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TOO PRECIOUS TO DRILL:
THE MARINE BIODIVERSITY OF BELIZE

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THE MARINE BIODIVERSITY OF BELIZE

Fisheries Centre, University of British Columbia, Canada

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edited by

Maria Lourdes D. Palomares and Daniel Pauly

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DIRECTOR'S FOREWORD

The April 2010 Deepwater Horizon oil rig blowout in the Gulf of Mexico has sharpened attention on the oil spills occurring in many parts of the world ocean, and their potential damaging effects on marine ecosystems and the living organisms they sustain. This report focuses on the sustainability of marine fisheries of Belize in the face of potential impacts of ocean threats – in particular, oil spills. The report is timely and important in at least two ways. First, it addresses oil spills in the ocean, which occur frequently worldwide and can have significant effects on life in the ocean and the wellbeing of the people dependent on it. Second, the report focuses on a small developing country, Belize – an example of a country that does not usually receive the attention it deserves by researchers, even though the ocean and the resources it contains is the main source of existence for its citizens. Thirdly, this work is a collaboration between academic researchers, NGOs and management partners, thereby making the research output more relevant to real life problems.

This report consists of several chapters that tackle issues ranging from the ecology of the marine ecosystem of Belize right through to the economic benefits currently derived from activities dependent on the ecosystem. These include fishing, angling and whale(shark) watching. A crucial point made in the report is that while oil is a non-renewable resource, fish is renewable. This means that in comparing the benefits from drilling the marine ecosystem of Belize, it is important that in the short term, possibly larger benefits from oil drilling should not be allowed to trump benefits that, if well-managed and protected, are capable of continuing to flow through time, benefiting all generations.

The result of the work reported in this contribution, which is based on a broad collaboration between scientists, civil society members and managers, serves as a good example of how to produce policy relevant research that serves societal goals and objectives.

I commend the authors of the report for producing a significant piece of research that has a strong potential to contribute positively to policy making in Belize.

U. RASHID SUMAILA
Director and Professor
The Fisheries Centre, UBC

EDITORS' PREFACE

There is a huge amount of zoological and botanical publications on the marine biodiversity of Belize, notably because the American Museum of Natural History in New York and the Smithsonian Institution in Washington, D.C., established marine stations many years ago in Belize and used these for continuous monitoring, and for generations of graduate students to complete their theses. All these and similar materials were, however, published mainly in US and British scientific journals, with only sporadic efforts to make it accessible to the Belizean students and members of the public. Thus, those Belizeans who live with their back to the sea do not get the information that they need to turn around, and fully appreciate the beauty and wealth of the biodiversity along their shores, and its role in attracting tourists and producing seafood. This also leads to the Belizean public not fully appreciating the risk to marine biodiversity of an oil spill and the potential cost to their economy.

In view of the debate and the possibility of a national referendum on offshore oil drilling in Belize, a conference entitled 'Too Precious to Drill: the Marine Biodiversity of Belize' was organized jointly by Oceana Belize and the *Sea Around Us* project, with major funding from the Oak Foundation. This report assembles the contributions presented at this conference, and is complemented by a conference website ('Too Precious to Drill: the Marine Biodiversity of Belize' at www.seararoundus.org, under 'Hot Topic') which assembles all the published material that was used in enhancing the content of SeaLifeBase (www.sealifebase.org) and FishBase (www.fishbase.org) for Belize, two global information systems documenting nomenclature, geography, ecology and biology of marine organisms of the world, and which hopefully will become tools for familiarizing Belizean students with their marine biodiversity. Also, we hope that this report and the conference website will contribute to informing the national debate on oil drilling in Belizean waters.

We thank Ms Audrey Matura-Shepherd and her staff at Oceana Belize for their enthusiastic assistance with the preparation of this material and the event at which it was released, and the Oak Foundation for funding the event and the preparation of this report. The *Sea Around Us* project, of which this report is a product, is a scientific collaboration between the University of British Columbia and the Pew Environment Group.

BIODIVERSITY OF SPONGES: BELIZE AND BEYOND, TO THE GREATER CARIBBEAN¹

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ABSTRACT

Sponges represent one of the most diverse benthic faunal groups in subtidal habitats of Caribbean coral reefs and mangroves. On coral reefs, sponges (100-261 species) surpass the species richness of other conspicuous reef organisms, such as octocorals (60-80 species) and scleractinian corals (50-60 species). In the past 35 years, researchers supported by the Caribbean Coral Reef Ecosystems program (Smithsonian Institution) have produced more than 125 publications about marine sponges. These studies have covered many disciplines, including traditional morphological descriptions of new species, but also developmental biology, ecology, symbioses, disease, and evolutionary analyses revealing population affinities throughout the Caribbean using DNA fingerprinting. Various studies have shown that the Belizean coral reefs and mangroves harbor the third richest sponge fauna in the greater Caribbean (after Cuba, and the Florida peninsula). Comparisons between reef and mangrove faunas show that, throughout the Caribbean, they are consistently distinct in their species composition. Many more species will be discovered once the less accessible habitats, such as mesophotic reefs and deeper hard bottoms, are explored.

The importance of sponges as a marine resource in Belize is substantial, with respect to services relevant to both their own communities and the human domain. First, they are well known as unique biological pumps and filters, due to great living biomass combined with high water filtration capacity (up to 1 liter per cubic-centimeter sponge per hour), and to complex bacterial assemblages living symbiotically in their bodies (cyanobacteria, nitrifying bacteria, archaeobacteria). Secondly, a varied morphologic diversity (shape and color), some with large sizes (up to several meters in diameter), makes them one of the most attractive and intriguing creatures to the curious sport diver visiting Belizean coral reefs. Some sponges are the main dietary component for marine turtles, and a food supplement for many reef fishes (butterfly fishes, angelfishes). Besides their nutritional benefit to sea turtles and fishes, they also provide habitats to hundreds of species of invertebrates and fishes living in cavities inside sponges. In mangrove habitats, too, we have found that sponges are diverse and abundant, particularly on stilt roots of red mangrove lining the tidal channels, and that they probably have developed a long-standing relationship with these plants, offering protection from root borers and possibly exchanging nutrients with them.

Besides their attractiveness to underwater tourism, sponges, together with algae and bacteria, are among the marine organisms with highest pharmacological potential for human use, mainly from secondary metabolites produced as defensive chemicals. This well-known capacity makes them a unique resource that must be protected for the future benefit of marine as well as human communities.

