Dive Planner" would be the name of the instrument. Nowadays people are regularly talking about Dive Planning. Some people have always talked about it, but not many. One never used to hear about it as much as we do now. It is over two years since the multi-day limitations were introduced. Over two years ago the S.A.F.E.Diver campaign "Slowly Ascend From Every Dive" was introduced. In the middle of 1989 was the introduction of the idea, for the dinosaurs who just do not want to give up their beloved USN tables, which had been paid for, to at least mark them down to the limits which were tested in Seattle. Later in 1989 the 15 feet stop was extended to include all ascents to the surface.

Also in 1989, the limitation on deep repetitive diving were issued, once we found out there were crazy people doing things like making repetitive dives past 100 feet we said "Quit doing it, it is just not a safe practice."

TABLE 5

PADI'S EVOLVING PRACTICES

Mid 1985	Stop at 15 feet for 3 minutes
Jan 1988	Popularized term "Dive planning"
Mid 1988	Limitations on Multiday diving
Mid 1988	AFE Campaign (Slowly Ascend....)
Mid19 89	Reduced USN NDL's to RDP limits
Mid 1989	Extended 15/3 stop to ALL dives
Mid 1989	Limitation on deep repetitive dives

Sometime in the first quarter of 1990, there was a new rule that henceforth, if one goes past 130 feet in one's dive, that will be considered in the same category as exceeding the no-stop limit. It puts one in an emergency decompression status, and one should not dive for the next six hours, after one exonerates oneself with a 15 foot stop for 8 minutes. So we are getting quite bit stricter. With these established trends, it is highly likely that the limitations will remain.

Reference

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This is an edited transcript of a lecture given at the 1990 Annual Scientific Meeting of SPUMS.

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AN INTRODUCTION TO PALAU'S REEFS

Steven R. Dent

Palau is one of the richest coral reef areas in the world. Biologists define a location's richness in terms of its biological diversity or the number of species inhabiting a defined area. Within Palua's 370 km^2 it is estimated that there are over 1000 species of fish and 700 species of corals and anemones.[1-3] In contrast, the fish fauna of the entire state of Queensland is believed to number approximately 1600 species[4], 1500 of which occur within the 332,000 km^2 of the Great Barrier Reef Marine Park.[5] A further illustration of this richness is the collection by marine biologists of thirteen new species and one new genus of fish on a Palauan reef during a two hour period. While this may not seem like a large number to some people, one needs to consider that annually there are only 75 to 100 new species collected worldwide.[3]

The reasons for this high degree of diversity are believed to be twofold; first the archipelago has a long history of a steady, tropical climate and second is the presence of a wide variety of habitats within a relatively small area. The 340+ islands are volcanic in origin and capped by porous coral limestones. Every type of reef structure is represented here. To the north of the inhabited islands are small atolls and bank reef areas. A barrier reef encloses the lagoon while fringing reefs grow along the shore of many of the islands. Within the lagoon are many patch reefs, seagrass meadows, level sand and mud bottoms. These habitats are further subdivided into microhabitats due to the porous nature of the reef and limestone. The blue holes, caves, crevasses and smaller interstices provide great spatial heterogenity and enable more organisms to exist in a smaller area. Freshwater run-off adds to the diverse habitats by producing streams and extensive estuarine mangrove habitats. There are also a number of lakes which range from freshwater to marine conditions.

The unique nature of this reef system was recently acknowledged by CEDAM (an acronym for Conservation, Education, Diving, Archeology and Museums) International when that conservation organization placed Palau on its list of the seven underwater wonders of the world. The New York based CEDAM recognized Palau along with the Great Barrier Reef, northern Red Sea, the Belize barrier reef, Lake Baikal in the USSR, the Galapagos Islands and deep ocean vent communities. Among the criteria used in selecting the sites were scientific research value, environmental significance, unique marine organisms, natural beauty, geological significance and how representative the site was of a particular region.

