GLOBAL CORAL REEF ALLIANCE
A non-profit organization for protection and sustainable management of coral reefs

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INFIERNILLO MARICULTURE RESOURCE ASSESSMENT PHASE 2, SEPTEMBER 2015

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The second phase of assessing the mariculture resource potential of Infiernillo Strait, between Sonora, Northwest Mexico, and Isla Tiburon in the Sea of Cortes was carried out in September 2015.

Due to limited time it was only possible to look at marine habitats in the southern and eastern sides of Infiernillo, and not those in the far north or northwest. The focus was on species that have potential for greatly increased production by mariculture. This report discusses only new information from this second trip, to be appended to the previous document on the findings and suggestions from the first trip.

Our team (Tom Goreau, Martin Jeffers, & Carlos Munguia) established excellent working relationships with key leaders of the Comca'ac fishing community, including Ricardo Comito Sesma (from Desemboque), the head of the Comca'ac Cooperativa Pesquera (Fishermen's Cooperative), Enrique Robles Barnett (from Punta Chueca), who will become the next hereditary chief of the entire Comca'ac community, Israel Robles Barnett, and others.

1. Callo de hacha

Both species of this extremely valuable mollusc, callo redondo and callo riñon, were observed by diving in their natural habitat. The callo were seen to grow isolated and dispersed, rather than clumped, and were buried in sediment with only around the top 10% above the surface. Comca'ac fishermen confirmed the extraordinary growth rate of callo, which must rank among the fastest of any shellfish. This exceptional growth is due to the quantity of rich food transported by the currents, which they filter from the water. The waters are green and turbid with suspended organic matter and plankton.

It seems clear that growth of callo could be greatly enhanced if they were suspended in mesh bags in the water, as is done for cultivation of pearl oysters and food oysters. It is not clear if their solitary and dispersed habits are due to competition for food, so experiments should be done with callo in separate bags, and with many together, to see if they compete and interfere with each other's feeding. If they can be grown together in bags, like oysters, that would be much more productive. Such cultivation would not only produce greater returns to Comca'ac fishermen, they could be suspended from buoys and be harvested directly from the surface without need for diving to collect them. Diving would only be needed to collect young live callo to be grown out in bags. This could produce much more income for the fishermen with much less work. The same techniques should be tested for growth of local pearl oysters, clams, and scallops. The growth rate would probably be greatly increased by use of Biorock technology, as has been shown for the North American oyster and for Indonesian and Polynesian pearl oysters. It is recommended that experiments be done to see if Biorock methods can enhance growth rates and production using floating solar panel rafts for power.

2. Corals

Coral communities were dived on in several locations. They consist of a single species of hard coral, almost certainly *Porites panamensis*. Since there was no hard rock bottom at any of these locations, the corals settle on rocks and pebbles lying on top of the soft sediment, typically 10 centimeters or less across. Due to the strong currents these rocks get rolled over, burying the corals in the sand and mud. Most of the corals were dead on the lower buried side, but continued growing on the upper side exposed to food and light. The constant rolling limits their growth and therefore their size. This rolling protects them from overgrowth by algae, which also settle on the stones, but are killed when rolled over. Nevertheless these corals were surprisingly abundant in many places, with live coral coverage of around 30% of more, more than many coral reefs.

These corals are perhaps the northernmost corals of the entire Eastern Pacific, and are likely expanding their range northwards due to global warming. One fossil specimen of the same species was seen in rich fossil shell beds exposed along the eastern shore of Infiernillo. These fossil beds are likely to be about 120-130,000 years old.

Peter Glynn, the world's top expert on the corals of the Eastern Pacific, tells me that he dived in the early 1950s on the southwest of Isla Tiburon, where these species grew directly on hard rock bottom, and got much larger than those seen in Infiernillo. Therefore the corals in Infierniello should be capable of much more growth if they are stabilized from being rolled over by the currents.

Biorock methods should allow these corals to be grown much faster to large size in structures above the bottom, where they are exposed to more light and food.

This would create real structural coral reefs where now there are only coral communities, and create habitat underneath them for fishes to hide from predators, in places where there is now little shelter, building up their populations. This should be especially effective in increasing lobster populations. It is recommended that experiments in Biorock coral growth be initiated in Infiernillo.

3. Algae

High algae abundances were observed in shallow water where there were sufficient pebbles for them to attach and grow. The nutrient levels are high, but the algae are limited by the small number of stones and shells on which to settle, and the fact that these are turned over by the strong currents, killing the algae. In particular, at least two species of *Gracilaria* were seen in shallow water. These produce economically valuable agar, used in the food, pharmaceutical, microbiological, and biotechnology industries. The quality of the agar determines its price. My colleagues and I have developed methods to grow *Gracilaria* at the highest rates ever documented, and due to the high nutrients in these waters, very rapid growth rates should be achieved on floating lines.

It is recommended that experiments be started to see if local species of *Gracilaria* can be grown in mariculture in Infiernillo, and the quality of the agar produced be measured. If both are high, a new, sustainable, economically-valuable product could be produced.

