DOCTOR OF PHILOSOPHY

Elasmobranchs of the Persian (Arabian) Gulf: diversity, taxonomy, and fisheries studies to inform sustainable management.

Moore, Alec

Award date:
2013

Awarding institution:
Bangor University

Elasmobranchs of the Persian (Arabian) Gulf: diversity, taxonomy, and fisheries studies to inform sustainable management

Critical analysis of Published Works

Submission by Alec B.M. Moore

For the degree of Doctor of Philosophy (Published Works)

School of Ocean Sciences
Bangor University

2013

Abstract

Elasmobranchs (sharks and rays) have been apex predators in aquatic ecosystems for over 400 million years. In contrast to most bony fishes, elasmobranchs generally have life history characters that severely restrict the ability of populations to recover from anthropogenic causes of mortality. Intensive and expanding fisheries, driven by a growing human population and the shark fin trade, have resulted in major declines in elasmobranch populations globally. With an increasing realisation of the vulnerability of elasmobranchs - and that scientific data to help inform their sustainable management were severely lacking - recent years have seen relevant studies flourish. However, much of this work has been limited geographically, with vast marine areas – particularly those associated with developing nations - still largely unknown.

The Persian (Arabian) Gulf represents one such area, despite being a unique marine environment surrounded by wealthy nations with significant fisheries interests. The handful of previous studies providing useful elasmobranch data are either geographically limited, or outdated, or both. An exhaustive literature review was undertaken (*Rev. Fish Biol. Fisheries* (2012) **22**: 35-61), which collated scattered data from a wide range of sources including published scientific studies, 'grey' literature, and those from other disciplines such as archaeology and historical accounts. While seemingly disparate, these data were distilled into a coherent and comprehensive synthesis that i) provides a single foundation source for future researchers of Gulf elasmobranchs ii) identifies key concerns and realistic research priorities iii) identifies novel ideas, such as the possibly overlooked biogeographic importance of the region to elasmobranchs. The literature review was important in demonstrating that even without targeted field studies, a large amount of less 'useful' desk-based data can collectively identify areas of interest relevant to management and conservation.

Complementing this desk-based work, the first major survey of the diversity, biology and fisheries of Gulf elasmobranchs was undertaken through intensive visits to fish markets and landing sites in Kuwait, Qatar and Abu Dhabi Emirate (*J. Fish Biol.* **80**: 1619-1642). The elasmobranch fauna in landings was distinctive, and included species that are undescribed, rare and have a highly restricted known distribution. Numerical abundance was dominated by sharks (c. 80%), of which carcharhinids were by far the most important. The milk shark *Rhizoprionodon acutus* and whitecheek shark *Carcharhinus dussumieri* together comprised just under half of all recorded individuals. Around 90% of recorded sharks were small (50–90 cm total length, L_T) individuals, most of which were mature individuals of species with a small maximum size (<100 cm L_T), although immature individuals of larger species (e.g. *Carcharhinus sorrah* and other *Carcharhinus* spp.) were also important. The first size, sex and maturity data for a wide range of Gulf elasmobranch species are presented and include some notable differences from other locations in the Indo-West Pacific Ocean. A number of concerns regarding the sustainability of the fishery were highlighted by this study, notably that most of the batoid species recorded are classed by the IUCN Red List as vulnerable, endangered, data deficient or not evaluated. Despite their considerable elasmobranch landings, none of the three countries sampled have developed an FAO 'Shark Plan', and Kuwait and Qatar currently report zero or no elasmobranch landings to the FAO.

Without a clear understanding of the biodiversity present in any ecosystem, management or conservation efforts are significantly hampered. Previous reports of the Gulf's elasmobranch fauna have been fragmentary, erroneous (*Zootaxa* (2007) **1591**: 67-68) and confusing. The present work corrects these errors, and significantly advances a robust elasmobranch inventory for the Gulf based on accountable evidence such as museum specimens, genetic samples (using the mitochondrial COI 'barcoding' gene) from market surveys, and historic and recent photographs. In addition to that already known, the occurrence of a further 15 elasmobranch species in the Gulf is confirmed based on new evidence (*Afr. J. Mar. Sci.* (2012) **34**: 297-301; *Zool. Mid. East.* (2010) **49**: 101-103 and **50**: 83-88). Major findings were the rediscovery in Kuwait of the very rare smoothtooth blacktip shark *Carcharhinus leiodon*, previously known only from a single specimen collected in Yemen (3000 km away) in 1902 (*Mar. Fresh. Res.* (2011) **62:** 528-539); and the description of a new species of whipray (*Zootaxa* (2012) **3327:** 20-32), which may be endemic. The first evidence-based checklist of Gulf shark species was also collated, which not only lists those species reliably recorded but also those that have previously been reported without evidence (*Zootaxa* (2012) **3167**, 1-16).

Acknowledgements

This work benefitted from the support, input and generosity of many people.

At Bangor University, Dr. Ian McCarthy (Ocean Sciences), Professor Gary Carvalho and Dr. Mark DeBruyn (Biological Sciences) have been generous with their time and provided helpful support, feedback, and opportunities for learning. Over several years, strong collaborative research links were formed with Dr. Aaron Henderson (formerly Sultan Qaboos University, Oman), Drs. Will White, Peter Last and Bob Ward (CSIRO Marine Research, Hobart), and Professor Gavin Naylor (Charleston College), all of whom are thanked for their helpful discussions, support and encouragement.

Much of the fieldwork in markets would not have been possible without assistance from others. Richard Peirce of the Shark Conservation Society (SCS) has raised the profile of sharks in the Gulf by developing collaborations with, and securing generous expedition support from, many individuals from the Kuwait Ministry of the Interior; the Kuwait Scientific Centre; Gulf Telecom; the Public Authority for Agriculture and Fisheries Resources (Kuwait); the Kuwait Institute for Scientific Research (KISR); Qatar University Environmental Studies Centre; and the Department of Fisheries (Qatar Ministry of Environment). Fieldwork in Kuwait in 2011 would not have been possible without Dareen Almojil and Ali 'Ministry of Ali' Alhafez (Kuwait Environment Research and Awareness Centre). Rima Jabado (UAE University), the many volunteers of the SCS (particularly Al Reeve), and a number of fisheries personnel are thanked for their enthusiastic help and good humour in the markets. Outside of the markets, many others have been generous with time, information or other help, including Laith Jawad (Ministry of Fish Wealth, Oman), Dr. Jim Bishop (KISR), Kaveh Samimi-Namin (Netherlands Centre for Biodiversity Naturalis, Leiden), Andrew Marriott (Ocean Sciences, Bangor University), and Dr. Leonard Compagno (Shark Research Centre, Iziko-South African Museum).

My employers RSK Environment - particularly Dr. Dave Watson and Dr. Alan Ryder - are thanked for their much-appreciated understanding, accommodation and tolerance of this work, not to mention financial support.

To my family. Dad, because of you we grew up surrounded by books and experienced wildlife walks, snorkelling and fishing. Mum, I wouldn't have completed this task without your ethics of steadily working towards distant goals, attention to detail, and self-discipline. To you both, I will always be grateful of your hard work that allowed me to attend university, and I hope this research in some ways repays the faith you have had in me. I am proud and privileged to have you as my parents. Stuart, my companion in many happy days of newt-catching, fishing on the Wye, and taxonomy of Star Wars figures. Your rightful scorn of my dubious bird sightings provided me with an early paranoia of misidentification that I carry through to this day.

Lastly, to my wife, Francesca. You have had five Aprils, innumerable weekends and many evenings on your own, and, without complaint (…or maybe only the occasional one) taken on all the tasks that I have shirked out of. You have organised me on the bad days and tolerated numerous one-way conversations when I have drifted into 'shark-world'. You have provided stability, endless encouragement, and passionate belief in what this work has hoped to achieve. It could not have been completed without your love and support.

Alec B.M. Moore
Chester, August 2012

Table of Contents

Tables

Introduction

This submission in candidature of a PhD is based upon Bangor University's 'Regulations for the Award of the Degree of PhD by Published Works (Regulation 05 2009 Version)'('the Regulations').

In this submission the Published Works comprise a series of 9 papers in peer-reviewed academic journals. Details of these papers are presented in Table 1. Copies of the full papers are presented in Appendix 1.

Throughout the text in this critical analysis, papers submitted as Published Works will be referred to by their numbering in Table 1 (e.g. '**Paper 1**'), rather than conventional academic referencing style.

Table 1: Details of peer-reviewed academic journal papers submitted as Published Works.

Chapter	Paper	Reference
1) Literature review	1	**Moore, A.B.M.** (2011) Elasmobranchs of the Persian (Arabian) Gulf: ecology, human aspects and research priorities for their improved management. *Reviews in Fish Biology and Fisheries* **22**, 35-61. doi: 10.1007/s11160-011-9222-x
2) Fisheries	2	**Moore, A.B.M.**, McCarthy, I.D., Carvalho, G.R., and Peirce, R. (2012) Species, size, sex and male maturity composition of previously unreported elasmobranch landings in Kuwait, Qatar and Abu Dhabi Emirate. *Journal of Fish Biology* **80**, 1619-1642 doi:10.1111/j.1095-8649.2011.03210.x
3) Diversity & taxonomy	3	**Moore, A.B.M.** (2012) Records of poorly-known batoid fishes from the north-western Indian Ocean (Chondrichthyes: Rhynchobatidae, Rhinobatidae, Dasyatidae and Mobulidae). *African Journal of Marine Science* **34**, *297-301*. doi: 10.2989/1814232X.2012.675129
	4	Last, P.R., Manjaji-Matsumoto, M., **Moore, A.B.M.** (2012) *Himantura randalli* sp. nov., a new whipray (Myliobatoidea: Dasyatidae) from the Persian Gulf. *Zootaxa* **3327**, 20-32.
	5	**Moore, A.B.M.**, Ward, R. D. and Peirce, R. (2012) Sharks of the Persian (Arabian) Gulf: a first annotated checklist (Chondrichthyes: Elasmobranchii). *Zootaxa* **3167**, 1-16.
	6	**Moore, A.B.M.**, White, W.T, Ward, R.D., Naylor, G.J.P. & Peirce, R. (2011) Rediscovery and redescription of the smoothtooth blacktip shark *Carcharhinus leiodon* (Carcharhinidae), from Kuwait, with notes on its possible conservation status. *Marine and Freshwater Research* **62**, 528-539. doi: 10.1071/MF10159
	7	**Moore, A.B.M.**, White, W.T., & Peirce, R. (2010) Additions to the shark fauna of the Persian (Arabian) Gulf (Carcharhiniformes: Hemigaleidae and Carcharhinidae). *Zoology in the Middle East* **50**, 83-88.
	8	**Moore, A.B.M.** (2010) The smalleye stingray *Dasyatis microps* (Myliobatiformes: Dasyatidae) in the Gulf: previously unreported presence of a large, rare elasmobranch. *Zoology in the Middle East* **49**, 101-103.
	9	**Moore, A.B.M.**, Compagno, L.J.V and Fergusson, I.K. (2007) The Persian/Arabian Gulf's sole great white shark *Carcharodon carcharias* (Lamniformes: Lamnidae) record from Kuwait: misidentification of a sandtiger shark *Carcharias taurus* (Lamniformes: Odontaspididae). *Zootaxa* **1591**: 67-68.