INTRODUCTION

While oceans harbor approximately 80% of animal life on the planet, the Caribbean contains the greatest concentration of species in the Atlantic Ocean and is a global-scale hot spot for marine Biodiversity (Roberts *et al.*, 2002). The Caribbean Sea is a semi enclosed basin of the western Atlantic Ocean, with an

¹ Cite as: Diaz, M.C., Rützler, K., 2011. Biodiversity of sponges: Belize and beyond, to the greater Caribbean. *In*: Palomares, M.L.D., Pauly, D. (eds.), *Too Precious to Drill: the Marine Biodiversity of Belize*, pp. 57-65. Fisheries Centre Research Reports 19(6). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

area of about 2,754,000 km², bathed by currents that enter through the Lesser Antilles and the Windward Passage, and leave northwesterly towards the Gulf of Mexico to form the Gulf Stream. The most prominent marine ecosystems in the Caribbean are sea grass beds (66,000 km²), coral reefs (26,000 km²), and mangroves (11,560 km²) (Miloslavich *et al.*, 2010).

Coral reef and mangrove ecosystems are among the most productive and biodiverse tropical marine communities. Coral reefs harbor 4-5% of all known species and are responsible for the highest recorded oceanic productivities (1,500-5,000 gC·m⁻²·year⁻¹). Mangroves forests line as much as 60-75 % of tropical coasts and may constitute 'biodiversity hotspots' themselves (Rützler *et al.*, 2000), which have been demonstrated to increase reef fish productivity (Mumby *et al.*, 2007). In recent decades, these ecosystems have suffered the consequences of uncontrolled human development (waste water pollution, habitat destruction, clear cutting, among others), and global warming. The area coverage of mangrove has decreased about 1% per year since 1980 (Agard *et al.*, 2007), while live coral coverage has decreased 80% during the last two decades (Gardner *et al.*, 2003; Wilkinson, 2004). Therefore, these ecosystems and the organisms within them are not in their prime conditions and must be studied to understand their role and function and preserved if we intend for the next human generations to continue benefitting from them.

Sponges may represent the most diverse benthic faunal component on Coral Reef and mangroves in the Caribbean (Figure 1). Reef sponges may reach four times the diversity of hard and soft corals (Diaz and Rützler, 2001), and mangrove sponges may equal or surpass the richest groups of macroalgae and ascidians, representing from 10 to 70% of the total root epiphytic diversity in various Caribbean sites (Diaz and Rützler, 2009). Marine sponges are essential to the ecology of these systems, mainly owing to their high capacity of water filtration and their role in metabolic processes, including those of their microbial associates (Diaz and Rützler, 2001; Lesser, 2006; de Goeij *et al.*, 2008).

In 1972, the Smithsonian Institution's Caribbean Coral Reef Ecosystems Program (CCRE) established a field station on Carrie Bow Cay, a tiny sand islet off southern Belize formed by reef-crest debris, to provide year-round support for research by varied experts concerned with investigating biodiversity in the broadest sense, developmental biology, species interaction, oceanographic and carbonate-geological processes, community development over time, starting in the Pleistocene, and distributional, physiological, and chemical ecology. Early on, program participants consisted of staff of the National Museum of Natural History, but eventually, despite financial constraints, collaborators were brought in from other academic institutions worldwide. Numerous studies examined the biological and geological role of Porifera in the reef communities. At last count, 113 researchers focused on sponges of the Carrie Bow area, with 88 (78%) conducting fieldwork and the remainder coauthoring publications. Of the fieldworkers, 63 (72%) studied sponges directly, while the rest (25 or 28%) dealt with sponge associates. To date, 125 scientific papers have been published on the results of this research, while many more are in progress (Rützler, 2011). The present paper reviews our understanding of marine sponges in Belize and beyond to the greater Caribbean. We intend to reflect on the importance of these organisms to the marine communities they inhabit and to the human domain.

MATERIAL AND METHODS

We carried out a historical review of research in marine sponge biodiversity from Belize and the Caribbean from the early 1800s to the present using a comprehensive taxonomic list that contains classification and authorship information for all sponge species described for the Caribbean (Diaz, van Soest, Rützler and Guerra-Castro, in progress) The list can be found in the World Porifera database: <http://www.marinespecies.org/porifera/> (Van Soest *et al.*, 2010), or on the Porifera Tree of Life (PorToL) website (<http://www.portol.org/resources>).

We compiled our own data and published data from other authors and summarized information about the ecological role and pharmacological use of tropical marine sponges, updating our previous review (Diaz and Rützler, 2001).

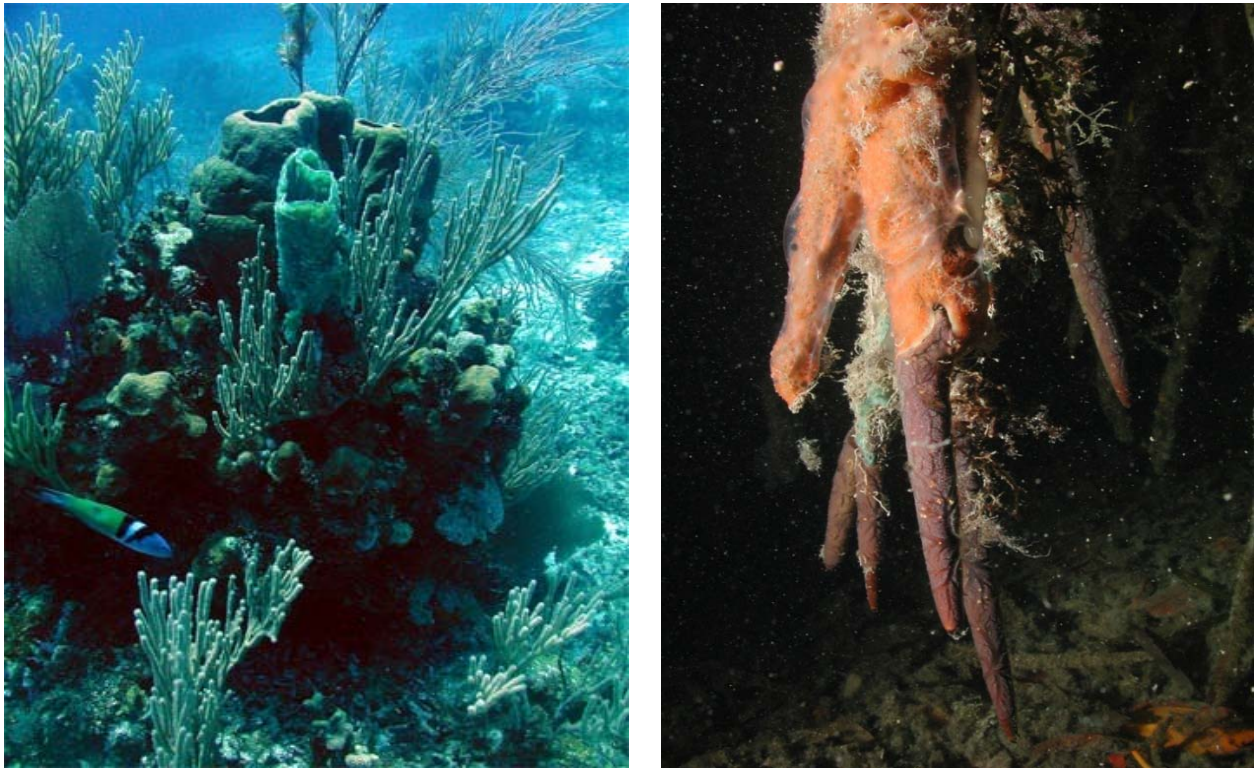


Figure 1. Sponges are conspicuous components of coral reef and mangrove fauna. (Left) *Neofibularia nolintangere* (brown mounds) and *Callyspongia plicifera* (light bluish-gray tube) on a patch reef near Carrie Bow Cay, Belize. (Right). Three common mangrove species, *Mycale magniraphidiphera* (translucent), *M. microsigmatosa* (orange), and *Haliclona manglaris* (light green) covering red mangrove (*Rhizophora mangle*) rootlet tips in a tidal channel at Twin Cays.

