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The Elusive Decibel: Thoughts on Sonar and Marine Mammals

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Introduction

A few years ago, there was considerable controversy over the effects of a proposed global acoustic experiment designed to measure the temperature of the world's oceans¹. The focus of concern was the possible effect of the acoustic signals on whales and other marine life. There is continued interest in the effects of underwater sound on marine animals, according to a recent news item in *The Economist*² based on related scientific correspondence in *Nature*³. The thesis is that loud signals from experimental sonars harm marine mammals, or at least harass them enough to unacceptably alter their behavior patterns. In the various discussions of this important issue that can be found in the press and on the Internet, one often see questionable comparisons being made, such as the acoustic output of a naval sonar being compared with the noise from a jet aircraft. Some misunderstandings between professionals in different fields can be traced to the multiple uses of the term "decibel." Acoustic terms can be confusing, even for experts. It is not at all surprising that well-intentioned articles sometimes fail to present situations clearly. By definition, the decibel is a relative unit, not an absolute unit with a physical dimension; unless the standard is cited, the term "decibel" is to all intents and purposes

useless. The confusion is not helped by the use of decibel to specify distinctly different physical quantities, or the same physical quantity with different reference levels. Some reporters — and even some scientists — are getting their "apple" decibels mixed up with their "orange" decibels, as it were.

The decibel (dB) is simply a numerical scale used to compare the values of like quantities, usually power or intensity. Acousticians introduced the decibel to devise a compressed scale to represent the large dynamic range of sounds experienced by people from day to day, and also to acknowledge that humans — and presumably other animals — perceive loudness increases in a logarithmic, not linear, fashion. An intensity ratio of 10 translates into a level difference of 10dB⁴; a ratio of 100 translates into a level difference of 20dB; 1000 into 30 dB; and so on. The term "level" usually implies a decibel scale. In a uniform acoustic medium, the magnitude of the acoustic intensity is proportional to the square of the pressure for a freely-propagating sound wave. Accordingly, the level difference in decibels associated with two sound pressure values (measured in the same medium) is determined by calculating the ratio of the pressures, squaring this number, taking the logarithm (base 10), and multiplying by 10.⁵ If one

chooses a standard reference pressure value, then sound pressure levels can be specified in decibels relative to that reference, but this should be stated along with the number, for clarity.

The following is a typical erroneous statement found in the press, on radio, on television and on Internet discussion groups. Referring to an experimental sonar source that produces very low-frequency sound, *The Economist* wrote: "It has a maximum output of 230 decibels, compared with 100 decibels for a jumbo jet." Regardless of the author's intention, the implication is that a whale would experience an auditory effect from the sonar that would be substantially greater than that of a person exposed to the jet aircraft. However, this type of comparison is misleading for at least three reasons: (1) the reference sound pressure used in underwater acoustics and in air acoustics are not the same; (2) it compares a source level with a received level; and (3) there is no obvious connection between an annoying or harmful sound level for a human in air and an annoying or harmful sound level for a marine animal in water. In the remainder of this note, we will expand on these topics somewhat, attempt to correct the mistaken impression, and try to direct attention to the real issue at the heart of the controversy.

...continued on page 2

Standard Reference Sound Pressures In Air and In Water

The standard reference pressures used in underwater acoustics and in-air acoustics are not the same. In water, acousticians use a standard reference sound pressure of 1 micropascal (i.e. 10^{-6} newtons per square meter), abbreviated μPa . In air, acousticians use a higher standard reference sound pressure of 20 μPa . The in-air standard was chosen so that the threshold of hearing for a person with normal hearing would correspond to 0 dB at a frequency of 1000 Hz. Adopting different standards for air and water inevitably leads to a confusing consequence: the same sound pressure that acousticians label 0 decibels in air would be labeled 26 decibels in water. Presumably, both factions of acousticians had equally good reasons for proposing their respective standards, and this dichotomy is now entrenched in an ANSI standard⁶, which is unlikely to change. Accordingly, the following dictum should always be observed, especially when dealing with cross-disciplinary issues: *It is essential that sound levels stated in decibels include the reference pressure.*

Sound Level and Received Level

The erroneous statement compares a *source* level with a *received* level. In underwater acoustics, a source level usually represents the sound level at a distance of one meter from the source, while a received level is the sound level at the listener's actual position, which could be considerably more distant with a correspondingly reduced sound level. In an unbounded uniform medium, loudness decreases rapidly with increasing source-receiver distance, 6 dB less per doubling of distance. For example, *The Economist* (and even *Nature*), in referring to the 230 dB sonar source level, neglected to mention the reference distance of 1 meter. In contrast, the 100 dB number that *The Economist* associated with the jumbo jet is not a source level at all, but is typical of

a received level measure during jet airplane take-off, averaged over several microphones situated hundred to thousands of meters from the runway⁷. *It is incorrect to compare a source level at 1 meter with a received noise level at an unspecified (and probably much greater distance).*

Combining these two remarks, the output of the sonar source should have been written as 230 dB re 1 μPa at 1 m, while the jumbo jet noise level should have been written as 100 dB re 20 μPa . The inclusion of the reference values shows that these are not like quantities, and that the numbers are not directly comparable. *The*



*Encyclopedia of Acoustics*⁸ offers 120 dB re 20 μPa as a typical noise level associated with jet aircraft take-off measured at 500 m distance (although there is sure to be a wide variation about this number, depending upon the type of aircraft, etc.) With the assumption of spherical spreading, referencing this level back to 1 meter distance adds 54 dB. Switching to the 1 μPa standard reference adds another 26 dB. Accordingly, the source level of a large jet looks more like $120 + 54 + 26 = 200$ dB re 1 μPa at 1 m, compared with 230 dB re 1 μPa at 1 m for sonar. Both of these are loud sources, but now at least the comparison is sensible. The ratio of sound pressures is around 32, rather than over 3 million as some commenters would

have you believe!

