of this industry varies greatly from site to site, from little to no regulations in Thailand to license caps and interaction guidelines in Australia. Further, the long-term sustainability of whale shark tourism is dependent not only on local scale management, but also global scale issues affecting the targeted species. This study assesses the current status and future sustainability of the whale shark tourism industry on Isla Holbox, Mexico. Specific areas of focus include: (1) tourist motivations and satisfaction with the environmental and tour features offered, (2) shark tourist specialisation, (3) a comprehensive assessment of the site's sustainability using Duffus and Dearden's (1990) Wildlife Tourism Model, and (4) an assessment of the whale sharks' vulnerability to global scale threats (e.g. marine pollution; global climate change). Methods included a questionnaire provided to whale shark tour participants on Isla Holbox from June to September, 2008 (n=392, response rate=90%), in-water observation of human-whale shark interactions, and the application of a semi-quantitative climate change vulnerability framework. Results suggest that the industry on Holbox is reaching its tipping point if changes are not made to improve its management policies and design. Industry issues include: (1) crowding due to poor control of the industry's growth (visitation and number of operators), (2) significant impacts on the whale shark population due to poor compliance with interaction guidelines, and (3) the inequitable distribution of benefits within the community, including significant economic leakages. The results of the vulnerability assessment to large-scale threats suggest that global climate change could have a significant impact on the size and distribution of whale shark aggregations in the future. Thus, the majority of whale shark tourism activities, which are based on whale sharks aggregating in vulnerable habitats, may be unsustainable in the long-term regardless of management approach. The type of users and format of tours on Holbox further supports an increased vulnerability to climate change. This study provides a significant contribution to understanding the sustainability of marine wildlife tourism activities targeting threatened species within critical habitats through the assessment of whale shark tourism sustainability using an integrated, multidisciplinary model that addresses both the social and biological dimensions of sustainability. It also includes the first comprehensive assessment of whale shark vulnerability to global climate change based on habitat type and its implications for whale shark tourism activities targeting this species at seasonal aggregation sites. In addition, this study also provides a greater understanding of tourist motivation and satisfaction within marine wildlife tourism, and shark tourism in particular and a first look at shark tourist specialisation and its links to environmental impacts and management preferences.

Author: Ziegler, J.

Year: 2019

Title: Conservation outcomes and sustainability of whale shark tourism in the Philippines

Academic Department: Department of Geography

University: University of Victoria (BC)

Thesis type: Doctoral

Abstract: Biodiversity loss is one of the major environmental threats facing the planet. Incentive-based conservation is one means to reduce human pressure on wildlife by providing economic incentives for resource-dependent people to protect the environment. Marine wildlife tourism is one of the fastest growing tourism sectors globally and is viewed as an important incentive-based approach for achieving marine conservation goals. However, few studies have linked participation in the provisioning of marine wildlife tourism activities with positive social and ecological conservation outcomes. The goal of this dissertation is to provide greater understanding of the conservation value of marine wildlife tourism using whale shark tourism as a case study with a main focus on social conservation outcomes amongst tourism providers. Positive changes in perceptions, attitudes and values towards target species and their environments can be an important element of incentive-based conservation. The study has the following objectives: (1) to assess the status of the global whale shark tourism industry, including types (e.g., captive, non-captive), real and potential impacts, conservation value and management challenges and best practices; (2) to examine the ethics of provisioning whale sharks in Oslob, Philippines, the largest, noncaptive viewing site in the world; (3) to determine if working in ecotourism changed the attitudes and behaviours of locals towards whale sharks and the ocean, and if tourism type affects those outcomes; (4) to assess the marine wildlife value orientations of locals working in whale shark tourism to achieve greater understanding of the factors influencing their conservation attitudes and behaviours; (5) to explore the potential long-term impacts of poorly conceived incentive-based conservation projects on social and ecological conservation outcomes; and (6) to re-examine and update the conceptual and theoretical background for wildlife tourism in light of the findings of this study. Methods include a comprehensive literature review, tourist surveys, social media content analysis, and interviews with locals working in whale shark tourism at four sites in the Philippines. Results suggest that marine wildlife tourism can play an important role in changing locals' attitudes and behaviours towards the focal species and habitat; however, smaller-scale, more established sites had greater conservation value than the mass tourism or failed sites suggesting that small-scale, community-based ecotourism is the best approach to meeting conservation goals of marine wildlife tourism. Yet, few tourism sites meet these standards. Global standards are needed to ensure whale shark tourism activities meet desired conservation goals. Such standards should include management requirements (e.g., licensing, mandatory education program) and interaction guidelines (e.g. minimum viewing distances, limits on the number of swimmers/boats, etc.). The findings also emphasise that economics should not be the only or primary metric used to measure conservation success; rather, the focus should be on assessing a more comprehensive range of social and ecological conservation outcomes of these activities.