Structure of this document

As noted in Table 1, this critical analysis is divided into three main chapters, corresponding to the subject areas within which the Published Works fall. These are:

- Chapter 1: Literature review (**Paper 1**);
- Chapter 2: Fisheries (**Paper 2**); and

- Chapter 3: Diversity and taxonomy (**Papers 3-9**).

As per University requirements, each of these chapters aims to:

- Evaluate the field in which the candidate has worked; and
- Indicate the original contribution to learning that the Published Works have made.

In addition, the chapters also aim to:

- Provide the context and rationale for the Published Work(s) under consideration; and
- Provide a brief critique of the methodologies used.

Authorship and collaboration

In accordance with point 17 of the Regulations, it is noted that:

"Candidates may submit work(s) completed in collaboration with others in support of the candidature, but such work shall be accompanied by a detailed statement signed by each collaborator indicating the nature and amount of the work done by the candidate."

A Table is provided in Appendix 2 outlining roles of each author on all papers.

Chapter 1: Literature review

Elasmobranchs in crisis

Elasmobranchs (sharks and rays), together with the holocephalans (chimaeras), form the class Chondrichthyes (cartilaginous fishes). They are an evolutionary success and have functioned as apex predators in a diverse array of aquatic ecosystems for over 400 million years. In contrast to most bony fishes, elasmobranchs are generally characterised by high natural survivorship and 'slow' life history characters of long gestation periods, a small number of relatively large young, slow growth, late maturity, and a long life span. These characters conform with many of the criteria that are thought to render marine species vulnerable to extinction and local extirpation (Roberts and Hawkins 1999), and severely restrict the ability of populations to recover from anthropogenic causes of mortality (Musick 2005; Compagno *et al.*, 2005a). This is perfectly illustrated by sawfishes (Pristidae) in the western Atlantic, where even limited recovery after serious decline has either not occurred or been predicted to take decades, and only then with effective conservation measures in place (e.g. Simpfendorfer 2000; McDavitt 2002; Carlson *et al.*, 2007).

Yielding a range of valuable products such as meat, fins, liver oil, skin, cartilage and curios (e.g. teeth and jaws), elasmobranchs have often been sought after by targeted commercial fisheries or valued as bycatch. Targeted fisheries have generally had a poor record of sustainability (Stevens *et al.*, 2000), and a number of severe population declines as a result of fishing have been documented (e.g. Thorson 1982; Dulvy *et al.*, 2000; Ferretti *et al.*, 2008). Along with fisheries, other threats to elasmobranchs include habitat loss (Stevens *et al.*, 2005) and climate change (Chin *et al.*, 2010).

Against this context, in 1991 the Species Survival Commission of the International Union for the Conservation of Nature (IUCN) formed the Shark Specialist Group (SSG). The current mission statement of the SSG is simple:

"To promote the long-term conservation of the world's sharks and related species (the skates, rays and chimaeras), effective management of their fisheries and habitats, and, where necessary, the recovery of their populations."

The SSG's establishment at this time was not arbitrary, but in response to a number of alarming new developments - primarily the rapidly expanding market for shark fins for the East Asian market. Other issues were also of concern, such as the realization that basic biological and distributional information for the majority of elasmobranch species was either absent or insufficient, and the development of deepwater fisheries.

Until relatively recently, there was a paucity of key information to inform sustainable management of elasmobranchs, although this group had long been the subject of research on aspects such as anatomy and sensory biology (e.g. Hisaw 1959; Gilbert 1970; Kalmijn 1971). However, since the 1990s there has been a growing body of research examining aspects directly relevant to management such as taxonomy, diversity, reproductive and life history biology, fisheries, population genetics and habitat utilisation. The majority of this research has focused on a few relatively well-studied areas (notably Europe, the USA, Australia and South Africa) leaving large areas of the globe that are still poorly known. Such bias in geographic focus is felt most acutely in (sub-) tropical developing nations, where high densities of human communities, requirement for marine protein and fishing activity contrast sharply with minimal - or no - fisheries management. For example, research is lacking in the Indian Ocean, despite high and increasing reported elasmobranch landings (Anderson and Simpfendorfer 2005).

For fisheries management in general, theoretical approaches have changed greatly in the past decade or so. Traditional management focused largely on single-species assessments to arrive at a maximum 'sustainable' yield as a target for harvesting, and usually took little or no account of important factors such as environmental variability and bycatch. Yet it was, and is, clear from severe fisheries declines globally that this approach was failing. For example, based on analysis of 230 fish populations, Hutchings and Reynolds (2004) reported an 83% median reduction of breeding population size from historic levels; cod (*Gadus morhua*) had declined by as much as 99.9% in some areas. Increasing recognition of the inadequacies of management led to the development of the ecosystem approach to fisheries management (e.g. Garcia *et al.*, 2003), aswell as the realisation that the 'shifting baseline syndrome' (Pauly 1995) had masked our understanding of what natural, pre-exploitation marine ecosystems should be like (Roberts 2007). Current interpretations of sustainable fisheries management vary, but often include consideration of a broad array of factors such as essential habitat, multi-species interactions and human decision-making. Large predatory fishes have been estimated as declining by at least 90% over the past century, with sharks particularly vulnerable; as a result, it has been suggested that management of multi-species fisheries needs to be tailored to these more sensitive species (Myers and Worm 2005).

The Gulf - in search of relevant data

While working in Kuwait in 2002, the present author attempted to source published literature on the elasmobranchs in the Persian (Arabian) Gulf (hereafter referred to as the Gulf; see Sheppard *et al.*, (1992) for nomenclatural discussion), convinced that such a charismatic group of vertebrates in such a geopolitically important waterway must have been the subject of substantial research. Nine years of desk-based review spanned a spectrum of sources encompassing the widely available (e.g. Carpenter *et al.* 1997), the obscure (e.g. Khaleghi Ghadiri and Gorki 2004), and the difficult to obtain (e.g. Al-Daham 1974); the review process covered published scientific literature, unpublished technical reports, historical documents, popular literature of travel and exploration, online local newspapers and personal communications.

From the perspective of directly informing ecology and sustainable management, the results were disappointing. The handful of studies that had addressed management-related aspects such as diversity were unreliable (e.g. Khalaf 1987), outdated (e.g. Blegvad 1944), geographically limited (Vossoughi and Vosoughi 1999), or all three (e.g. Goubanov and Shleib 1980) (**Paper 1**). Frustratingly, while the most basic studies of Gulf elasmobranch diversity or ecology were conspicuous by their absence, there had in some cases been much greater research effort by local authors on specialised aspects of Gulf elasmobranchs such as their parasitology (**Paper 1**).

Given the lack of research directly concerned with Gulf elasmobranch ecology or management, the review extended itself to a range of other topics that were nonetheless relevant. These included palaeontology, biogeography, archaeology, anthropology, parasitology, food science and pharmaceutical science. Archaeological data, for example, has shown that elasmobranchs have been widely used by humans along the Gulf coast for thousands of years, and that the shark fin industry has a local history spanning back hundreds of years. This is important context for both ecology (remains can provide information on past distribution and relative abundance of taxa) and fisheries management – Gulf sharks are not a pristine or virgin resource, and there is a strong historical association with shark finning locally. Similarly, pharmaceutical studies of shark cartilage from Iran may also appear to be irrelevant. Yet the publication of a number of studies in recent years demonstrates growing interest in this potential resource, with obvious implications for elasmobranchs – not least because Iran already has the highest reported landings of this group in the Gulf area (**Paper 1**).

Thus, the pertinent aspects of a wide range of disparate data were distilled into a coherent synthesis (**Paper 1**) that:

- Identified key data gaps, and priorities for research to address these;

- Identified key causes for concern, such as the presence of threatened species; lack of baseline or monitoring data; lack of relevant and/or effective management on both domestic and international scales; possible historic fisheries-driven changes in elasmobranch community structure; and major elasmobranch landings by Iran; and
- Proposed or recognised underlying themes or aspects, such as the possible biogeographic importance of the region to elasmobranchs.

Paper 1 provides a foundation resource for elasmobranch researchers not only in the Gulf, but for the broader western and northern Indian Ocean regions. It also provides a template to encourage other researchers working in locations with a paucity of robust scientific data to publish syntheses of potentially valuable 'grey' sources of information.

Basic needs

Research priorities identified by **Paper 1** were:

1) *"…resolution of taxonomic issues, (particularly of commonly landed species)…"*

How this has been addressed by the Published Works will be described in Chapter 3 (Diversity and taxonomy), but includes an evidence-based checklist of shark species (**Paper 5**); description of a new and possibly endemic species of stingray that is common in fisheries landings (**Paper 4**), re-discovery of a very rare shark species (**Paper 6**), and additions of both shark and ray species to the reported Gulf fauna (**Papers 3, 7, 8, 9**). In addition, collection of material by the author for a collaborator has also been vital in the taxonomic resolution of a species complex of small, commonly landed carcharhinid sharks (White 2012).

2) *"…species-level monitoring and reporting of landings (and/or routine fisheries surveys) by each Gulf state. [This] would provide key missing information on diversity (including urgently needed records of rare species), patterns of*

abundance and sex/maturity composition, and the fisheries catching them. Further work should also aim to identify areal and seasonal sensitivities (such as seasons of high bycatch, or areas with neonates/gravid females)..."

As will be discussed in Chapter 2 (Fisheries), **Paper 2** addressed many of these issues.

3) *"...[Further work to identify] the relationship between elasmobranch populations in the Gulf with those of other waterbodies..."*

Once foundations for the diversity and broad characteristics of the Gulf elasmobranch fauna had been established (e.g. **Papers 1** and **5**), it then become possible to begin examining how this might relate to other populations. While not undertaken as part of this PhD, collaborative work is currently planned with researchers from the UAE, Oman and the Saudi Arabian coast of the Red Sea to examine population genetics of two commonly landed carcharhinid shark species (spot-tail *Carcharhinus sorrah,* and milk shark *Rhizoprionodon acutus*) around the Arabian peninsula.

4) *"There is also a pressing need for robust data on the fin trade in Gulf states, especially the species involved and the areas of origin."*

This is outside the scope of the current PhD, although it is currently being addressed by a PhD student from UAE University with whom the current author has collaborated.

Together, **Paper 1** therefore achieved its objectives in identifying data gaps. The overall PhD study also made considerable steps into addressing many of these, as well as providing a necessary and robust foundation for future research work to address them.

Time and place

Current research on the spatial distribution of extant elasmobranchs often tends to focus on existing environmental factors, such as salinity, temperature and water depth (e.g. Wiley and Simpfendorfer 2007; Knip *et al.*, 2011). The influence of broader geological processes and environmental history is less often considered, but the opportunity to explore this within the framework of literature review provides a broader understanding of patterns of elasmobranch diversity and distribution.