There are other minor issues that could be discussed. The signal from the sonar is narrowband, and the concentration of all the signal at one frequency may be particularly troublesome for an animal that has a cavity that resonates at that frequency. On the other hand, the jet noise is broadband, and the acoustic signal was probably passed through a filter that approximately matches the sensitivity of the human ear before the measurement was made, so this measurement would be meaningless for an animal with a different sensitivity curve. Much more could be said about these issues, but the principal reason for raising them is to underscore the message that the sonar / jet plane comparison has little validity.

What Hurts?

There is no clear connection between a harmful sound level for a human in air and that for an animal in water. All creatures have evolved and adapted to their respective environments and there is no reason why human hearing characteristics should apply to any other animal, including whales. If a given sound pressure hurts a human, would the same sound pressure level in water hurt a whale (or a fish or shrimp)? Is the threshold of pain higher? Is it lower? Particularly when comparing acoustic effects in media of widely different impedance, is acoustic pressure the relevant acoustic quantity, or is it acoustic intensity?⁹ In the end, it is the answers to these and related questions that really matter, not juggling decibels. To properly answer these questions and to determine the "community" noise standards for marine animals, scientific research is necessary — just as it was for humans. Some of this work has been done, and an excellent review¹⁰ of the state of knowledge up to 1995 is a good starting point for acousticians and biologists interested in deepening their understanding. A single example cannot represent the whole range of species

...continued on page 8

Laguna San Ignacio

By Michelle Kinzel
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Each fall, gray whales end their summer feeding season and begin an incredible journey. The whales leave the rich and productive feeding grounds located in the Arctic and migrate south to Baja California, Mexico. Most of the population will swim 5,000 miles to the breeding and calving lagoons located along the Pacific side of Baja California. Here the whales congregate in breeding groups or give birth to the calves conceived the previous winter. This annual trek is the longest known migration of any mammal. The pregnant females are the first to arrive in the warm, protected waters of Mexico. The sexually mature adults are close behind, completing a breeding cycle that has enabled this magnificent species to recover from near decimation twice in the last century. Although the gray whale was officially removed from the U.S. Endangered Species List in 1994, it remains listed in Annex I of CITES, The Convention for International Trade of Endangered Species. Thus, the gray whale is still classified as an endangered species worldwide. Yet this species is once again facing eminent danger from proposed land development along the shores of one of the breeding and calving sanctuaries.

Currently, the last pristine and undeveloped calving lagoon, Laguna San Ignacio, is targeted for an industrial development with potentially staggering consequences. The Mitsubishi Corporation and the Mexican Government have joined efforts in a corporation known as Exportadora de Sal, S.A. (ESSA) in an effort to build the largest saltworks plant in the world, in the middle of Laguna San Ignacio. The gray whale population occupies three principal breeding grounds each spring, Magdalena Bay, Laguna San Ignacio and Laguna Ojo de Liebre. With a saltworks plant in operation in Guerrero Negro, near Laguna Ojo de Liebre and a 2,000 hectare tourist resort development in the planning stages for Magdalena Bay, Laguna San Ignacio stands alone as the final remaining pristine

World Class Nature Refuge..... Not an Industrial Wasteland, Not Yet

haven for these whales. This lagoon has the environmental and geological characteristics ideal for the production of industrial salt. The combination of low rainfall, high evaporation rates, little vegetation and impermeable soils make the site a highly desirable location for a saltworks plant.

But Laguna San Ignacio supports a wide array of plant and animal species. The lagoon and surrounding mangroves provide a wintering ground for hundreds of birds. The lagoon currently represents habitat for numerous marine and terrestrial plant and animal species, many of which are threatened or endangered. The upper portion of the lagoon also provides a birthing environment for gray whales which is free from noise, container ships, and urban pollution. In fact, the lagoon is located within the Vizcaíno Biosphere Preserve, the largest of Latin America's reserves. This reserve includes Laguna San Ignacio, Ojo de Liebre and Guerrero Negro. These three lagoons make up the Whale Sanctuary of El Vizcaíno. The entire Vizcaíno Preserve has been designated a UNESCO World Heritage Site in recognition of its status as a nature reserve. The initial proposal was rejected by the Mexican environmental authorities as being incompatible with the status of a biosphere preserve. The current proposal has been modified and is currently undergoing environmental impact assessment. However, we should not celebrate the "friendliness" of the new proposal or the prospect of a safe saltworks operation. The current proposed project, even after being redesigned to address the concerns raised by Mexican and International Environmental Groups, still promises to have several major impacts on the area and its resident plant and animal species.

If approved, the construction of the saltworks plant will destroy approximately 100,000 hectares of land by altering the entire watershed's drainage through increased erosion and influx of freshwater into the lagoon. The surrounding area will be dramatically impacted by noise, urban

development, physical disturbances and indirect economic development. Seventeen loud diesel engines would pump 6,000 gallons of salt water per second out of the lagoon around the clock, 365 days a year. This water would be directed into the 116 square miles of evaporating ponds, obviously displacing any plant or animal life currently inhabiting the area. The company intends to cut down the mangrove swamp in Bahia de Ballenas to make room for the pier. The loss of any ecosystem or wetland is devastating, but mangroves especially so, as they provide a habitat, feeding grounds or a nursery for thousands of bird, fish and invertebrate species. The mangroves in Laguna San Ignacio mark the northernmost limit of mangroves in the western hemisphere. Additionally, this 1.25 mile long pier would be built in a key abalone and lobster fisheries area. This conduit for transporting the salt to the ocean-going ships would also be located in the whales' migration path. 3,408,190 gallons of diesel fuel and toxic concentrated salt brine would be the by-products after one year of operation. This staggering accumulation of toxins and biohazards would only be separated from the lagoon itself by man made earthen dikes, creating a potential hazard from leakage or spillage. Changes in the eel grass beds will affect the 10,000 brant geese that winter in the lagoon. The large katarina scallop fishery will suffer consequences from the changes as well. Among the staggering list of species at risk are the peregrine falcon, golden eagle, osprey, northern pintail, blue-winged teal, American widgeon, lesser scaup, white pelican, green sea turtle, gray whale and countless fish and invertebrate species.