RESULTS AND DISCUSSION

Porifera biodiversity in time

From the earliest descriptions by P.S. Pallas and J.B. Lamarck (mid-1700s and early 1800s) to the present, approximately 100 authors have contributed taxonomic descriptions of some 800 species of sponges from the greater Caribbean (Figure 2). The earliest comprehensive study of Caribbean sponges, published in 1864 by P. Duchassaing and G. Michelotti, dealt exclusively with collections from the Lesser Antilles, and included approximately 43 species. Subsequent work by J. S. Bowerbank, H. J. Carter, A. Dendy, O. Schmidt, and E. Topsent between 1858 and 1890 covered mainly the Gulf of Mexico and the West Indies, and added more than 150 species. The most prolific authors were the Austrian naturalist Oscar Schmidt, who contributed more than 165 species in 1870-80, and the North American Max Walker de Laubenfels who contributed more than 60 species during 1932-1954 (see Wiedenmayer, 1977 for literature review).

The first sponge known from Belize (then British Honduras) was a tiny (5x12 mm) *Polymastia biclavata* (now genus *Coelosphaera*), sent to England by a local collector and described by B.W. Priest before the Quekett Microscopical Club of London in 1881. This remained the only record from Belize for the next 56 years, until the British Rosaura Expedition of 1937/38 collected five species from Belize City harbor and Turneffe Island atoll; even those specimens were not described until M. Burton's treatise in 1954. When the participants of the CCRE program (Smithsonian Institution, National Museum of Natural History) arrived in Belize in the early 1970s, studies centered on systematics and faunistics, including the quantitative distribution of benthic organisms among the various shallow-water habitats (reachable with scuba diving). Over the next 30 years or so, taxonomy was approached by methods ranging from basic morphology to fine structure, DNA barcoding, and ecological manipulations. One highlight of these years was a workshop for six experts on Caribbean Porifera held at Carrie Bow Cay in 1997. CCRE studies have identified 30 new species, many as part of taxonomic revisions, local or Caribbean-wide, for instance of

the families Clionidae, Mycalidae, Chalinidae and Axinellidae, and the genera *Lissodendoryx* (Coelosphaeridae) and *Iotrochota* (Iotrochotidae). Several species first described from Belizean mangroves were later found distributed on mangroves Caribbean wide.

Until now, 189 sponge species have been reported from Belize reef and mangrove habitats (Diaz *et al.*, in progress). This number represents only part of the diversity because many species that we collected remain unclassified and enigmatic and several prime sponge habitats remain unexplored for logistical reasons, such as the deep (below scuba) forereef, mesophotic bottoms, and cryptic environments. Experts estimate that once many regions, depths and habitats get explored, sponge biodiversity might nearly double, from the approximately 10,000 species recognized worldwide so far. The cumulative curve of number of species described per year in the greater Caribbean (Figure 2) shows that the sponge diversity in this region is still underestimated, and that whenever new geographic areas or different habitats are explored, undiscovered species are encountered. Such is the case of the recent description of thirteen new species from sciophilous habitats (cryptic areas of reefs, caverns, or small caves) from Curaçao and Colombia (Van Soest, 2009).

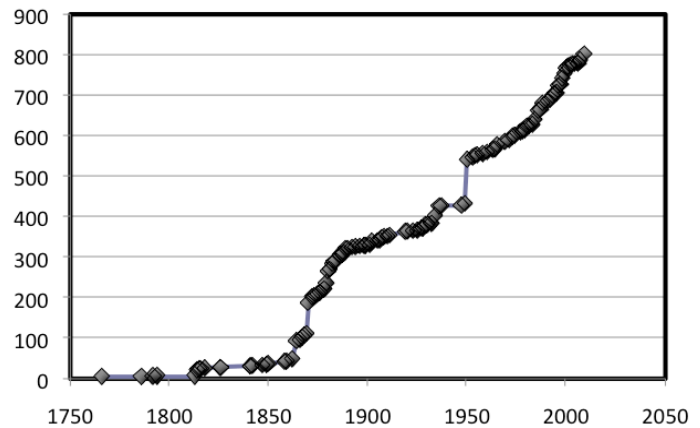


Figure 2. Cumulative number of sponge species described in the Caribbean from 1766 to the present.

Sponges are the most species-rich benthic animal group (165-265) in Cuba, Belize, and Jamaica, a higher diversity than elsewhere in the Caribbean (Miloslavich *et al.*, 2010). Belizean sponges (189 species) represent the third most diverse fauna in the greater Caribbean after Cuba (265 species) and South Florida with (228 species; Diaz *et al.*, in progress.). Comparing the diversities of five important marine animal groups (mollusk, crustaceans, echinoderms, corals and sponges) from 17 countries within various Caribbean marine ecoregions, Miloslavich *et al.* (2010) found that Belize ranked seventh in species richness. But, when they related species richness to the coastal area of each country, Belize ranked the fourth richest country, with 248 species/100 km, after Cayman islands (388 species/100 km), Costa Rica (362 species/100 km), and Puerto Rico (262 species/100 km).

Porifera in the Caribbean and habitat preservation

A classical approach to species conservation is to preserve the habitats where they live. This approach becomes even more critical when the species have specific habitat preferences. Scientists, park managers, or government officials might wonder how distinct mangrove and reef faunas are, and which habitat might be more important to protect. We have found that despite geographic contiguity between both habitats, their sponges present biological distinctness, which shows the importance of preserving both ecosystems. Diaz (in press) compared mangrove and coral reef sponge species composition in four distant Caribbean regions (Belize, Cuba, Panama, and Venezuela) and showed that the compositions of these faunas were statistically different. The taxonomic distinctness among faunas was observed at various supraspecific levels (genera, families). For example, major reef players such as species in the family Petrosiidae (genera *Xestospongia*, *Neopetrosia*, *Petrosia*), the family Agelasidae (*Agelas* spp.) and the order Verongida (*Aplysina*, *Verongula*), are basically absent from contiguous sponge-rich mangrove communities. On the other hand, the family Chalinidae (*Haliclona*, *Chalinula*) and the family Mycalidae (*Mycale* spp.) are more species-rich in mangroves than on coral reefs. It is assumed that differences might reflect distinct histories for both faunas. These results place in evidence the need to preserve both ecosystems in order to protect such distinctive faunal components.