Based on a broad appreciation of the environmental history and characteristics of the Gulf, **Paper 1** recognised the following:

- Closure of the Tethys Sea in the Arabian region might be a possible factor for the observed taxonomic and molecular distinctiveness of elasmobranchs locally, such as the observation that a substantial proportion of taxa there are genetically distinct from their closest relatives in other regions (Naylor *et al.* 2012). This is therefore a strong incentive for taxonomy and diversity research;
- The semi-enclosed and post-Holocene nature of the Gulf's marine environment may contribute to its intriguing elasmobranch diversity, such as a number of unresolved taxa (Naylor *et al.* 2012; W. White, P. Last and R. Ward, pers. comms.). Molecular evidence of reproductive isolation in the Gulf has already been observed in a large, mobile teleost fish locally (Hoolihan *et al.*, 2004), and indeed a new species of benthic elasmobranch limited in dispersal ability appears to be endemic, possibly as a result of these factors (**Paper 4**);
- The historic distribution of the critically endangered river shark genus *Glyphis* (known only from the Indian subcontinent, SE Asia and Australia) might realistically have included the under-sampled Tigris-Euphrates system, several hundred kilometres from the nearest known record;

- Certain ecological or taxonomic groups such as pelagic and coral-reef associated species are either known as, or likely to be 'naturally' absent or rare in the Gulf as a result of habitat requirements. This has important implications for biodiversity management, for example in setting realistic and attainable conservation targets of what species might comprise a healthy fauna. Absence of some otherwise widely distributed Indo-Pacific reef shark species in the Gulf, for example, may not necessarily be due to fisheries impacts; and
- Whereas the decline of elasmobranchs globally is usually attributed to fisheries, the shallow and heavily impacted Gulf might well represent a landmark example where anthropogenic habitat degradation is also playing a significant role in changes to natural elasmobranch communities.

Inference and informed speculation

Syntheses of literature in a review (**Paper 1**) gives the researcher the opportunity to make inferences as to what ecological interactions might be occurring in a poorly-studied area (such as the Gulf), based on similar, well-studied locations elsewhere. For example, in western Australia it has been suggested that tiger sharks indirectly influence seagrass and benthic communities, via avoidance behaviour by their dugong prey (Wirsing *et al.*, 2007). As the southern Gulf also has extensive seagrass, relatively abundant dugongs, and (at least historically) tiger sharks, **Paper 1** proposed that similar trophic interactions might occur (or have occurred) there.

Personal observations, combined with literature from other study locations, can also support informed speculation of aspects relevant to fisheries management. Different elasmobranch taxa have highly variable within- and post-trawl survival, with some batoids (e.g. guitarfish) relatively hardy, while smaller carcharhiniform sharks tend to have a high mortality rate. Evidence for this is both from field studies off Australia (Stobutzski *et al.* 2002), and the current author's personal observations from trawl surveys off Kuwait (**Paper 1**). From this, it is not unreasonable to predict that higher mortality of eventual predators of batoids (such as young great hammerhead sharks *Sphyrna mokarran*), but higher survival of their prey, will lead to increases in the relative abundance of these prey species (**Paper 1**). This inference is made more compelling when increases in ray biomass - along with a decline in shark biomass - have been reported along the Iranian coast (Valinassab *et al.*, 2006). **Paper 1** proposed that variable trawl survival could be a possible factor in this.

Realistic opportunities

Paper 1 recognised that elasmobranchs are, and are likely to remain, a very low priority to local fisheries research interests. A key aim of the review was therefore to identify realistic opportunities for research that had minimal requirements in terms of expertise, capital investment, and logistics, as illustrated by the following examples.

Where possible, **Paper 1** identified where existing strengths could be extended to address existing gaps and weaknesses in elasmobranch management. For example, as well as large reported elasmobranch landings, Iran has considerable expertise in the 'pure' aspects of elasmobranch parasitology, particularly of cestodes (e.g. Caira *et al.* 2010; Haseli *et al.* 2010; Malek *et al.* 2010). As parasites can provide a range of data on the ecology of their elasmobranch hosts (including stock discreteness and migrations; Caira 1990) Iran's existing expertise could therefore realistically be applied to address questions of elasmobranch management.

Similarly, tag, release and re-capture programmes enabled through recreational fishing has provided an array of information on the distribution and movements of elasmobranchs in a number of locations worldwide (e.g. Cartamil *et al.*, 2011, Dicken 2011). It has also provided important information relevant to sustainable management of a large pelagic teleost species in the Gulf

(Hoolihan 2003). However, significant elasmobranch tagging has not been adopted in the Gulf, even though recreational angling is highly popular. In the absence of other dedicated fieldwork, **Paper 1** proposed that such popular activities could provide a valuable opportunity for both research and public engagement.

Limitations and language

As part of the literature review, hundreds of data sources and publications were reviewed. As well as the 178 cited references, many more sources were examined in vain for relevant data. Literature ranged from peer-reviewed scientific journal articles to popular accounts by Jacques Cousteau, and from easily accessible internet sources to local journals that could only be obtained through a network of contacts.

Yet despite this seemingly exhaustive and comprehensive coverage, the review suffers from a glaring omission: none of the literature examined was primarily in the local languages of Arabic and Farsi. English is widely accepted as the language of science, and indeed in the Arab Gulf states at least, scientific journal articles by Arab authors are either in English or occasionally in Arabic with an English abstract. Journal articles are however likely to represent only a small proportion of the potentially relevant data available. Internal and/or unpublished reports housed in the many local research institutes could provide important long-term datasets relevant to elasmobranch management. Examples could be results of routine fisheries-independent trawl surveys, market inspections or export trade data.

Use of local language and appropriate customs would also allow access to a large and potentially valuable resource for elasmobranch researchers: the local ecological knowledge and experience of fishermen. With robust design of interviews, this resource can provide vital information and has been used to document declines in fish diversity and abundance of large fish species in the

Gulf of California, for example (Saenz-Arroyo *et al.*, 2005). Clearly, there is a need for local involvement in elasmobranch research.

Despite any shortcomings, **Paper 1** achieved many of its objectives and is likely to remain as an authoritative reference work on elasmobranchs in the Gulf region for some time. It adds considerably to the state of broader ecological knowledge of Arabia, and, in the context of elasmobranch management, stands as a clear example of the value of critically synthesising multiple, disparate data sources of varying quality and scope into a coherent whole.

Chapter 2: Fisheries

Context

Sustainable elasmobranch fisheries management is not possible without basic biological data on the fished resource, accurate fisheries data (e.g. effort, catch and landings), together with successful application of scientific advice. A clear example of this was provided from a commercial fishery for sawfish that developed suddenly in Lake Nicaragua in 1970, when they were highly abundant. A failure by fishery managers to heed recommendations drawn from biological data (Thorson 1976) resulted in one of the first well-documented complete and rapid collapses of a targeted elasmobranch fishery: sharp declines in catches occurred within just two years, followed by expiration within around ten years (Thorson 1982).

Key biological data requirements for any fishery encompass species composition; relative abundance; sex, size and life-class composition; and life history parameters. As noted in **Paper 1**, life-history parameters (such as size-at-maturity) can vary across a species' range, which highlights the need for location- or region- specific data.

In addition to biological data, knowledge of the human aspects of the fishery (e.g. fleet size, vessel range, gear types, and discarding practices) is also vital to determine the degree of likely interaction with elasmobranch resources.

All at sea – the cost of data

In terms of data, perhaps the best way to document elasmobranchs in a fishery is directly, i.e. through recording of their capture at sea. This can provide significant benefits including accurate information on location, as well as allowing for standardised measurement of effort that facilitate repeatable and comparable datasets. There are two main types of such surveys, both of which have been used to inform sustainable management of elasmobranchs. 'Fisheries-dependent' surveys record data from normal commercial or artisanal fishing operations, often using trained scientific observers aboard, for example, shark longlining vessels on the east coast of the United States (Carlson *et al.*, 2012) or aboard trawlers targeting rajid skates off the Falkland Islands (personal observation). 'Fisheries-independent' surveys are those undertaken purely for data collection (often using research vessels) such as demersal groundfish trawling around the British Isles (Ellis *et al.*, 2005) or longlining specifically for pelagic sharks in the northwest Atlantic (Simpfendorfer *et al.*, 2002).

However while data from these surveys can be high quality, it is relatively expensive: the observer program for the US east coast shark fishery costs an estimated $US 1,200-1,400 per observer per sea day (J.K. Carlson, National Oceanic and Atmospheric Administration, pers. comm.). Given that **Paper 1** clearly identified that both economic value and research priorities for elasmobranchs by Gulf states is low, alternatives that are less costly are required.

Quick and dirty: advantages of market surveys

Surveys of fish markets and landings sites can provide a highly valuable yet inexpensive alternative to at-sea surveys. These locations can concentrate the collective effort and catches from a large number of vessels into a single relatively small location that can be rapidly surveyed by one or two people. As a variety of fishing locations, gear types, and activity patterns are often represented, a diversity of elasmobranchs are often available for inspection. Market and landings surveys have provided important data for elasmobranchs in tropical and sub-tropical locations on a range of aspects including reproductive biology (e.g. White & Dharmadi 2007), fisheries (Bizarro *et al.* 2009), and new species (Last *et al.* 2010a). Surveys of landings have also provided valuable information on elasmobranch fisheries in the Arabian region, in Oman (Henderson *et al.*, 2007; 2009). Capacity building and development of local expertise during studies such as these also has the potential to provide an important foundation for further work. Nevertheless, there are several disadvantages to using market and landings data that need to be considered.

From Gulf to spreadsheet: bias factors in market sample provenance

Before a wild elasmobranch becomes available for data capture on a market slab, a considerable number of potential bias factors may be in operation.

- The size, timing and periodicity of the survey itself is a key factor, as landings are likely to vary considerably with both natural (e.g. seasonal and ontogenetic movements by elasmobranchs) and human factors (fisheries activity). Surveys conducted for **Paper 2** were short-term (1-3 weeks), confined to one month (April), and only took place in one (Qatar and UAE) or two years (Kuwait). While these provided a highly valuable baseline of new information, they only represent a brief view of the overall picture of the fishery operating that would be better captured through a long-term monitoring program throughout the year (**Paper 2**);
- Secondly, elasmobranchs have to be present in the area being fished by the fleet landing into the survey site under consideration. The composition of elasmobranchs available for capture is thought to vary considerably in the Gulf, given both likely seasonal variation due to water temperature (**Paper 1**), as well as spatial variation, possibly due to environmental factors such as estuarine discharge (**Paper 2**);
- Even though several elasmobranch species may be present in the area being fished, not all of them will necessarily be caught. Benthic substrate-feeding batoid species such as dasyatid whiprays are far less likely to be captured in pelagic gillnets deployed in the upper water column, compared to larger species of carcharhinid sharks; the converse is true for demersal otter trawling. Other factors such as diurnal activity patterns may also be important;
- Of the species present in the area, it is also possible that only a certain sex or size range of the larger population will actually be caught due to

behaviour and/or gear selectivity factors, as has been demonstrated elsewhere (Clarke *et al.*, 2005);

- Once captured and the gear is retrieved, some elasmobranchs may be discarded due to low economic value, either because of their species (particularly non-guitarfish batoids) or possibly their size (e.g. small individuals). Discarding may either take place at sea, or in the harbour (possibly as a result of safety considerations in poor sea conditions; **Paper 2**);
- Other confounding factors exist for captured elasmobranchs. It is possible that some 'finning' at sea (removal of pectoral, dorsal and caudal fins for the valuable Asian soup market, and discarding of the body) takes place locally from sharks and some batoids (especially rhynchobatid guitarfish). As this practice is usually illegal and secretive, data is unlikely to be captured. Similarly, it is possible that transhipment of elasmobranch captures may take place at sea. It is therefore possible that large carcharhinid sharks – the target of the lucrative fin trade - may be under-represented by market sampling;
- Determining the correct origin of samples may also be an issue, as various factors such as lack of communication between fisher and seller, or deliberate misreporting due to illegal fishing practices. Overland transport of sharks may also occur in certain areas, such as from Oman into the UAE. However, the nature of many of the fishing vessels in the Gulf observed to be landing elasmobranchs (small open speedboats with single outboard engines) meant that it could be reasonably inferred that they were fishing in local coastal waters; and
- Once landed, some individuals may simply not be recorded by a survey, either through oversight or deliberate actions of traders. In Kuwait, single large carcharhinid sharks (particularly valuable for fins and meat) were sometimes observed bypassing the main wholesale area and being rapidly handled from vessels into closed vans (personal observation).