These potential dangers are neither contrived nor inconceivable. The small community of Las Lisas, located on a small sand strip between the Chiquimuililla canal and the Pacific Ocean in Guatemala has experienced negative effects from the advent of salt production. Twenty salt and shrimp factories have consumed thousands of hectares in that area over the past 15 years. This expansion has destroyed

...continued on page 10

Battling a Coral Disease in the Florida Keys National Marine Sanctuary

By Erik C. Franklin
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In the mid-1980s, a major outbreak of black band disease occurred in the Florida Keys, especially at the coral reefs in the Looe Key National Marine Sanctuary. Sanctuary managers were frustrated by the killer that was gradually overwhelming the majestic framework-building mountain star corals and brain corals. At the time, Sanctuary biologist Harold Hudson was determined to develop a technique to halt the progress of the disease. After experimenting with various ideas, he settled on an effective and inexpensive technique that uses an airlift to vacuum the black band from a coral head into a holding tank. Next, the treated area of exposed coral skeleton is capped with modeling clay to smother any remaining bacterial filaments. The bacteria are then brought ashore and destroyed to eliminate the potential re-infection of nearby corals. Hudson's technique appeared to successfully halt the immediate spread of the disease, but the long-term effects of the treatment were not adequately monitored.



Black band on Colpophyllia natans

Erik C. Franklin photo

Much has been discovered about the nature of black band disease, which was first documented in the early 1970s by scientists. The disease is initiated by a

cyanobacterium, *Phormidium corallyticum*, which resides in sediment depressions on a coral head. As summer approaches, rising sea temperatures promote the growth of this photosynthesizing bacterium. The mature stage of black band disease consists of a consortium of bacteria that infects injured coral heads and progressively smothers coral tissue. The bacteria are noticeable as a dark-purple, brown line that separates the margin of living coral tissue and dead skeleton. It is a virulent disease that can decimate large coral colonies over a period of several months.

Nearly a decade after the initial outbreak at Looe Key, another wave of black band assailed the reefs of the Keys. In response to the renewed threat of the disease, another attempt to combat black band was begun by the staff of the Florida Keys National Marine Sanctuary (FKNMS). Preventing coral degradation by treating coral diseases falls within the resource management responsibilities of the FKNMS. The mission of the Florida Keys National Marine Sanctuary is to conserve and enhance the biodiversity, ecological integrity, and cultural legacy of the marine resources surrounding the Keys. The incursion of black band endangered the unique coral reefs that prompted the designation of the Sanctuary in 1990. The National Oceanic and Atmospheric Administration (NOAA) and Florida Department of Environmental Protection (DEP) cooperatively manage the marine resources within the 2800 square nautical miles of the FKNMS.



Capping coral with modeling clay.

G.P. Schmahl photo

A three-year program to treat black band disease within the Sanctuary was established with funding from the National Marine Fisheries Service to the Florida DEP and the FKNMS. During the first year of the program in 1998, a total of 10 coral heads infected by 71 active black bands were treated. The total length of black band disease treated equaled approximately 60 feet. Linear spreading rates of black band disease have been recorded at about 1/8" per day. At this rate, the total length of black band treated could consume about 19 square feet of live coral tissue per month. This estimate provides a glimpse of the potential influence that black band disease has on the structure of coral reef communities.

Up until press time, the treated coral heads had not been re-infected. The corals have been tagged and will be monitored to assess the effectiveness of the technique. If the technique continues to be successful, a more intense treatment program will be pursued during 1999. As the summer approaches, Sanctuary staff is again preparing to quell the black band invasion and protect the precious marine resources of the Florida Keys National Marine Sanctuary.

If you wish to learn more about the activities that occur within the Florida Keys National Marine Sanctuary or would like to become involved with a project, visit the FKNMS web site at www.nos.noaa.gov/nmsp/fknms.

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Marine Turtle Research and Conservation in Greece

The Three Ages of a Field Project

By David Suggett and Thomas Stringell
Kefalonian Marine Turtle Project (KMTP)

Most field researchers working overseas will tell you that their achievements would be limited without some degree of co-operation from the native peoples. This may sound obvious, and why not? They have the most intimate, first hand knowledge of the land, its inhabitants and, often most importantly, its history. A close coupling between peoples and their 'working' environment meant that many South American peoples could describe periodic changes to ecosystem conditions, now assigned El Niño. On a smaller scale, it is common for hunters and fishermen to have an understanding of the life history of their prey in order to catch them. These relationships have fixed the basis of many cultures long before classical descriptions to science. Whilst the achievements of our field work in Greece is owed to the effort from volunteers of many different nations, the work has proved most eye-opening thanks to contributions from local peoples of a variety of backgrounds.

The Difficult Childhood

The Marine Turtle Project (U.K.) arrived on the Greek island of Kefalonia in 1984. Preliminary surveying described extensive nesting by loggerhead turtles, *Caretta caretta*, on the south coast of the island. The significance of this population was unknown, however, a field camp was swiftly established to describe this population relative to those from neighbouring islands. This initial settlement was basic and local peoples were relied upon for the provision of food and water. Despite this contact, there was relatively little communication with the locals concerning the activities of this foreign group. This was not deliberate, however, questions speculative stories quickly arouse: Smugglers? Poachers? Drug-users? Drug-dealers? The locals also felt cheated. Work permits had essentially been issued from the highest level of Greek government. This information was

slow to be provided to the locals and accusations of trespassing were rife. This lack of understanding was seen to be insignificant compared to the lack of respect and information given from the foreigners and a lack of co-operation followed.

