

There has been much discussion in recent years about the effect of increasing global temperatures on marine fauna (see also the last issue of this magazine). However, it has often been overlooked that the increasing acidity of the oceans may have an even greater, and more insidious, effect on marine life than just a simple rise in temperature. Although acid rain, which contains nitric acid and sulphuric acid, falls into the oceans, it is the absorption of  $\text{CO}_2$  from the atmosphere that is the most important contributor to oceanic acidity. This is because the shells of many marine creatures are made of calcium carbonate, which is a salt of carbonic acid, and which itself derives from  $\text{CO}_2$ . Any change, therefore, in the concentration of  $\text{CO}_2$  in sea water could have drastic consequences for marine invertebrates in particular and thereby marine life in general.

# Acidification *of the oceans*

## Effect of absorbed $\text{CO}_2$ on marine fauna

Text by Michael Symes



The absorption of  $\text{CO}_2$  may have slowed global warming, but there has been a resulting change in seawater chemistry. To understand why the effect of increasing atmospheric  $\text{CO}_2$ , which leads to increased absorption of  $\text{CO}_2$  in sea water, is important, it is necessary to understand some of the chemistry of carbonic acid and its salts. However, before we can discuss the effect of this acidity, we must have a useful description of what we mean by acidity and acid strength. The most common and useful unit to describe the magnitude of acidity is the pH value.

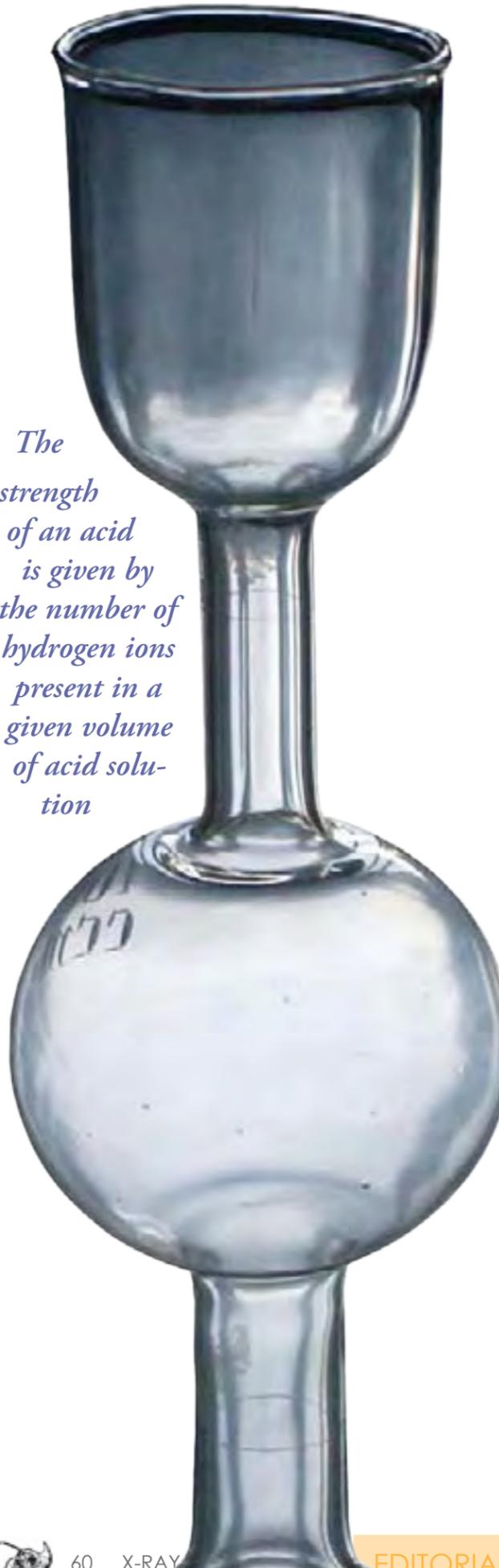
### Measurement of acidity using the pH scale

When compounds, be they acids, alkalis or salts of these, dissolve in water they dissociate, wholly or partly, and in some cases extremely slightly, into their component ions.

For example, the gas hydrogen chloride,  $\text{HCl}$ , dissolves in water to give the ions  $\text{H}^+$  and  $\text{Cl}^-$ . We call this solution *hydrochloric acid*.

Similarly, when the salt calcium sulphate,  $\text{CaSO}_4$ , dissolves in water the ions  $\text{Ca}^{++}$  and  $\text{SO}_4^{--}$  are formed.

The strength of an acid is given by the number of hydrogen ions present in a given volume of acid solution

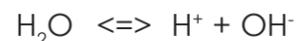


### Acid strength

Now, the strength of an acid such as HCl is given by number of hydrogen ions present in a given volume of acid solution.

If the acid is very concentrated and therefore very strong, the concentration of hydrogen ions will be very high. The strength of the acid is therefore proportional to the concentration of hydrogen ions.

Water partially dissociates into hydrogen ions and hydroxyl ions according to the following equilibrium:



So water, like many other substances, can act both as an acid (having  $\text{H}^+$  ions) and as a base (having  $\text{OH}^-$  ions).

The concentration of hydrogen ions, given in moles, is generally of the order of between  $10^{-1}$  and  $10^{-14}$  moles per litre, with water having a hydrogen ion concentration of  $10^{-7}$  moles per litre. This means that water dissociates to only a very small degree.

However, these are cumbersome values to use, so the hydrogen ion concentrations are converted to the much more convenient pH values.

This is done by taking the negative of the  $\log_{10}$  of the hydrogen ion concentration. To give an example—If the hydrogen ion concentration is  $3 \times 10^{-6}$  moles per litre then the pH value is given by:

$$\begin{aligned} \text{pH} &= -\log_{10}(3 \times 10^{-6}) \\ &= -(\log_{10}3 - 6) \\ &= -(0.48 - 6) \\ &= 5.52. \end{aligned}$$

It will be seen, then, that a decrease of one unit in the potential of the hydrogen ion concentration, say from  $10^{-4}$  to  $10^{-3}$ , means a decrease of one pH unit.

*To understand why the effect of increasing atmospheric  $\text{CO}_2$ , which leads to increased absorption of  $\text{CO}_2$  in sea water, is important, it is necessary to understand some of the chemistry of carbonic acid and its salts.*



Accordingly, a unit decrease in pH value means a ten times increase in the hydrogen ion concentration i.e. a ten times increase in acidic strength.

The molality of hydrogen ions in pure water is actually  $1.004 \times 10^{-7}$  mol  $\text{kg}^{-1}$ . The pH value of pure water is therefore  $-0.0017 + 7$  i.e. 6.998 or to 2 decimal places 7.00.

As water is a neutral substance from the acid/base point of view, a pH value of 7 is considered as being midway between acid and alkali.

An aqueous solution of HCl of unit molarity, i.e. 1 mole per kg, with virtually complete dissociation, will have a pH of 0.09.

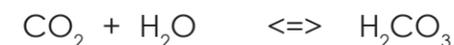
### Some typical pH values

- Battery acid: ca 1
- Gastric juices: 1 – 3
- Lemon juice: ca 2.2
- Household vinegar: 2.5 to 3
- Tomato: 4.0
- Cheddar cheese: ca 5.90
- Camembert cheese: ca 7.44
- Concentrated solution of baking soda: 8.2
- Household cleaning fluids: 10 to 11

Note: It is usually claimed that the pH scale runs from 0 to 14. However, there is no fundamental reason why pH values cannot exist outside this range. For example, a 2 mole per kg solution of HCl in water has a pH value of  $-0.31$ . Also there is no reason why a very strong basic solution should not have a pH value exceeding 14. For most purposes, however, it is sufficient to confine our attention to the range 0 to 14.

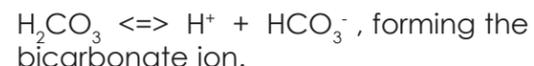
### Carbonic acid

As stated above, the acidity of seawater mainly arises from the amount of  $\text{CO}_2$  in it and the acids it forms. Carbon dioxide is highly soluble in water in which it forms an equilibrium with carbonic acid,



About 0.5% of the dissolved  $\text{CO}_2$  remains as  $\text{H}_2\text{CO}_3$  with the rest immediately dissociating in the two steps given by the following equilibria:

Firstly,



Then,



In absolute terms there are, on average, about 45ml total  $\text{CO}_2$  per litre of sea water, but because of these two equilibrium reactions, nearly all of this is found in the carbonate and bicarbonate ions. Only about 0.23ml  $\text{CO}_2$  per litre occurs as dissolved gas in the water i.e. 0.51%.

Hydrogen ions are liberated in these equilibrium reactions, which means that the pH of seawater is largely determined by the concentration of bicarbonate and carbonate ions. The pH is usually  $8 \pm 0.5$ . However, when  $\text{CO}_2$  is added to seawater, more  $\text{H}_2\text{CO}_3$  is formed and the number of hydrogen ions increases. The pH thereby decreases, with the seawater thus becoming more acidic—though it might be more descriptive to say less alkaline.

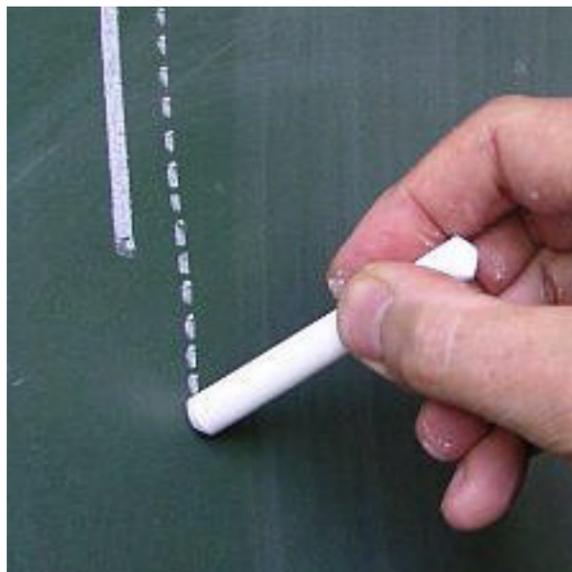
*Calcium carbonate is an important constituent of coral reefs and mollusc shells*

The carbonate ion can interact with cations such as  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$  in the seawater causing them to precipitate as insoluble carbonates. Calcium carbonate is the main constituent of chalk, limestone and marble. It has a solubility of only about 20mg per litre of cold water, and because it is so insoluble, it is an important constituent of coral reefs and mollusc shells.



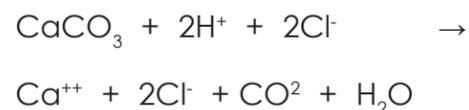
However, and this is important for understanding the effect of increasing  $\text{CO}_2$  in sea water, this calcium carbonate, although it is insoluble in water, dissolves in acidic solutions.

For example, as many of you will have seen, the strong acid hydrochloric acid,  $\text{HCl}$ , will dissolve chalk. This gives a solution of calcium chloride and carbonic acid, which then dissociates to produce water and the emission of a froth of bubbles of  $\text{CO}_2$ .



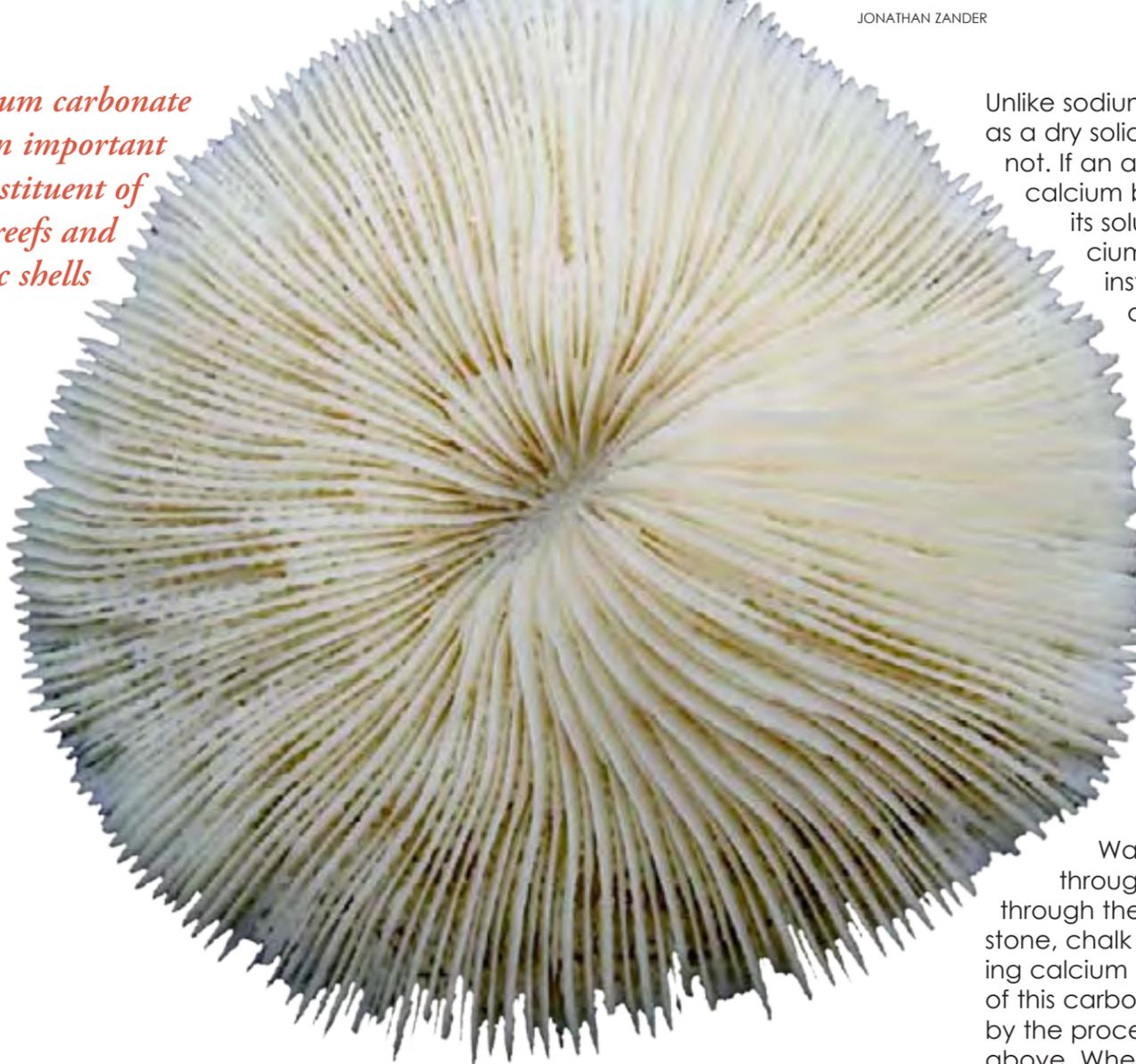
Acids will dissolve chalk. Chalk is made by minute calcite plates shed from micro-organisms called coccolithophores

This is shown in the following reaction. Note that it is not an equilibrium; it only goes one way as the  $\text{CO}_2$  is continually removed as a gas.



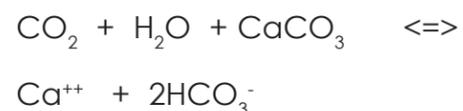
When acids dissolve, chalk  $\text{CO}_2$  is released

*Calcium carbonate is an important constituent of coral reefs and mollusc shells*



With carbonic acid, however, which is a weak acid, a different reaction occurs. When there is excess  $\text{CO}_2$  dissolved in the water, the following equilibrium occurs in which the bicarbonate ion is formed:

#### Equilibrium A



The right hand side of the equilibrium is thus a solution of calcium bicarbonate that, unlike calcium carbonate, is quite soluble, having a solubility of 166 g per litre. However, it exists only in solution. This solution contains calcium ions, carbon dioxide, bicarbonate ions and carbonate ions.