Other challenges of market surveys

Gulf fish markets are often hectic locations with frantic activity by buyers, sellers and porters, and fish moving back and forth between vehicles, wholesale and retail. Elasmobranchs are often relatively large, and, often in the case of rays, slime-covered, twisted and malformed from retention in cool boxes. While this presents certain challenges to the scientist wishing to collect robust, reliable data, these can be overcome.

In ideal conditions, fisheries-focused elasmobranch studies would record size (e.g. total length) measurements down to the nearest mm; male maturity data would include accurate measurement of clasper length (to compare against total length, and determine size-at-maturity), and female maturity data would be collected from laboratory examination of reproductive organs of a relatively large sample size of purchased individuals (e.g. Henderson *et al.* 2006).

Yet it is possible to collect important - if not as wholly accurate - data rapidly: consistent measurement down to the nearest cm and male maturity assessment based on rapid external classification of clasper calcification. While systematic assessment of female maturity was omitted for logistical and financial reasons, even opportunistic observations (for example of females with emergent embryos) provided some of the first reported female maturity data for some poorly-known species (**Paper 2**).

In intensive market surveys performed on a daily basis, an additional challenge is the potential for individuals to be erroneously re-sampled, particularly of common small carcharhinid species. However, this was easily resolved in one of three ways: by marking animals with a distinctive incision on the snout (sometimes not permitted by market stall holders), only sampling a single entry point (e.g. the wholesale market, or the quayside), or not sampling any individuals over which there was any doubt.

Key findings and wider implications

The findings from **Paper 2** contributed significantly to a better knowledge of the Gulf elasmobranch fishery, which was previously undocumented (**Paper 1**). The findings were not only relevant to a limited Gulf-specific audience; as noted in **Table 2**, they have broader regional and global implications as well.

Table 2: Examples of key findings of **Paper 2**, with local and regional/global implications.

Finding	Implication	
	Local	Regional/global
Significant elasmobranch landings recorded	Proof that the zero/no landings currently reported to the FAO by Kuwait and Qatar are incorrect.	Regional/global capture of elasmobranchs is likely to be underreported, particularly in developing countries with limited capacity
Most elasmobranchs caught as gillnet by-catch	Gillnet fisheries should be the focus of any further elasmobranch fisheries research locally (e.g. gear use patterns)	Further evidence for the need for elasmobranch bycatch reduction technology for gillnets
Most elasmobranchs were a few species of common small sharks	Local fisheries research should focus on the biology of these species	Regional research should identify broader population biology (e.g. interconnectivity)
Sensitive life history stages present (e.g. neonates; statistically significant ratios of (pregnant) females)	Indicates probable spatial and temporal sensitivities worthy of further investigation for fisheries closures. In the example of cownose rays in Kuwait, this may assist both fisheries (reduction of a nuisance, low-value bycatch) and the species (large numbers of pregnant females in April)	Further highlights that elasmobranch populations are not homogenously distributed, and local research is needed to identify key areas/seasons for sustainable management.
Male size-at-maturity data determined for four common shark species	Provides practical data for local management, e.g. minimum landing size	Confirms that life history parameters can vary significantly within a species' broad Indo-Pacific range, highlighting the need for local data
Rare, undescribed, and threatened species recorded in landings	Identification of unique biodiversity interest and conservation priorities	Rare or undescribed species are likely to be present in poorly sampled regions

Can Gulf elasmobranch fisheries be sustainable?

The IUCN Shark Specialist Group (SSG) recognises the importance of elasmobranchs in human economies and food security, and does not promote the concept of a blanket ban on fisheries. Indeed, the SSG promotes "...effective management of fisheries...". Although **Paper 2** identified a number of serious sustainability and conservation concerns (e.g. **Table 2**), were any elements of a potentially sustainable fishery identified?

Over a third of the elasmobranch individuals recorded in market surveys (**Paper 2**) were small carcharhinid shark species currently classed as "Least Concern" by the International Union for the Conservation of Nature (IUCN) Red List (IUCN, 2011). This classification is based on the relatively favourable life-history characters of these small carcharhinids compared to many other shark species, such as rapid growth and early maturity. It is also notable that small carcharhinids appear to be the elasmobranch type most in demand in retail markets around the Gulf.

While many elasmobranch fisheries have proven to be unsustainable, it is important to recognise there is sometimes the potential for some of them to be so, depending on the species involved and a high degree of management: for example gummy sharks (*Mustelus* sp.) off southern Australia (Stevens *et al.*, 2005). The development of targeted fisheries in the Gulf - along with the economic value this generates - could theoretically provide incentives for better overall management, including research on aspects such as bycatch reduction. However, as noted earlier (Myers and Worm 2005) sustainable management of multi-species fisheries should be based upon providing for the survival of the most sensitive species. As Gulf gillnet fisheries catch an array of elasmobranch species ranging from rare, poorly-known and endangered to common and abundant (**Paper 2**), existing fisheries cannot progress sustainably without focussing on these vulnerable species as a priority. **Paper 2** therefore provided clear evidence-backed advice to local governments and research institutes on two main points: that elasmobranch landings were substantial and in need of routine detailed monitoring, and that research into elasmobranch ecology and fisheries – particularly of the most vulnerable species – is required.

Chapter 3: Diversity & taxonomy

Why identify?

The ability to correctly identify an organism is fundamental to all biological sciences. Results of costly research could potentially be rendered meaningless if more (or less) taxa than are thought to be under study are actually involved. Areas of research relevant to elasmobranchs and their sustainable management (such as environmental and reproductive biology, behavioural and population ecology, zoogeography, diet and habitat use) could all be severely compromised without a robust means to identify species.

Without the ability to accurately record presence and/or abundance in landings and surveys, datasets are likely to be limited in their ability to detect any changes in diversity, such as those resulting from anthropogenic impacts. A possible fisheries-related shift in the composition of elasmobranch communities over time was reported along the Iranian coast (Valinassab et al., 2006), yet further investigation of the published data is impossible due to reporting as the broad groups of 'sharks' and 'rays' only, a situation commonly found elsewhere in the Gulf (e.g. Ali *et al.*, 1993; Environment Agency Abu Dhabi 2010). Failure to record elasmobranch landings down to species level has previously caused misinterpretation of apparently stable landings elsewhere, masking serious ecosystem-level shifts in community composition. Of the number of skate species comprising landings reported simply as 'skates' in the north-east Atlantic, some had disappeared and some had declined over time, whereas the shortfall in biomass had been made up by an increase in abundance of smaller species more resilient to fisheries (Dulvy *et al.* 2000). Species-level reporting enabled by correct identification could have alerted authorities to this issue much earlier.

The ability to identify an elasmobranch is based on taxonomic clarity, combined with an understanding of the species' geographical distribution. Species-level identification is particularly important in tropical inshore waters of the Indo-

Pacific, where the diversity of morphologically similar species - such as carcharhinid sharks - may be particularly high (e.g. White *et al.*, 2006). Within this diversity may be species varying significantly in life history characters and therefore in their resilience - or vulnerability - to fisheries. For example, in surveys of Gulf fish markets **Paper 2** found that mature individuals of naturally small (<1m maximum total length, TL) carcharhinid sharks were abundant, but occurred alongside neonates and juveniles of *Carcharhinus* species with a far greater maximum TL. In Kuwait in particular, widespread and abundant *Carcharhinus* species are landed alongside *C. leiodon*, a species with an unusual highly restricted distribution that is thought to be highly vulnerable (**Paper 6**). It is simply not possible to monitor any changes, such as a decline in rare species or an increase in faster-growing, smaller species, without a reliable basis for identification.

Taxonomy - the unglamorous essential

Underpinning all identification is taxonomy: the study of the classification of organisms. Taxonomy suffers from a popular perception as a tedious, old discipline confined to dusty museum archives. Chondrichthyan taxonomy is a poorly resourced field with very few research positions available globally. Part of the reason for this may be due to taxonomists being at a disadvantage to other science fields in terms of the impact factors of publications, a metric often used by science employers to gauge quality and quantity of research (White and Last 2012).

However, these setbacks are countered by the fundamental importance of taxonomy to chondrichthyan science. Taxonomic clarity is the basic building block of identification guides, themselves the main tool to researchers in documenting diversity. In addition, chondrichthyan taxonomy has been reinvigorated with the use of molecular techniques such as COI barcoding (Ward *et al.*, 2008; White and Last 2012), which can even be used in monitoring of otherwise unidentifiable shark fins in trade (Holmes *et al.*, 2009). Finally, a renaissance in chondrichthyan taxonomy in the last decade has formally described around 15% of the 1185 currently recognised species (White and Last, 2012). The progression of this work is essential, as molecular studies have indicated that a number of cryptic, unresolved and even hybridised elasmobranch taxa exist (Ward *et al.*, 2008; Morgan *et al.*, 2012; Naylor *et al.*, 2012). Many widely distributed elasmobranch taxa previously considered as a single species are now thought to consist of a number of species, such as the spotted eagle ray *Aetobatus* sp. (Richards *et al.* 2009; Schluessel *et al.*, 2010; White *et al.*, 2010).

Morphological and molecular techniques were used to define the re-discovered smoothtooth blacktip shark *Carcharhinus leiodon* from two very similar congeners (**Paper 6**); both sets of evidence supported *C. leiodon* as a valid species. Taxonomic re-description was necessary, as the species had originally been described based on only a single, preserved, juvenile specimen from over 3,000 km away on the coast of Yemen. Perhaps most importantly however, **Paper 6** provided field characters for this species, which has an unusual highly restricted distribution and is therefore likely to be more vulnerable to extinction, particularly so given that it is caught in local fisheries (**Paper 2**). The awareness raised by the work will hopefully contribute to further records and a better understanding of true distribution and habitat preferences, knowledge vital for any conservation efforts.