A team of individuals from the U.K. continued to man the research on Kefalonia. For a few months each year this team would collect information regarding the dynamics of this population through tagging and morphometric studies. The position of the Marine Turtle Project (MTP) within the local communities failed to improve. Local peoples became increasingly disgruntled over the years since they were not getting any satisfying answers about this group of foreign people from either the government or from the group themselves. The speculative stories concerning the 'actual' nature of this group of foreigners gathered pace. The lack of communication between the MTP and the locals meant that the project volunteers were generally unaware of their ignorance. It wasn't until 1993 that serious problems of confrontation began to appear.

By this time, the research had revealed little more than a 9 year data set concerning the population dynamics and morphometrics from the largest nesting beach, Mounda Beach. In addition some casual surveying had revealed that there was also some nesting characteristic to beaches towards the north-west of the island, however, steep rock faces were implicated to impede nesting around the most northerly coast of the island. A group of locals confronted the researchers one night with instructions to leave. This action achieved little between the 2 parties. Furthermore, there became increasing concern by some volunteers within the project that the research on Kefalonia was providing nothing more than a short term colonial looting of the behaviour and ecology of this population of turtles. The project would require

severe (r)evolution if it were to continue.

The Mid-life Crisis?

The approach towards the conservation of sea turtles requires some degree of scientific application. If there is an uneven balance of research, fundamental parts of a population, or ecosystem, which require some effort of conservation will be neglected. Conservation approaches require a balance of effort from both research (knowledge) and conservation techniques. However, these approaches can conflict with those of foreign communities where compromises, for example culture and economy, are made. It was clear that before any serious conservation approach towards *Caretta caretta* was introduced on Kefalonia, there would have to be drastic changes with regards to the relationship between MTP and the local community. The 1994 field season was to provide the catalyst for such change.

In 1993 the MTP moved to a permanent base-camp site in the local village of Ano-Katelios and began to entertain patrons from an Italian environmental vacation scheme. This was to provide additional income towards the field research and logistical costs. This relationship was to last until 1996, however, their presence had already made a profound influence by the 1994 season. The volunteers from the U.K. were assigned to give them their environmental holiday. This responsibility initially appeared costly since less and less time was being devoted to scientific research, let alone promote conservation ideas. However, in hindsight, these circumstances in fact proved fortuitous. The volunteers from the U.K. had spent more time communicating with local peoples (albeit initiated through increased amenity use: bars, clubs, shops and restaurants) during 1994 than had occurred throughout the entire previous 9 years. Thus, it finally dawned on a handful of volunteers that the principles of the project were headed in the wrong direction down a one-way street.

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Turtle Research in Greece

A principle problem that emerged from talking with the locals (aside from the lack of communication, respect and understanding of culture!) was that there had been little continuity of people associated with the project. The MTP had returned year after year but with few, if any, familiar faces. The Greeks had no one they could trust, and who could blame them after nearly a decade of being ignored. Skeleton crews of volunteers from the U.K. returned to Kefalonia in 1995 and 1996 in order to expand the research that had potential and continue the growing links that were forming with the local communities. Most importantly, some well-known faces were beginning to emerge amongst the U.K. volunteers. The last great conflict that remained for the MTP was that the Italian organisation still dominated the time of the U.K. volunteers. As such, the 1996 season was to be the last with the involvement of the Italians, but this liberation (independence?) became a huge milestone.

This era remains one of the most turbulent for the history of the field project on Kefalonia. Most of the team were completing university qualifications and so outside of the field season very little could be achieved except fund raising and preparations for the next season. The scientific finds that were emerging were proving very exciting. This population was showing an ecology and behaviour that had very strange characteristics, most notably (at that time) a nest emergence period lasting up to 2 weeks. Indeed, research objectives had now expanded to cover many aspects of the life history of *Caretta caretta* that was associated with Kefalonia to include nesting behaviour, nest development, inter-nesting behaviour and ecology, to name a few. In all, it was frustrating. There was so much that could be done and there was boundless energy and enthusiasm, however, the basic funding and organisation were proving just too limiting. Furthermore, all this was occurring at a time when we were trying to salvage a working relationship with the local communities.

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The Golden Years

The period from the winter of 1996 up until the present time marks the maturity that has evolved through the history of the project and (some!) of the long standing volunteers involved. The project had become registered as a charity and returned under the guise Kefalonian Marine Turtle Project (KMTP). With the addition of specific branches and funding allocation to the project (all with respective scientific, conservation and logistic 'managers' who already had several seasons experience), pre-season training for volunteers, and vehicles that would last more than just one season, the project was starting to feel organised. More importantly, it felt as though our efforts were continuous as opposed to picking up (even repeating) the previous season. However, as with any golden era, not all things have run as quickly (or follow the most direct course) as our enthusiasm wanted.

The research side of the project is now essentially self-contained but, of course, lends itself to the conservational approaches. However, recent conversations with the locals have begun to reveal the most ground breaking of all finds. It is from these finds that it is apparent that not only has the power of the local community been gravely underestimated but that the ignorance associated with the approach by the MTP is quite unforgiving. The most important information has come from the local fishermen. This group of the community have the potential to act as an ally or an enemy to sea turtles. On Kefalonia, it appears that this decision must remain in recess since there is no universal relationship. Sea turtles appear to be drawn to the fishing nets around Kefalonia as a source of food, but often become entangled in the nets. Whilst some fishermen release them, others do not. This is not surprising since it is a function of individual values. Perhaps what is more important is the source of this entanglement.

The population of *Caretta caretta* has been monitored around the island of Kefalonia using plastic cow-ear tags since 1985. It is these tags that have been implicated as one of the contributory sources to entanglement. We have observed netting from fishing nets around the tags on nesting females, and must face the fact that if fishermen are to release entangled sea turtles we must compensate them. Without the help of these people we would also not know that a large number of both male and female sea turtles remain in Kefalonian waters over-winter, or that sea turtles of many different sizes have been washed ashore all round the year at different locations around the island. Nor would we be aware that a significant feeding ground for sea turtles exists at the best fishing grounds (later identified as a productive frontal region). Superficially, it appears we are again guilty of ignorance in presuming the approaches of the KMTP are useful, however, the story runs much deeper.