The corals that construct these reefs are animals whose tissues are packed with symbiotic algae. These algae, called zooxanthellae, combine sunlight, and wastes (carbon

dioxide and ammonia) from the coral animal to produce oxygen and carbohydrates which are then used by both zooxanthellae and the coral polyps in growth. This interrelationship is extremely important to both participants since the clear, blue tropical waters in which they thrive are extremely low in nutrients. The zooxanthellae allow corals to flourish in waters which are virtually biological deserts. Zooxanthellae not only act as nutrient sources and waste removal systems, they also facilitate the production of the calcium carbonate skeleton secreted by the coral. Reefs are only produced by corals containing zooxanthallae as no other corals are capable of depositing enough calcium carbonate to build massive skeletons.

The hermatypic or reef building corals have very particular ecological requirements. They require warm, clear, relatively sediment-free marine water and a hard substrata. Clear water allows sunlight to reach the zooxanthellae. Water of low turbidity is also important because corals have only a limited ability to cleanse themselves of potentially smothering silt. The physiology of the coral requires salinities close to that of undiluted sea water and a temperature range between 16° and 36°C, although a range of 23° to 25° is most conducive to reef growth. For successful larval settling and growth, a hard, sediment-free substrata is needed.

Corals exhibit a wide range of growth rates and forms. These forms and their rates of growth vary between different species and even within the same species. Geographic location and water depth are among the major contributors to this variability. For example, some species form massive, boulder-like heads in shallow water, while other colonies of the same species which live at greater depths appear more plate-like. Generally the branching corals grow the fastest (5-8 cm per year) while the massive, boulder-like species may only add several millimeters of calcium carbonate per year.

Competition for space among corals and all attached reef invertebrates is very intense. Corals have developed aggressive reactions to organisms encroaching upon their territory. They extrude their digestive surfaces, termed mesentaries, out to cover competitors and digest them away.

Coral reefs are places where biology and geology become very entwined. The organisms fabricate the limestone and sediments and these, in turn influence the distribution of the organisms. Reefs are huge, shallow water accumulations of calcium carbonate (limestone) which are composed of several structural components. Corals construct the main framework. Voids within the framework are filled by small particles of calcium carbonate secreted by a host of different organisms: green algae, mollusks, foraminifera (protozoans), and the corals themselves. The most important producers of fill, based on volume alone, are the calcareous green algae. These plants are often not even noticed by most divers. Massive coral skeletons are turned into "fill" material by boring organisms (algae, sponges, worms, mollusks and crustaceans) and grazing mollusks, urchins, and fish. These assaults can be of a chemical or physical nature. Most boring algae and sponges dissolve away the host material while mollusks use a combination of chemical dissolution and mechanical abrasion to erode away a refuge or graze on encrusting algae. Urchins and fish all use mechanical methods of destruction. The mushroom profile of the Rock Islands owe their morphology to the combined action of these bioeroders. The unconsolidated fill material and framework are bound together by encrusting organisms such as sponges, soft corals, sea fans, tunicates (sea squirts), colonial anemones, and calcareous red algae.

The fish fauna of coral reefs is what initially attracts the majority of divers. As mentioned above, Palauan reefs have a myriad of colorful and interesting fish. The clear water of coral reefs is believed to have greatly contributed to the evolution of reef fish colors. Good visibility allows fish to rely heavily on visual cues, unlike fish from dark or turbid waters which must depend upon olfactory, auditory, and gustatory cues to differentiate potential mates, meals and predators. Colors allow fish to discriminate between individuals of the same species and determine the reproductive state of another fish. Reds and oranges can act as warning colors, as with the poisonous butterfly cod. Other fish will change colors to produce a threat display or disrupt its outline among the corals. Some fish have markings which resemble eyes on their posterior flanks that are suppose to confuse potential predators as to which end is the head. A related ploy is to have a dark colored bar across the eye to obscure it.