Recent collaborative taxonomic work by the present author has proposed a new elasmobranch species - a stingray - from the Gulf (**Paper 4**). Despite commonly occurring in local fisheries landings this species has remained either unnoticed, or a source of confusion, until very recently. It is also noteable in that it appears to be endemic to the Persian Gulf, possibly as a result of speciation following the post-Holocene re-flooding of the drained Gulf basin (**Paper 4**).

Towards an elasmobranch inventory for the Gulf

The publication of ichthyological checklists is not generally favoured by one of the leading taxonomic journals (MR de Carvalho, Chondrichthyes editor, *Zootaxa*, pers. comm.). This is perhaps not surprising, given that localised inventories of the highly mobile elasmobranchs usually offers little additional information to that already known about the ichthyofauna of the wider water body. Where checklists have been attempted for the Gulf region, these have merely been a list of species collated from other publications, with no critical evaluation of records, or a requirement for evidence (Tourenq *et al.* 2008).

However, checklists can assume greater importance and relevance when they consider locations that are fundamentally different from adjacent waterbodies. The Gulf is such an example, being shallow (average depth 35 m), semi-enclosed, and post-Holocene in origin, in stark comparison to the adjacent Gulf of Oman (>3000 m). As a result, the number of fish species in the Gulf has previously been reported as around half that of Omani waters (Carpenter *et al.* 1997). Understanding natural levels of diversity - especially where they are naturally impoverished - is key in management, as it allows for a realistic perspective on what the 'baseline' should be. **Paper 5**, an evidence-based shark checklist, therefore provides an important foundation and resource for other workers.

Re-appraisal of historic literature for biodiversity and conservation

Critical review of earlier data is as important as more recent studies in establishing a comprehensive biodiversity inventory. For example, **Paper 8** identified a large, rare, and poorly-known stingray species (*Dasyatis microps*) based on re-appraisal of a photograph and other data from the 1930s (Blegvad 1944), where it had previously been misidentified. Not only did this provide the first record of this species in the entire northwestern Indian Ocean, but it suggested that *D. microps* was once a normal part of the Gulf's elasmobranch fauna. *Dasyatis microps* has not been reported from the Gulf since the 1930s, and it is likely to be vulnerable with 'slow' life history characters and high susceptibility to fisheries interactions (Fahmi *et al.*, 2009). Similarly, the historic presence of two large shark species (lemon shark *Negaprion acutidens* and grey reef shark *Carcharhinus amblyrhynchos*) in the Gulf was confirmed by **Paper 7** from misidentified photographs from the 1970s (Basson *et al.*, 1977), although these species have not been reported in the Gulf since (**Papers 2, 5**; unpublished data). Elsewhere in their range, these two species are known to have undergone severe localised depletion and in some cases extirpation (Pillans, 2003; Smale, 2009). Therefore, the historic records of these three species, based largely on examination of a few old photographs, may provide tangible evidence of the possible anthropogenically-driven loss of elasmobranch biodiversity in the latter half of the 20th century. This is especially important given that the Gulf is in a region where any more conventional data on elasmobranch diversity, distribution or abundance - is sorely lacking (**Paper 1**).

As well as adding species to the baseline, critical review of earlier records can also remove species lacking substantiated records that might otherwise distract efforts for conservation planning. The great white shark *Carcharodon carcharias* is perhaps the most well-known and high-profile shark species in the world, and is protected by a number of national (e.g. USA, South Africa and Australia) and international conservation measures (e.g. listing on the Convention on Trade in Endangered Species). A report of a single *C. carcharias* from Kuwait in an obscure publication (Khalaf 1987) eventually found its way on to a distribution map for this species in the authoritative field guide to world sharks (Compagno *et al.*, 2005b), although the lead author of this document had apparently not previously read the Khalaf (1987) paper (pers. comm. L. Compagno, May 2007). Closer examination of Khalaf (1987) clearly confirmed that the Kuwait '*Carcharodon carcharias*' record was in fact a species from an entirely different family, i.e. the grey nurse shark *Carcharias taurus* (**Paper 9**). This correction effectively shrank the proven distribution of *C. carcharias* by several thousand kilometres out of the north-western Indian Ocean, with the nearest confirmed record from Sri Lanka (**Paper 9**). This correction is not only relevant to the Arabian region, but also provided supporting distribution information to a high-profile study on ancestral global dispersion of *C. carcharias*, that had far-reaching conservation implications (Gubili *et al.*, 2011).

Chapter 4: Further work and conclusions

Further work

The Published Works provide a strong foundation for ongoing collaboration with Bangor University. Further innovative work is in progress on the biology and ecology of the iconic elasmobranch species of the Gulf (and the PhD) - the smoothtooth blacktip shark, which **Paper 6** reported the rediscovery of.

The vulnerability of this species to extinction is likely to be high, based on a highly restricted known distribution (**Paper 6**) and ongoing capture of pregnant females and young in fisheries (**Paper 2**). However, very little is currently known about its habitat requirements or reproductive strategies, knowledge of which can inform conservation planning. While further year-round market sampling or telemetric tagging could provide useful data, currently these are prohibitively expensive and/or time-consuming. Maximising the use of the relatively small amount of data or samples already collected is therefore a priority to help answer ecological questions.

Fisheries landings suggest that the distribution of the smoothtooth blacktip might be related to the estuarine-influenced north-western Gulf, but at present there is no evidence of this. Collaborative environmental microchemistry work with Dr. Ian McCarthy of the School of Ocean Sciences (in partnership with Dr. Simon Chenery at the British Geological Survey) is in the process of analysing vertebrae of smoothtooth blacktip sharks by laser-ablation inductively coupled plasma mass spectrometry (LA-ICPMS). This aims to detect a chemical signature of freshwater origin within growth bands, which might provide valuable information on the comparative degree of usage of estuarine and marine environments. Such data might prove important in conservation, such as identifying areas for seasonal fishery closures. As a useful secondary output of this study, analysis of sectioned vertebrae by conventional sectioning methods will also provide age estimates (albeit unvalidated) of mature females, which can provide key information on extinction vulnerability.

The author is also collaborating with Dr. Mark de Bruyn and Professor Gary Carvalho (School of Biological Sciences) to determine whether multiple genetic paternity (MGP) occurs in litters of the smoothtooth blacktip. Knowledge of genetic mating systems has been identified as an important consideration in shark conservation programs (Chapman *et al.* 2004), as MGP is thought to have a role in increasing both genetic diversity and effective population size (N_e), i.e. the number of individuals contributing genetically to the next generation (Pearse and Anderson, 2009). In addition, any factors restricting the genetic diversity of the smoothtooth blacktip may affect its ability to adapt to ecological change, such as is known to be occurring in the known range of this species.

In addition, while the Published Works themselves may not have developed broad theoretical aspects of elasmobranch ecology, observations made during the course of it - and ideas stimulated by them - have provided material for a number of future studies. These include:

- Demonstrating a novel example of sexual dimorphism in the head morphology of an elasmobranch species, which may possibly be associated with courtship, mate selection, or copulation;
- Drawing on **Paper 1**'s strength of synthesising disparate data sources, demonstrating the importance of documenting nursery areas - widely recognised as one of the global conservation priorities for elasmobranchs (Heupel *et al.* 2007) - in data-poor environments such as the Gulf, and in developing countries in general. This is in contrast to the model of data-rich, highly resourced studies in developed countries, such as in the USA (e.g. Froeschke *et al.*, 2010); and

- Developing theoretical concepts as to how environmental change over time might be an important factor contributing to the speciation and distribution of elasmobranch species.

Conclusions

As a submission for a modern scientific PhD, the Published Works are collectively open to a number of criticisms. They are all based on observation, with no experimental or hypothesis-driven work, and none of the works (with the possible exception of **Paper 1**) develop theoretical concepts. Secondly, none of the studies have advanced knowledge of data recording, measurement or analysis techniques, as is often the case for PhDs related to elasmobranch ecology and management (e.g. Tillett *et al.*, 2011). Thirdly, several of the papers are shorter notes (**Papers 3, 7-9**), or are collaborative efforts as a junior author (**Paper 4**). Finally, despite gaining valuable skills and experience in fisheries biology, taxonomy and molecular ecology, the approach of the PhD - essentially a broad monograph of many aspects of Gulf elasmobranchs - has not encouraged advanced expertise in a single area.

Despite these shortcomings, the Published Works have made a significant contribution to knowledge. In stark contrast to the position the author found himself in in 2001, a researcher interested in Gulf elasmobranchs today has a number of resources available to him, all of which comprise the Published Works: an accurate and accountable picture of what species are present; what fisheries are operating; and an authoritative structured review that draws together much of what is already known (and, perhaps most importantly, what needs to be known), about Gulf elasmobranchs. While not specialising in a certain field, the broad array of subjects studied included taxonomy, biodiversity, molecular biology, biogeography, fisheries, ecology, conservation and management - an understanding of which is essential to researchers of these incredible and threatened fishes.

References

Al-Daham, N.K. (1974) Two new records of sharks from Iraqi territorial waters with their descriptions. *Bulletin of the Basrah Natural History Museum* **1**: 99-111.

Ali, T.S., Mohamed, A.R.M., and Hussain, N.A. (1993) Trophic interrelationships of the demersal fish assemblage in the northwest Arabian Gulf, Iraq. *Asian Fisheries Science* **6**: 255-264

Anderson, R.C. and Simpfendorfer, C.A. (2005) Regional overview: Indian Ocean. In: Fowler, S.L., Cavanagh, R.D., Camhi, M., Burgess, G.H., Cailliet, G.M., Fordham, S.V., Simpfendorfer, C.A., Musick, J.A. (eds) Sharks, rays and chimaeras: the status of the chondrichthyan fishes. Status survey. IUCN SSC Shark Specialist Group, Cambridge.

Basson, P.W., Burchard, J.E., Hardy, J.T. and Price, A.R.G. (1977) Biotopes of the western Arabian Gulf: marine life and environments of Saudi Arabia. Aramco Department of Loss Prevention and Environmental Affairs, Dhahran

Blegvad, H. (1944) Danish Scientific Investigations in Iran. Part III. Fishes of the Iranian Gulf. Einar Munksgaard, Copenhagen.

Bizarro, J.J., Smith, W.D., Marquez-Farias, J.F., Tyminski, J. and Hueter, R.E. (2009). Temporal variation in the artisanal elasmobranch fishery of Sonora, Mexico. *Fisheries Research* **97**, 103-117. doi: 10.1016/j.fishres.2009.01.009

Caira, J.N. (1990) Metazoan parasites as indicators of elasmobranch biology. In: Pratt, H.L., Gruber, S.H. and Taniuchi, T. (eds) Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. NOAA Tech Rep 90: 71-96

Caira, J.N., Malek, M. and Ruhnke, T. (2010) A new genus of Phyllobothriidae (Cestoda: Tetraphyllidea) in carcharhiniform sharks from Iran and Australia. *Journal of Helminthology* **20**, 1-11. DOI: 10.1017/S0022149X10000222

Carlson, J.K., Osborne, J. and Schmidt, T.W. (2007) Monitoring the recovery of smalltooth sawfish, *Pristis pectinata*, using standardised relative indices of abundance. *Biological Conservation* **136**, 195-2002.