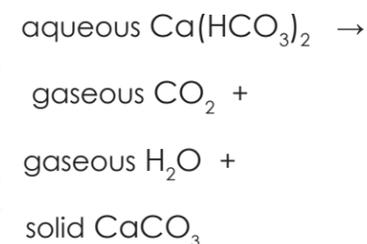
As this is an equilibrium, the more  $\text{CO}_2$  pushed into the left hand side of the equilibrium, the more it will force the equilibrium to the right i.e. the more the insoluble calcium carbonate will be changed into the soluble bicarbonate.

Incidentally, the bicarbonate ion is useful in the kitchen were it is to be found in  $\text{NaHCO}_3$ , sodium bicarbonate, better known as baking soda. When it combines with moisture and an acidic ingredient such as milk (pH about 6.4), bubbles of  $\text{CO}_2$  are formed that expand under the oven temperature, causing the cake, or what ever is being made, to rise.

*Equilibrium A is fundamental for understanding the effect of the increase of  $\text{CO}_2$  on the chemistry of seawater and on the life in it*

Unlike sodium bicarbonate, which exists as a dry solid, calcium bicarbonate does not. If an attempt is made to prepare calcium bicarbonate by evaporating its solution to dryness, solid calcium carbonate will be obtained instead, together with water and  $\text{CO}_2$  as shown in the following reaction.

#### Reaction B



This reaction is important, for example, in the formation of speleothems such as stalactites and stalagmites.

Water picks up  $\text{CO}_2$  as it passes through the atmosphere and through the topsoil. As it flows past limestone, chalk and other minerals containing calcium carbonate, it dissolves some of this carbonate, forming bicarbonate by the process given in equilibrium A above. When this solution reaches the roof of a subterranean cave, the water will evaporate, and insoluble calcium carbonate will be formed as shown by reaction B. As this is formed preferentially where the evaporation is greatest i.e. at the lower ends of protuberances, increasingly longer formations will be formed.

Reaction B is thus important for understanding certain geological processes. However, it is reaction A that is the most important for understanding the effect of  $\text{CO}_2$  on life on Earth. It is fundamental, in fact, for understanding the effect of the increase of  $\text{CO}_2$  on the chemistry of seawater and on the life in it.

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*Even small local changes in pH towards the acidic can have great effects on marine life*

rents circulate around the globe, they eventually arrive in the North Pacific where they rise to the surface before plunging down deep again to continue on their deep journey. As it upwells, the cold water absorbs more CO<sub>2</sub> from the atmosphere, which means that equilibrium is pushed to the right giving an increased production of bicarbonate ions at the expense of carbonate ions.

#### Effect on marine fauna

Most of shell-forming molluscs which utilise CaCO<sub>3</sub> to form their shells belong to two classes: the *Gastropoda* i.e. the univalves, snails, and the *Bivalvia* i.e. the clams, oysters, scallops, etc. Other classes of molluscs that form calcium carbonate shells are the *Scaphopoda* (the tusk shells), the *Polyplacophora* (the chitons) and the *Monoplacophora* (for example the deep sea *Neopilina*). Some echinoderms such as starfish, sea urchins and sand dollars have hard exoskeletons formed of calcium carbonate, as do some annelid worms; and so, of course, do the reef structures of corals.

All shells of the mollusca are composed of basically the same material. This is calcium carbon-

ate, in the form of calcite or aragonite, crystallised out in an organic matrix and laid down in layers by the shell glands of the mantle tissue. Aragonite and calcite are two polymorphs of CaCO<sub>3</sub> in which the crystal structures differ. Aragonite forms naturally in almost all mollusc shells as well as in the endoskeletons of both warm- and cold-water corals. In some mollusca, the entire shell is aragonite, while in others, it is a mixture of both aragonite and calcite. These shell-forming animals produce their calcium carbonate shells or skeletons from the CO<sub>3</sub><sup>2-</sup> ions in the sea water.

The shells of crustacea, such as lobsters, crabs and shrimps are different in that they are built up from only 30-50% calcium carbonate together with 30-40% protein and 20-30% chitin. Chitin is a polysaccharide polymer also found in the exoskeletons of terrestrial insects.

Now, we have seen that the insolubility of calcium carbonate in seawater depends

*As the concentration of CO<sub>2</sub> in the water increases, the carbonate ion concentration decreases. There will therefore be less material for animals to build their shells*

on its acidity i.e. its pH value; and as the concentration of CO<sub>2</sub> in the water increases, the carbonate ion concentration decreases. There will therefore be less material for animals to build their shells. This will inhibit calcification i.e. the process by which these animals rebuild

their shells, and the skeletal growth rates of calcareous plankton, for example, will be reduced. Not only that, the increasing acidity can actually dissolve away the shells of oysters, clams, krill and pteropods, so that in areas of high CO<sub>2</sub> concentration these animal will die. Creatures with shells living at higher, colder, latitudes, and also in near-shore waters, will therefore probably be in the most trouble. For example, shell-building planktonic organisms such as the coccolithophorids and foraminifera are an important basis of the food chain in the waters of Antarctica which,



*Increasing acidity can actually dissolve away the shells of oysters, clams, krill and pteropods*

#### Acidity of the oceans

The acidity of the oceans can arise from two main sources.

- Acid rain, which is formed when rain water absorbs CO<sub>2</sub>, together with nitric acid and sulphuric acid, on its fall through the atmosphere.
- Direct absorption of CO<sub>2</sub> in the surface water layer.

Although acid rain is obviously important for terrestrial life, it seems to play a minor role in making sea water more acidic on a global scale. Its impact, though, is somewhat greater in shallower waters such as the coastal regions. It is the direct absorption of CO<sub>2</sub> by the surface of the sea water itself and the corresponding impact on its chemistry that affects marine creatures. We therefore concentrate here on the acidity arising from absorption of CO<sub>2</sub>.

Since about 1800 i.e. from the start of industrialisation in Europe, the amount of CO<sub>2</sub> in the atmosphere has increased by about 36%, from 280 parts per million (ppm) to 380 ppm i.e. 0.038%. It is claimed that nearly 50% of the CO<sub>2</sub> released due to human activities over the last 200 years has been absorbed by the oceans.

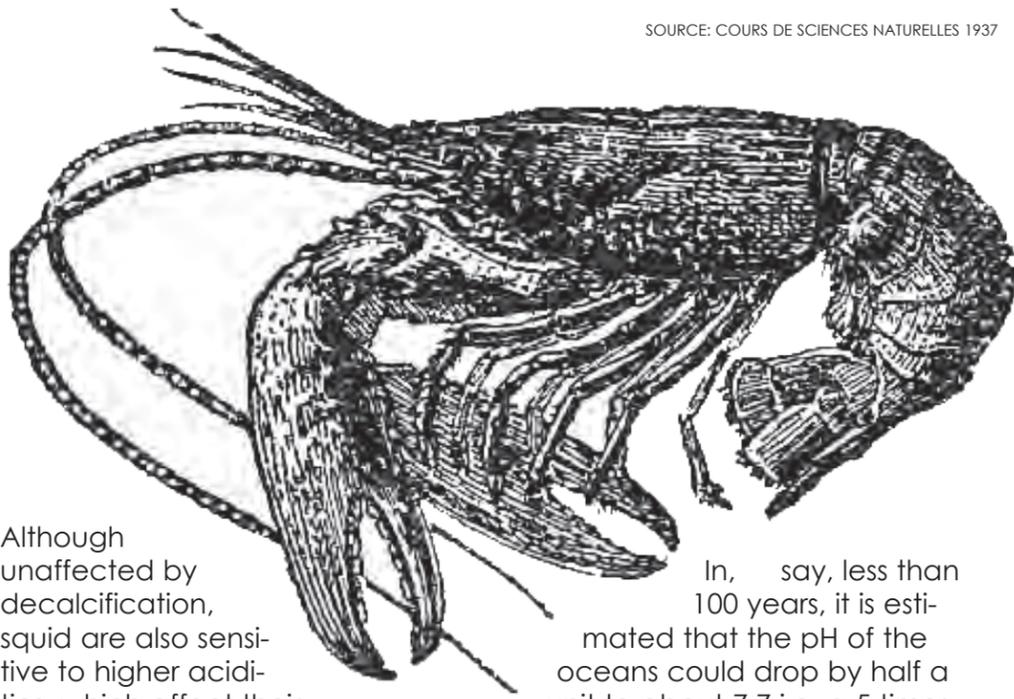
Currently, the oceans absorb about 22 tons of CO<sub>2</sub> per day. However, the oceans tend to mix rather slowly and, because CO<sub>2</sub> mainly enters the water by gas exchange at the surface, most CO<sub>2</sub> is found in the top layers of

*It is claimed that nearly 50% of the CO<sub>2</sub> released due to human activities over the last 200 years has been absorbed by the oceans*

the oceans or in the shallow seas. This means that the acidity is not completely uniform throughout the oceans. Deep cold waters, which only circulate to the surface very slowly, are far from being saturated. In 2005, the warm waters around the widely separated islands of the Canaries, Hawaii and Bermuda, had a pH of ca 8.09.

It is important to remember, especially in these times of global warming, that warm water dissolves less CO<sub>2</sub> than cold water. This means that, according to equilibrium A, this will favour the production of carbonate over bicarbonate.

As stated, the pH of seawater varies both in time and place, and due to the equilibrium A given above, even small local changes in pH towards the acidic can have great effects on marine life. For example, as the deep cur-



being cold, can absorb greater amounts of CO<sub>2</sub>. The increasing CO<sub>2</sub> content of sea water will also affect the thickness and strength of lobster and other crustacea shells thus affecting their ability to survive in their normal habitats.

Although protected by their spines, echinoderms are preyed upon by, among others, the triton shell, the trigger fish, crabs and shrimps, and by other carnivorous echinoderms. Echinoderms also serve as hosts to many symbiotic shrimps, crabs, worms, snails and even some fish. Any change in the ability of these creatures to form their protective armour, and to survive in their present environment, could therefore be a disaster for both host and prey.

Krill and pteropods are major food source for juvenile salmon, herring, pollock, cod mackerel and many other fish. Disturbing the lower end of a food chain can have dramatic effects at the higher end of the chain. As these organisms provide food and habitat for other species fewer of these animals will then have a feedback effect on the populations of their predators and their prey. Entire eco-systems can therefore change or even completely disappear for ever.

Although unaffected by decalcification, squid are also sensitive to higher acidities, which affect their blood circulation and respiration.

### The future

The situation is very complex. The increasing amount of CO<sub>2</sub> in the atmosphere will lead to an increased uptake of CO<sub>2</sub> in the oceans. However, the increasing level of CO<sub>2</sub> is leading to an increase in global temperature thereby causing ocean water temperatures to rise. This increase in water temperature will then decrease the solubility of CO<sub>2</sub>. So, will we arrive back at the status quo or will there be a permanent change in the CO<sub>2</sub> content of the oceans? At this time, it is not known how this interaction will be resolved.

Some things do already appear to be clear, though. The surface waters will become more and more saturated with CO<sub>2</sub> so that in the short term, the oceans will probably become a much less efficient sink for CO<sub>2</sub>. This will obviously have an effect on the Earth's climate.

In, say, less than 100 years, it is estimated that the pH of the oceans could drop by half a unit to about 7.7 i.e. a 5 times increase in acidity, with the amount of carbonate available to marine organisms dropping by 60%. And some scientists believe that in less than 50 years, the oceans could become too acidic for corals to survive at all.

Although the future may seem somewhat black for the marine fauna, the increase in CO<sub>2</sub> content of the oceans may actually be beneficial to a number of marine flora, for example the sea grasses, although this is not certain.

In the long run, it is estimated that over a period of several thousand years about 90% of the anthropogenic CO<sub>2</sub> emission will end up in the oceans, and that the pH of the oceans could be lowered permanently. It is somewhat naive perhaps, but we must assume that humans are sensible enough, and clever enough, to reduce CO<sub>2</sub> emissions to a level below that which they are today. What the effect on marine life will be of all the already accumulated CO<sub>2</sub> in the oceans is, however, unclear. One thing seems to be certain though: it probably won't be a benign effect. ■



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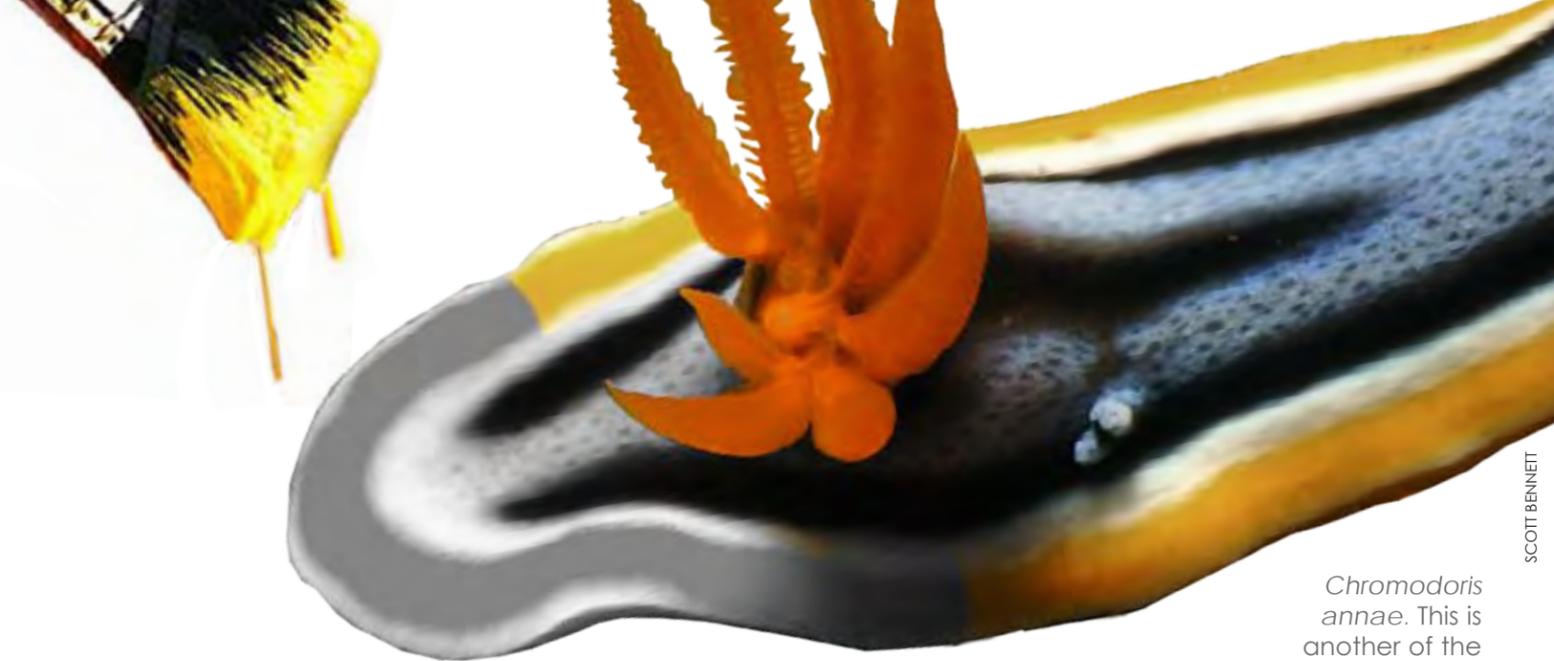
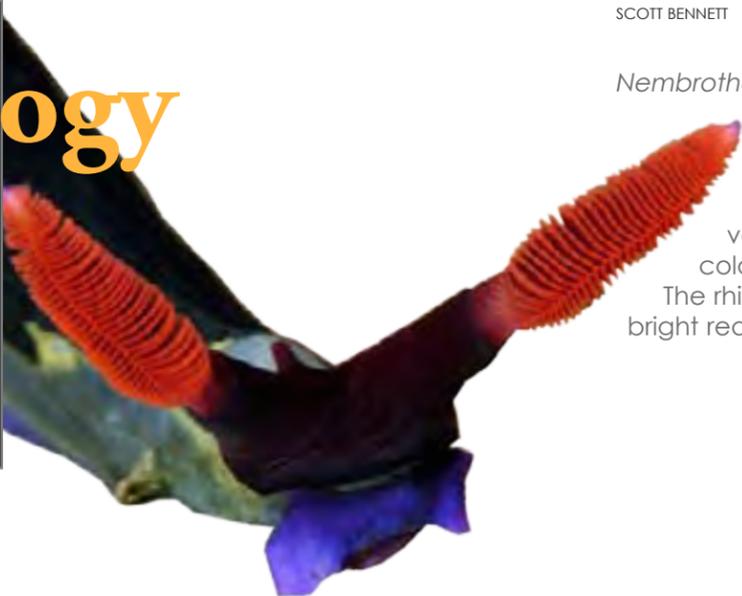


By Michael Arvedlund



SCOTT BENNETT

*Nembrotha chamberlaini*  
This recently (1997) described species has a very distinctive colour pattern. The rhinopores are bright red



SCOTT BENNETT

*Chromodoris annae*. This is another of the *Chromodoris* quadricolour colour group of species characterised by black longitudinal lines, bluish backgrounds and orange borders

Why are they so colourful?