Authors: Ziegler, J. A. and Dearden, P.

Year: forthcoming

Title: Protecting an endangered species: The role of whale shark tourism as an incentive-based conservation approach

Editors: S. Pierce and A. Dove

Book Title: Saving Earth's Largest Fish: Biology and Conservation of Whale Sharks

City: Boca Raton, FL, United States

Publisher: Taylor & Francis CRC Press

Pages: forthcoming

Abstract: This chapter discusses the role of whale shark tourism within the context of incentive-based conservation. Whale sharks are the most watched shark in the world, with tourism worth an estimated US\$1.7 billion worldwide attracting over 25.5 million people annually at 46 sites in 23 countries. The largest collection of sites is in Asia. Tourist opportunities range from captive aquaria and sea pen tourism to non-captive provisioned activities and wild encounters. Whale shark tourism can be an important means to protect whale sharks by providing economic incentives to local communities, as well as changing local attitudes and behaviours towards this endangered species. However, research suggests that the activity can also lead to negative impacts on individual sharks and overall fitness. Effective management is critical in order to minimise impacts, incorporate community perspectives, build conservation awareness and ensure a satisfactory tourist viewing experience in line with expectations for a genuine ecotourism activity. Although codes of conduct exist for most sites these need to be reviewed to meet international standards and assistance provided to ensure that they are implemented and enforced.

Authors: Ziegler, J. A., Dearden, P. and Rollins, R.

Year: 2012

Title: But are tourists satisfied? Importance-performance analysis of the whale shark tourism industry on the Isla Holbox, Mexico.

Journal: Tourism Management

Volume: 33

Issue: 3

Pages: 692-701

Abstract: The objective of this paper is to understand the motivations and satisfactions of whale shark tour participants on Isla Holbox, Mexico in order to assess the success of this industry in meeting customer expectations. Whale shark tour participants were provided with a list of environmental and setting features and asked to rate the importance of, and satisfaction with, each feature. Importance-performance (IP) analysis was used to compare these scores and identify areas of management concern. The IP analysis identified key issues with false advertising, lack of educational information, perceived crowding, and tour cost. These factors are representative of larger issues related to the uncontrolled growth of the whale shark tourism industry on Holbox. Management should focus on limiting the growth of the industry, ensuring the equitable distribution of economic benefits within the industry, and developing and implementing effective guide training and interpretation programs.

Authors: Ziegler, J. A., Dearden, P. and Rollins, R.

Year: 2016

Title: Participant crowding and physical contact rates of whale shark tours on Isla Holbox, Mexico

Journal: Journal of Sustainable Tourism

Volume: 24

Issue: 4

Pages: 616-636

Abstract: Whale shark tourism is a growing niche market within the marine wildlife tourism sector. Increased visitation and declining whale shark numbers at some tourism sites worldwide raise questions over the long-term sustainability of this industry. This study examines the social and potential biological impacts of “swim-with” whale shark tourism on Isla Holbox, Mexico. A total of 397 tour participants completed a self-administered questionnaire regarding perceived crowding, reported encounters and encounter norms, as well as self-reported physical contact rates with whale sharks. Relatively high physical contact rates suggest that tourism may cause some harm to sharks. Users who encountered more swimmers than their norm felt significantly more crowded and were more likely to perceive the industry as having a negative impact on the sharks and surrounding environment. However, the results suggest that the number of boats in the whale shark viewing area may have a greater influence on crowding than number of swimmers. Management interventions to improve the sustainability of the industry include improved interpretation and guide intervention, achieving higher compliance with existing guidelines, and limiting the number of boats allowed in the whale shark viewing area.

Authors: Ziegler, J. A., Araujo, G., Labaja, J., Legaspi, C., Snow, S., Ponzo, A., Rollins, R., and Dearden, P.

Year: 2019

Title: Measuring perceived crowding in the marine environment: Perspectives from a mass tourism „swim-with“ whale shark site in the Philippines

Journal: Tourism in Marine Environments

Volume: 14

Issue: 4

Pages: 211-230

Abstract: Perceived crowding is an important measure in assessing the social impacts of tourism activities. The goal of this study was to determine if the method used to measure perceived crowding in the marine environment (numerical vs. visual approach, boat vs. swimmer crowding) affects the crowding outcome and to apply the concept to a high-density marine wildlife tourism site, viewing whale sharks in Oslob, Philippines. The influence of various variables, including specialisation, gender, nationality, swimmer behaviours, and proximity, was also tested to see if they affected crowding levels. Results indicate that a visual approach is more accurate in measuring reported encounters and encounter norms, and that boat and swimmer crowding are not interchangeable. Boat crowding is a serious problem in Oslob (95.6% crowded). Specialisation, nationality, and swimmer behaviours and proximity all affected perceived crowding. Individuals who reported feeling crowded were more likely to perceive negative impacts of tourism activities on the local community, whale sharks, and wider environment. They also showed higher levels of support for management interventions to limit the number of people and boats at the site and to better regulate or ban whale shark provisioning activities. This study provides important insights regarding how to measure perceived crowding in the marine environment and management implications for a mass tourism wildlife site experiencing overcrowding.