Carlson, J.K., Hale, L.F., Morgan, A. and Burgess, G. (2012) Relative abundance and size of coastal sharks derived from commercial shark longline catch and effort data. *Journal of Fish Biology* **80**, 1749-1764 DOI: 10.1111/j.1095-8649.2011.03193.x

Carpenter, K.E., Krupp, F., Jones, D.A. and Zajonz, U. (1997) The living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates. FAO, Rome

Cartamil, D.P., Sepulveda, C.A., Wegner, N.C., Aalbers, S.A., Baquero, A., and Graham, J.B. (2011) Archival tagging of subadult and adult common thresher sharks (*Alopias vulpinus*) off the coast of southern California. *Marine Biology* **158**, 935-944. DOI 10.1007/s00227-010-1620-4

Chapman, D.D., Prodohl, P.A., Gelsleichter, J., Manire, C.A. and Shivji, M.A. (2004) Predominance of genetic monogamy by females in a hammerhead shark, *Sphyrna tiburo*: implications for shark conservation. *Molecular Ecology* **13**, 1965-1974.

Chin, A., Kyne, P.M., walker, T.I. and McAuley, R.B. (2010) An integrated risk assessment for climate change: analysing the vulnerability of sharks and rays on Australia's Great Barrier Reef. *Global Change Biology* 16, 1936-1953. doi: 10.1111/j.1365-2486.2009.02128.x

Clarke, M.W., Borges, L., and Officer, R.A. (2005) Comparisons of trawl and longline catches of deepwater elasmobranchs west and north of Ireland. *Journal of Northwest Atlantic Fisheries Science* **35**, 429-442.

Compagno, L.J.V., Didier, D.A. and Burgess, G.H. (2005a) Classification of Chondrichthyan fish. In: Fowler SL, Cavanagh RD, Camhi M, Burgess GH, Cailliet GM, Fordham SV, Simpfendorfer CA, Musick JA (eds). Sharks, rays and chimaeras: the status of the chondrichthyan fishes. Status Survey. IUCN SSC Shark Specialist Group, Cambridge.

Compagno, L., Dando, M. and Fowler, S. (2005b). A field guide to the sharks of the world. London: Harper Collins.

Dicken, M.L. (2011) Population size of neonate and juvenile dusky sharks *Carcharhinus obscurus* in the Port of Ngqura, South Africa. *African Journal of Marine Science* **33**, 255-261.

Dulvy, N.K., Metcalfe, J.D., Glanville, J., Pawson, M.G. and Reynolds, J.D. (2000) Fishery stability, local extinctions, and shifts in community structure in skates. *Conservation Biology* **14,** 283–293. doi:10.1046/j.1523-1739.2000.98540.x

Ellis, J. R., Cruz-Martínez, A., Rackham, B.D., and Rogers, S.I. (2005) The distribution of chondrichthyan fishes around the British Isles and implications for conservation. *Journal of Northwest Atlantic Fisheries Science* **35,** 195-213. doi:10.2960/J.v35.m485

Environment Agency Abu Dhabi (2010) Annual Fisheries Statistics Report for Abu Dhabi Emirate 2009. Available at http://www.ead.ae/en/portal/fisheries.report.and.bulletin.aspx (last accessed 9 July 2011).

Fahmi, White, W.T., Manjaji, M., and Peirce, S. (2007) *Dasyatis microps*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. www.iucnredlist.org. Downloaded 03 December 2009.

Ferretti, F., Myers, R.A., Serena, F., and Lotze, H.K. (2008) Loss of large predatory sharks from the Mediterranean Sea. *Conservation Biology* **22,** 952–964. doi:10.1111/j.1523-1739.2008.00938.x

Froeschke, J.T., Stunz, G.W., Sterba-Boatwright, B., andWildhaber, M.L. (2010) An empirical test of the 'shark nursery area concept' in Texas bays using a long-term fisheries-independent data set. *Aquatic Biology* **11**, 65-76. doi:10.3354/ab00290

Garcia, S.M., Zerbi, A., Aliaume, C. Do Chi, T. and Lasserre, G. (2003) The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. *FAO Fisheries Technical Paper* **443**.

Gilbert, P.W. (1970) Studies on the anatomy, physiology and behaviour of sharks. *US Government Research and Development Reports* **70**, issue 15.

Goubanov, E.P. and Shleib, N.A. (eds) (1980). Sharks of the Arabian Gulf. Ministry of Public Works, Agricultural Department, Fisheries Divisions, Kuwait.

Gubili, C., Bilgin, R., Kalkan, E., Karhan, S.U., Jones, C.S., Sims, D.W., Kabasakal., H., Martin, A.P. and Noble, L.R. (2011) Antipodean white sharks on a Mediterranean walkabout? Historical dispersal leads to genetic discontinuity and an endangered anomalous population. *Proceedings of the Royal Society B- Biological Sciences* **278**, 1679-1686.

Haseli, M., Malek, M. and Palm, H.W. (2010) Trypanorhynch cestodes from the Persian Gulf. *Zootaxa* **2492**, 28-28

Henderson, A.C., McIlwain, J.L., Al-Oufi, H.S. and Ambu-Ali, A. (2006). Reproductive biology of the milk shark *Rhizoprionodon acutus* and the bigeye houndshark *Iago omanensis* in the coastal waters of Oman. *Journal of Fish Biology* **68**, 1662-1678. doi: 10.1111/j.1095-8649.2006.01011.x

Henderson, A.C., McIlwain, J.L., Al-Oufi, H.S. and Al-Sheili, S. (2007). The Sultanate of Oman shark fishery: Species composition, seasonality and diversity. *Fisheries Research* **86**, 159-168. doi: 10.1016/jfishres.2007.05.012

Henderson, A.C., McIlwain, J.L., Al-Oufi, H.S., Al-Sheili, S. and Al-Abri, N. (2009). Size distributions and sex ratios of sharks caught by Oman's artisanal fishery. *African Journal of Marine Science* **31**, 233-239. doi: 10.2989/AJMS.2009.31.2.11.883

Heupel, M.R., Carlson, J.K. and Simpfendorfer, C.A. (2007) Shark nursery areas: concepts, definition, characterization and assumptions. *Marine Ecology Progress Series* **337**, 287-297

Hisaw, F.L. (1959) Corpea lutea of elasmobranch fishes. *Anatomical Record* **135,** 269-277.

Holmes, B. H., Steinke, D., and Ward, R. D. (2009). Identification of shark and ray fins using DNA barcoding. *Fisheries Research* **95**, 280–288.

Hoolihan, J. (2003) Sailfish movement in the Arabian Gulf: a summary of tagging efforts. *Marine and Freshwater Research* **54**, 509–513. doi:10.1071/MF01252

Hoolihan, J.P., Premanandh, J., D'Aloia-Palmieri, M.A. and Benzie, J.A.H. (2004) Intraspecific phylogeographic of Arabian Gulf sailfish *Istiophorus platypterus* inferred from mitochondrial DNA. *Marine Biology* **145,** 465–475. doi:10.1007/s00227-004-1346-2

Hutchings, J.A. and Reynolds, J.D. (2004) Marine fish population collapses: consequences for recovery and extinction risk. *BioScience* **54,** 297-309.

IUCN (2011) The IUCN Red List of Threatened Species. Available at http://www.iucnredlist.org/ (last accessed 9 July 2011).

Kalmijn, A. J. (1971). The electric sense of sharks and rays. *Journal of Experimental Biology* **55**, 371-383.

Khalaf, N.A.B. (1987) The great white shark (*Carcharodon carcharias*) from the State of Kuwait, Arabian Gulf. *Gazelle: Palestinian Biological Bulletin* **16**, 1-7.

Khaleghi Ghadiri M. and Gorki, A. (2004) Natural remedies for impotence in medieval Persia. *International Journal of Impotence Research* **16,** 80-83. DOI:10.1038/sj.ijir.3901153

Knip, D.M., Heupel, M.R., Simpfendorfer, C.A., Tobin, A.J. and Moloney, J. (2011) Ontogenetic shifts in movement and habitat use of juvenile pigeye sharks *Carcharhinus amboinensis* in a tropical nearshore region. *Marine Ecology Progress Series* **425**, 233-246.

Last, P.R., White, W.T., and Pogonoski, J.J. eds (2010a). Descriptions of new sharks and rays from Borneo. *CSIRO Marine and Atmospheric Research Paper* No. 032.

Malek, M., Caira, J.N. and Haseli, M. (2010) Two new species of *Paraorygmatobothrium* Ruhnke, 1994 (Cestoda: Tetraphyllidea) from the carcharhinid shark *Carcharhinus* cf. *dussumieri* (Muller & Henle) in the Persian Gulf. *Systematic Parasitology* **76**, 59-68. DOI: 10.1007/s11230-010-9241-3

McDavitt, M.T. (2002) Lake Nicaragua revisited; conversations with a former sawfish fishermenan. *Shark News* **14,** 4-5.

Morgan, J.A.T., Harry, A., V., Welch, D.A., Street, R., White, J., Geraghty, G., Macbeth, W.G., Tobin, A., Simpfendorfer, C.A., and Ovenden, J.R., (2012) Detection of interspecies hybridisation in Chondrichthyes: hybrids and hybrid offspring between Australian (*Carcharhinus tilstoni*) and common (*C. limbatus*) blacktip shark found in an Australian fishery. *Conservation Genetics* **13,** 455-464.

Musick, J. (2005) Introduction. In: Fowler SL, Cavanagh RD, Camhi M, Burgess GH, Cailliet GM, Fordham SV, Simpfendorfer CA, Musick JA (eds). Sharks, rays and chimaeras: the status of the chondrichthyan fishes. Status Survey. IUCN SSC Shark Specialist Group, Cambridge.

Myers, R.A. and Worm, B. (2005) Extinction, survival or recovery of large predatory fishes. *Philosophical Transactions of the Royal Society* B **360,** 13-20.

Naylor, G.J.P., Caira, J.N., Jensen, K., Rosana, K.A.M., White, W.T., and Last, P.R. (2012) A DNA sequence-based approach to the identification shark and ray species and its implications for global elasmobranch diversity and parasitology. *Bulletin of the American Museum of Natural History* **367,** 1-262.

Pauly, D. (1995) Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution* **10,** 30.

Pearse, D.E. and Anderson, E.C. (2009) Multiple paternity increases effective population size. *Molecular Ecology* **18,** 3124-3127.

Pillans, R. (2003) *Negaprion acutidens.* In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. - www.iucnredlist.org, downloaded on 13.v.2010.

Roberts, C. (2007) The unnatural history of the sea. Island Press.

Roberts, C. and Hawkins, (1999) Extinction risk in the sea. *Trends in Ecology and Evolution* **14,** 241-246.

Richards, V.P., Henning, M., Witzell, W. and Shivji, M.S. (2009). Species delineation and evolutionary history of the globally distributed spotted eagle ray (*Aetobatus narinari*). *Journal of Heredity* **100,** 273–283.