# Naked beauties

Most divers have seen them. Weird-looking crawling creatures with odd shapes, antennae and amorphous bodies and draped in pychedelic colours. We are not talking about aliens from outer space but nudibranchs. But why do they have to look so weird?

Photos by Scott Bennett and Nonoy Tan  
Text by Michael Arvedlund and Peter Symes

Nudibranchs are found in all of the seven seas, from the tropics to the polar regions. More than 3000 species are known, and new species are being discovered and described at regular intervals. The word "nudibranch" comes from the Latin *nudus*, naked, and the Greek *branchia*, gills, and in several languages their name translates into "naked snails".

Naked indeed, and clearly exposed as such. How do they manage to survive in a brutal world full of hungry predators?

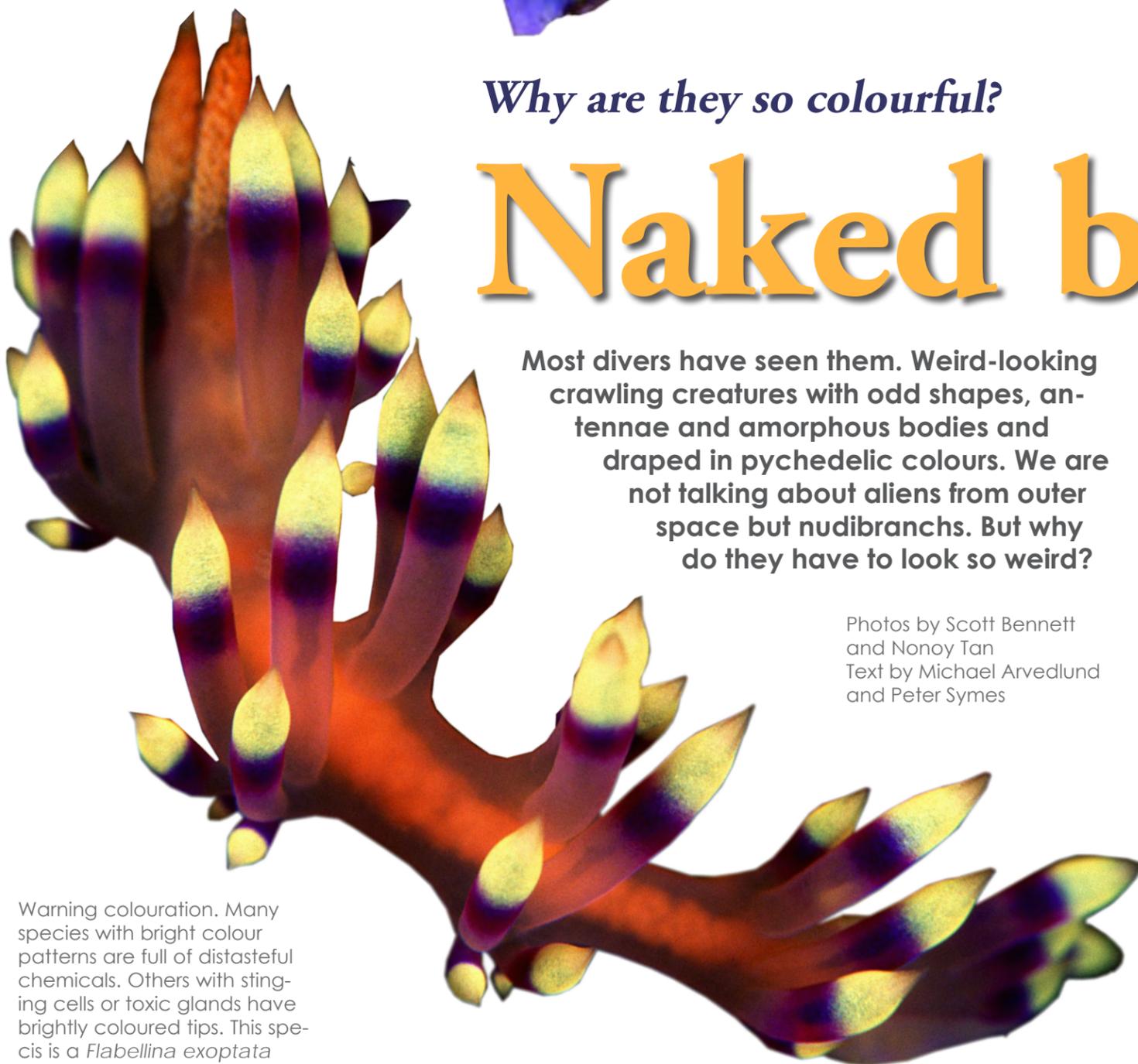
## Chemical defences

Without a protective shell, nudibranchs, and other sea slugs, had to develop a number of other defensive mechanisms against predation. These include cryptic colouration, or camouflage, and behavioural modifications, such as only being active at night. But probably the most significant development has been the use of

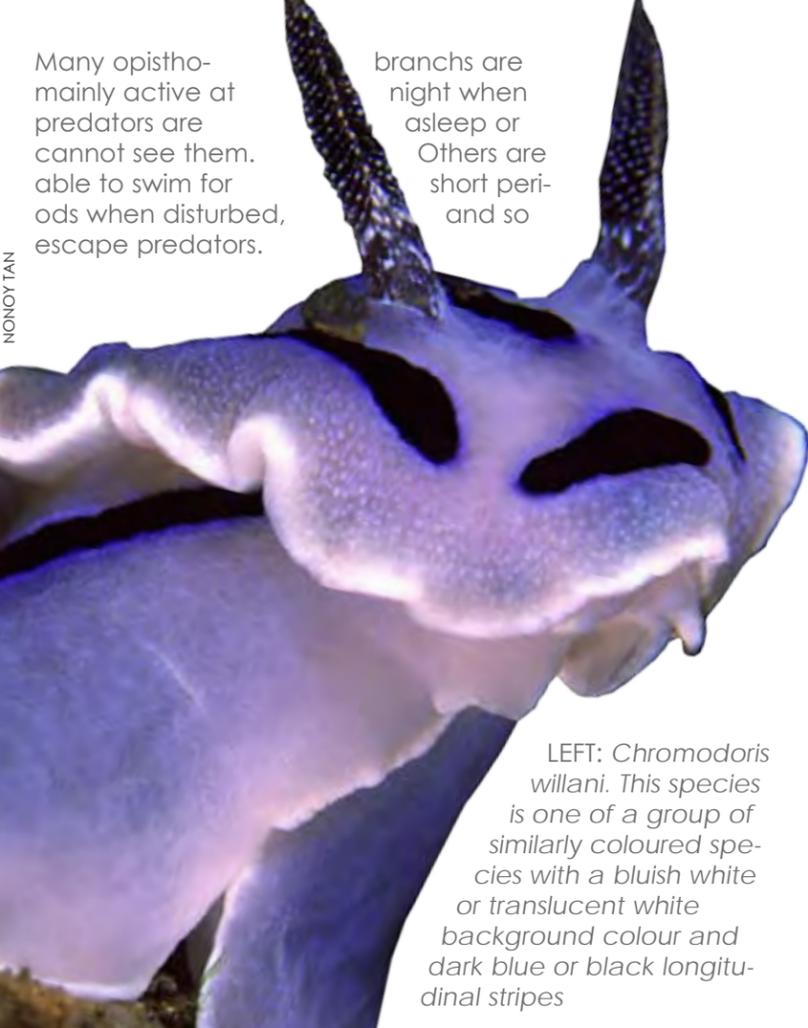
Nudibranchs have nude gills. Therefore the scientific Latin name "Nudi" (nude) "branches". LEFT: *Chromodoris Willani*



SCOTT BENNETT



Warning colouration. Many species with bright colour patterns are full of distasteful chemicals. Others with stinging cells or toxic glands have brightly coloured tips. This species is a *Flabellina exoptata*



NONOY TAN

Many opistho-  
mainly active at  
predators are  
cannot see them.  
able to swim for  
ods when disturbed,  
escape predators.

branches are  
night when  
asleep or  
Others are  
short peri-  
and so

LEFT: *Chromodoris willani*. This species is one of a group of similarly coloured species with a bluish white or translucent white background colour and dark blue or black longitudinal stripes

related species.  
In particular, terpenoid compounds, which are derived from sponges, are concentrated around the mantle border and in the mucous secretions of the mantle. At their natural concentrations these chemicals deter crabs and reef fishes from preying on the slug.

**Why all the colours?**  
Many animals, which are very distasteful or poisonous to eat, have bright colour patterns. The bright colours are considered to be a message to potential predators warning them to stay away. We call such warning colouration *Aposematic colouration*.

In one nudibranch family, the Chromodorididae, the colour patterns of many species are spectacular and obvious. Research in recent years has shown that these animals have specialised glands in their mantle that contain poisonous and distasteful chemicals from their sponge food. It is thought that by linking bright colour to bad tastes, these nudibranchs can teach fish and other potential predators to leave them alone.

In a development of this, we often find geographic areas where groups of unrelated chromodorids have evolved very similar colour patterns, so that they share the load of teaching fish to leave the colour pattern alone. One example of this mimicry in southeastern Australia are a group of about ten red spotted species, some of which are very difficult to tell apart. Most chromodorids have these mantle glands. ■

chemicals to make them poisonous, or at least extremely distasteful, to potential predators. In fact, *Opisthobranchs* (the subclass that nudibranchs belong to) have become subjects for research by marine products chemists who are gradually uncovering just how widespread and in what complex ways chemicals are used by sea slugs. Many store these chemicals in special glands in their skin.

What has caught the attention of chemists and physiologists are the many different pathways the molecules are produced. In some cases, these compounds are absorbed from ingested prey and stored unaltered by the opisthobranch, and in other cases, the compounds undergo some modifications. They may also be produced entirely by the opisthobranch itself.

**All different**  
Usually, each species has very specialised food requirements, and often its defensive molecules are also unique and differ from even closely



Egg mass from a Spanish Dancer



SCOTT BENNETT

Yellow and black. Classic warning colouration displayed by a Sagami Bay Tambja

Many opisthobranch egg masses form a spiral ribbon, and most of these spiral in an counter-clockwise (sinistral) direction from the centre. However some such as *Melibe australis* and *Melibe engeli* seem to be dextral, coiling clockwise from the centre. There is some discussion in the scientific community as to whether spiraling tends to be counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere. To complicate the matter, some species start the egg spiral from the outside, whereas the majority start from the centre, in which case, the spiral will be made turning the other way.



Spanish Dancer

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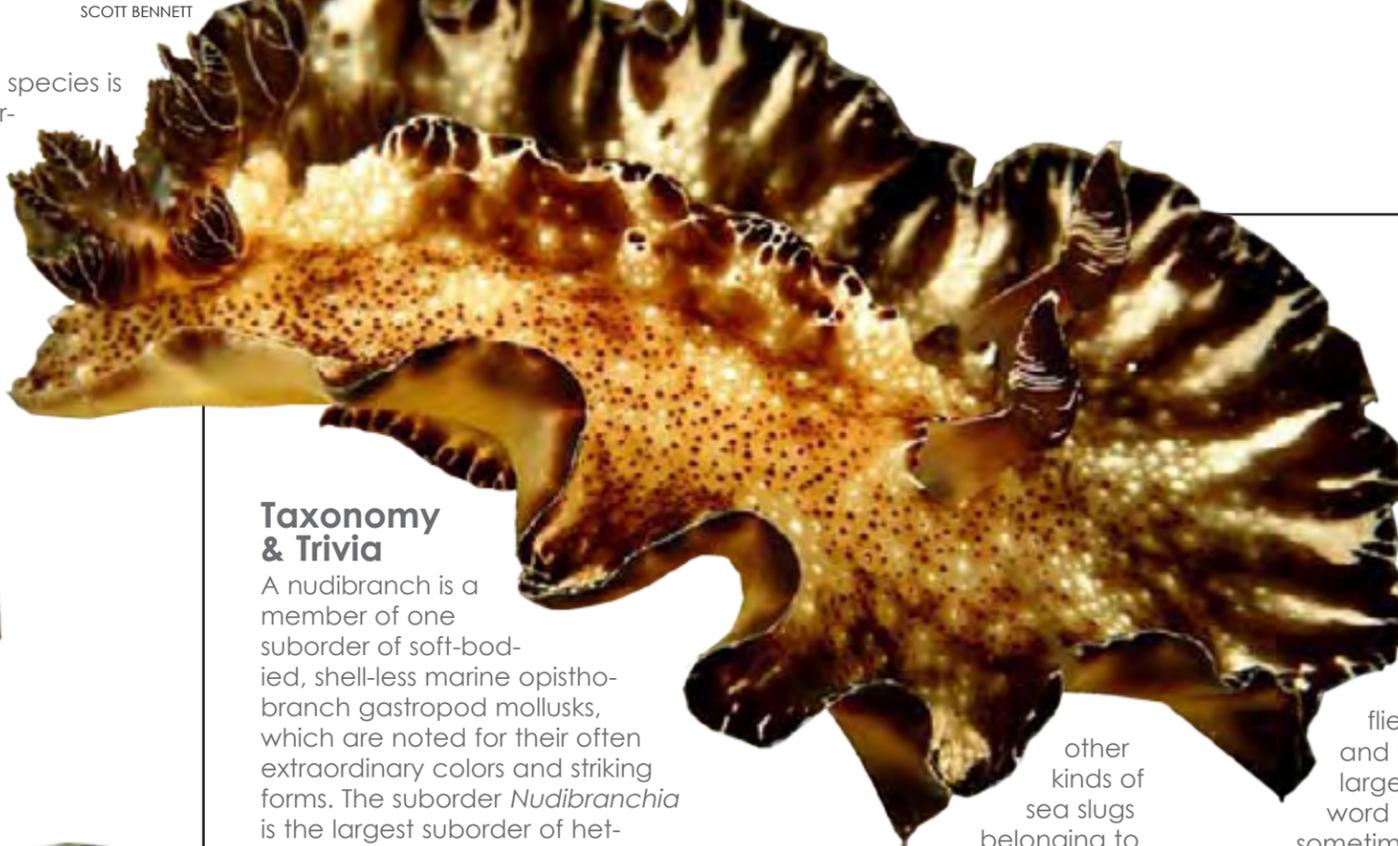
**Nudibranchs?**