Ecosystem services

Biological pumps

Vast volumes of water (up to 1 liter·cm⁻³ sponge tissue per hour) can be pumped and filtered by marine sponges (Reiswig, 1974). Estimating the biomass of sponge populations in three reef types in Belize, Wilkinson (1989) found the highest values (in wet weight) on inner (lagoon) reefs (1,011-2,458 g·m⁻²), followed by barrier back reefs (99-1354 g·m⁻²), and outer reefs (368-702 g·m⁻²). Assuming an average daily pumping activity of 12 hours (Pile *et al.*, 1997), and a wet volume to weight ratio for sponge tissue of 0.5 (Corredor *et al.*, 1988), we can extrapolate that sponges in Belize reefs may pump 594-14,748 l water m⁻²·day⁻¹. This large capacity of water filtration makes sponges not only filter feeders par excellence (Vacelet and Boury Esnault, 1995) but—owing to animal and microbial metabolic processes referred to below—gives these animals a unique role in water transformation with unprecedented ecological consequences. For example, sponges are well known to have high removal rates of particular organic carbon (POC; Reiswig, 1971; Richter *et al.*, 2001; Scheffers *et al.*, 2004) and even higher rates (up to two orders of magnitude) of removal of bulk dissolved organic carbon (DOC; Yahel *et al.*, 2003; de Goeij and van Duyl, 2007). De Goeij *et al.*, (2008) conclude that the three Caribbean thinly encrusting sponges *Halisarca caerulea*, *Merlia normani*, and *Mycale microsigmatosa*, are dissolved organic matter (DOM)-feeders and thus act as sinks of DOC on the reefs they inhabit.

The microbial processes of nitrification (aerobic transformation of ammonium to nitrite and nitrate) and denitrification (anaerobic reduction of nitrate to nitrogen gas) have been shown to occur among Caribbean and Mediterranean sponges, and project the highest benthic nitrification rates in tropical waters (Diaz and Ward, 1997; Southwell *et al.*, 2007; Schläppy *et al.*, 2010). Therefore, sponge population size and composition could strongly influence the concentration and speciation of dissolved inorganic nitrogen (DIN) in the reef and mangrove water column, affecting the new production in the ecosystems where they abound.

Other metabolic pathways must be evaluated to further predict the role of sponges in these marine systems.

Space competitors

Various encrusting sponges have been found to overgrow corals and other sessile invertebrates in the Caribbean (Vicente, 1978; Suchanek *et al.*, 1983; Aerts and van Soest, 1997). *Chondrilla nucula* (now, *C. caribensis*) has been the principal aggressor at least at three Caribbean sites: Puerto Rico (Vicente, 1978), St. Croix (Suchanek *et al.*, 1983), and Belize (Rützler, *et al.*, 2007). Two recently discovered thinly encrusting reef sponges, *Xestospongia bocatorensis* and *Haliclona walentinae*, both containing filamentous cyanobacteria as endosymbionts, were reported to overgrow even some highly aggressive species, fire coral (*Millepora* sp. and the toxic sponge *Neofibularia notilangere*; Diaz *et al.*, 2007). These species as well were shown to be phototrophs, acting like plants, sustaining photosynthetic rates much higher than their respiratory rates (Thacker *et al.*, 2007). Studies in the Colombian Caribbean identified the thickly encrusting *Desmapsamma anchorata* and the ramose species *Aplysina cauliformis* and *Callyspongia armigera* as the most frequent overgrowers (Aerts and van Soest, 1997). Morphological plasticity of sponges, their ability to attach to one another without causing harm (Rützler, 1970; Sarà, 1970), diverse chemistry (Faulkner, 2002), and microbial associations (Taylor *et al.*, 2007) are probably among the most important causes for their capacity to overgrow other organisms and avoid being overpowered by them.

Calcium carbonate cycle in the reefs

Sponges have a dual effect on reef frameworks: firstly, high levels of boring sponge activity may result in net decrease of reef accretion (Rützler, 2002) and, secondly, non-excavating demosponges are found to increase the rates of carbonate accretion by binding coral colonies, in both shallow and deep reef areas, reinforcing the reef frame and decreasing considerably the loss of coral colonies due to dislodgement by wave action, fish predation, and other forces (Wulff and Buss, 1979). Some burrowing ctenid species have become more abundant and have started to be considered as pests for Caribbean coral reefs (Williams and Bunkley-Williams, 2000).

Food and home for others

Spongivory is a common life style among several endangered turtle species and among coral reef fishes and seastars (Wulff, 1994; 2005). Hawksbill turtles (*Eretmochelys imbricata*) are known to feed mainly on a large variety of sponges in the Caribbean, and the green turtle (*Chelonia mydas*) includes among its varied diet several species of marine sponges. Besides being food for other organisms, sponges may harbor hundreds of animal and algal species during their lives (Villamizar and Laughlin, 1991).

Human services

Traditionally, some sponge species have been appreciated for their natural softness and resistance to tearing, and their ability to hold and discharge large amounts of water. Since the Roman times, they have been used to hold water or wine, to bath, or for medicinal uses. Nowadays, they are still used for cleaning cars or boats and for cosmetic purposes.

For the past 50 years, marine sponges have been considered a potential gold mine, owing to the diversity of their chemicals compounds called secondary metabolites (Sipkema *et al.*, 2005). They produce an enormous array of antitumor, antiviral, anti-inflammatory, immunosuppressive, antibiotic, and other bioactive molecules that can affect the pathogenesis of many human diseases. Sponges, in particular, are responsible for more than 5300 different chemical products, and every year hundreds of new compounds are being discovered (Faulkner, 2002), such as Ara-C, the first marine-derived anticancer agent, and the antiviral drug Ara-A (Proksch *et al.*, 2002). Ara-C is currently used in the routine treatment of patients with leukemia and lymphoma. Ara-A (Acyclovir) is an important antiviral agent. The marine biotech company Porifarma is developing sponge farms in western Turkey to supply sponge metabolites and act as biofilters for neighboring fish farms (de Goeij and Osinga, personal communication). Porifarma will farm two sponge species: *Dysidea avara*, which produces avarol that has antitumor, antibacterial, and antifungal properties, and *Chondrosia reniformis*, which is a good source of collagen that can be converted into nano-particles and used to deliver drugs to the target location (Duckworth, 2009). An important question for the future remains how to actually prepare the potential novel drugs on a large scale (Sipkema *et al.*, 2005). Belize's sponge biodiversity represents an unexplored 'treasure trunk' for metabolites with high pharmacological potential.