4. Salt plants

The estuary wetlands are bright green oases in the middle of the Sonoran Desert. The plants are adapted to grow in salt water, and since there is little land runoff of nutrients into the estuaries, they are mostly fed by oceanic nutrients from Infiernillo that are flow in with each high tide. The estuaries are critical nursery habitat for many species of juvenile fish and lobsters.

Some of these plants are quite productive, and are potential sources of bio-energy or food. One plant that commonly grows around the margins of the mangroves is *Salicornia*, which can be processed to produce biodiesel fuels. Another seagrass in Infiernillo is traditionally harvested for its seeds, which are cooked and eaten by the Comca'ac, the only people in the world to use marine plant grains for food.

Biorock methods have been shown to greatly increase the growth rate of sea grasses and intertidal salt marsh grasses, both above ground as well as the roots, and to allow them to be grown under conditions under which they normally can't survive. Experiments should be done using solar panels to see if the salt plants in the Infiernillo area can similarly be grown more rapidly, and explore the possibility of their large-scale cultivation.

5. Erosion

No hard bottom was seen. The bottom consisted of sand and mud mixed with pebbles. Corals, algae, sponges, and oysters settle and grow only on the pebbles. Sea grass areas were not observed on this trip, although Infiernillo has the largest area of sea grass in Western Mexico and in the Latin American Pacific. For that reason it also had historically the largest populations of green turtles in the eastern Pacific, which sustained the Comca'ac people during their 300 year exile on Isla Tiburon, hiding from Spanish and Mexican oppression. The areas of Infiernillo in the north and west that were not visited during this trip contain large sea grass beds with shellfish as seen during the current survey on the first trip. Sea grass only grows on well-lit shallow soft bottom and cannot grow on rock where the roots cannot establish itself, with the exception of one species of *Thallassodendron* found in the West Pacific and Indian Ocean. However using Biorock methods it has been possible to grow sea grasses (*Posidonia oceanica*) directly on rock with prolific root growth and development of shellfish and fish communities in places where they normally would not exist. This allows rapid restoration of sea grass where it has been lost. Normal methods of sea grass restoration have largely failed, either because the environment had become too polluted or muddy for sea grass, blocking light from turbidity or algae overgrowth, or the waves washed them away before the roots could become established. Therefore Biorock methods could be used to restore damaged seagrass areas and expand them, increasing the habitat and food for turtles.

Due to the very strong currents this is a very dynamic environment with high nutrients and strong sediment movement. The water was very green and turbid, with a visibility of 0.5 to 1 meter, but the vast majority of the suspended matter appeared to be organic matter and plankton, the food for the callo, clams, oysters, corals, and sponges, and not re-suspended mud or fine sediments. The area is sediment-starved, that is to say there is little input of fine sediments into the system, and the currents tend to wash out the mud, leaving behind coarser sand and pebbles. It is clear from the aerial images that the sand bars are very dynamic, and migrate during storms.

Our Comca'ac informants said that severe erosion was underway, and that the shore of Infiernillo was eroding away at 6-8 meters per year. There was clear evidence of a strong erosion event in the past year, both as erosion scarps on beaches, and dead mangroves in the estuaries that had been uprooted by waves. They said that this had occurred during a hurricane last year. But in addition the entire landscape bears the marks of tsunami events in the past. The Sea of Cortes contains the world's fastest spreading center, where new ocean floor is made from volcanic activity, which is pushing Baja California away from Sonora. The major activity lies in deep water to the west of Isla Tiburon. As a result this is an area of strong submarine earthquake activity, and due to the very

steep slopes on both sides of the submarine trench, these cause massive underwater landslides that trigger tsunamis. Much of the sediment in Infiernillo may have been put there by past tsunami erosion of the coasts, and may be now being slowly rearranged by the currents.

Biorock shore protection could provide a solution to the erosion problem wherever coral and oyster reefs could be grown. These are the most efficient mechanism for preventing shore erosion and causing beach growth that are known. Biorock reefs in the Maldives turned a severely eroding beach into 15 meters of new beach growth in a couple of years.

6. Diving compressors

The fishermen are using ordinary air compressors for hookah diving. No filters are being used on the air that the diver breathe, so the lubricating oil in the air pumps is being inhaled and coating their lungs, slowly killing them. I personally know of many places in the world where large numbers of divers have died from the effects of long-term unfiltered compressor oil inhalation. All such pumps should have filters so that the divers breathe clean air and protect their lives.

Gabriel Despaigne, a highly experienced commercial diver in Panama who has worked with Biorock for 20 years, recommends that the best and most cost-effective cartridges are the Hankinson HF 20 Filter packages, which come with indicators of filter life and the filters are reasonably priced and are easily changed:
https://www.nuvair.com/store/category/filtration/lp/hankison-hf-20-series-filter-packages.html
These should NOT be bought from this site, the link is purely for information, because their price is way too high and they can be bought for much less at any hardware store that sells compressed air tools.