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*Discodoris boholiensis*. This species is characterised by the narrow visceral hump, which forms a narrow median ridge from the rhinophores to the gills, and wide mantle skirt



Millers Nembrotha, *Nembrotha milleri*. One widespread method of defence is to hide from predators by having a colour, shape and/or texture that matches their food or background environment. Grey-green to dark green body with blackish longitudinal wrinkles down the body. There are three basal gill stalks which split into five branching gills

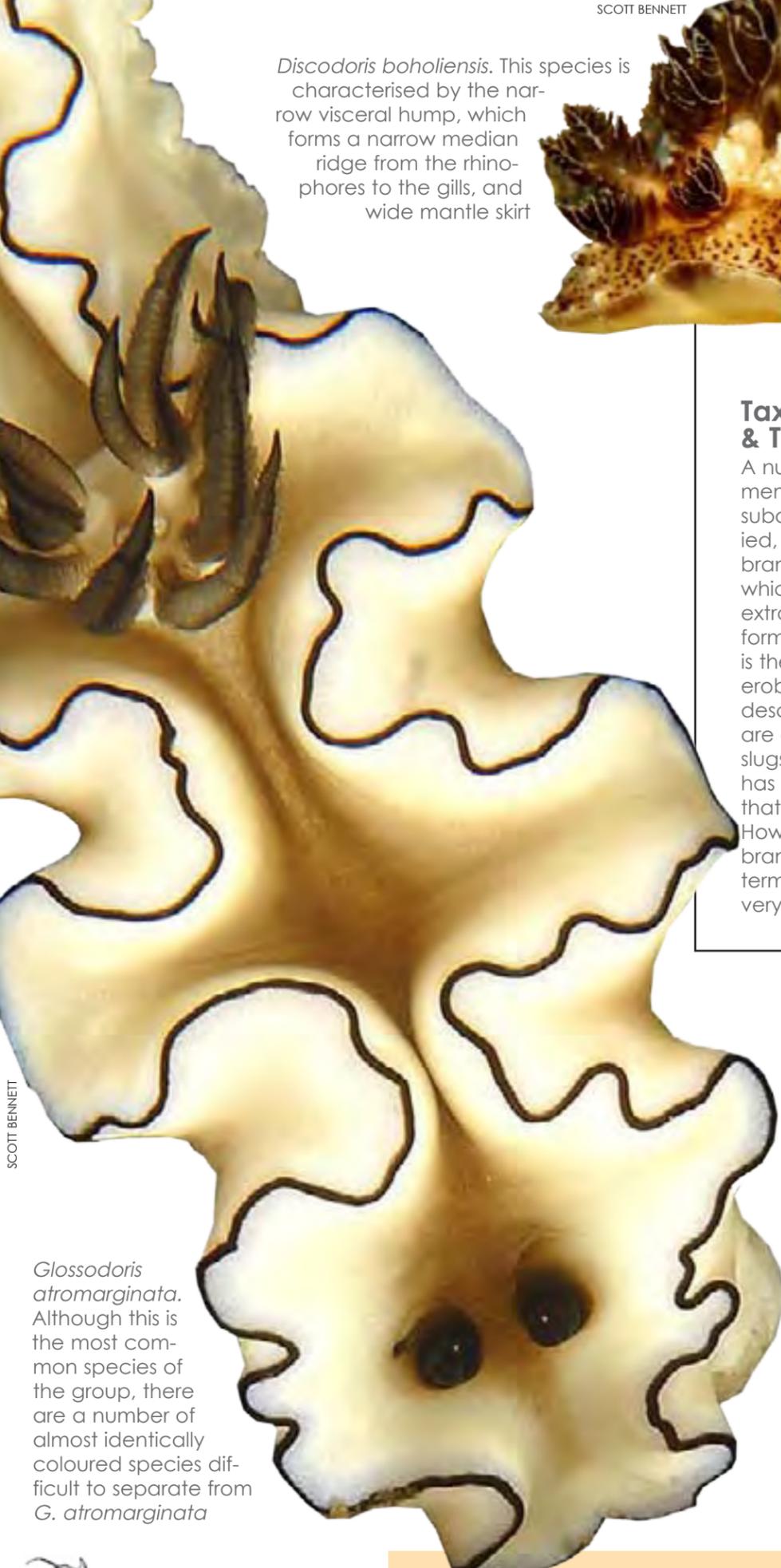
### Taxonomy & Trivia

A nudibranch is a member of one suborder of soft-bodied, shell-less marine opisthobranch gastropod mollusks, which are noted for their often extraordinary colors and striking forms. The suborder *Nudibranchia* is the largest suborder of heterobranchs, with more than 3,000 described species. Nudibranchs are often casually called "sea slugs", a non-scientific term that has led some people to assume that every sea slug is a nudibranch. However, while it is true that nudibranchs are very numerous in terms of species, and are often very attractive, there are numerous

other kinds of sea slugs belonging to several taxonomic groups that are not very closely related to nudibranchs. A fair number of these other sea slugs are colorful, and thus, even more easily confused with nudibranchs. Other marine shell-less gastropods or "sea slug" groups include additional heterobranch shell-less

tropod groups such as the *Cephalaspidea* sea slugs including the colorful *Aglajidae*, and other heterobranchs such as the *Sacoglossa*, the sea butterflies, the sea angels, and the often rather large sea hares. The word 'sea slug' is also sometimes loosely applied to the only very distantly related, pelagic, caenogastropods within the superfamily *Carinarioidea*, and may also be casually used for the even more distantly related pulmonate sea slugs, the *Onchidiidae*. (From Wikipedia). ■

Chemical defence. The skin of many opisthobranchs contains distasteful and sometimes toxic chemicals

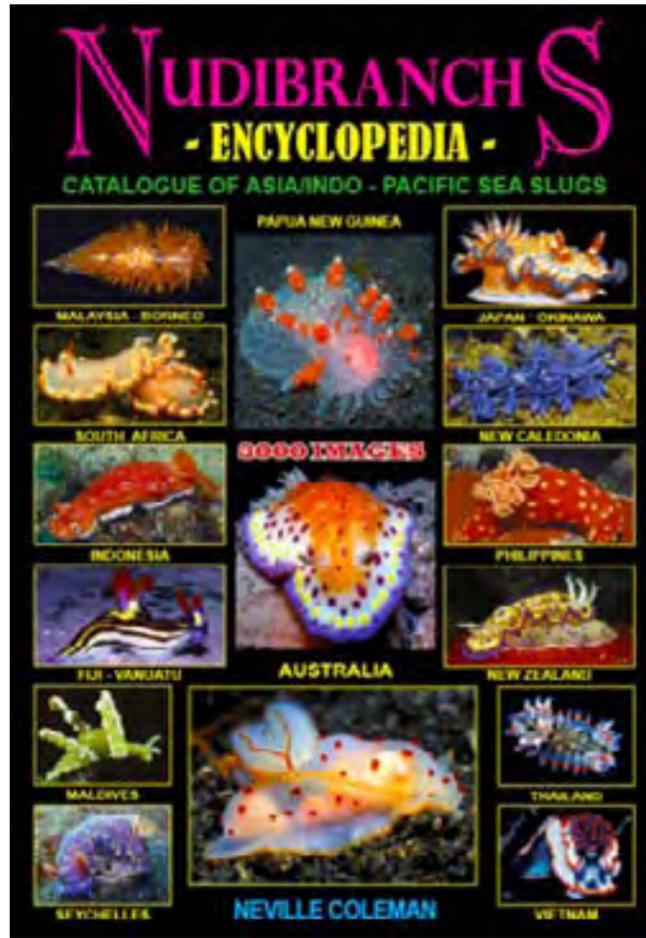


*Glossodoris atromarginata*. Although this is the most common species of the group, there are a number of almost identically coloured species difficult to separate from *G. atromarginata*

# New nudibranch books

Neville Coleman's new *Nudibranchs Encyclopedia* – a review and how it compares to the new Debelius and Kuitert *Nudibranchs of the World*.

Tim Hochgrebe, Underwater Australasia



The long awaited *Nudibranchs Encyclopedia - Catalogue of Asia and Indo-Pacific Sea Slugs* by Neville Coleman has finally arrived and what an encyclopedia it is!

Neville Coleman has made the excellent decision to publish this massive book as a hardcover, and with its over 400 pages, it really needs to be. The hardcover makes the book more professional, and naturally, it will last longer in any diver's library. He still managed to keep the book quite compact in its dimensions (160

x 235 mm), and for nudibranch fans, this book will still fit into their travel case.

The first 30 or so pages is dedicated to nudibranch biology, which makes this book much more than just a reference book to identify that strange new nudibranch you found on your last dive. He talks about the different habitats where nudibranchs are found and also how to find them. He explains how they see, smell, hear, taste and feel and all with beautiful photographs to illustrate each fact.

There are some excellent sections on nudibranch behaviour, including tailing of individuals, burrow-

ing and mantle flapping behaviour, and of course, nudibranch sex and defence.

In his typical emotional style of writing, Coleman manages to draw the reader into the passion and excitement that these critters bring to his life. This makes the book much less 'dry' than many of the books written by scientific 'purists'.

Another difference to Coleman's previous nudibranch publications is the fact that he openly invited many nudibranch lovers from around the world to contribute their findings and

images to this book. It is great to see how many people share the passion and enjoy finding new and previously unseen species and behaviour. By accepting other people's contributions, the scope of the book has certainly widened, and the quality of the imagery has improved, as there were more images to choose from.

Over 3000 images are contained in this work, which makes it the most comprehensive publication on nudibranchs in the world. And since it focuses solely on Asia and Indo-Pacific Sea slugs, it is clear that this book is to become 'the bible' for slug lovers diving this region of the planet.

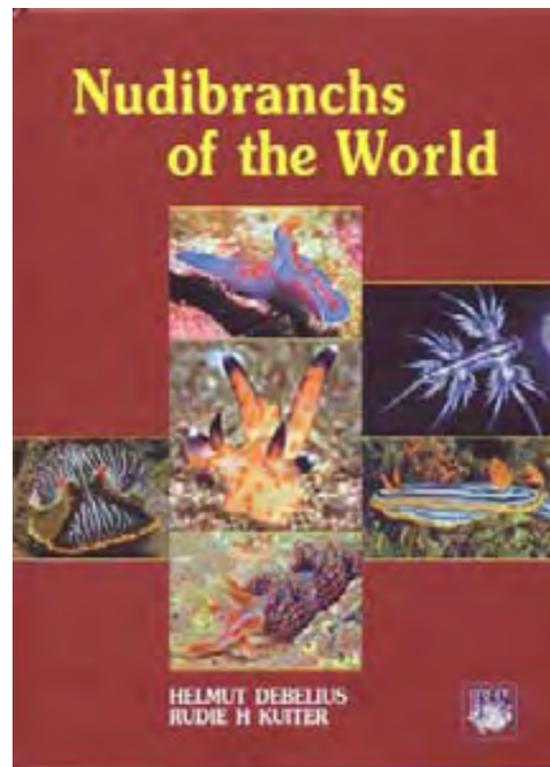
Another new book on nudibranchs is Helmut Debelius and Rudi Kuitert's title *Nudibranchs of the World*. This book is much larger in size (210 x 280 mm), and therefore quite a bit heavier. Pages within the book have excellent print quality and stunning photography. *Nudibranchs of the World* feels more like a coffee table book of nudibranchs than a reference book,

In contrast to Coleman's book, which includes ophiotobranch (non-nudibranch) sea slugs, *Nudibranchs of the World* only covers true nudibranchs and sorts them in a more evolutionary or scientific manner. It has an introductory section to each family that highlights the specific features that differentiate each family from the others. Over a third of

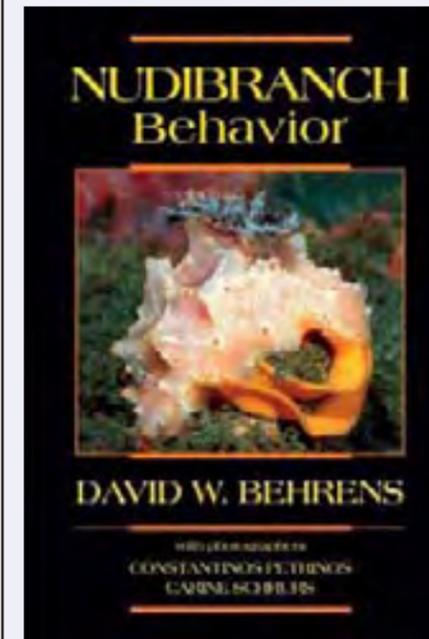
the Debelius/Kuitert book focuses on the family *Chromodoridae*. It is amazing to see the regional colour variations in some species.

In summary, as a big nudi lover, you will obviously have to have both books. The Debelius/Kuitert book really made me want to go and spend more time diving outside the Asia and Indo-Pacific region, as there are so many beautiful nudibranchs I have yet to discover. In terms of usefulness, I prefer Neville's book—there are more images, it is focused on my favorite region, and will definitely become the first book to open when I see a new nudibranch, or when people submit images to the Underwater Australasia photo galleries and ask questions about the identity of their find.

To purchase your own copy of these books, have a look at the book section at the link below: [underwater bookshop](#). ■



## Not new but still very handy



The book should really be titled Sea Slug Biology ... I also find the term behaviour a bit misleading. It is, however, a great book.

Nudibranchs are among the most beautiful creatures on the reef, with colors and shapes that dazzle and delight. Unlike fish that may disappear before our eyes in a flash, the showy nudibranch glides slowly along the substrate, allowing us the time to savor this extraordinary sight. With their shell-less unprotected bodies, how do they survive in seas filled with hungry mouths? How do these sightless creatures navigate the reefs to find food and mates? What and how do they eat? How do they reproduce? What special relationships have they developed with other reef inhabitants? These and many more questions are answered in this informative and lavishly illustrated book. You will never look at nudibranchs the same way again. ■

Soft cover: 177 pages  
Size: 180mm x 250mm  
ISBN: 1-878348-41-8

## Good to know: *Aeolid cnidosac*

The *Aeolid cnidosac* is one of the most remarkable examples of recycling in the animal kingdom. These animals feed on cnidarians (sea anemones, corals, hydroids, jellyfish, etc.) and are capable retaining at least some of the cnidarian's stinging cells (nematocysts) in a functional state, so that they are able to reuse them in their own defence.

The *Glaucus atlanticus* (below) is an example of a nudibranch that can severely sting humans.