Last but not least, sponges, together with fishes, stony corals and soft corals are one of the most attractive members of the coral-reef community, thus having commercial importance for the diving industry. Their variety in shape, size, and intensity of colors, makes them stars in professional as well as amateur photography. One of the most attractive species in Caribbean coral reefs, the giant barrel sponges (*Xestospongia muta*), is considered the 'redwood' of the reef, for its size and presumed old age. McMurray *et al.* (2008) estimated that a sponge of 1 m diameter could be 100 years old, certain very large specimens as old as 2,300 years of age.

Threats to marine sponges

Caribbean sponges are under the same threats that menace their habitats. Among them are habitat destruction, sewage discharge, storm water run-off from polluted land, and global warming which has been increasing water temperatures and altering the ocean food chain and sea floor environment. Various diseases and mass mortalities have already been reported (Williams and Bunkley-Williams, 2000; Olsen *et al.*, 2006; Gochfeld *et al.*, 2007). In particular, although data are still scarce, these ancient animals should be sensitive to oil pollution as their survival depends on large volumes of water processed through their bodies. Zahn *et al.*, (1983) demonstrate irreversible DNA damage of polycyclic aromatic hydrocarbon (PAH) through the binding of these oil derived compounds to macromolecular fractions in sponges.

The effect of large-scale oil spills, or long-term oil contamination has been recorded both from mangroves and coral reef ecosystems in the Caribbean. The largest oil spill in the Americas occurred in 1986 when more than 8 M liters of crude oil spilled into a complex region of mangroves, seagrasses, and coral reefs just east of the Caribbean entrance to the Panama Canal (Jackson *et al.*, 1989). Extensive mortality of shallow subtidal reef corals, mangrove communities, and infauna of seagrass beds were reported. After 1.5 years, only some organisms in areas exposed to the open sea had recovered. The results of chronic oil pollution from a refinery in Aruba (Netherlands Antilles), including spills and clean-up efforts are, after 60 years, still clearly discernible over a distance of 10 to 15 km along the reef, and includes deteriorated

reef structure, low living-coral cover, and fewer juveniles of reef organisms in front and down current of the refinery (Bak, 1987).

CONCLUSIONS

Sponges are one of the most diverse marine animals in coral reefs and mangroves of the Caribbean, representing an important structural and functional component of these ecosystems.

Belize, with respect to its marine habitat diversity and benthic marine fauna (echinoderms, mollusks, corals and sponges), is one of the richest countries in the Caribbean; therefore, its ecological integrity is important for the entire Caribbean ecosystem.

Estimates by experts indicate that probably at least 5000 sponge species worldwide remain to be discovered.

Sponges are the source for the highest benthic nitrification rates on the bottom of the oceans, the largest 'dissolved inorganic carbon sink' on Caribbean coral reefs, and the most diverse source of natural products from the ocean.

The protection of Belizean coral reefs and mangroves, and the waters that sustain them, is essential to the future existence of these important organisms and the potential of new discoveries and possible exploitation of their biomedical properties.

ACKNOWLEDGEMENTS

We would like to thank our colleagues Rob van Soest and Edlin Guerra-Castro for allowing the use of our jointly obtained data for this publication. We are also grateful to the *Sea Around Us* Project for inviting us to participate in this important forum, and to Belize and the Belizeans who have giving us and many other scientists the opportunity to study and better understand their marine world. This is contribution no. 906, Caribbean Coral Reef Ecosystems Program, Smithsonian Institution.

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APPENDICES

CONFERENCE AGENDA

<p style="text-align: center;">Too Precious to Drill: The Marine Biodiversity of Belize Conference Agenda 29-30 June 2011, Biltmore Best Western, Belize City</p>			
Date/Time	Event/Presentation	Presenter/Chair	Affiliation/Venue
JUNE 28	ARRIVAL OF PARTICIPANTS		
14:00 – 17:00	Registration		
JUNE 29	INTRODUCTION		
8:00 – 9:00	Late registration		
9:00 – 9:05	Welcome remarks	Tanya Williams, Coalition Coordinator	Belize Coalition to Save Our Natural Heritage
9:05 – 9:15	Welcome remarks	Senator Gordon	
9:00 – 9:15	Welcome remarks	Audrey Matura-Shepherd	Oceana Belize
9:15 – 9:30	Introduction to the Conference	Daniel Pauly	University of British Columbia
9:30 – 10:00	Offshore oil vs 3E's (Environment, Economy & Employment)	Frank Gordon Kirkwood and Audrey Matura-Shepherd	Retired Engineer/Independent Oil Advisor & Oceana respectively
10:00 – 10:30	The Belize Barrier Reef: a World Heritage Site	Janet Gibson	Wildlife Conservation Society Belize Site
10:30 – 10:45	COFFEE BREAK		
JUNE 29	THREATENED BELIZEAN MARINE BIODIVERSITY	Chairs: Melanie McField and Mike Hirschfield	Healthy Reef & Oceana respectively

Too Precious to Drill: The Marine Biodiversity of Belize			
Conference Agenda			
29-30 June 2011, Biltmore Best Western, Belize City			
Date/Time	Event/Presentation	Presenter/Chair	Affiliation/Venue
10:45 – 11:15	Threats to coastal dolphins from oil exploration, drilling and spills off the coast of Belize	Ellen Hines	San Francisco State University
11:15 – 11:45	The fate of manatees in Belize	Nicole Auil Gomez	Sea to Shore Alliance
11:45 – 12:15	The elasmobranchs of Glover's Reef Marine Reserve and other sites in northern and central Belize	Demian Chapman , Elizabeth Babcock, Mark Bond and Ellen Pikitch	Stony Brook University
12:15 – 14:15	LUNCH		
14:15 – 14:45	Grouper and snapper assemblages in Belize: possible impacts from oil exploration	William Heyman	Texas A&M University
14:45 – 15:15	Endemic marine fishes of Belize: evidence of isolation in a unique ecological region	Phillip Lobel	Boston University
15:15 – 15:30	COFFEE BREAK		
15:30 – 16:00	Functional importance of biodiversity for coral reefs of Belize	Janie Wulff	Florida State University
16:00 – 16:30	Biodiversity of sponges: beyond Belize and to the greater Caribbean	Maria Cristina Diaz and Klaus Ruetzler	Museo Marino de Margarita National Museum of Natural History
16:30	DINNER COCKTAILS		Sponsored by Oceana Belize and partners