Authors: Ziegler, J. A., Araujo, G., Labaja, J., Snow, S., King, J. N., Ponzo, A., Rollins, R., and Dearden, P.

Year: Forthcoming

Title: Can ecotourism change community attitudes towards conservation?

Journal: Oryx

Volume: Forthcoming

Issue: Forthcoming

Pages: Forthcoming

Abstract: A basic tenet of ecotourism is to enhance conservation. However, few studies have assessed its effectiveness in meeting conservation goals and whether the type of tourism activity affects outcomes. This study examines whether working in ecotourism changes the perceptions, attitudes and behaviours of local people towards the focal species and its habitat and, if so, if tourism type affects those outcomes. The authors interviewed 114 respondents at four whale shark *Rhincodon typus* tourism sites in the Philippines to compare changes in perceptions, attitudes and behaviours towards whale sharks and the wider marine environment. They found that the smaller scale tourism sites had greater social conservation outcomes than the mass or failed tourism sites, including changes in perceptions and attitudes towards whale sharks, conservation ethic and behaviours towards whale sharks and the ocean. Furthermore, of the three active tourism sites, the smallest site with the lowest economic returns and the highest negative impacts on whale sharks prior to tourism activities had the largest proportion of respondents who reported a positive change in perceptions, attitudes and behaviours towards whale sharks and the ocean. The results suggest that tourism type, and the associated incentives, can have a significant effect on conservation outcomes and ultimately on the ecological status of a species and its habitat.

Authors: Ziegler, J. A., Silberg, J. N., Araujo, G., Labaja, J., Ponzo, A., Rollins, R., and Dearden, P.

Year: 2018

Title: A guilty pleasure: Tourist perspectives on the ethics of feeding whale sharks in Oslob, Philippines

Journal: Tourism Management

Volume: 68

Issue: -

Pages: 264-274

Abstract: This study explored the ethics of provisioning wildlife to enhance tourist interactions at a whale shark tourism site in Oslob, Philippines. TripAdvisor comments (n=947) and tourist surveys (n=761) were used to better understand tourists' perceptions of whale shark provisioning in Oslob. The ethical decisions made were then critically assessed using utilitarian and animal welfare ethical philosophies. The majority of respondents supported whale shark provisioning, despite many being aware of the ethical complications of provisioning sharks for tourism purposes. Respondents justified their participation in this activity using mainly economic, human enjoyment, and animal welfare arguments. A utilitarian assessment of the potential costs and benefits of this activity highlighted the gaps in our knowledge regarding the economic and social benefits of this activity, as well as the negative impacts on the sharks' welfare. Until such analyses are completed, significant ethical questions remain regarding the provisioning of these sharks.

Authors: Ziegler, J. A., Silberg, J. N., Araujo, G., Labaja, J., Ponzio, A., Rollins, R., and Dearden, P.

Year: 2019

Title: Applying the precautionary principle when feeding an endangered species for marine tourism