The issue concerning tagging could have been (indeed should have been) rectified years ago had anyone taken time to communicate with the fishing community. Other issues have surfaced in more recent years that have resulted in more immediate action. Much of the land that borders the nesting beaches is not typically owned by locals but by wealthy mainland developers. The nature of this circumstance still remains unclear to both us and the locals, irrespectively, it has resulted in tourism developments. There now exists one hotel and several other developments on the main nesting beach, where 5 years ago there was nothing. While we are unable to stop these constructions there have been alternative courses of action. The local government made a big difference for which we thank them. Whilst the buildings are not a local enterprise, the local building laws still have to be observed. The local government accepted and have now put to use a building charter drawn up by the KMTP to minimise impact on the nesting beaches from artefacts such as lighting and noise from both building works and the resultant development(s). At times a field

...continued on page 10

The Truth about the Makah Whale Hunt

By Dian Hardy
Environmental Activist

It's late on a starry night in mid-October when I pull into the small fishing port of Sekiu, close to my destination of Neah Bay. I have come here, to the northwestern edge of the continental United States, to try to understand why a modern people with ancient ties to the great whales wish to hunt them again after a period of some seventy years. The reservation at Neah Bay is the home of the Makah people, and the place from which the gray whale will be hunted. The Makah have claimed their ancient treaty rights to hunt whale and in 1997, they received an allotment of twenty whales over the next five years by means of a trade for bowhead whales brokered by the United States with Russia.

My eyes ache from two days of driving past clearcuts on the steep hillsides of Oregon and Washington. Certainly these clearcuts bear some weight in the decision of the Makah to seek re-establishment of their treaty rights to whale; profits from forestry and fishing have diminished severely over the last decade. Indeed, there is unemployment, teenage pregnancy, and poverty at Neah Bay. But there are also cell phones, satellite dishes, restaurants, a supermarket, a \$7.8 million dollar marina, fax machines, e-mail, Federal Express. Here, too, is great beauty and the potential for a viable ecotourist industry.

There is another reason the Makah may have to go whaling: there are great profits to be made. It is estimated that a gray whale is worth between \$500,000 and \$1 million to Japan. I have documents which show that as early as 1995, our government knew of the Makah's desire to establish a commercial fishery, not only in whales, but also in harbor seals, sea lions, minke whales and other small cetaceans, and sea otters, and to operate a processing plant to sell to markets outside the U.S. Such a plan may seem improbable now, yet if the Makah are able to proceed with their gray whale hunt, it is possible

to envision a return to worldwide whaling under the guise of indigenous cultural rights. And it would be our country and our "environmental" administration that brought this about.

At a meeting of a support group for the anti-whalers, I hear Lisa Distefano of Sea Shepherd, Heidi Tiura, captain of the Sea Dog, and Alberta Thompson, elder of the Makah, speak of their struggle to save the whales. Three remarkable women, and perhaps the most notable is Alberta Thompson, "Binkie," to her grandchildren and friends. She has lived all her life in Neah Bay. Alberta stands before us, upright in her seventy-four years, her hair raven black but for a pure white streak that haloes her face. She speaks quietly and simply, and tells us of her opposition to the whale hunt. When the whaling plan first surfaced, she was not alone in her dissent, but the others have fallen away and she has found herself standing alone. It is clear that dissent on this issue is not tolerated. She has lost her job, her dog was killed, her family has been harassed. When violence against nonviolent demonstrators flared recently, she was blamed. There is talk of detribalizing her, and she has been forced from her home. But, she says, it was all worth it, she would do it again. Taken by friends on a trip to the calving lagoons at Baja California, a mother whale brought her calf to the boat Binkie was on. Looking down at that trusting face, she stroked the whale and found her life changed.

On the morning I am to leave to return home, I awaken to realize I can sense the whales in the waters of the Strait of Juan de Fuca. Have I spent so much time on the water, in the presence of the whales, that I have in some way altered, and can now enter into their watery domain? As this longest migration of all mammals begins, I know a part of myself is traveling with these great and gentle creatures. I urge you to join this journey too: call your Congressional representative, ask for an investigation into the hunt and a moratorium while alternatives are

explored. Contact and support the work of the anti-whaler activists: the Sea Shepherd, In the Path of Giants, Progressive Animal Welfare Society and the Canadian Anti-Whaling Society. Even if it was the present administration which brought us the hunt, it will be our silence which gives it permission.



FIELD UPDATE, NEAH BAY
March 26, 1999

The gray whale migration was remarkable this year for several reasons: The whales completely bypassed the coasts of Washington and Oregon, disappointing both the Makah and whale watchers along the coast. Californians reported seeing the whales further out to sea than in recent years.

The migration was also delayed this year, possibly due to increased numbers of fish available in northern waters, a by-product of El Niño. Once the whales were spotted nearing the Baja California calving lagoon, however, their lowered numbers created concern among observers. Then, the discovery of unusually high mortality rates among the whales, sea turtles, and sea lions in that area brought the pitch of concern to high levels. Most deaths have occurred within the Vizcaino Biosphere reserve, the largest sanctuary of its type in Latin America.

These southerly concerns do not appear to have slowed the Makah hunt, although funding for the whalers is reported to have disappeared. A boycott on Washington state apples has been called and Clallam County commissioners have been presented with thousands of signatures asking the hunt be stopped. On March 23, in Friday Harbor, Washington, the San Juan County Board of Commissioners voted 3-0 to adopt a resolution opposing the Makah whale hunt. It's rumored that because of concerns expressed by the public, as well as increased interest by Congressional representatives, the hunt may be postponed until the fall. And, finally, a legal appeal asking the hunt be delayed pending more investigation has yet to be heard.