Too Precious to Drill: The Marine Biodiversity of Belize			
Conference Agenda			
29-30 June 2011, Biltmore Best Western, Belize City			
Date/Time	Event/Presentation	Presenter/Chair	Affiliation/Venue
JUNE 30	THREATENED BELIZEAN MARINE BIODIVERSITY, CONTINUED	Chairs: Melanie McField and Mike Hirschfield	Healthy Reefs and Oceana respectively
8:30 – 9:00	Status and distribution of seabirds in Belize: threats and conservation opportunities	Lee Jones and Philip Balderamos	UNDP
9:00 – 9:30	Biodiversity, ecology and biogeography of hydroids (Cnidaria: Hydrozoa) from Belize	Lea-Anne Henry	Heriot-Watt University
9:30 – 10:00	Documenting the marine biodiversity of Belize through FishBase and SeaLifeBase	Maria L.D. Palomares and Daniel Pauly	University of British Columbia
10:00 – 10:30	Summary of marine biodiversity sessions	Mike Hirschfield	Oceana
10:30 – 10:45	COFFEE BREAK		
JUNE 30	THREATENED BELIZEAN MARINE HABITATS AND LIVELIHOODS	Chairs: Lisa Carne and Margot Stiles	Consultant and Oceana, respectively
10:45 – 11:15	Evaluating potential impacts of offshore oil drilling on the ecosystem services of mangroves in Belize	Timothy B. Smith	Brooksmith Consulting
11:15 – 11:45	A deep-sea coral 'gateway' in the northwestern Caribbean	Lea-Anne Henry	Heriot-Watt University
11:45 – 12:15	Natural and anthropogenic catastrophe on the Belizean Barrier Reef	Richard Aronson and Ian G. Macintyre	Florida Institute of Technology
12:15 – 14:15	LUNCH		
14:15 – 14:45	Evaluating coral reef health on a large scale	Melanie McField	Healthy Reefs for Healthy People
14:45 – 15:15	Reconstruction of total marine fisheries catches for Belize, 1950-2008	Dirk Zeller	University of British Columbia

<p style="text-align: center;">Too Precious to Drill: The Marine Biodiversity of Belize Conference Agenda 29-30 June 2011, Biltmore Best Western, Belize City</p>			
Date/Time	Event/Presentation	Presenter/Chair	Affiliation/Venue
15:15 – 15:45	Under the threat of oil: assessing the value and contribution of Belizean fisheries	Sarah Harper and U. Rashid Sumaila	University of British Columbia
15:45 – 16:00	COFFEE BREAK		
16:00 – 16:30	The economic value and future of marine ecotourism in Belize	Andres Cisneros and U. Rashid Sumaila	University of British Columbia
16:30 – 17:00	Letter of scientists to Belizeans	Daniel Pauly	University of British Columbia
17:00 – 17:30	Conclusions and closing remarks	Audrey Matura-Shepherd & Daniel Pauly	Oceana & Sea Around Us Project respectively
18:00	DINNER		Sponsored by the <i>Sea Around Us</i> Project
JULY 1	FIELD TRIP FOR PARTICIPANTS		Turneffe Atoll
JULY 2	DEPARTURE OF PARTICIPANTS		

LETTER OF SCIENTISTS TO BELIZEANS

We, the undersigned scientists, representing 10 nationalities, have studied the diversity of marine life in Belizean waters over the last three decades.

We gathered in Belize City on June 29-30 2011 to compile and review the knowledge of this biodiversity: the living marine organisms; the plants, animals, fungi, and other species associated with the coral reefs, mangrove forests, seagrass beds, and sand and mud areas that together comprise the Belizean Barrier Reef and Atoll complex. We have also considered the vulnerability of this biodiversity to threats such as destructive fishing practices, uncontrolled effluent from land, poorly planned development on land, and both chronic and acute oil spills.

Given the enormous importance of the diversity of marine life to the Belizean economy, way of life and national pride, notably through its contributions to fisheries, tourism, and coastal protection, we urge Belizeans to fully acquaint themselves with this wealth of marine life along their coastline, and to protect it when developments- such as oil drilling- are proposed that endanger this foundation of Belize's natural wealth.

(Scientists signed here on 30 June 2011)

CONFERENCE PARTICIPANTS

THE ORGANIZERS

AUDREY MATURA-SHEPHERD

Oceana Belize; Email: amatura-shepherd@oceana.org

Audrey is the VP of Oceana's Belize office and is a well-known public figure in Belize. She is an attorney-at-law by profession but now an environmental advocate. She began her career as a journalist, working in radio, television and print and is the founding editor of various established media outlets and has over two decades experience in this field. She remains involved in her media work as a weekly television talk show host of "Power of Attorney", which will be going into its third season and through her weekly newspaper column Right to the Point, in the most read Belizean newspaper, Amandala.



MARIA LOURDES D. PALOMARES

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Deng is a Senior Research Associate with the Sea Around Us Project at the Fisheries Centre and the Coordinator of the SeaLifeBase Project (www.sealifebase.org). She has a PhD from the Ecole National Supérieure Agronomique de Toulouse (France) and worked with FishBase (www.fishbase.org) since its inception in 1989. Deng, with Daniel Pauly, represents the Fisheries Centre to the FishBase Consortium and continues to work closely with FishBase.

Deng will discuss on: *Documenting the marine biodiversity of Belize through FishBase and SeaLifeBase*



DANIEL PAULY

The Sea Around Us Project, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver BC V6T1Z4 Canada; Phone: +1 604 822 1201; Email: d.pauly@fisheries.ubc.ca

Daniel is the Principal Investigator of the Sea Around Us Project. He is a French citizen who completed his high school and university studies in Germany; his doctorate (1979) and habilitation (1985) are in Fisheries Biology, from the University of Kiel. After many years at the International Center for Living Aquatic Resources Management (ICLARM), in Manila, Philippines, Daniel Pauly became in 1994 Professor at the Fisheries Centre of the University of British Columbia, Vancouver, Canada, of which he was the Director from 2003 to 2008. Since 1999, he is also Principal Investigator of the Sea Around Us Project (see www.seararoundus.org), funded by the Pew Charitable Trusts, Philadelphia, and devoted to studying, documenting and promoting policies to mitigate the impact of fisheries on the world's marine ecosystems

Daniel will introduce this conference to the invited audience.



THE PRESENTORS

RICHARD ARONSON

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Rich is currently the Head of Department at the Biological Sciences Department, College of Science at the Florida Institute of Technology. He has a Ph. D. from Harvard University and is recently involved in global climate change research, i.e., the effect of climate change on coral reefs. He has worked extensively on the ecology of lagoonal reefs in Belize notably on the historical evolution (both geological and biological) of these reefs through examination of cores.

Richard will discuss the: *Natural and anthropogenic catastrophe on the Belizean Barrier Reef*



NICOLE AUJL GOMEZ

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Nicole is a biologist from Belize who is an Associate Scientist for the Florida-based Sea to Shore Alliance. Ms Gomez will talk about the fate of manatees of Belize.

She has worked in coastal conservation for 14 years and has engaged in various roles regionally and locally. She has worked with international alliances between Belize and neighboring countries on research and management initiatives, as well as teamed with local grassroots organizations serving to build their capacity to manage specific protected areas in Belize.