Cnidarians, or coelenterates, have a wide range of nematocysts, some of which are used for poisoning prey, some for catching by harpoon-shaped barbs, others for entrapping with sticky secretions or entangling coils. The three nematocysts in the cnidosac photo above are barbed nematocysts. When they are triggered, the spiral thread, which is easily seen in the photo, uncoils as a long thread to attach the barb to the cnidarian, or in this case, to the cnidosac.

It is now thought that nematocysts reach a state of physical but not physiological maturity in the cnidarian. Usually, after some time, they then become part of the cnidarian's functional armoury. It is thought that the nematocysts, which are captured and able to be used by the aeolids, are those that are physically mature when eaten, but not yet physiologically mature. ■

TARO TAYLOR



*Dr Shawna  
Meyer &*

# The Red Demon

Text and photos by Cindy Ross

**As the Mexican Baja sky blazes fiery pink in the warm evening air, Shawna Meyer, founder of SquidDiving.com, loads the tanks aboard the panga boat for the divers daring to encounter the Humboldt squid face-to-face. This is not diving for the meek.**

The Humboldt Squid, also known as "The Red Demon", is a large, aggressive carnivorous creature that moves in shoals of up to 1200 individuals, at speeds of up to 24 km/h. Weighing in at 48-100 kilos and spanning up to three metres in length, these intelligent, powerful squid communicate by flashing red to white as they work together to capture prey, then simultaneously turn and cannibalize each other. With eight arms, two specialized feeding tentacles, ice blue blood and problem solving intelligence, these creatures are constantly identifying other marine dwellers as "predator" or "prey".

So, what drives this mermaid to frolic in the water with these monsters? Shawna began diving in 2006 and found a world under the water that changed her life. "Prior to diving, I saw the ocean as a big blue mass of water with waves crashing on the beach. Not anymore. I've been given a chance to see the life it offers. It provides adventure you can't get anywhere on land. In just the last few years of diving, I've seen some amaz-



Dr Shawna Meyer is an expert on close encounters with Humboldt squid





Meyer manages to get up close and personal with the Red Demon

ing animals. I have also seen those animals already disappear. I understand the diversity in the oceans, how important each species is to each other and to us; that when one goes away, if extinct or simply leaves the area, how it effects the rest of the life in the water,

and that it can even effect us on land. I've been out on the water, and where there were supposed to be fish, there were none. I hear stories from the locals how the water is acting unusual. It's colder when it should be warmer and vice versa. Fishermen report they don't

catch as many fish as before, and they say the fish are all gone. I know that we can't just leave it up to the scientists, with letters behind their names, to say when and how to make a difference. We as human beings have a responsibility to take care of our planet, and

we need to start doing it now. We also have a responsibility to see all we can. Underwater, there is still so much life to experience, to learn from, and to enjoy."

Shawna's mission with the Squid has provided a very limited few (less than

100 divers) a chance to see these creatures in their natural habitat, and she wants to encourage more people to have this experience. Diving with squid is dangerous, however, all precautions to ensure the safety of the divers are taken. Suspended in 300 vertical metres of water column, and donning an 8 kilogram chainmail armor suit, divers are suspended by a 12 metre safety cable attached to the boat. As they watch and wait in the dark water, the Humboldt are lured in. Suddenly, the divers see the mammoth creatures with human like eyes. It's an adventure that is for the brave-hearted, and one that will bring you a deeper perspective of the world beneath the waves. Here, divers witness one of the most ferocious creatures on earth, having a chance to see the intelligence and grace that are too often left out of television documentaries.

### Researching the Humboldt

When Shawna isn't escorting tourists, she participates in research studies on the Humboldt Squid. On a recent expedition with Steve Blair, curator of the Aquarium of the Pacific in Long Beach, California, Shawna assisted with conducting experiments that will help determine the possibility of keeping Humboldt Squid in captivity.

Once out in the water, they set up the free-floating net pen, where squid are placed to conduct the experiments. The squid are lured to the surface by first deep water jiggling a squid, and hopefully, as the first jigged squid comes up, he brings the whole shoal along, as they are fierce cannibals. It wasn't long before Steve was shouting that there are squid coming en masse. Shawna grabbed a camera and dove into the water to record the event. With dead fish thrown in the water, the 40 – 50 squid were in full attack mode chomping away at the bait.

Shawna stayed close to the floating pen, even though it was not tethered to the boat, deciding it was sturdy enough to clutch, so the squid couldn't snatch her to the depths easily. Positioning herself, she pushed the record button on the HD camera, and aimed at the action below. As the 2 – 3 metre squid danced for the camera, a large squid took notice of Shawna and aimed toward her. She grasped



Underwater photographer captures the amazing interaction between Meyer and a Humboldt squid



## Humboldt Squid trivia

Humboldt Squid are large, aggressive and predatory squid that move in schools of up to 1200 individuals in the waters of the Humboldt Current in the Eastern Pacific Ocean. They swim at speeds of up to 13 knots miles per hour (24 km/h,) propelled by water ejected through a hyponome (siphon) and by two diamond shaped fins. Their tentacles bear suckers lined with sharp teeth with which they grasp prey and drag it towards a large, sharp beak. They are most commonly found at depths of 200-700 metres from Tierra del Fuego to California.

Recent findings suggest the range of this species is spreading north all the way up to Canada. Historically, the two-metre-long Humboldt squid would only ride warm ocean currents northwards from the tropical waters off Central America and Mexico only during El Niño events. There, they would feast on Pacific hake, a fish that can grow up to a metre in length. But when the periodic warming ended, they would make their way back to the tropics.

Bruce Robison of the Monterey Bay Aquarium Research Institute in California says overfishing of tuna in the tropics has caused squid populations to rise. This occurs because tuna feed on the same smaller fish that squid eat, and also prey on young squid, keeping the population in check. The growing squid population has now moved north as global ocean temperatures have risen.

These animals have demonstrated a tendency to meet unfamiliar objects aggressively, attacking divers and rendering deep-sea cameras inoperable. Each of the

squid's suckers is ringed with sharp teeth, and the beak itself can tear flesh, although it's believed they lack the jaw strength to crack heavy bone.[5] Nevertheless, they eat their prey by grabbing it with their tentacles and biting it repeatedly with their beak. Working together, several squid are able to devour large prey very quickly.

Recent research suggests that the squids are only aggressive while feeding, being quite passive at other times. Their behaviour while feeding often extends to cannibalism, and they've been seen to readily attack injured or vulnerable squids of their own school. This behavior may account for a large proportion of their rapid growth. As they are believed to have a lifespan of only about one year—although some researchers believe they may survive up to four years—during which they may grow to 2m and weigh 45kg; their growth rate is astounding. ■



Watch this video clip from Monterey Bay Aquarium at [www.x-ray-mag.com/node/395](http://www.x-ray-mag.com/node/395)

ahold of the pen, but there were already several huge squid inside the pen, so there was no refuge to be had there. Feeling something near her head, she turned to find the angry jiggled squid. She was right in the middle of the bait. Quickly, she exited the water, realizing the danger she had been in.

Shawna actively is documenting location sightings. The Humboldt have been expanding their migration into new waters, not known for Humboldt activity. This causes alarm, as these creatures devour everything in their feeding frenzy. Even though the squid are vulnerable out of water, when slammed onto the deck of a commercial fishing boat, they are still very powerful creatures in the water. Intelligent, strong, resilient and able

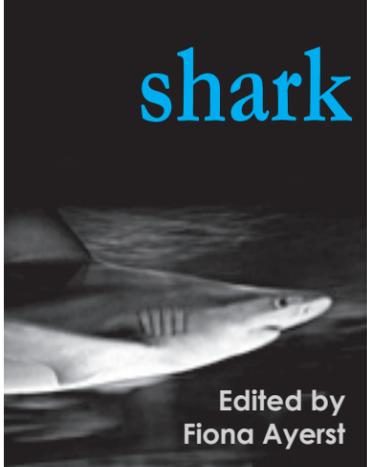
to reproduce in mass quantities. If the population soars out of control, Shawna fears that we could be looking at a devastating future for other fish populations in our oceans. She would like to see an enforcement of fishing for sharks, whales and other apex predators in the oceans, as these are the creatures who feed upon, and balance out, the populations of squid.

For as long as she has been diving with the squid, Shawna can only count three women who have encountered the Humboldt while SCUBA diving. Two were with Jean-Michel Cousteau's "Ocean Futures Society", acquiring pictures for a photo essay. The third diver unfortunately arrived late in the season, and due to bad weather, only witnessed one squid and not a shoal.

Shawna and the customer agreed that diving with one squid didn't achieve the full effect, and she would come back in the warmer season to complete her experience.

Shawna wants to encourage more women to come and dive with these magnificent creatures. Diving in crystal blue waters on a typical dive vacation, where you can see the bottom, all the life on reefs, and tiny tropical fish is nice, but nothing compares to the awe that comes with experiencing the Humboldt naturally in its environment. There really is nothing else like it on the planet. ■

*Cindy Ross is the founder of **GirlDiver.com** and **Dive For The Cure**. She is a regular contributor to X-RAY MAG's column, **Mermaid Matters**.*



Edited by  
Fiona Ayerst



# Evil prevails when good men sit and do nothing

— Edmund Burke

News from South Africa has rocked the shark diving world. We have lost eight of our Tiger Shark ambassadors to a local fisherman in the past month. These Tigers were famous. With their soulful eyes and striking silver stripes, they were trusting and playful and, above all, incredibly beautiful. We will sorely miss them, the majestic ladies from the Mecca of shark diving in Kwa-Zulu Natal. The site for their demise was Aliwal Shoal (The Shoal), off Umkomaas.

It is suspected that three of the sharks were illegally slaughtered during the first two weeks of February 2008, for their fins and meat. There have been many more sharks killed before and since, but these are the ones of which we are sure. Their bodies were recovered at a fishery holding fridge and are now evidence of the crime committed against them, wrapped in plastic and lying in a freezer. These are the three sharks whose deaths are causing anguish and fury amongst those who spent hours enjoying their antics in the water.

There are 14 local operators who take clients to see sharks in this area, and many visitors are international. The place is a mini-

Gansbaai in the making, and with warmer and cleaner water than the Cape, a draw-card for the country. Local marine biologist, Matt Dicken, who has been investigating such things, told me that in a recent survey, 41 percent of people interviewed would not dive at The Shoal, nor travel there, if the Tiger shark diving was not available as an option for them to enjoy.

*No wonder there is an uproar!*

My first whiff of trouble was an anguished SMS from Mark Addison, the owner of Blue Wilderness. Mark and his team have, over the past ten years, taken many an ardent diver and scientist out to view

Text by Fiona Ayerst. Photos by  
Fiona Ayerst & Wolfgang Leander

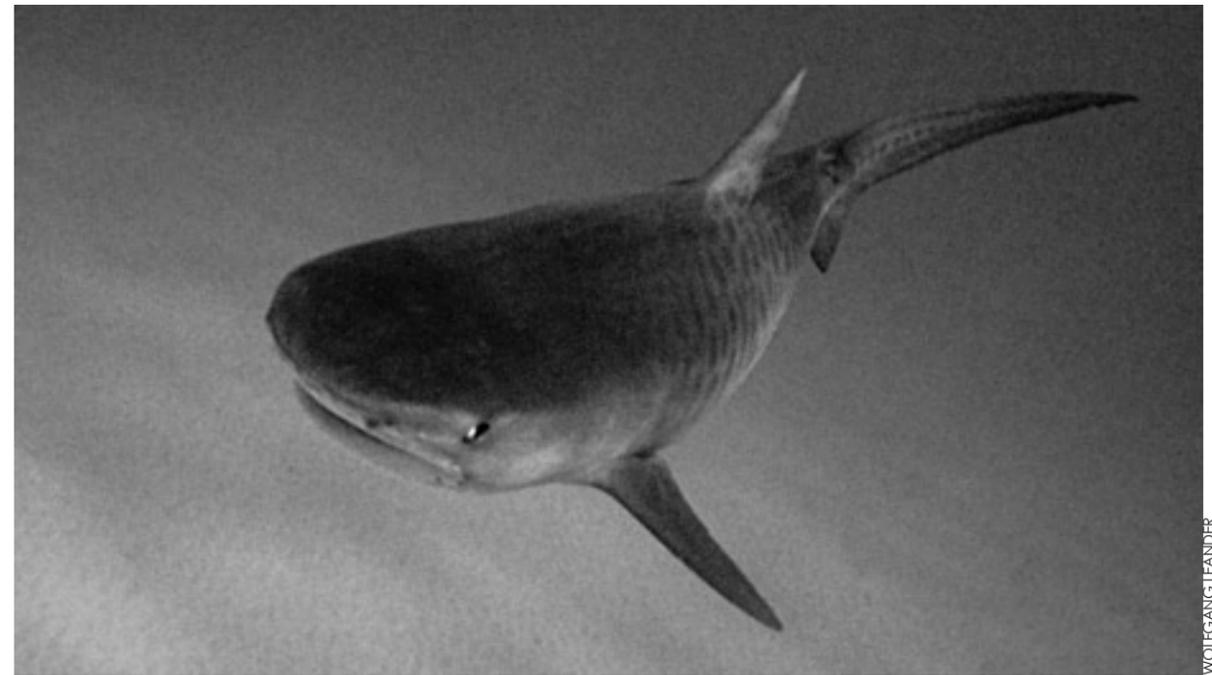




With their soulful eyes and striking silver stripes, they were trusting and playful, and above all, incredibly beautiful

Why did they have to be killed?

He would argue not, but I beg to differ. It would have been beneficial for him to attend the crime scene even if it was just for the sake of fishermen, operators and tourists who look to KZN Wildlife for support and enforcement of laws. In this instance, KZN Wildlife had been entrusted with the pro-



WOLFGANG LEANDER

tection of our heritage. Perhaps Naidoo would not be out there today wagging a finger at those he blames for "turning him in" and threatening to take away their

livelihoods—which he may have managed to do already—and even their lives. Is it possible that if enforcement was forthcoming and obvious, unscrupulous op-

and study the Tigers. Renowned advocate for shark diving, free diver Wolfgang Leander wrote an informative and passionate article in X-RAY MAG issue 18 about the spectacular thrill of diving with the Addisons and the sharks of The Shoal. If you look back and read the two articles, this will firmly plant in your mind the supreme waste and tragedy of this incident.

The furor started on February 15, 2008, when a fisherman from Durban area, Mr. R Naidoo (Naidoo), came ashore at the Park Rynie launch site (Rocky Bay) and was spotted with three dismembered Tiger Sharks on board. Local dive operators and tourists watched helplessly, and in horror, as they saw Naidoo driving away from the site with headless and gutted sharks—their tails hanging over the back of his vehicle.

Rocky Bay is within the newly proclaimed Aliwal Shoal Marine Protected Area (MPA). Compliance in the MPA is entrusted to

Ezemvelo KZN Wildlife (KZN Wildlife) who receive fees for their work in the area. It is illegal to catch, transport or to be in possession of any of the following fish in the MPA: Great Whites, Spotted Ragged-Tooths, Tigers, Bull, and Whale Sharks. That Naidoo caught the sharks is not in dispute. On more than one occasion, Naidoo has publicly admitted to killing the sharks.

Once the carcasses had been spotted, the local KZN Wildlife officer for that area was called in. The compliance officer said he could do nothing as it was a Friday afternoon, and he had to get a search warrant to be able to go to Naidoo's home. The incensed operators were told that there was no possibility of the officer getting a search warrant on that day, nor over the weekend. Worse than this, they were made to feel like accessories to the crime for not having taken a picture of the sharks with their cell-phones! The

disbelieving onlookers were told that if they had a photo, there would be no need to get a warrant, and an arrest would have been immediate!