Gabriel Despaigne also recommends use of a low-pressure tank. This also helps provide cleaner air by letting water vapor condense out, provides more even air pressure to the divers, and gives them an emergency air reserve in case the compressor fails:
https://www.nuvair.com/air-storage-containment/low-pressure-volume-tanks/
https://www.nuvair.com/store/horizontal-low-pressure-air-receivers-tanks.html
Once again he says these are available at much lower prices from any hardware store selling compressed air tools.

7. Training in sustainable marine resource management

Utilizing the rich sustainable natural resources of Infiernillo, which have supported the Comca'ac people throughout their history, for perhaps as much as 20,000 years, and managing them so that they can become more economically productive in the future, will take education and training in new methods. The

Comca'ac are acute observers of natural history, and have a wealth of knowledge of their habitat based on experience. This needs to be complemented with increased education in the modern science they need to understand their observations better, and use their environment as wisely and sustainably as possible. The aim of such training should be to preserve traditional knowledge, to add new concepts and tools for the Comca'ac to prepare for future challenges, and to be able to use information from the outside world and adapt it on their own terms to achieve their own goals for their greatest benefit.

I work with many indigenous communities around the world, and there are a wide variety of differences in how they deal with the outside world. Most indigenous communities have lost their culture and language once outsiders came in, stole their land, destroyed their cultural traditions, and forced them to follow foreign cultural traditions. Many of these groups live in severe poverty, with severe social problems, and have little or no opportunity to learn new concepts or advance their own future progress. Many have lost their cultures entirely and are oppressed and depressed, with little hope of advancement or getting ahead in a complex and changing world that has simply left them behind. The Kuna Indians of Panama, who I have worked with for more than 20 years, never lost their independence to the Spanish and their cultural and political institutions are intact because they do not allow outsiders to own anything in their lands, nor do they allow anyone to cut down their forests for cattle pastures. However, they also do not allow any outsiders to invest in their land, so they are unable to get funds for development. Their view is that it is better not to have outside money than to be controlled by it, but this has held back development that could have happened if they had allowed it to happen under their own control.

My aunt, Bertha Arango de Urriola, was the Panamanian Minister of Education who started the schools in the Indigenous Communities and personally trained the first generation of teachers. The Kunas greatly admire eloquent speech and knowledge and meet daily to discuss new ideas and information. As a result they love education, and although still very poor, they now have the highest level of educational participation of ANY group in Panama, including the very rich in Panama City. Because of their love of knowledge, and strong political institutions, they are well placed to adapt new ideas and use them to their best advantage. As a result they are eager to learn advanced concepts, and are not threatened by new knowledge, because they are secure in their sovereignty and able to adapt them to their own needs.

On the other hand, the Panamanian Indian community that I am descended from, the Ngobe Indians, the largest and poorest indigenous community in Panama, fears education as a tool to destroy their culture, and their response to the outside world has been to avoid it in order to live in traditional ways, which has prevented their economic development. I am also a hereditary leader of the Australian Aboriginal Yolgu people, who were so fierce in defending their land that the Australians simply decided to leave them alone on their land because

they had nothing worth stealing. My clan preserves a history that is 50,000 years old, they remember all the places they lived that were drowned beneath the sea at the end of the last Ice Age, 20,000 years ago. But unlike the Kuna, where power comes from sharing knowledge, Yolngu knowledge is secret, and cannot be given to anyone outside the clan. Thus they cannot share their knowledge, nor can they accept outside knowledge. Their only options are to live on their land in the traditional way, or move to towns and become alcoholics, and they are unable to deal with education or adapt to the modern world. The challenge to the Comca'ac is to be able to preserve their traditions while adapting to the outside world for their own benefit. This requires the sort of serious and disciplined approach that the Kunas have, but which most indigenous communities lack due to long histories of oppression.

It is recommended that an experimental research station in applied mariculture be started in the Comca'ac Ejido, focusing on practical experiments to determine the growth rate of the major living marine resources the Comca'ac use, and to see if they can be increased. This would involve hands-on work, as well as training and education in the scientific principles involved. This will give the fishermen a chance to learn new methods that should be much more productive, and to experiment with them to make them as effective as possible in the unique habitat of Infiernillo. Funding would need to be found not only for equipment and facilities, but also for scholarships for all of the Comca'ac involved so that they do not lose income by learning new methods.

Another focus of this research/educational facility should be to hire and train enthusiastic Comca'ac to map their resources for future management. This should include mapping of marine habitats and species distributions, monitoring erosion, compiling traditional knowledge about their environment and species with modern scientific information, and documenting traditional oral history and mythology related to the environment. Such efforts should be done in collaboration with Prescott College's Bahia Kino campus, which has done extremely impressive work with the Comca'ac for decades.

As part of this study, a community meeting was held to discuss the observations and suggestions from this and the previous visit. The meeting was held with the Punta Chueca community, and included Antonio Robles Torres, Jefe de Consejo de Ancianos (Chief of the Comca'ac Council of Elders), and the Comca'ac Governor, Genaro Gabriel Herrera Astorga. The audience was very attentive, and vigorous and positive discussion followed.

Tom Goreau discussing his observations and suggestions with the Comca'ac community at Punta Chueca.

The Chief of the Comca’ac Council of Elders (seated) listens attentively.