Nicole will discuss: *The fate of manatees in Belize*



DEMIAN CHAPMAN

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Demian is an Assistant Professor at the School of Marine and Atmospheric Science, Stony Brook University, New York. His primary research interests lie in elucidating dispersal and reproductive patterns in marine vertebrates (principally elasmobranch fishes) by integrating genetic and electronic tagging data, with a particular focus on how these patterns influence the spatial structure of genetic variation, population dynamics and apply to conservation. He is also interested in the development of wildlife forensic techniques and resources for law enforcement and trade monitoring purposes.

Demian will discuss: *The elasmobranchs of Glover's Reef Marine Reserve and other sites in northern and central Belize*



THE PRESENTORS (CONTINUED)

ANDRES CISNEROS-MONTEMAYOR

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Andrés has a BSc in Marine Biology from the Universidad Autónoma de Baja California Sur, La Paz, Mexico, and an MSc in Resource Management and Environmental Studies from the University of British Columbia, Vancouver, Canada. He believes that fisheries scientists have a responsibility to study the many aspects of fisheries in the context of improving the quality of life for the people and communities that depend on them; conserving (and perhaps restoring) marine ecosystems is perfectly compatible with this. His MSc thesis focused on assessing the benefits and possible impacts of the growing marine recreation industry in order to identify potential alternatives for fishermen. His current PhD work uses ecosystem models to help explore the role of socioeconomic conditions in achieving successful marine resource management. Having grown up around fisheries, he appreciates the fact that knowing how many fish are caught and catching them is not the problem; he hopes that economics may help to understand and ultimately solve current problems in fisheries and marine ecosystem management.



Andrés will discuss: *The economic value and future of marine ecotourism in Belize*

MARIA CRISTINA DIAZ

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Cris is a research associate at the Museo Marino de Margarita in Venezuela, and a visiting scientist at the National Museum of Natural History, Washington DC. (PhD from the University of California, Santa Cruz). She applies traditional and molecular approaches to study sponge biodiversity and ecology, for over 20 years, focusing on sponge-microbe nitrification, sponge-cyanobacteria associations, sponge systematics and biogeography. Cris is very interested in marine sponge biodiversity, both from a present and an historical perspective. She collaborates with other taxonomists, natural product researchers, microbiologists, and ecologists to explore the Caribbean, the South Pacific, and the Indian Ocean. Cris and Bob Thacker created a course, Taxonomy and Ecology of Caribbean Sponges (www.scri.org, Diaz et al., 2006), which has introduced 40 young scientists to the science of sponge taxonomy and ecology and its applications.



Cris will discuss the: *Biodiversity of sponges: beyond Belize and to the greater Caribbean*

JANET GIBSON

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Janet is a biologist and is the Country Director for the Wildlife Conservation Society in Belize and is involved with the management, education and research of marine ecosystems in Belize. She was awarded the Goldman Environmental Prize in 1990 for her efforts on conservation of the marine ecosystems outside the Belizean coast, in particular the barrier reef system. The Belize Barrier Reef was granted UNESCO World Heritage status in 1996.



Janet will discuss: *The Belize Barrier Reef: a World Heritage Site*

SARAH HARPER

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Sarah is a Senior Research Assistant with the Sea Around Us Project. She works with Dr Dirk Zeller on the reconstruction of fisheries catches. She has an MSc in marine resources management from the Heriot-Watt University in Edinburgh, Scotland. She worked the Smithsonian Tropical Research Institute in Panama for her dissertation on habitat mapping of a proposed marine protected area in the Las Perlas Archipelago, Panama.



Sarah will discuss: *Under the threat of oil: assessing the value and contribution of Belizean fisheries*

LEA-ANNE HENRY

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Lea-Anne is a Research Fellow with the Centre for Marine Biodiversity and Biotechnology at Heriot-Watt University in Edinburgh, UK, a member of the Marine Alliance for Science and Technology for Scotland. Her interests include the biodiversity, biogeography and ecology of benthic marine epifauna, particularly the benthic hydrozoans (hydroids). She has worked on deep-sea 'cold-water corals' and their associated biodiversity since 2000, and is a Charter Member of the Canadian Centre for Marine Biodiversity (<http://www.marinebiodiversity.ca>). Her current research involves an interdisciplinary look into factors that control the biodiversity and biogeography of fauna inhabiting deep cold-water coral reefs. This work is ampho-Atlantic in scope, with the objective of linking data acquired from acoustic remote-sensing methods (sidescan, multibeam) to ground-truthed species composition data across multiple spatial scales. She has worked with colleagues to develop the Trans-Atlantic Coral Ecosystem Study since its inception in 2008 (<http://www.lophelia.org/traces>) and helps maintain the online resource Lophelia.org (www.lophelia.org), dedicated to advancing public knowledge about cold-water corals.



Lea-Anne has two presentations: *Biodiversity, ecology and biogeography of hydroids (Cnidaria: Hydrozoa) from Belize and A deep-sea coral 'gateway' in the northwestern Caribbean*

WILLIAM D. HEYMAN

Texas A&M University, Department of Geography, Texas, Texas USA; Phone: +1 979 845 5411; Email: wheyman@tamu.edu

Will is Associate Professor at the Department of Geography at Texas A&M University. He developed a broad interest in science and sustainable management of tropical coastal and marine systems from the time he was a child. He graduated from Tufts University with a major in Marine Biology and Environmental Studies in 1983. He then spent three years working in marine aquaculture in the Bahamas, Turks and Caicos, and the Marshall Islands. He did his MSc and PhD through the University of South Carolina, conducting field research in both the Marshall Islands and Belize, finishing in 1996. In 7 years of graduate work, he spent only 5 semesters in residence, gaining the dubious honor of the student with the most degrees, and least amount of time on campus at USC. Meanwhile, he began working for the International Division of the Nature Conservancy in Belize where he lived for ten years. He is now an Associate Professor of Geography.



THE PRESENTORS (CONTINUED)

ELLEN M. HINES

San Francisco State University, Department of Geography and Human Environmental Studies, 1600 Holloway Ave., San Francisco, California 94132 USA; Email: ehines@sfsu.edu

Ellen has a Ph. D. from the University of Georgia. She is currently an Associate Professor at the San Francisco State University and Director of the Marine & Coastal Conservation and Spatial Planning Center at San Francisco State University, part of the Institute for Geographic Information Science, a research center dedicated to utilizing and developing the most relevant, powerful and practical geospatial tools to contribute to interdisciplinary marine and coastal conservation. The faculty, students and collaborators seek to describe, model and predict the effects of human use on the marine and coastal environment. This includes habitat modeling and mapping for marine endangered species and ecosystems, sea level change scenarios, documenting of human use and values. She is interested in research that explores tools to facilitate the creation, implementation, and subsequent monitoring of localized scientific and conservation oriented management.