The reproductive behavior of reef fish is quite varied. The majority of parrotfishes and wrasses have the ability to change their sex. These populations are divided into two groups; the initial or primary phase individuals (male and female) whose sex is immutable, and the terminal stage or secondary phase males which are transformed females. Such changes are controlled by the social structure of the school, the presence of a secondary phase males suppresses sex changes in other females. If these males are absent or low in numbers, the dominant female will transform into a male. Some groups, such as clownfish are protandrous hermaphrodites, beginning life as males. A typical group consists of a single reproducing pair and numerous sexually immature individuals all associated with an anemone. The largest fish is female and, if it should disappear, the mature male changes to a female while the largest juvenile becomes the next sexually mature male.

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EDITED QUESTION AND ANSWER SESSION.

Q How can man stuff it all up? Have they any program here to prevent him from doing it?

A As far as damaging the reef? Development impacts on reefs largely by making changes in freshwater run-off. If there is an alteration in an area's drainage pattern additional freshwater inflow and silt can kill off coral. Also an increase in sewage effluent is another major contributor to reef problems. Sewage provides additional nutrients that stimulate algae blooms. These blooms can kill existing coral by overgrowing it and exclude coral larvae from recolonizing an area.

Snorkelers and scuba divers can and do damage reefs. Indiscriminate anchoring practices by vessels contribute to coral destruction. Divers have a negative impact by walking, kneeling or resting their hands on live coral. Corals are quite susceptible to physical damage, being simply thin layers of tissue overlaying a hard skeleton which has numerous sharp protrusions. Any pressure upon the coral polyp squeezes it down on to the skeleton resulting in tissue damage. Sometimes the wound may heal, but often the site becomes infected and the death of the entire colony can result. High concentrations of divers are blamed for extensive damage to popular reefs in many parts of the world.

Q I believe the Crown of Thorns starfish did a lot of damage here for a while. What is there that can deal with the Crown of Thorns in areas where it is a real problem?

A Unfortunately, most of my experience has been in the Caribbean so the following information is based only upon what little I have read. Some people believe that the outbreaks are natural fluctuation in the population, based on geological studies of starfish remains within the sediment. However, this type of study is hard to do, because often areas of unconsolidated sediment will be churned up by the actions of burrowing organisms. As far as controlling the starfish, the only method I know involves divers hunting down and injecting starfish with a copper sulfate solution. This technique has been found to be impractical because it can cover only a limited area and is very labor intensive.

Q Many of the fish are obviously very voracious predators but there was not a single sign of one fish eating another that I could see. Is this because it is not feeding time? Or conversely, why the hell are they all so busy?

A First, they are probably very busy trying to dodge predators. Fish are looking for food and trying to avoid becoming someone else's dinner. Generally, an assemblage of reef fish can be divided into diurnal and nocturnal components. During the day one set of fish are out and about while the nocturnal shift rests within the reef. Shift change occurs and the most active feeding periods coincide at sunrise and sunset.

Q Another thing I noticed was that none of the smaller fish seemed to be concerned with the bigger fish. They were not moving out of the way at all.

A Many of the smaller fish and even quite a few of the larger fish we see feed on the small drifting organisms (plankton) or particulate matter. You see the smaller fish move into the cover of the reef only when a large groper or another predator swims into an area. They seem to recognize who has an interest in them and who does not.

Q Why are there corals in the cooler waters off southern Australia?

A While I do not knowing the specifics, two possibilities do come to mind. The first involves temporary range extension of a species. It is important to remember that animals do not always do what you expect. For example, on the Texas Gulf coast we have reef fish living close to shore during the summer. Many of these animals arrive as planktonic larvae transported in seasonally by currents from the tropics. Mild winter weather will make conditions favorable for the survival of these new arrivals and they may be present for a year or more. When the normal winter conditions return these animals perish.

There are also cold water corals, however they are generally smaller and do not form reefs like their tropical cousins. I have dived off California and seen such cold water corals, so perhaps the southern Australian ones are related to those.

Q We were told that the jellyfish in jellyfish lake do not sting. Is it true and why have they lost that ability? Also, why are some people more sensitive to stings than others?

A The sting strength can often be relative, at least with the less venomous Caribbean types with which I am familiar.