Saenz-Arroyo, A., Roberts, C.M., Torre, J., Carino-Olvera, M. and Enriquez-Andrade, R.R. (2005). Rapidly shifting environmental baselines among fishers of the Gulf of California. *Proceedings of the Royal Society B: Biological Sciences* **272** (1575), 1957-1962.

Schluessel, V., Broderick, D., Collin, S.P., Ovenden, J.R. (2010) Evidence for extensive population structure in the white-spotted eagle ray within the Indo-Pacific inferred from mitochondrial gene sequences. *Journal of Zoology* **281,** 46-55.

Sheppard, C., Price, A. and Roberts, C. (1992) Marine ecology of the Arabian region: patterns and processes in extreme tropical environments. Academic Press, London

Simpfendorfer, C. (2000) Predicting population recovery rates for endangered western Atlantic sawfishes using demographic analysis. *Environmental Biology of Fishes* **58,** 371-377.

Simpfendorfer, C.A., Hueter, R., Bergman, U., and Connett, S.M.H. (2002) Results of a fisheries-independent survey of pelagic sharks in the western North Atlantic, 1977-1994. *Fisheries Research* **55,** 175-192.

Smale, M.J. 2009. *Carcharhinus amblyrhynchos.* In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded on 16 February 2012

Stevens, J.D., Bonfil, R., Dulvy, N.K. and Walker, P.A. (2000) The effects of fishing on sharks, ray and chimaeras (chondrichthyans), and the implications for marine ecosystems. *ICES Journal of Marine Science* **57,** 476–494. doi:10.1006/jmsc.2000.0724

Stevens, J.D., Walker, T.I., Cook, S.F., and Fordham, S.V. (2005) Threats faced by Chondrichthyan fish. In: Fowler SL, Cavanagh RD, Camhi M, Burgess GH, Cailliet GM, Fordham SV, Simpfendorfer CA, Musick JA (eds). Sharks, rays and chimaeras: the status of the chondrichthyan fishes. Status Survey. IUCN SSC Shark Specialist Group, Cambridge.

Stobutzki, I.C., Heales, D.S., Miller, M.J. and Brewer, D.T. (2002) Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. *Fisheries Bulletin* **100,** 800-821

Thorson, T.B. (1976) Observations on the reproduction of the sawfish, *Pristis perotteti,* in Lake Nicaragua, with recommendations for its conservation. Published in Investigations of the Ichthyofauna of Nicaraguan Lakes, ed. T.B. Thorson. (University of Nebraska-Lincoln, 1976).

Thorson, T.B. (1982) The impact of commercial exploitation on sawfish and shark populations in Lake Nicaragua. *Fisheries* 7: 2–10. doi:10.1577/1548-8446(1982)007\0002:TIOCEO[2.0.CO;2

Tillett, B.J., Meekan, M.G., Parry, D., Munksgaard, N., Field, I.C., Thorburn, D. and Bradshaw, C.A.B. (2012) Decoding fingerprints: elemental composition of vertebrae correlates to age-related habitat use in two morphologically similar sharks. *Marine Ecology Progress Series* **434,** 133-142.

Tourenq, C., Shuriqi, M.K., Foster, K., Foster, G., Chellapermal, C. and Rein, D. (2008) First record of a bowmouth guitarfish in northern Oman, with an up-date on elasmobranches (sharks and rays) status in United Arab Emirates. *Zoology in the Middle East* **44,** 114-118.

Valinassab, T., Daryanabard, R., Dehghani, R. and Pierce, G.J. (2006) Abundance of demersal fish resources in the Persian Gulf and Oman Sea. *Journal of the Marine Biological Association of the United Kingdom* **86,** 1455-1462. DOI: 10.1017/S0025315406014512

Vossoughi, G.H. and Vosoughi, A.R. (1999) Study of batoid fishes in northern part of Hormoz Strait, with emphasis on some species new to the Persian Gulf and Sea of Oman. *Indian Journal of Fisheries* **46,** 301-306.

Ward, R. D., Holmes, B. H., White, W. T., and Last, P.R. (2008). DNA barcoding Australasian chondrichthyans: results and potential uses in conservation. *Marine and Freshwater Research* **59,** 57-71.

White, W.T. (2012) A redescription of *Carcharhinus dussumieri* and *C. sealei,* with resurrection of *C. coatesi* and *C. tjutjot* as valid species (Chondrichthyes: Carcharhinidae). *Zootaxa* **3241,** 1–34.

White, W.T. and Dharmadi (2007). Species and size composition and reproductive biology of rays (Chondrichthyes, Batoidea) caught in target and non-target fisheries in eastern Indonesia. *Journal of Fish Biology* **70,** 1809-1837. doi: 10.1111/j/1095-8649.2007.01458.x

White, W.T. and Last, P.R. (2012) A review of the taxonomy of chondrichthyan fishes: a modern perspective. *Journal of Fish Biology* **80**, 901-907. doi: 10.1111/j.1095-8649.2011.03192.x

White, W.T., Last, P.R., Stevens, J.D., Yearsley, G.K., Fahmi and Dharmadi (2006) Economically important sharks and rays of Indonesia. Canberra: Australian Centre for International Agricultural Research.

White, W.T., Last, P.R., Naylor, G.J.P., Jensen, K. and Caira, J.N. (2010). Clarification of *Aetobatus ocellatus* (Kuhl, 1823) as a valid species, and a comparison with *Aetobatus narinari* (Euphrasen, 1790)(Rajiformes: Myliobatidae). In Descriptions of new sharks and rays from Borneo (Last, P.R., White, W.T., Pogonoski, J.J. eds), pp. 141-164. CSIRO Marine and Atmospheric Research Paper No. 032.

Wiley, T.R. and Simpfendorfer, C.A. (2007) The ecology of elasmobranchs occurring in the Everglades National Park, Florida: Implications for conservation and management. *Bulletin of Marine Science* **80,** 171-189.

Wirsing, A.J., Heithaus, M.R. and Dill, L.M. (2007) Living in the edge: dugongs prefer to forage in microhabitats that allow escape from rather than avoidance of predators. *Animal Behaviour* **74,** 93-101. DOI:10.1016/j.anbehav.2006.11.016

Appendix 2: Authorship & collaboration

Paper	Reference	Authorship
1	**Moore, A.B.M.** (2011) Elasmobranchs of the Persian (Arabian) Gulf: ecology, human aspects and research priorities for their improved management. *Reviews in Fish Biology and Fisheries* **22**, 35-61.	**ABMM**: Conception & sole author.
2	**Moore, A.B.M.**, McCarthy, I.D., Carvalho, G.R., and Peirce, R. (2012) Species, size, sex and male maturity composition of previously unreported elasmobranch landings in Kuwait, Qatar and Abu Dhabi Emirate. *Journal of Fish Biology* **80**, 1619-1642.	**ABMM**: Conception & author of all text. All field sampling and data processing. Most data analysis. IDM: Some data analysis. Advice on data presentation and editing. Technical review. GRC: Technical review. RP: Logistical enablement of fieldwork.
3	**Moore, A.B.M.** (2012) Records of poorly-known batoid fishes from the north-western Indian Ocean (Chondrichthyes: Rhynchobatidae, Rhinobatidae, Dasyatidae and Mobulidae). *African Journal of Marine Science* **34**, 297-301.	**ABMM**: Conception & sole author.
4	Last, P.R., Manjaji-Matsumoto, M., **Moore, A.B.M.** (2012) *Himantura randalli* sp. nov., a new whipray (Myliobatoidea: Dasyatidae) from the Persian Gulf. *Zootaxa* **3327**, 20-32.	PRL: Lead author, taxonomic aspects. MMM: Earlier PhD thesis (supervised by PRL) formed the taxonomic foundation of the work. **ABMM**: Sampling, collecting, photographing and measuring specimens; provision of size and maturity data; author of regional context (synonymy/misidentifications, possible endemism & biogeography, habitat, fisheries, ecology).
5	**Moore, A.B.M.**, Ward, R. D. and Peirce, R. (2012) Sharks of the Persian (Arabian) Gulf: a first annotated checklist (Chondrichthyes: Elasmobranchii). *Zootaxa* **3167,** 1-16.	**ABMM**: Conception; author of all text excepting molecular aspects. RDW: Analysis, interpretation and authorship of molecular aspects. RP: Logistical enablement of fieldwork.
6	**Moore, A.B.M.**, White, W.T, Ward, R.D., Naylor, G.J.P. & Peirce, R. (2011) Rediscovery and redescription of the smoothtooth blacktip shark *Carcharhinus leiodon* (Carcharhinidae), from Kuwait, with notes on its possible conservation status. *Marine and Freshwater Research* **62**, 528-539.	**ABMM**: recognition of indeterminate species requiring clarification; all fieldwork including sampling, collecting and photographing specimens; measurement of museum specimens under supervision by WTW; authorship of regional context (e.g. misidentifications, distribution, habitat, fisheries & conservation aspects) and some text on identification characters. WTW: conception & framework; lead author on description, taxonomy and identification; preparation of images. RDW/GJPN: analysis, interpretation and authorship of molecular aspects. RP: Logistical enablement of fieldwork.
7	**Moore, A.B.M.**, White, W.T., & Peirce, R. (2010) Additions to the shark fauna of the Persian (Arabian) Gulf (Carcharhiniformes: Hemigaleidae and Carcharhinidae). *Zoology in the Middle East* **50**, 83-88.	**ABMM**: Conception and all fieldwork; author of all text. WTW: Technical review. RP: Logistical enablement of fieldwork.
8	**Moore, A.B.M.** (2010) The smalleye stingray *Dasyatis microps* (Myliobatiformes: Dasyatidae) in the Gulf: previously unreported presence of a large, rare elasmobranch. *Zoology in the Middle East* **49,** 101-103.	**ABMM**: Conception; sole author.
9	**Moore, A.B.M.**, Compagno, L.J.V and Fergusson, I.K. (2007) The Persian/Arabian Gulf's sole great white shark *Carcharodon carcharias* (Lamniformes: Lamnidae) record from Kuwait: misidentification of a sandtiger shark *Carcharias taurus* (Lamniformes: Odontaspididae). *Zootaxa* **1591**, 67-68.	**ABMM**: Author of most text. LJVC: Technical review and some additional text on species distribution. IKF: Technical review; initially suggested paper would be worthy of publication.

Re: PhD thesis - brief response kindly requested - Message (Plain Text)

You replied on 17/09/2012 16:58.
Extra line breaks in this message were removed.

From: McCarthy,Ian Donald [ossc02@bangor.ac.uk] Sent: Mon 17/09/2012 16:50
To: Alec Moore
Cc:
Subject: Re: PhD thesis - brief response kindly requested

Dear Alec,

I agree with your proposed text regarding my involvement in the Gulf shark fisheries paper published this year in Journal of Fish Biology (Vol 80, pp 1619-1642). I am happy for you to include this email in your thesis submission as evidence of my agreement of your lead role on the paper and for you to include it in your PhD by published works submission.

with best wishes

Ian

--
Dr Ian McCarthy

Senior Lecturer in Fish Biology,
Course Director, MSc Marine Biology

School of Ocean Sciences, / Ysgol Gwyddorau Eigion,
College of Natural Sciences, / Coleg Gwyddorau Naturiol
Bangor University, / Prifysgol Bangor,
Menai Bridge, / Porthaethwy,
Anglesey, / Ynys Mon,
LL59 5AB. / LL59 5AB.