Ellen will discuss the: *Threats to coastal dolphins from oil exploration, drilling and spills off the coast of Belize*

H. LEE JONES

7 West Street, Punta Gorda, Belize; lee_jones@att.net

Lee has a PhD in avian biogeography from UCLA. He is internationally recognized as an authority in ornithology and is one of the leading field ornithologists in Central America. In addition to birds, his taxonomic knowledge embraces the vascular plants, the major terrestrial vertebrate groups and, among invertebrates, the Lepidoptera. By profession, he is an environmental consultant and research biologist. For the past two decades he has resided part-time in Belize where he has been conducting research on the country's birds and other wildlife. He also volunteers as a technical advisor to various conservation organizations including the Belize Audubon Society, Birds Without Borders/Aves Sin Fronteras, Programme for Belize, Toledo Institute for Development and the Environment (TIDE), and Ya'axché Conservation Trust (YCT).

Lee will discuss the: *Status and distribution of seabirds in Belize: threats and conservation opportunities*

FRANK GORDON KIRKWOOD

Independent Petroleum Engineering & Economics Consultant, Belize City; Email: kirkwoodg@ymail.com

Gordon obtained his PhD in Chemical Physics from the University of Kent at Canterbury in 1979. He worked thirty years in the oil and gas industry for BP as a Petroleum Engineer and Commercial Advisor in various locations worldwide (UK, Egypt, Venezuela and the United Arab Emirates). He is a Chartered Engineer in the UK, a European Engineer and a Fellow of the Institute of Materials, Mining and Metallurgy. During his retirement he has volunteered as an Independent Oil Advisor to Oceana Belize, consulted with Dive Centers on their Emergency Procedures and provided underwater photographs to Dive Centers. He is also a member of the Marine Mammal Stranding network and a helps to run the Belize Humane Society and Animal Center.



Gordon will discuss: *Offshore oil vs 3E's (Environment, Economy & Employment)*

MELANIE MCFIELD

Healthy Reefs for Healthy People Initiative, Smithsonian Institution, 1755 Coney Dr, Belize City, Belize; Phone: +501 223 4898; Email: mcfield@healthyreefs.org

Melanie McField is the Director of the Healthy Reefs for Healthy People Initiative (HRI) based in Belize City, Belize. She is employed by the Smithsonian Institution and serves on a number of national and international marine conservation and research committees, including the Council of the International Society of Reef Studies. Melanie has lived and worked in Belize since 1990; first as a field biologist with the Hol Chan Marine Reserve (and Peace Corps volunteer), then with and Coastal Zone Management Authority and Institute, and later with World Wildlife Fund. Melanie earned a PhD degree (2001) at the College of Marine Science, University of South Florida, after receiving the first International Society of Reef Studies Coral Reef Ecosystem Science Fellowship for her dissertation research exploring the role of disturbance events and the impact of marine protected areas on coral reef community structure in Belize. Melanie has published numerous scientific manuscripts, book chapters and technical reports on topics ranging from coral bleaching to coral reef monitoring methods, marine protected areas and coral reef management. She has also been featured on several television appearances including the TODAY show, National Geographic, Animal Planet and the BBC.



Melanie will discuss on: *Evaluating coral reef health on a large scale*

PHILLIP S. LOBEL

Boston University, Biology Department, Boston, MA 02215 USA; Phone: +1 617 358 4586; Email: plobel@bu.edu

Phil is a professor of Biology at the Boston University. His areas of interest are ichthyology; behavioral ecology and taxonomy of fishes. He is interested in fundamental concepts of fish biology and in applying this knowledge to scientific issues and to societal concerns of fisheries management and conservation. His scientific work has focused on field studies of fish behavior and ecology. He has worked in a variety of habitats worldwide where fishes are a significant component of the fauna. In recent years, he has applied his scientific expertise to contemporary problems in conservation biology and environmental protection. From 1983 to 2003, his main study site was Johnston Atoll, Central Pacific Ocean conducting research as part of the US Army marine ecological monitoring program evaluating operation of the Johnston Atoll Chemical Weapons Disposal System. Since 2003, he has been working primarily in Belize, Central America on fish ecology and discovery of new species.



Phil will discuss the: *Endemic marine fishes of Belize: evidence of isolation in a unique ecological region*

TIMOTHY SMITH

Brooksmith Consulting, Illinois, USA; E-mail: timothy@tbrooksmith.com

Tim (M.S., Biology, University of Illinois) is the founder of Brooksmith Consulting, a company dedicated to projects in aquatic ecology associated with ecosystem integrity, water quality, ecosystem management, fisheries, and education. Tim has twenty-one years of experience dealing with applied ecological issues and the detection, quantification and management of a wide variety of ecological disturbances. Tim's work has helped provide a scientific basis for Total Maximum Daily Load (TMDL) regulations in aquatic ecosystems for the Environmental Protection Agency in the US. He has also been instrumental in restoring coastal seagrass and mangrove ecosystems in Belize.



Tim will discuss: *Evaluating potential impacts of offshore oil drilling on the ecosystem services of mangroves in Belize*

THE PRESENTORS (CONTINUED)

JANIE WULFF

Department of Biological Science, Florida State University, Tallahassee, FL, USA;
wulff@bio.fsu.edu

Janie is the Associate Professor of Biology at Florida State University. She does underwater research on sponges, corals, and other sessile clonal animals, that inhabit coral reefs, seagrass eadows, and mangrove prop roots. Her focus is on ecological interactions, especially mutually beneficial associations that ameliorate the influence of predators, competitors, and abiotic environmental challenges for all participating species. Her first underwater experiments, in Belize (Lighthouse Atoll) in 1977, demonstrated that sponges can improve the survival of corals by an order of magnitude, even though they may appear to be competing with THEM. Some of her publications ARE LISTED at: <http://www.bio.fsu.edu/faculty-wulff.php>.



Janie will discuss the: *Functional importance of biodiversity for coral reefs of Belize*

DIRK ZELLER

The Sea Around Us Project, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver BC V6T1Z4 Canada; Phone: +1 604 822 1950; Email: d.zeller@fisheries.ubc.ca

Dr Dirk Zeller is Sea Around Us Project's Senior Research Fellow and Project Manager. Dirk leads a catch data reconstruction team and associated projects that deal with Illegal, Unreported and Unregulated fishing by deriving more accurate estimates of total catches by countries. He contributed such data to stock assessment collaborations with the Fisheries Centre Quantitative Modeling Group for Hawaiian bottom fish assessments, and illustrated that ICES (EU) catch data for the Baltic Sea substantially underreport total catches. Dirk also investigates coral reef fisheries (e.g., Coral Triangle Initiative) and global marine pollution modelling, engages in ocean governance and fisheries policy research (e.g., FishEU international policy working group), and collaborates with the Fisheries Economics Research Unit on issues in resource economics, and with the UBC Faculty of Law on issues related to international maritime boundary law and the UN Law of the Sea Convention. He also directs day-to-day research activities and management issues of the Project, and actively engages in and directs strategic research and funding decisions in close coordination with Daniel Pauly.



Dirk will discuss the: *Reconstruction of total marine fisheries catches for Belize, 1950-2008*



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