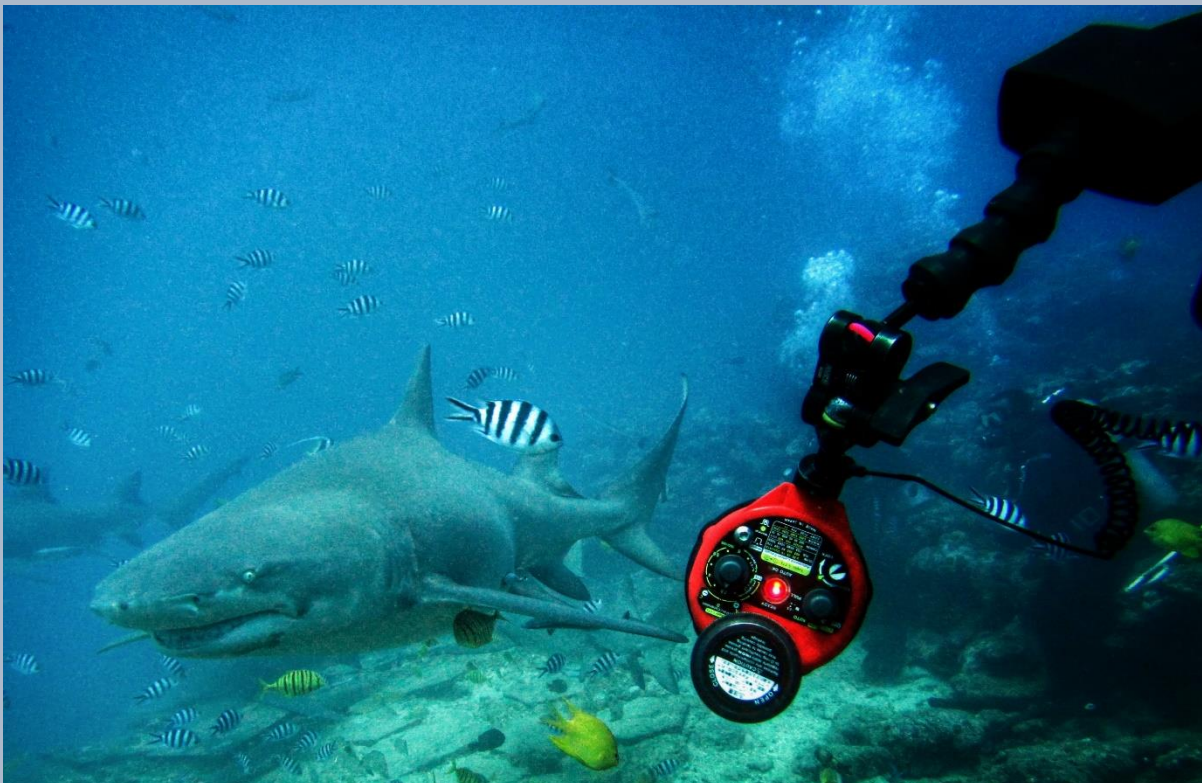
Journal: Tourism Management

Volume: 72

Issue: -

Pages: 155-158

Abstract: Ziegler and colleagues assessed tourists' perceptions of the ethics of feeding an endangered species for tourism purposes. The ethical decisions made, and justifications provided, were assessed using utilitarian and animal welfare ethical philosophies. The authors concluded that despite the substantial social and economic benefits of this activity, it remains unclear whether these benefits outweigh the potential costs to the whale sharks, the community, and the greater environment. There is no evidence that provisioning is not detrimental to the sharks. Consequently, the authors invoke the precautionary principle whereby the onus to prove no detrimental impact should be on the proponents of provisioning whale sharks. Due to the lack of published, peer-reviewed "robust and unequivocal" scientific evidence of the impacts of this activity alluded to by Meekan and Lowe, Ziegler and colleagues' conclusions stand until thorough cost-benefit analyses are completed.



Sicklefin lemon shark (*Negaprion acutidens*) photographed at Beqa Lagoon, Fiji

4. ABOUT THE EDITORS

Chantal D. Pagel

Chantal is a PhD candidate at Auckland University of Technology, New Zealand, exploring commercial in-water interactions with marine wildlife in the South Pacific. While becoming a conservation biologist, Chantal has worked with sustainable wildlife watching since 2010 including the global whale-watching phenomenon and baseline research on swim encounters with Norwegian killer whales. Chantal obtained experience with human-shark interactions within her PhD by selecting shark diving activities with predatory species as one of her case studies. She also gained valuable insights into the work of several institutions, including the Wildlife Conservation Society (WCS) in Fiji and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) in Bonn, Germany. Chantal is also an artist designing comprehensive and educational infographics on marine wildlife tourism issues for the wider public in which she has integrated own watercolour artwork.



Dr Michael Lück

Michael is a professor in the School of Hospitality and Tourism at Auckland University of Technology, New Zealand. He has worked in Germany, Belize, Canada, and Scotland, and is founding co-chair of the International Coastal & Marine Tourism Society (ICMTS). Michael has more than 10 years' work experience in the tourism industry and his research interests include (marine) wildlife tourism, the cruise ship industry, ecotourism, interpretation and education on wildlife tours, the impacts of tourism, and aviation. He has published in a number of international journals, is founding editor-in-chief of the academic journal *Tourism in Marine Environments*, Associate Editor of the *Journal of Ecotourism* and editorial board member of *Marine Policy*. Michael has edited or co-edited ten volumes on ecotourism, marine (wildlife) tourism, polar tourism, sustainable events, and low cost airlines, as well as the *Encyclopedia of Tourism and Recreation in Marine Environments* (CABI), and co-authored the introductory text *Tourism* (CABI).



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