The Elusive Decibel

under consideration, but is typical: The response threshold of a Beluga at 1000 Hz is just over 100 dB re 1 μ Pa. Of course, this says nothing about the Beluga's threshold of pain, and says nothing about what sound level would unacceptably alter its behavior. *It is unwise to assume that the auditory experience of any animal would be the same as that of a human exposed to the same sound level.*

Conclusion

As sonar engineers, marine biologists, and environmentally conscious citizens continue to discuss these important issues, we should at least agree to use the same acoustical units to convey our point of view, to avoid confusion and misrepresentation. Some sensible acousticians have advocated abandoning the use of the decibel — which is partly to blame for

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- ¹ Whitlow W.L. Au *et al.*, "Acoustic effects of the ATOC signal (75 Hz, 195 dB) on dolphins and whales," *J. Acoust. Soc. Am.* **101**, 2973-2977 (1997).
- ² "Quiet please. Whales navigating," *The Economist*, 1998 March 7, page 85.
- ³ R. Frantiz, "Does acoustic testing strand whales?" *Nature* **392**, 1998 March 5, page 29.
- ⁴ In fact this defines 1 bel, named after Alexander Graham Bell. The bel turned out to be too large for practical purposes and the decibel — which is 1/10 of a bel — is the preferred unit. Also, one decibel is about the smallest incremental change of sound pressure level a person can sense.
- ⁵ Mathematically, this is equivalent to taking the logarithm of the pressure ratio and multiplying by 20, but knowing when to multiply by 10 or 20 in such calculations is an endless source of confusion to the neophyte, so we advocate the definition in the main text.
- ⁶ *American National Standard Preferred Reference Quantities for Acoustic Levels*, ANSI S1.8-1969, page 8.
- ⁷ Malcolm J. Crocker, editor, *The Encyclopedia of Acoustics*, (John Wiley and Sons, Inc. New York, 1977), page 1095.
- ⁸ Malcolm J. Crocker, editor, *The Encyclopedia of Acoustics*, (John Wiley and Sons, Inc. New York, 1977), page 11.
- ⁹ The suggestion that acoustic intensity has more bearing than sound pressure in this context has been seriously proposed by some acousticians; however, the available evidence gives the nod to sound pressure, not intensity.
- ¹⁰ W. John Richardson *et al.*, *Marine Mammals and Noise* (Academic Press, NY, 1995).

...continued from page 2

our woes — in favor of the good old SI (i.e., metric) units for sound pressure, acoustic intensity, power, etc. Until that happy day dawns, let us include reference values with our decibels, so we don't end up with fruit salad dBs. Ultimately, what is important is to determine what underwater sound levels are harmful to marine life. We must develop mitigating measures to allow underwater acoustic systems to be operated while ensuring the protection of the marine environment with due diligence.

The authors thank Harold M. Merklinger for his helpful comments on the manuscript.

This article was originally published in *Canadian Acoustics / Acoustique Canadienne* (1998). David M. F. Chapman may be contacted by email at dave.chapman@drea.dnd.ca.

Contributions!

Jon D. Lowry has contributed \$30,000 towards Baja California sea turtle research, a project which has been directed by Wallace J. Nichols for a number of years. Nichols' work includes the radio tagging of adult turtles off the Pacific coast of Baja and in the Sea of Cortez, and the writing of a Spanish-English book about turtles in Baja.

Contributions towards the reconstruction of the Douglas Robinson Sea Turtle Research Center in Ostional, Costa Rica are also being received. This facility was destroyed by fire in mid-1998. Leslie du Toit and Anny Chaves, are anxious to complete reconstruction and begin their marine research. Donations in March towards this project include: Roswitha S. Augusta, \$5,000; Richard A. Lowell, \$300; Ronald A. Javitch, \$200; Mary A. Donnelly, \$25; Marilee B. Henneberger, \$25; and Ardi J. Guilbeault, \$10.

It is the generous support of concerned individuals who keep research and conservation active. The staffing of field research, provisioning expeditions, developing educational materials, and bringing the excitement of marine life to children are costly efforts.



ASUPMATOMA photo

Scouts learn about hatchling turtles

We continue to seek financial support for Baja sea turtle nesting studies and restoration work, coral surveys at Cabo Pulmo Reef, and protection efforts of the gray whales' calving ground at Laguna San Ignacio. We are also seeking new and used laboratory equipment for the Ostional Research Center. Help us make a difference - join ORF today! Click on www.orf.org and get a free T-shirt!

Grupo Tortuguero de Baja California

First Meeting of Sea Turtle Group in Loreto Sets Goals for Marine Conservation in Baja California

By Dana Nichols

What do the members of five fishing communities, four non-profit organizations, three universities, two government institutions and a handful of travelers have in common?

In January 1999 they joined together, over 60 people in all, called themselves the Baja California Sea Turtle Group/ Grupo Tortuguero de Baja California, and spent the day learning about sea turtles and discussing the future of these ancient creatures in Baja California. "Never before has such a diverse group of people sat at the same table to discuss the delicate subject of sea turtle recovery in Baja California", said Wallace J. Nichols, a marine biologist studying the genetics and migration of Baja's turtles. "I am impressed by the overall feeling of cooperation and collaboration at this meeting. I think everyone felt that we were taking an important step today."

Nichols and his colleague Jeff Seminoff began their graduate careers at the University of Arizona and were told that there weren't enough turtles remaining for either of them to complete their proposed research projects. Now, five years later and nearing the completion of their PhD's they sit among a large group of people determined to change that. "Turtle populations in Baja hit their lowest levels in the early 1980's. There's still a long way to go before they recover but we are all hopeful-otherwise we wouldn't be here," Nichols notes. Seminoff makes it clear that "this is history in the making." And he says that he is motivated by the desire to "have turtles in the ocean for my kids to see some day."