Is this acceptable and is it, in fact, correct? I believe we should be looking deeper into this. Other instances of neglect and disinterest by KZN Wildlife and its officers are "sleeping out of the woodwork". As Naidoo drove away with three tails of their livelihood hanging over the back of his vehicle, the operators had a compliance officer on the other side of a phone saying there was nothing he could do. One can just imagine the frustration and anger.

To compound issues, the officer did not venture to Rocky Bay at all on that fateful afternoon. Why not? There were many witnesses still around. If he had at least arrived at the scene of the crime, would it have made a difference?

Is this how we want to see our sharks?



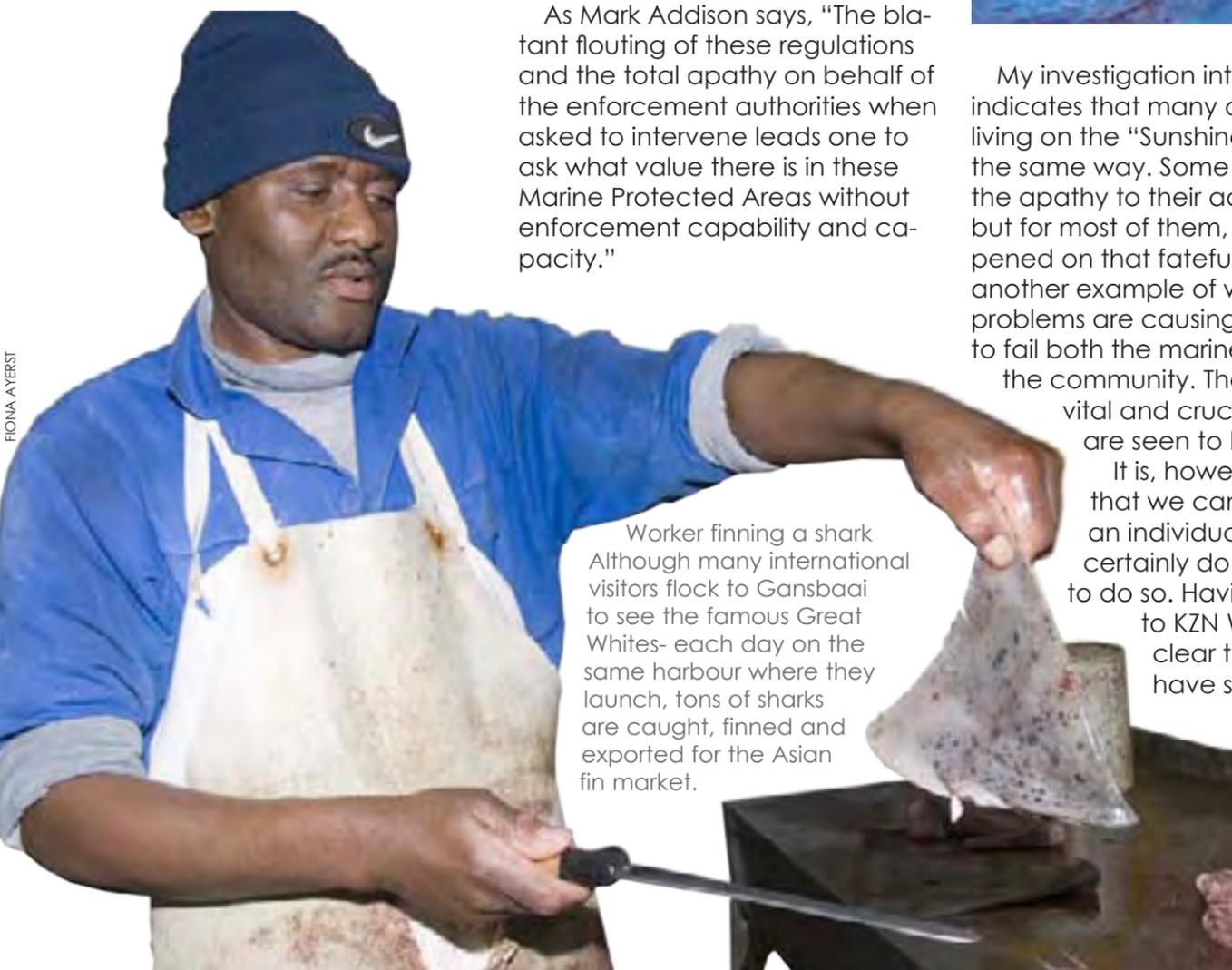
FIONA AYERST





portunists would think twice about slaughtering the animals that live there?

As Mark Addison says, "The blatant flouting of these regulations and the total apathy on behalf of the enforcement authorities when asked to intervene leads one to ask what value there is in these Marine Protected Areas without enforcement capability and capacity."



Worker finning a shark  
Although many international visitors flock to Gansbaai to see the famous Great Whites- each day on the same harbour where they launch, tons of sharks are caught, finned and exported for the Asian fin market.



FAR LEFT AND BELOW: Tiger sharks  
LEFT: Reserchers tagging sharks

media having indicated that Naidoo has been charged and his home raided, this is not the case. Why, after one month has already passed, has Naidoo still not been charged—even if it is initially with at least the crimes to which he has admitted? Naidoo is out on the water each day hunting sharks. His belief that he has not committed a crime grows stronger with each day that passes. What is his next step whilst the authorities delay?

All is not well along this peaceful area termed the Sunshine Coast for its clean soft beaches and clear warm waters. Enforcement appears to be weak. It is a perfect setting for a Chinese triad to infiltrate, as they are an ever-reducing source of shark fin for the infamous soup. I heard suggestions that this has already happened, but that's another story altogether!

My investigation into this matter indicates that many of the people living on the "Sunshine Coast" feel the same way. Some of them use the apathy to their advantage, but for most of them, what happened on that fateful day is just another example of whatever problems are causing KZN Wildlife to fail both the marine life and the community. Their function is vital and crucial, but they are seen to be impotent.

It is, however, clear that we cannot blame an individual, and I certainly do not intend to do so. Having spoken to KZN Wildlife, it is clear that they do have sufficient resources and manpower to manage the area with which they have been entrusted.

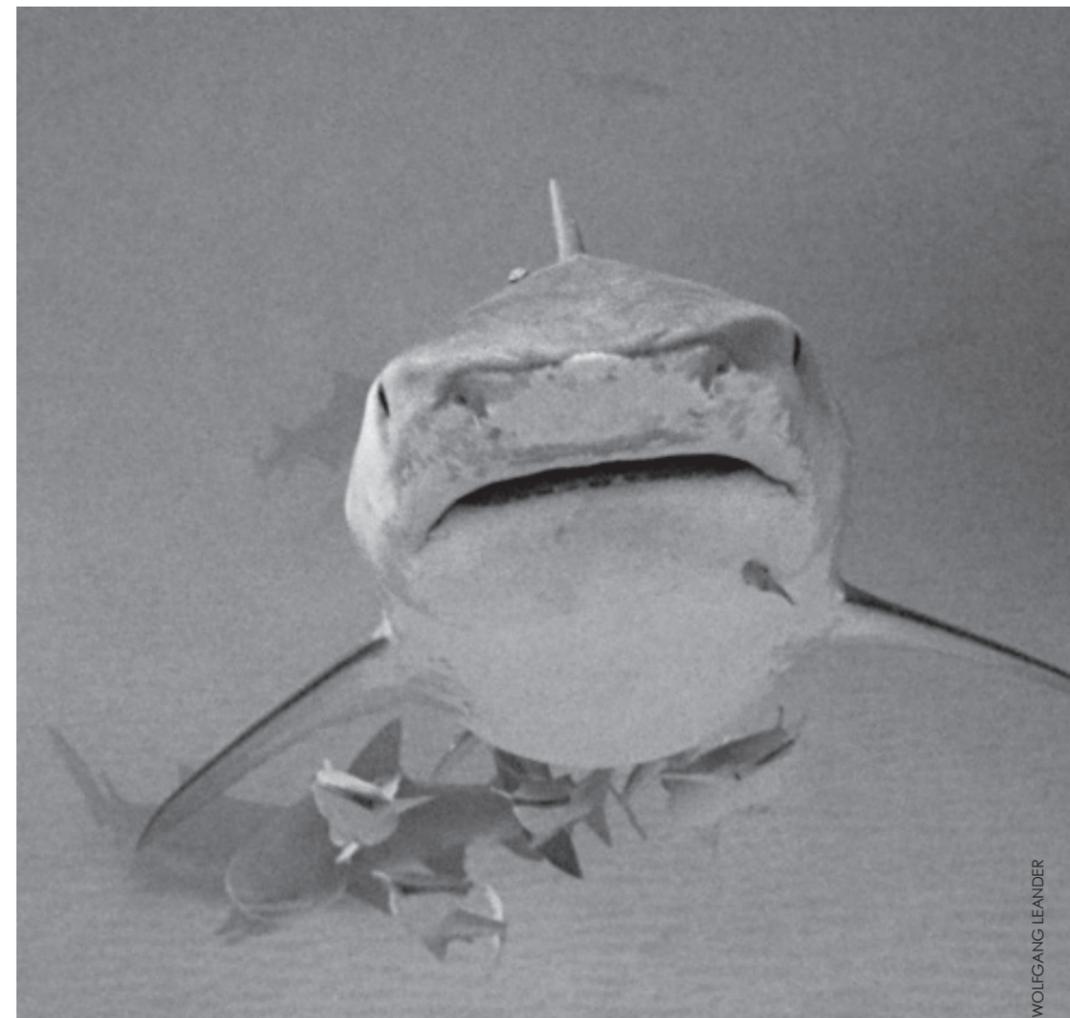
What needs to be investigated is how and why.

How is it that vital evidence may have been lost due to certain omissions on the agency's part, and why did this occur? More importantly, how can this be addressed, so it does not happen again? KZN Wildlife sees how important their role is, and they have told me "the will is there". They are dedicated to holding these enquiries and coming up with resolutions. I will be holding them to this.

### The culprit

Naidoo is denying that he did anything illegal. He did not catch the sharks in a protected area, he says. Naidoo is forgetting that he is not allowed to transport these animals within an MPA, and he has broken the law even in his own version of the facts. He transported them and landed them within an MPA. For this, Naidoo should be prosecuted.

Despite certain international





Apparently, shark meat is sold in this area for anywhere between R15 and R18 a kilo. Previously, I had heard that Tiger shark meat was inedible, as it contains high counts of mercury. Is it possible that these huge beauties are being targeted just for their fins, and that the rest of the body just goes to waste?

KZN Wildlife say they have completed their investigations, and the matter has been handed over to the organized crime unit of the South African Police Force (SAPS) who will gather evidence for consideration by the senior public prosecutor in the coastal town of Port Shepstone.

We have told KZN Wildlife and the SAPS that the Addisons had had divers in the MPA interacting with Tiger sharks in the morning of the same day when Naidoo killed the sharks. It may be possible to compare photos of the carcasses, and tie them in with pictures taken by the divers. Despite this

evidence being readily available, we are not being allowed access to the freezer.

### Evidence

It is clear that a quick and thorough investigation is required in marine crimes. I suggest that there is sufficient evidence that Naidoo caught the sharks in the Aliwal MPA. The evidence against Naidoo is mounting up and includes, but is not limited to, the following:

1. On the same day, he was seen driving his boat in the MPA by various witnesses;
2. On the same day, witnesses saw him fishing in the MPA for extended periods of time;
3. On the same day, he was called via cell phone to an area where a Tiger Shark viewing dive was taking place. He requested that more chum be put in the

water for the sharks (perhaps he wanted to keep the sharks in the vicinity until the divers had gone, and he could fish them out at very little cost to himself);

4. He could not get his anchor and buoy line off the reef where he had been fishing. His fishing area was inside the MPA, in an area where Tiger sharks are dived with regularly, and where the Tiger dive had taken place that very morning. When he left for the beach with his kill, he had to cut the line off close to the surface. The line and two buoys were located still hooked into the reef and inspected by a local dive operator the following morning.

I sincerely hope that the senior public prosecutor will find this, and the statements taken, sufficient evidence to charge Naidoo not only with that which he has admitted to, but also to fishing WITHIN a protected area. Naidoo needs

How many times must it be said? We have made ourselves the custodians of all things natural. The future of sharks is up to us

to be brought to book with the same laws that he so blatantly flouted.

### Honoring the dead

Whilst remembering our friends the Tigers, let us not forget the hundreds of Black Tip and Dusky sharks that form part of the ecosystem and the thrilling shark diving experience at Aliwal Shoal. These sharks are not protected within the Aliwal MPA and so are pulled out in much higher numbers every week and should also be mourned.

A recent IUCN indicates that, globally, dusky sharks are going to be afforded an Endangered or Vulnerable status. In South Africa, even WITHIN a protected area, these sharks can be caught with impunity.

I just can't seem to get my head around the bizarreness of this situation. Does man really have the ability to manage his surroundings? Do we really need to wonder why our environment is in such trouble everywhere we turn?

### To chum or not to chum...

A troubling thought, to which there is no easy answer yet worries me, is whether or not the chumming and attracting of sharks in this instance may have led them to their death. An opportunistic fisherman saw a "fast buck" and an easy catch. I am very much on the side of agreeing with shark diving with no cages. I think there is no better way to interact with and really learn about these fish. I also believe that it is also about changing perceptions of sharks as just being monstrous killing machines.

There is the argument that the fisherman may have taken the sharks out anyway. Its just that

all the evidence I have found leads to the fact that it was an easy kill for him. It appears that the sharks in this area MAY be "conditioned", as they gain significant and predictable food rewards. This is something that the operators are going to have to consider.

### Working together

It is so easy to blame others. This incident will hopefully show the operators in the area that they need to pull together in whichever way is appropriate for them.

I do think it is important that the industry grows strong and healthy for many reasons. The operators will need to find a

way to co-operate with each other, if they want it to continue. With incidents like the Abernathy shark fatality case in the current press, and with all eyes on the industry, it becomes increasingly important that operators and dive businesses come together and present a unified front.

Of course, it often takes something this sad to get "good" people to sit up and take notice. Positive action can flow from this situation, and already we are talking about local monitoring programs and vital training, not only for the enforcement agencies, but also for the SAPS and the legal teams who need to ensure that marine crimes no longer go unpunished.

Those in enforcement with

whom I have spoken say that these crimes do not go unpunished. Well, then I say, let's show this to the public and to those who are concerned. Let's get a conviction of Naidoo, and if necessary, his "team". Let's show the world what we care about and what happens when laws are broken.

### *These sharks need not have died in vain.*

These Tigers, due to their immense beauty and inquisitive natures—our ambassadors for the area—are gone, but we need to make sure that they are not forgotten.

How many times must it be

said? We have made ourselves the custodians of all things natural. The future of sharks is up to us. It's not too late, but only just! Please join the global fight for increased protection of sharks and control of all shark fisheries.

You can immediately help by adding your

voice to the petition started by a South African shark conservation group AOCA. Please go to <http://www.aoca.org.za/petition.php>. Please add your signature to the 1000 people out there who have already done so. We need MILLIONS of you—not just 1000! If you are still undecided, then consider this sobering statistic: in the next five minutes during which you consider the petition, 1000 more sharks will die. Just do it! ■

*Despite certain international media having indicated that Naidoo has been charged and his home raided, this is not the case. Why, after one month has already passed, has Naidoo still not been charged—even if it is initially just with the crimes he himself has admitted to?*





Edited by  
Fiona Ayerst

*"We started calling it the café because that is where you might go to have a snack or maybe just to 'see and be seen.' We are not sure which."*

## 'Superhighways cafés and hotspots'

Researchers using sophisticated tracking system have found that there are two distant destinations the white sharks favour, which they visit on a regular basis each year, migrating quickly along "super highway" routes and congregate at established "stepping stone" sites.