Tel. 01248 382862 / ffon. 01248 382862
Fax. 01248 716367 / ffacs. 01248 716367
i.mccarthy@bangor.ac.uk
http://www.sos.bangor.ac.uk/staff/php/staffdetails1.php?person=0016
--
Rhif Elusen Gofrestredig / Registered Charity No. 1141565

Re: PhD thesis - brief response kindly requested - Message (Plain Text)

Extra line breaks in this message were removed.

From: Carvalho,Gary Robert [g.r.carvalho@bangor.ac.uk] Sent: Wed 19/09/2012 13:45
To: Alec Moore
Cc: i.mccarthy@bangor.ac.uk
Subject: Re: PhD thesis - brief response kindly requested

This is absolutely fine with me Alec, and is an accurate representation of the various roles including the leading one by yourself.
Best wishes
Gary

On 14/09/2012 12:34, AMoore@rsk.co.uk wrote:
> DearIan, Gary
> As you are aware, I am nearing completion of my PhD studies and am
> finalising my thesis to submit to Bangor University. As part of this,
> I am required to provide details of the role of both myself and
> co-authors on all joint publications, to conform to the following regulation:
> "/Candidates may submit work(s) completed in collaboration with others
> in support of the candidature, but such work shall be accompanied by a
> detailed statement signed by each collaborator indicating the nature
> and amount of the work done by the candidate/."
> I attach below my proposed text regarding roles and responsibilities
> on our joint publication(s).
> *Please can you reply by email, briefly stating* *whether you a**gree
> or
> disagree* with the proposed text. If you disagree please contact me
> with your concerns.
> Please ensure you include your title/affiliation in any response, and
> also note that I will be required to include your e-mail
> correspondence as an Appendix to my thesis.
> Many thanks in advance for your help
> Kind regards
> Alec
>
> *__*
>
> **
>
> **
>

Re: PhD thesis - Message (HTML)

File Edit View Insert Format Tools Actions Help

Reply | Reply to All | Forward

You replied on 01/10/2012 12:21.

From: Richard Peirce [rpaconsult@peirceshark.com]   Sent: Mon 01/10/2012 12:21
To: Alec Moore
Cc:
Subject: Re: PhD thesis

Hi Alec

Am battling through my desk post Azores exped. As far as I am aware this looks fine. Good luck.

With kind regards

Richard

From: Richard Peirce
Sent: Wednesday, September 19, 2012 11:35 AM
To: Alec Moore
Subject: PhD thesis

Hi Alec,

I have spoken with Richard via skype today and briefly read out your e-mail. He says he will be back in the office on Monday 1st October and if it can wait until then when he can read it properly that would be great. If not and you need to get it in before, on the basis of what I have read him he is happy with the wording.

With kind regards

Denise

Start 16:16

RE: PhD thesis - brief response kindly requested - Message (HTML)

File Edit View Insert Format Tools Actions Help

Reply | Reply to All | Forward

From: Peter.Last@csiro.au   Sent: Sun 16/09/2012 06:47
To: Alec Moore; mabel@ums.edu.my
Cc:
Subject: RE: PhD thesis - brief response kindly requested

Hi Alec

Fine by me - good luck.

Peter

From: AMoore@rsk.co.uk [mailto:AMoore@rsk.co.uk]
Sent: Friday, 14 September 2012 9:03 PM
To: Last, Peter (CMAR, Hobart); mabel@ums.edu.my
Subject: PhD thesis - brief response kindly requested

Dear Mabel, Peter

As you may be aware, I am nearing completion of my PhD studies and am finalising my thesis to submit to Bangor University. As part of this, I am required to provide details of the role of both myself and co-authors on all joint publications, to conform to the following regulation:

"Candidates may submit work(s) completed in collaboration with others in support of the candidature, but such work shall be accompanied by a detailed statement signed by each collaborator indicating the nature and amount of the work done by the candidate."

I attach below my proposed text regarding roles and responsibilities on our joint publication(s).

Please can you reply by email, briefly stating whether you agree or disagree with the proposed text. If you disagree please contact me with your concerns.

Please ensure you include your title/affiliation in any response, and also note that I will be required to include your e-mail correspondence as an Appendix to my thesis.

Many thanks in advance for your help

Kind regards

Alec

Start 16:17

Re: PhD thesis - brief response kindly requested - Message (HTML)

File Edit View Insert Format Tools Actions Help

Reply | Reply to All | Forward

You replied on 14/09/2012 12:50.

From: Mabel Manjaji Matsumoto [mabel@ums.edu.my] Sent: Fri 14/09/2012 12:45
To: Alec Moore
Cc: peter.last@csiro.au
Subject: Re: PhD thesis - brief response kindly requested

Dear Alec
Thanks for your kind message. I agree with your proposed text.
And may I ask what is the title of your Ph.D. thesis?
Congratulations for the completion your thesis, and all the best!
Mabel

----- Original Message -----
From: AMoore@rsk.co.uk
Date: Friday, September 14, 2012 8:03 pm
Subject: PhD thesis - brief response kindly requested
To: peter.last@csiro.au, mabel@ums.edu.my

>
>

>
>
>

>

Dear Mabel, Peter
>

>

Start 16:17

RE: PhD thesis - brief response kindly requested - Message (Plain Text)

File Edit View Insert Format Tools Actions Help

Reply | Reply to All | Forward

Extra line breaks in this message were removed.

From: Bob.Ward@csiro.au Sent: Sat 15/09/2012 00:51
To: Alec Moore
Cc:
Subject: RE: PhD thesis - brief response kindly requested

Dear Alec,

I am fully in agreement with your assessment of my role in those two publications. I accept your statements as appropriate.

All best wishes, and good luck with your thesis,

Yours,

Bob Ward

Dr Robert D Ward
Post-Retirement Fellow
CSIRO Marine and Atmospheric Research
GPO Box 1538
Hobart
Tasmania 7001
Australia

From: AMoore@rsk.co.uk [AMoore@rsk.co.uk]
Sent: Friday, September 14, 2012 9:14 PM
To: Ward, Bob (CMAR, Hobart)
Subject: PhD thesis - brief response kindly requested

Dear Bob

As you may be aware, I am nearing completion of my PhD studies and am finalising my thesis to submit to Bangor University. As part of this, I am required to provide details of the role of both myself and co-authors on all joint publications, to conform to the following regulation:

"Candidates may submit work(s) completed in collaboration with others in support of the candidature, but such work shall be accompanied by a detailed statement signed by each collaborator indicating the nature and amount of the work done by the candidate."

Start 16:18

RE: PhD thesis - brief response kindly requested - Message (HTML)

From: William.White@csiro.au

Sent: Mon 17/09/2012 00:17

To: Alec Moore

Cc:

Subject: RE: PhD thesis - brief response kindly requested

Dear Alec,

I agree with the proposed text for both of those papers.

Congrats on the PhD's impending end.

Cheers
Will

From: AMoore@rsk.co.uk [mailto:AMoore@rsk.co.uk]
Sent: Friday, 14 September 2012 9:07 PM
To: White, William (CMAR, Hobart)
Subject: PhD thesis - brief response kindly requested

Dear Will

As you may be aware, I am nearing completion of my PhD studies and am finalising my thesis to submit to Bangor University. As part of this, I am required to provide details of the role of both myself and co-authors on all joint publications, to conform to the following regulation:

"Candidates may submit work(s) completed in collaboration with others in support of the candidature, but such work shall be accompanied by a detailed statement signed by each collaborator indicating the nature and amount of the work done by the candidate."

I attach below my proposed text regarding roles and responsibilities on our joint publication(s).

Please can you reply by email, briefly stating whether you agree or disagree with the proposed text. If you disagree please contact me with your concerns.

Please ensure you include your title/affiliation in any response, and also note that I will be required to include your e-mail correspondence as an Appendix to my thesis.

Many thanks in advance for your help

Kind regards

Re: PhD thesis - brief response kindly requested - Message (Plain Text)

Extra line breaks in this message were removed.

From: Gavin Naylor [gjpnaylor@gmail.com]

Sent: Fri 14/09/2012 12:16

To: Alec Moore

Cc:

Subject: Re: PhD thesis - brief response kindly requested

Hi Alec,

I agree with the proposed text.

Gavin

On Fri, Sep 14, 2012 at 7:09 AM, <AMoore@rsk.co.uk> wrote:
> Dear Gavin
>
> As you may be aware, I am nearing completion of my PhD studies and am
> finalising my thesis to submit to Bangor University. As part of this,
> I am required to provide details of the role of both myself and
> co-authors on all joint publications, to conform to the following regulation:
>
> "Candidates may submit work(s) completed in collaboration with others
> in support of the candidature, but such work shall be accompanied by a
> detailed statement signed by each collaborator indicating the nature
> and amount of the work done by the candidate."
>
> I attach below my proposed text regarding roles and responsibilities
> on our joint publication(s).
>
> Please can you reply by email, briefly stating whether you agree or
> disagree with the proposed text. If you disagree please contact me
> with your concerns.
>
> Please ensure you include your title/affiliation in any response, and
> also note that I will be required to include your e-mail
> correspondence as an Appendix to my thesis.
>
> Many thanks in advance for your help
>
> Kind regards
>

Re: PhD thesis - brief response kindly requested - Message (HTML)

File Edit View Insert Format Tools Actions Help

Reply | Reply to All | Forward

From: Leonard Joseph Victor Compagno [ljvctora@gmail.com] Sent: Fri 14/09/2012 23:03

To: Alec Moore

Cc:

Subject: Re: PhD thesis - brief response kindly requested

YEAH. IRAQ LIVES.

On Fri, Sep 14, 2012 at 2:49 PM, <AMoore@rsk.co.uk> wrote:

Dear Leonard

I hope all is well with you. I am nearing completion of my PhD studies and am finalising my thesis to submit to Bangor University. As part of this, I am required to provide details of the role of both myself and co-authors on all joint publications, to conform to the following regulation:

"Candidates may submit work(s) completed in collaboration with others in support of the candidature, but such work shall be accompanied by a detailed statement signed by each collaborator indicating the nature and amount of the work done by the candidate."

I attach below my proposed text regarding roles and responsibilities on our joint publication(s).

Please can you reply by email, briefly stating whether you agree or disagree with the proposed text. If you disagree please contact me with your concerns.

Please ensure you include your title/affiliation in any response, and also note that I will be required to include your e-mail correspondence as an Appendix to my thesis.

Many thanks in advance for your help

Kind regards

Alec

Publication

Moore, A.B.M., Compagno, L.J.V and Fergusson, I.K. (2007) The Persian/Arabian Gulf's sole great white shark *Carcharodon carcharias* (Lamniformes: Lamnidae) record from Kuwait: misidentification of a sandtiger shark *Carcharias taurus* (Lamniformes: Odontaspididae). *Zootaxa* **1591**: 67-68.

Authorship

ABMM: Author of most text.

Start 16:19