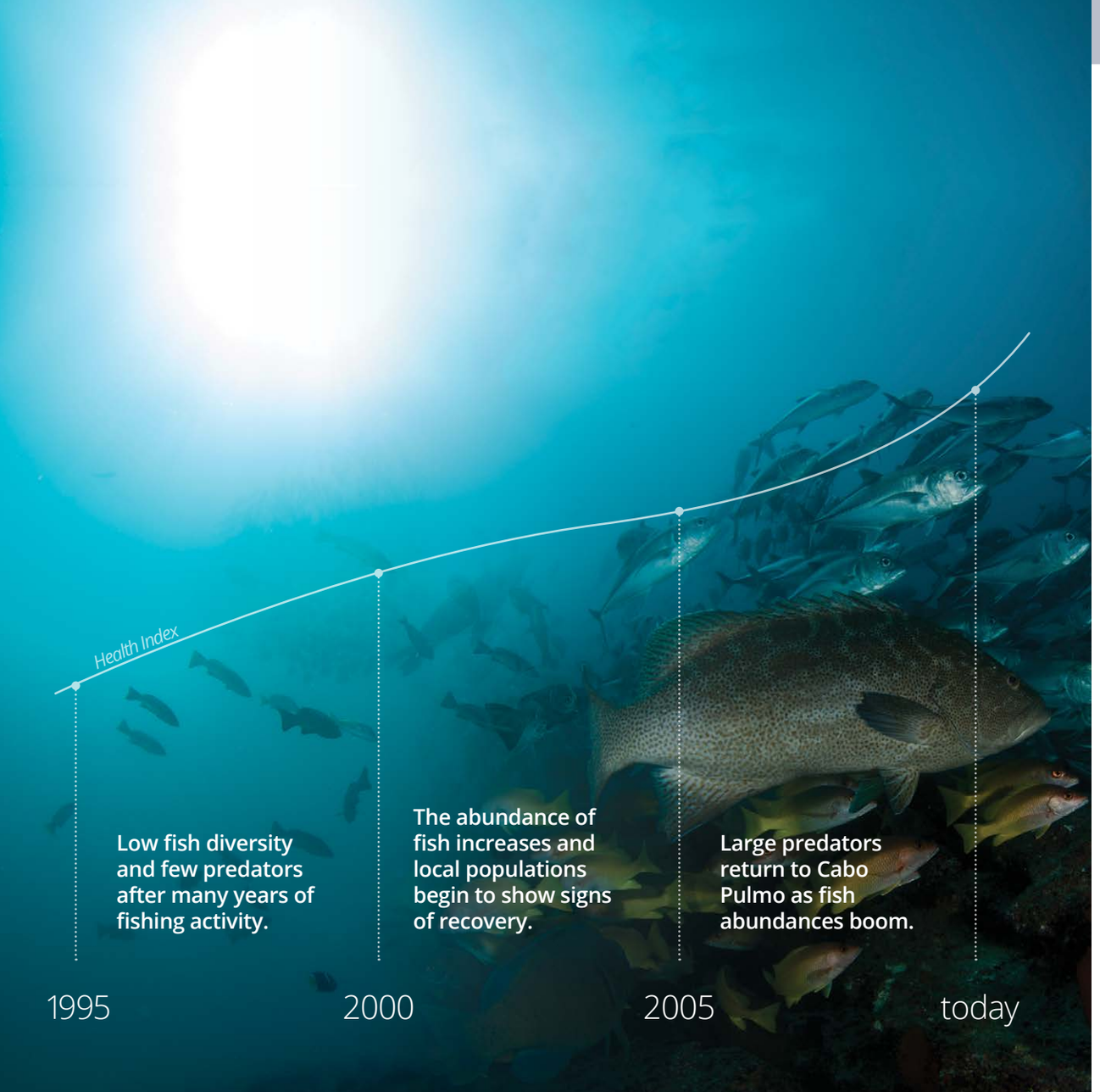
Cabo Pulmo Science

20 Years



intro

Just twenty years ago, the reefs at Cabo Pulmo were heavily degraded from a combination of sport and small-scale commercial fishing. Community foresight and hard work has turned this small village into a national park and conservation success story. A desire to develop sustainably and maintain the character of Cabo Pulmo has meant that the marine environment surrounding the community now thrives with life, as does the local economy of the village. Total fish biomass inside the reserve has increased more than 400% from pre-reserve levels and the abundance of sharks and other top predators now resemble some of the world's most pristine ecosystems.