Over the past five years the researchers have crossed paths and collaborated with several groups working regionally on local turtle issues. Biologists Antonio and Beatriz Resendiz have been working with

sea turtles for nearly twenty years in Bahía de los Angeles. ASUPMATOMA and students from the UABCS have been working to protect nesting beaches in the cape region and their projects have grown in size and numbers of turtles protected each year. Protected areas such as the Loreto National Marine Park provide needed protection for turtles and their habitat. Nichols is quick to point out that "fishermen are ultimately going to make the difference here-they are the ones who are dealing with sea turtles day in and day out."



The researchers also point out that without the participation of local fishermen their research projects wouldn't have gotten off of the ground. "I think I'd probably be lost at sea or dead by now without the help of some of these guys," Nichols insists, "and conservation efforts without community involvement at all stages just don't cut it."

The Nature Conservancy, Oceanic Resource Foundation (ORF) and the Chelonian Research Foundation sponsored this first meeting of the Turtle Group. The meeting was held at the office of Grupo Ecologista Antares, A.C. (GEA) in Loreto, BCS and was organized so that each participant had an equal voice to raise issues concerning sea turtle recovery and marine conservation.

Projects for 1999 were voted on and include the development of an Internet webpage for the group (www.baja-tortugas.org) and a bilingual photo guide to Baja's sea turtles. The next meeting of the group will be in January of 2000 in Loreto again and many participants are already looking forward to it.

Five different species of sea turtles come to Baja California to feed and reproduce from as far away as Japan, Hawaii and southern Mexico, the researchers have shown. The turtles were overharvested for many years through the early and middle of this century and now the populations are in need of some serious attention if they are to recover. The Baja California Sea Turtle Group aims to see that they have a fighting chance.

The group is in need of modest support for its efforts. Donations to help fund the year 2000 meeting and current projects will be accepted by GEA, Oceanic Resource Foundation (www.orf.org) in San Francisco, CA or via the turtle group's webpage.

For questions regarding the turtle group contact Fernando Arcas at GEA in Loreto at 113.50086 (gea@loretoweb.com.mx) or Wallace J. Nichols at 650.651.1579 or by email at jnichols@ag.arizona.edu.

Free T-Shirts!

That right! You can receive a free Grupo Tortuguero T-shirt by joining ORF with a membership of \$25 or more to support our next meeting . These quality cotton-poly shirts are white with the full-color turtle logo on the back and the ORF logo on the front, and are available in large or extra large. To join, you may mail us the form on page 12, along with your check, or FAX the form to us with your credit card information.

San Ignacio Lagoon

...continued from page 3

97% of the local mangrove forest. The forest strip is a mere 10-40 meters wide at the present, and the canal has become much shallower and wider. This change in habitat has pushed iguanas, pelicans and fish to the brink of extinction in that area. The local fisherman can now only harvest a small fraction of these resources on which they depend for subsistence. Guatemalan laws prohibiting the cutting of mangroves were not strong enough to withstand the pressure and enticement of the bribes from salt and shrimp businesses to the responsible officials.

By its own actions and refusal of initial proposals, the Mexican Government recognizes the danger and threat that the saltworks plant poses to Laguna San Ignacio. A Mexican Federal Government report dated July 1998 documented two spills of toxic brine waste into Laguna Ojo de Liebre. These spills have been implicated in the death of 94 endangered black sea turtles, and countless species of fish. It is also of note that following the construction of the saltworks operation at Guerrero Negro, the gray whale population abandoned the lagoon for over a decade. Their disappearance has been directly linked to the dredging of the lagoon mouth for the purpose of accommodating salt barge traffic. The whales did not return to the lagoon until the barge operations had been moved to another location.

The proposal of a salt works operation in a pristine biosphere reserve is quite disturbing. The proposed salt facility makes a mockery of the concept of a biosphere preserve. The project will destroy crucial

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core and buffer zones of Mexico's largest protected area. Numerous species will be displaced, habitat loss will be astronomical, and impacts yet unseen will undoubtedly occur. For the whales, the threats of boat collisions, loss of protected nursery areas and the inevitable bioaccumulation of toxins will be introduced if the construction of the saltworks operation is allowed. The gray whale has only been excluded from the endangered species list for 5 years. Perhaps we are rolling the dice a bit too soon for this still recovering species by allowing crucial habitat to be destroyed and introducing yet more threats caused by man. We should all be extremely cautious and vigilant in our efforts to protect this species.

Michelle Kinzel received her Bachelor's degree in Biology from San Diego State University and is

currently completing her Master's degree in Marine Science from Moss Landing Marine Laboratories. Her thesis work examined the respiratory behavior and feeding ecology of summering gray whales in Queen Charlotte Strait, British Columbia, Canada. She has studied the gray whales for six years, examining migratory behavior, physiological parameters associated with respiration and behavior of feeding whales. She has been a naturalist and trip leader with CERF for 4 years.



Turtle Research in Greece

...continued from page 6

researcher would be at a much greater advantage with a background in politics.

The conservation branch of the KMTP has grown exponentially since 1994. Simple tasks, such as slide shows to tourists were immediately introduced. These took place in local bars and hotels, therefore, demand by local bar owners to have these talks quickly grew. Talks are now routinely given in Greek throughout the local schools and villages. An information kiosk was established in Kato-Katelios in 1997. It is manned by an English and a Greek speaker to provide information for all ages about many aspects of Kefalonias' wildlife. The local children are taken to the beaches to learn more about wildlife and ecosystems. All of these actions have proved very successful and have shaped the standing of the project within the local community since the emphasis of education now focuses on the Greek communities. One of the most important details that directed much of this work is that many Kefalonians have never seen a sea turtle in the flesh.