### White shark café

Each winter, the white sharks move away from the California coast, with the minority choosing to go to the Hawaiian islands, and the majority travelling to the middle of the Pacific Ocean. The latter location is about 1,300 miles from the

mainland and has been dubbed the "white shark café" by researchers. When the sharks return to the mainland, they go to the same area each summer.

Salvador Jorgensen from Stanford University's Hopkins Marine Station said "Once they leave the café, they return year after year to the same exact spot along the coast, just as you might return to a favorite fishing hole. The white sharks "appear again and again at very specific areas".

Although there are white shark populations off South Africa and Australia, the populations do not appear to mix, instead sticking to consistent routes and destinations.

"This is really important in terms of management, so that management can focus on these population units," Dr Jorgensen said. "And this really sets the stage for us to census the population, now that we know it is a confined population in the eastern Pacific."

Jorgensen, and his colleagues continue to map out the migration routes and gathering sites of highly mobile sharks, including some of the most threatened species. As this information becomes available, it can direct conservation efforts by helping fisheries managers to focus on protecting these sites. ■



## Cosmetic Change

### Cosmetics giants agree to stop using shark oil

International companies L'Oreal and Unilever have agreed to replace the compound squalene—found in shark livers—in their cosmetic brands with other oils from plant sources. Deep-sea sharks have large reserves of squalene, widely used as an emollient in various creams, lotions and glosses, as their livers comprise up to one-third their entire body weight.

In what is seen as a significant victory for the campaign group Oceana, Unilever said it had stopped using shark oil in high street brands such as Pond's and Dove some years ago, and is withdrawing its use from the entire European range by April 2008. "This is part and parcel of becoming as responsible as one can in our supply chain," a spokesman for Unilever said. L'Oreal is now completing the phase-out of shark oil in skincare products. However, 12 make-up formulas, including eight lipsticks under the Shu Uemura brand name, which is owned by the company, remain unaltered. In a letter to Oceana, L'Oreal spokesman Pierre Simoncelli wrote: "We hope to finalise this substitution programme for these remaining formulas in 2008."

Beiersdorf (which makes Nivea products), Boots, Clarins, Sisley and La Mer have all either made the decision to stop using animal-based squalene some time ago or had a policy to never use it in the first place.

Rebecca Greenberg, a marine scientist with Oceana, said: "Some of the biggest names in the cosmetics industry are recognising their corporate social responsibilities and choosing not to contribute to the extinction of these important animals. ■

## Two new shark species found Down Under

Two new species of wobbegongs, otherwise known as carpet sharks, have been found in Western Australian (WA) waters. WA Department of Fisheries shark researcher, Justin Chidlow, said there were now eight known wobbegong shark species in Australia.

The new floral banded wobbegong has been spotted between Geraldton and Augusta, and the new dwarf spotted wobbegong was found in shark fishery catches between Green Head and Mandurah.

"It's amazing to think that the new species have been present off our coast, but that it's only now that they have

been formally identified as separate and been added to the list of known wobbegong species," Mr. Chidlow said.

The colour of the floral banded species is mainly dark brown with yellowish blotches on the upper surface and white on the underbelly, whereas the adult of the dwarf spotted wobbegong was a lighter yellowish brown with large white blotches on top and creamy coloured underneath. ■



The related spotted Wobbegong (file photo)

## Nine More Shark Species Face Extinction

### Nine more species of shark are to be added to the endangered list as scientists warn that oceans are being emptied of the fish by overfishing and finning.

The scalloped hammerhead shark, which has declined by 99 percent over the past 30 years in some parts of the world, is particularly vulnerable and will be declared globally endangered on the World Conservation Union (IUCN) list.

All three species of thresher sharks, known for scythe-like tails that can be as long as their bodies, were listed as Vulnerable globally. The bigeye and pelagic thresher sharks were assessed for the first time, while the "common" thresher was uplisted from the Data Deficient classification made in 2001.

The global threat status was heightened for shortfin mako, a favorite shark among commercial and recreational fishermen, from Near Threatened in 2000 to Vulnerable today.

The blue shark, the world's most abundant and heavily fished pelagic shark, stayed in the threat category Near Threatened. Scientists noted declines of 50-70 percent in the North Atlantic and concern over the lack of conservation measures, but could not reach consensus that the species is Threatened with extinction on a global scale. ■



Young mako shark

# Reporting from the Zambezi Shark Discovery Project

Text by Fiona Ayerst

**We decided to start the exploration and research with the Zambezi Shark population on pinnacles reef in Southern Mozambique as there is a seemingly large population of Zambezi Sharks inhabiting that area. The warm waters, moderate currents and good visibility also make Pinnacles an attractive and relatively stable study area.**

So, in January 2008 a team representing Sharklife and SAMPLA set out for an adventure in Southern Mozambique to begin a long overdue and crucial study of the Zambezi or Bull Shark, *Carcharhinus leucas*. On the team we had a marine scientist, Ryan Johnson from SAMPLA, three directors from Sharklife and a host of excited underwater photographers ready to capture the action. We took acoustic transmitter tags and a frequency synthesized ultrasonic telemetry receiver that enables tagged sharks to be tracked. Ryan is now finishing a report to enable Sharklife to present the information to prospective sponsors needed to continue the research. The

**SHARKLIFE** is a conservation organization that has the ultimate aim of addressing the alarming over-exploitation of shark populations (and ocean fisheries) in Southern African waters. **SAMPLA** is the acronym of the South African Marine Predator Lab. This is a research and exploration institute working on uncovering the hidden lives of sharks and other marine predators in Southern Africa. SAMPLA is run by a quartet of marine scientists who are dedicated to increasing our understanding and inspiring our passion for the underwater world. ■



photographers also played a crucial role as individual sharks could be clearly identified in the photographs taken allowing Ryan to approximate the size of the shark population living in the area.

As a group, we had decided we did not want to "fish for" and hook a shark to the side of the boat in order to tag it. We agreed that we preferred not to place the shark under any unnecessary stress, so Ryan undertook to tag the shark underwater. The tag Ryan would be using, a continuous pinger, would be inserted into the base of the dorsal fin where it would lodge and stay for a period anywhere between nine months to a year before dislodging. This would allow the shark to be tracked for a 9-12 month duration. Ryan has extensive experience in the tagging and tracking of Great White Sharks, but Zambezis were an extraordinarily tough adversary, much tougher than we had expected.

Ryan is a free diver and decided to initially try and tag the sharks whilst on breathhold. The team used bait to assist Ryan with this task. This method allowed the research team to get close enough to study the animals without having to use invasive capture techniques. Sharklife does not support the unregulated use of bait to attract Zambezi sharks outside of controlled research and education initiatives. This project aims to provide data to both the Mozabiquan and South African governments for improved protection and management of the species.

This method of attraction would also assist the photographers in capturing the images Ryan had asked for. However, we still found it difficult to get close enough the sharks. In particular, I found that it is true that if you swim after a Zambezi shark, it will swim away from you much faster! Underwater, these sharks all looked remarkably similar. I truly felt sorry

A specially adapted underwater video camera with parallel high intensity green laser beams to enable us to calculate the size of individual sharks.

for Ryan having to sift through all those i.d photos and to try and make some sense and structure out of it.

But I needent have worried, as Ryan had his own particular brand of problems to deal with. He didn't have any success in tagging whilst on breathhold as the sharks were cautious of the divers and would move out of reach of Ryan whilst he was descending on breath hold. Ryan then switched to scuba, which proved more successful when he was approaching the sharks. Ryan was using a

Hawaiian sling method to insert the tag i.e he had a tag on the end of a metal pole with a rubber bungie attached. The bungie propelled the pole toward the shark, and theoretically would embed the transmitter head into the cartilage base of the sharks dorsal fin. However, due to the water resistance and thickness of the sharks skin, this method proved unsuccessful. Ultimately, and as a last resort, Ryan ended up placing the tag in a fish head and feeding it to our target specimen. The negative part of this method was that the tag would probably only remain in the shark's system for a period of one week if we were lucky. Sharks have been known to regurgitate foreign objects from their stomachs with relative ease, and we were concerned that this may happen. Unfortunately, we were unable to launch for the next two days due to inclement weather. On the third day after our shark had ingested the tag, we found him at his usual spot

For information of projects please see

[www.sharklife.co.za](http://www.sharklife.co.za)  
[www.sampla.org](http://www.sampla.org)  
[www.sharkconservancy.org](http://www.sharkconservancy.org)

near the Pinnacles and Ryan hauled out the VR-60. Unfortunately, our fears had manifested, and our shark had expelled the tag one way or another. No signal was being transmitted from the shark. We learned much for our next tagging attempt on Zambezis.

Fortunately, the photographers saved the day. The sharks were hungry and greedy, and they were able to capture hundreds of images of sharks from every angle. Ryan got the identification pictures that he needed to complete the first part of his report to present to sponsors. Ryan found that there is a healthy population of nine different Zambezi sharks inhabiting study area, and this is a viable population for further study. Ryan was also able to study pictures that I had taken at exactly the same spot in January 2007 and to compare the two years. Three sharks were readily re-identified, giving a first hint that a resident population may exist there.

Currently, the Zambezi shark is not given any protection in South Africa. Sharklife is of the view that the Zambezi requires protection due to its low reproductive capacity and the threats to its habitat, especially in river mouths where it is known to pup. Sharklife has been advised by government that there is insufficient information on this shark to warrant protection. The ultimate aim of this joint study is to gather sufficient evidence in as short a time as is possible to advise and confirm our concerns to government. These concerns all point to the ultimate conclusion that the Zambezi shark needs help. The dynamic combination of Sharklife and SAMPLA and their combined passion and energies are committed to changing this situation and to protecting this much maligned shark before it is too late. ■



# Controversy Over Cageless Shark Diving Ensues As Diver Is Fatally Wounded By Bull Shark Off Bahamas



On February 24, 2008, Austrian diver Marcus Groh was fatally bitten by a shark in the Bahamas while on a shark diving expedition aboard the *M/V Shear Water*. He was flown via Coast Guard helicopter to Jackson Memorial Hospital in Miami for treatment, where he later passed away.

The debate that ensued following this tragic accident has been marred with controversy and accusations between rivaling dive operators over practices and safety of diving with big sharks without cages. The fronts were drawn up hard between the operator of *Shear Water*, Jim Abernathy, and Florida-based operator and president of the Bahamas Diving Association, Neal Watson, who condemned these interactions as dangerous and questionable.

Meanwhile, large parts of the dive community stepped in in defense of Mr. Abernathy and his operation, which is held in high regard by many as being conscientious and competent.

Our friends and colleagues at Wetpixel.com outright found Neal Watson's criticism harsh and unfair and initiated a petition in support of shark diving in the Bahamas, which they will deliver to the Bahamas Diving Association. On their blog, Tony Wu stated that "Jim and his crew are absolute professionals".

Eric Cheng wrote on Wetpixel's blog that "During my time in the water with him, Jim always wanted to have fun, and he seemed to be driven by a need to enjoy life. However, that desire for adventure was always secondary to his dedication in keeping his clients safe. I have never seen a better run shark diving operation, and full boats year after year show that I am not alone in my feelings. I vouch for Jim; he is a close friend, and I support him fully.

In **an open letter on Oceanic Dreams blog**, Mark Addison of Blue Wilderness, pioneer of Tiger Shark diving in South Africa, makes a forceful plea for cage-free shark diving in support of Jim Abernathy

and other professional shark operators who believe that educated divers who take personal responsibility need not be patronized:

"The reason for this letter is to place on record my support for Jim Abernathy and the like-minded 'cage-less' operators of this world. First and foremost, my sympathies to Mr. Groh's family and friends on his untimely passing. Secondly, my sympathies to Jim and his team—this is a traumatic time and despite the unnecessary distractions contained in the vitriol of Mr. Neal Watson.

"I live and work in South Africa. My business has crystallized around 'cage-less' shark diving over the last twenty years. My efforts span the entire eastern seaboard of South Africa, which brings me in contact with many wonderful shark species and some fantastic locations and marine settings. The privilege of working with these many species over such a prolonged period of time in no way makes me an expert, but I have experienced the gamut of this strange world's people.

"As a pioneer in this field in South Africa, I have been accused of many things, as no doubt Jim is being accused of now. As safe as I believe the 'cage-less' experience to be and as successful as the experience has been for my clients—I would never consider a cage dive as an option—and yet, I am always aware of the potential risk that any client is exposed to in the 'cage-less' environment.

"I am acutely aware that we have managed all risk out of our lives and to me; 'the cage' promotes this soul-

less experience. The connectivity to nature in a 'cage-less' environment is a freedom of individual choice and in the case of many species of shark on our coast, the only way to experience them in their world and on their terms.

"This experience is under threat from ill informed opinion and extractive abusers worldwide. Much of this justification for Jim and his chosen method of working with sharks will probably seem lame to many people, but it is what it is. I do not ascribe to the bravado/machismo thing and have used my experience and that of the many thousands of people who have enjoyed South Africa's shark product with me, to the positive benefit of sharks in South African waters." (Shortened by ed.)

## Shark Savers petition

Shark Savers "represent a cross-section of divers, conservationists, shark enthusiasts, scientists, and professional photographers and filmmakers who strongly support conscientious and responsible cageless shark diving operations including Jim Abernathy's *Scuba Adventures* in the Bahamas. Such operators have allowed tens of thousands of divers to safely go beyond the constraints of cages and experience compelling shark interactions.

"We urge The Bahamas Diving Association to preserve current shark diving policies and resist overreaction to this horrible, but isolated, tragedy." ■

**Link to Shark Savers petition to Bahamas Diving Association**

*The recent death of Markus Groh is truly an unfortunate tragedy. We are both saddened and shocked by this, the first fatality ever caused by a shark bite during an organized shark dive. Our hearts go out to his loved ones.*  
—*Sharksavers.org*

## Press Release from DEMA

DEMA (The Diving Equipment and Marketing Association) is deeply saddened by the recent events that led to a diver's death after participating in a shark dive in the Bahamas last weekend. This tragic incident is an unusual occurrence, yet serves as a reminder of the importance of following guidelines put in place for specialty dives such as shark diving.

Shark diving has been practiced safely and successfully for the last 25 years without major incident. Guidelines were formalized in 2001 by the Global Interactive Marine Experiences Council in the "Florida Guidelines and Management Programs for Interactive Marine Experiences", which are available industry-wide. These guidelines include: safe environmental practices; staff training for interactive marine experiences; marine animal feeding practices; participant preparation and education; marine animal conservation efforts; safety considerations for interactive marine experiences; location of interactive marine experience program sites; risk management and awareness; establishing an emergency procedures plan; and appointing an administrative officer and safety officer for interactive marine experience programs.

DEMA strongly encourages dive operators to review their interactive marine experience practices to ensure their adherence to the guidelines that have been established to reduce the likelihood of an accident happening in the future. While any type of diving inherently involves some level of risk, pursuing safe, recreational diving experiences will greatly reduce that risk. This particular incident last weekend appears to have been an extreme form of the sport involving some of the more aggressive shark species.