A chance encounter with a bar owner at a gas station one October morning summarised what many locals felt. He described how when he was a boy he could remember walking along beaches in the early morning and seeing sea turtle nesting tracks every other metre. He was sad that where once there was forest on the mountain slopes there now remained the scars of logging and intensive livestock grazing. He sad that many local peoples felt that time was running out for the next generation to have as much as they did. Now a group of locals, of both older and younger generation, have become key figures involved in the research and conservation work of the KMTP.

The KMTP has come along way and it is exciting to think that if all of this has occurred at an exponential rate then what

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Postcards from the Field

Wendee Holtcamp Freelance Journalist ORF Board Member



Matthew Holtcamp photo

Wendee Holtcamp is a freelance journalist, essayist, photographer and poet based in southeast Texas who earned her M.S. in Wildlife Ecology from Texas A&M University. She can be reached through her web site www.greendzn.com. Her Discovery Channel Online Expedition "Love & Death at Turtle Beach," covering the leatherbacks of Costa Rica can be viewed online at www.discovery.com/exp/turtles/dispatch.html.



I found myself under a distant sky in January 1999, searching for monstrously sized leatherback turtles along a Costa Rican beach. It was dark, a zillion stars above, the smell of the surf sprinkled on the breeze. Walking near the surfline, we could spot them easily - darkened blobs lurking in the distance. Sea turtle biologist Dr. Frank Paladino led the motley crew - myself a journalist on assignment with Discovery Channel Online, Gene Bednarek - freelance photographer, and a varied team of Earthwatch volunteers.

Frank was continuing his quest to learn more about the creatures' biology, and to discover just why numbers of nesting

females are plummeting so drastically at Las Baulas National Park at Playa Grande. I was there for observation and reporting, but could I help but be drawn by the prehistoric creatures' animal magnetism?

The massive reptiles - striped black leathery oddities in the otherwise hard-shelled sea turtle kingdom - crawl painfully slowly up the beach, gravity weighing down their every move. Laboriously, they find their spot, carve out a deep cavity, lay a bundle of white leathery eggs, cover up, and head back to their watery home. Total time: two hours. I was enthralled.

The sea turtle rendezvous reminded me of what first called me to write, to awaken long-buried feelings of kinship with other creatures in all humankind. While some scientifically study the creatures, some work in the playing fields of protection and conservation, and some lobby for legislation, my job is to humbly try to inspire a sense of urgency for the former among those not yet involved.

Turtle Research in Greece

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do the next few years have in store? We have had the luxury of, until recently, learning many directions following other peoples wrong turns. This story is a summary of many years hard work along a winding road to establish a project that can contribute to a community it has essentially invaded. I would like to think we are less naive, however, would it be paranoid to assume that any legislation will always have an opposition party? There is still a lot of hard work to be done before we can consider a fourth age of the project whereby the KMTP must pass

away in order to be replaced by a completely new (community) generation, let alone establish self-propagating conservation strategies. Yes, the next few years will be very interesting indeed.

Thanks goes to everyone who has contributed to getting the project to where it is now, especially the Greek communities of Katelios, Skala and Ratzakli, and all KMTP / MTP volunteers over the years. Thanks also to Lily Venezelos and MEDASSET for their unbridled support.

Expeditions!

BAJA CALIFORNIA - Team up with One World Workforce on two projects. At Punta San Cristobal join ASUPMATOMA to help with the restoration of Olive Ridley sea turtles. Scheduled for August 27-September 3 and September 3-10, the cost is \$650 and includes transportation to and from the Cabo San Lucas airport, improved camp site lodging, and all meals. Round trip air fare to Cabo San Lucas is not included.

BAHIA de LOS ANGELES - Sea Turtle Station and the Brown Pelican Project. Work with Antonio and Bety Resendiz, and Eduardo Palacios. We will be in close contact with sea lions, whales, dolphins, and many other species of marine life. Scheduled for May 16-23, May 25-June 1, and October 3-11, the cost is \$650. Travel to Bahia de Los Angeles is by van and departs from San Diego. Ground transportation, lodging and meals are included. Transportation to San Diego is not included.

COSTA RICA - Assist researchers at the Douglas Robinson Marine Turtle Research Center at the Ostional Wildlife Refuge. Trips are scheduled on an individual basis from one week to one month duration. The cost for a typical two week trip is \$850. This includes the first and last night stay in a hotel in San Jose, domestic round trip air fare to Nosara, ground transportation from Nosara to Ostional, and lodging and meals at the Research Center. Air fare to and from San Jose is not included.

MISMALOYA, MEXICO - Turtle research with the Universidad de Guadalajara, September 18-25.

CABO PULMO REEF, BAJA - Coral reef surveys with Hector Reyes and Edgardo Ochoa from the Universidad Autonoma Baja California Sur, dates and cost to be announced.

For further information, contact ORF at 888-835-9478, via mail at P.O. Box 280216, San Francisco, CA 94128-0216, or email participate@orf.org.

ORF needs your support. Become a member today!

The Oceanic Resource Foundation is restoring sea turtles and conducting coral reef research in the ocean waters off the Baja California peninsula. Patrolling remote beaches, collecting turtle eggs and releasing hatchlings, tagging and monitoring adult turtles, and conducting underwater coral reef surveys and fish population counts require the participation of volunteers and sustaining contributions from environmentally concerned supporters.

Become an ORF member. Help us protect Baja's Vizcaino Biosphere Reserve (a UN World Heritage Site), Laguna San Ignacio and Bahia Magdalena, Cabo Pulmo National Marine Park, Loreto National Marine Park, and over 100 kilometers of turtle nesting beaches at Los Cabos. And help us rebuild the Douglas Robinson Turtle Research Center in Ostional, Costa Rica!

ORF is a 501(c)(3) tax-exempt organization.

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CURRENTS WINTER 98-99 INSIDE THIS ISSUE

Sonar and Marine Mammals	1-2
Laguna San Ignacio's Whales	3
Florida Keys National Marine Sanctuary	4
Turtle Research in Greece	5-6
The Makah Whale Hunt	7
Baja Tortuguero Meeting	9