For more information about interactive marine experiences, or to receive a copy of the safety guidelines, please contact DEMA at 858-616-6408. ■

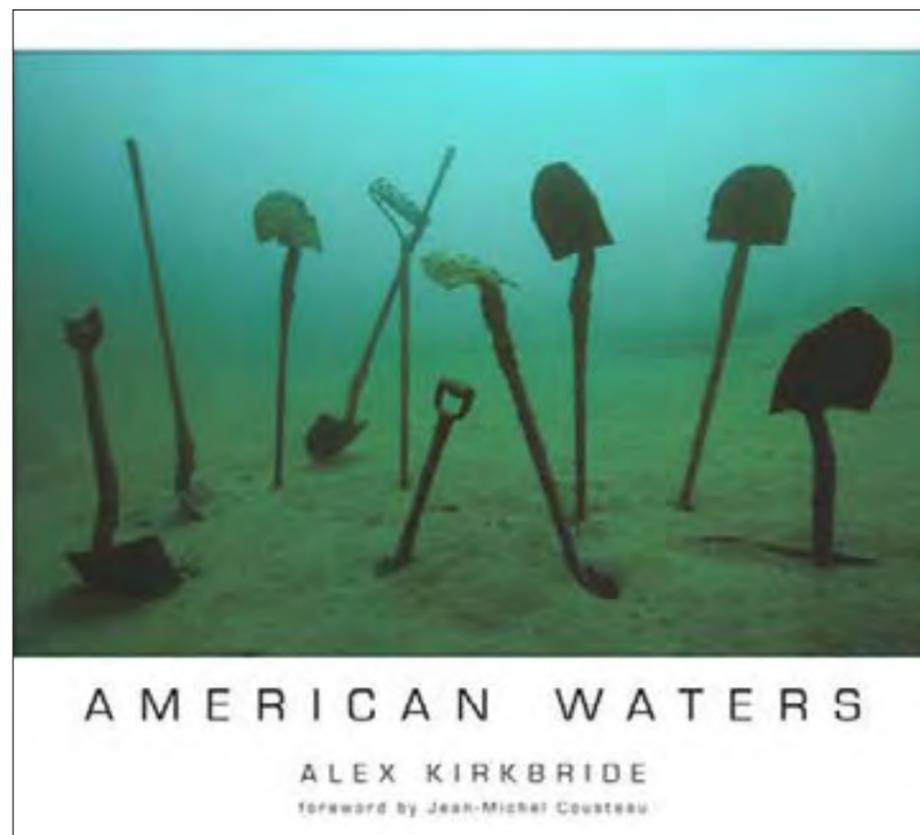




## Books Film DVDs CDs

Edited by  
Catherine GS Lim

**POINT & CLICK  
ON BOLD LINKS**



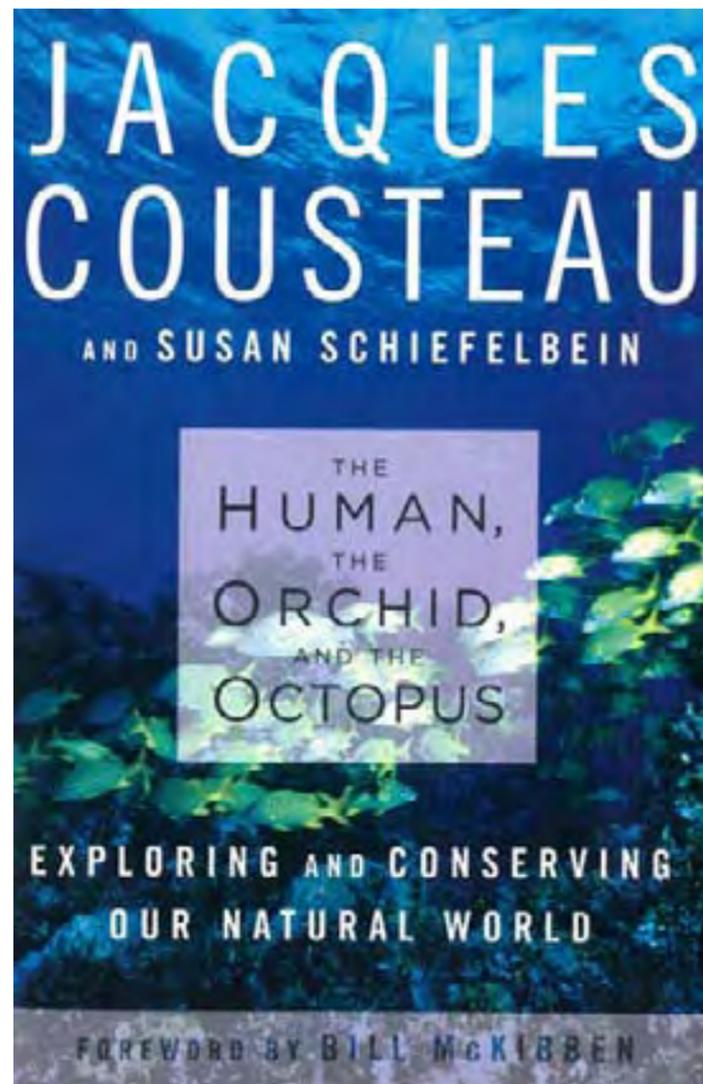
## American Waters

Just from a quick glance at the cover you can tell that Alex Kirkbride's *American Waters* is something different. As much as we all love colourful animal life from exotic locations, Alex found a way to make compelling images out of some surprising mundane things. An underwater odyssey that spanned over three years and 945 dives took him and his wife to be through the 50 United States where they photo-

graphed at least one water feature in each state. From flooded quarries to freezing Alaskan waters, from cranberry bogs to Elvis's swimming pool, not to mention a puddle in Manhattan. Images from deserts and prairies over bogs in the forest to the open ocean and captured throughout any of the seasons Kirkbride's book is a very refreshing look at a subject matter that tend to be reproduced in a repetitive and homogenous matter

This may be one of the last books shot exclusively on film. Kodak was one of Alex's sponsors, and the odyssey ran from 2002 through 2005. By that time the digital revolution was in full force, but he persevered despite the 36 shot limit.

[www.alexkirkbride.com](http://www.alexkirkbride.com)



## Cousteau explains

In this magnificent last book, Cousteau describes his deeply informed philosophy about protecting our world for future generations. Weaving gripping stories of his adventures throughout, he and co-author Susan Schiefelbein address the risks we take with human health, the overfishing and sacking of the world's oceans, the hazards of nuclear proliferation, and the environmental responsibility of scientists, politicians, and people of faith. Cousteau's lyrical, passionate call for action to protect our earth and seas and their myriad life forms is even more relevant today than when this book was completed in 1996. Written over the last ten years of his life with frequent collaborator Schiefelbein, who also introduces the text and provides an update on environmental developments in the decade since Cousteau's death, this prescient, clear-sighted book is a remarkable testament to the life and work of one of our greatest modern adventurers.

*The Human, the Orchid, and the Octopus: Exploring and Conserving Our Natural World* by Jacques Yves Cousteau and Susan Schiefelbein

Hardcover: 320 pages

Publisher: Bloomsbury Publishing PLC (30 Oct 2007)

Language: English

ISBN-10: 1596914173

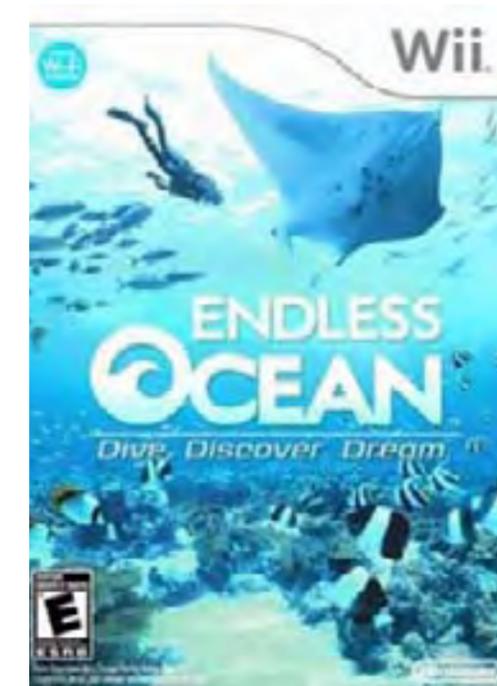
ISBN-13: 978-1596914179 ■

## Wii

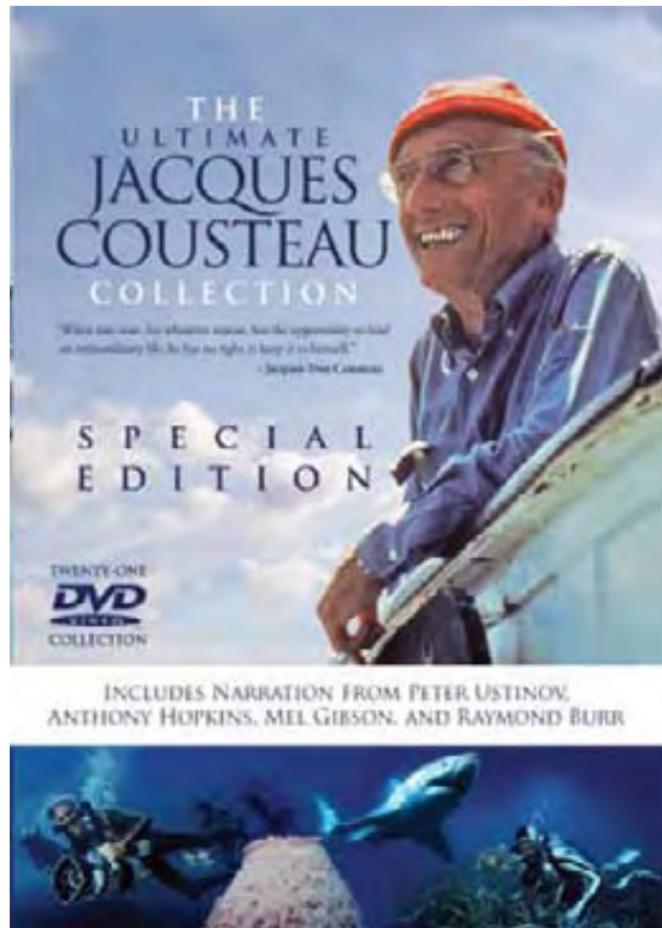
Is it a game, an interactive encyclopedia of the ocean's depths, or virtual exploration in scuba gear? Whichever the case, Nintendo's *Endless Ocean*, available exclusively on Wii, will paddle its way into stores this week. In the game, players will seek out a variety of treasures and record more than 230 different animal species. All of this is made possible via point and click swimming with the Wii Remote.

In what's slowly becoming more common on Wii, divers can go online and cooperatively explore an area with a friend via the Nintendo Wi-Fi Connection. "Endless Ocean is a siren song for adventurers, family gamers and the just plain curious," says Cammie Dunaway, Nintendo of America's executive vice president of sales & marketing. "Kids will love meeting and cataloguing all the sea life they meet, while their parents can lose themselves in a seemingly unlimited underwater landscape."

[www.amazon.com](http://www.amazon.com)



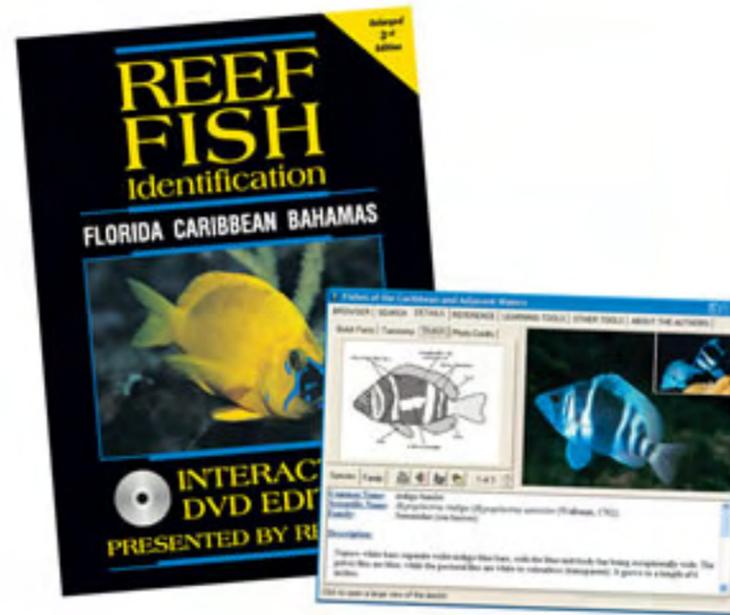
## The Ultimate Jacques Cousteau



Fans of sea life, underwater oceanic photography and adventure will be glad to know there is a new release of a 21 DVD box set depicting outstanding moments during the career of the intrepid, famous undersea explorer and conservationist Jacques Cousteau.

During his long career, Cousteau, who died in 1997, was rightly recognised as a pioneer. More than anyone else in history, he introduced us to the beautiful and mysterious world beneath the surface of our oceans, co-inventing the Aqualung during the Second World War, and then making award-winning films and scores of underwater documentaries for television.

This is ultimate collection of his lifetime's work spans a period of 40 years plus. This box set consists of 21 DVDs, almost 64 hours of marvellous filming, and is a rich and detailed production of his best work. ■



## Reef Fish

*Reef Fish ID: Florida, Caribbean, Bahamas - Interactive Edition* is the most comprehensive scientific reference of its kind—the product of nearly ten years of scientific research, photographic expeditions, and collaboration with academic experts. Whether you're a beginning fish watcher looking for a learning tool or an ichthyologist looking for an accurate reference, this electronic field guide is for you.

At the core of the interactive edition is a database of 842 unique species known to inhabit the Caribbean, the Gulf of Mexico, and adjacent waters. Each species is described in meticulous detail and is accompanied by a giant library of visual material. [reefnet.ca](http://reefnet.ca) ■

## Review

### "Five Bells", Job Done

As so many times before, reality beats fiction when it comes to captivation and sheer entertainment. This tale takes us back to some of the early diving days, starting in 1963 when the author joined the British Army, to be precise. The autobiographic narration is generously illustrated mainly with old grainy black and white photographs, like from an old family album. But that only adds to the realism. I can hardly believe the equipment they had—or didn't have—back then. It certainly puts things in perspective. Not only does one begin to appreciate the technological advances we can now all enjoy, but also how different the life of a military or commercial diver is from that of a recreational diver. During almost five decades of diving, Tony Liddiard has seen it all—from military assignments all over the world to excavating wrecks, searching for bodies in sewers and diving into nuclear reactors, to the more recreational aspects of diving taking place on tropical islands. It's a "boys' book" I guess, being full of adventure and bravado, military and hardware, but highly entertaining, and it gives you an insight into diving and sides of it that Discovery Channel cannot. So, if you don't want to

save it for a long flight overseas, or for your live-aboard, switch off the telly and put on the kettle and make yourself comfortable with "Five Bells", Job Done.

Tony Liddicoat hails from the West Country, England. He left school at 14 and joined the army, initially stationed at Dover in Kent, where his passion for underwater adventures began. He became a military diving supervisor, a commercial diving instructor and an advanced sports diver. He was nominated "British Diver of the Year" in 1981 for his rescue of an American recreational diver who was gravely ill after decompressing too quickly. He also took part in 16 major marine archaeology, scientific research and other expeditions around the globe. Liddicoat currently lives in Germany, though he remains an active member of the Folkestone Sub Aqua Club. "Five Bells" Job Done is his first publication. ■

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