1970's

Cabo Pulmo was heavily fished by the sports fishing community, a small artisanal fleet, and those working in the ornamental trade. Sharks and other large predators were regularly caught close to the coast and locals were benefiting greatly from the biological richness in the adjacent waters. Economic progress seemed easy and business was steadily increasing with consistently high catches and a steady influx of tourists visiting for fishing trips.

Left: Enrique Castro holds a hammerhead shark with tourists visiting Cabo Pulmo for its excellent sports fishing.

1980's

After more than a decade of lucrative sport fishing without formal management, top predators, such as sharks and marlin, began to decline in abundance and the focus of fishing operations turned to large reef species like grouper. As time progressed further, the reef was fished harder and harder, continuing to reduce both the number and size of the larger sport fish species.

Left: A happy tourist watches Juan Castro and a friend drag a huge grouper from a small fishing panga following a short trip out to Cabo Pulmo's reefs.

1990's

With sharks now a rare catch from Cabo Pulmo's waters and reef fish catches getting smaller by the season, Jesus Castro (one of the founding members of Cabo Pulmo) began to think seriously about the future of his village. There appeared to be two options: 1) to continue current activities until the reefs were depleted of fish and tourism stopped altogether or 2) cease fishing activities in an attempt to protect the reefs and the species that lived there, and begin bringing tourists to the area to admire the local natural beauty rather than harvest it.

Left: Jesus Castro stands overlooking Cabo Pulmo, considering the future of the village that had reached a critical moment in its short history.

Fortunately, several research groups, mainly from the Universidad Autónoma de Baja California Sur, gathered scientific information over many years that could help the community of Cabo Pulmo propose the formation of a National Park to the Mexican government in 1995. Some of the research topics can be seen below:

Turtle nesting ecology

• Nesting characteristics of the olive ridley turtle (Lepidochelys olivacea) in Cabo Pulmo, southern Baja California
Lopez-Castro et al.

Marine Protected Area evaluations

• Prospective and planning strategy for the northern-most coral reef of the Eastern Pacific: Cabo Pulmo, Gulf of California
Arizpe et al.

• Cabo Pulmo reef: A new marine reserve in the Gulf of California
Reyes-Bonilla

Local geological histories and sediment classifications

• Uranium-series ages of marine terrace corals from the Pacific Coast of North America and implications for last-interglacial sea-level history so quaternary research
Muhs et al.

• Sedimentary facies of the eastern Pacific's northernmost reef-like setting (Cabo Pulmo, MX)
Reigl et al.

Algal ecology and new terrestrial plant records

• Macroalgae of the coral reef of Cabo Pulmo Los Frailes, Southern Baja California, MX
Reyna and Rodriguez

• A new species of bidens (Asteraceae: Coreopsidae) from Baja California Sur, MX
Leon de la Laz and Medel-Narvarez

Invertebrate species identification, ecology and distribution

• Previous list of the polychaetes annelida polychaeta from Cabo Pulmo - Los Frailes Reef B.C.S. MX
Bastida-Zavala

• Range extension of Muricea hebes (Gorgonacea: Plexauridae) to the Gulf of California
Covarrubias et al.

• The echinoderms (Echinodermata) of Cabo Pulmo reef, Pacific of Mexico
Cintra Buenrostro et al.

• Brachyuran crabs of the Cabo Pulmo-Los Frailes reef and surrounding area, Gulf of California, MX
del Socorro Garcia-Madrigal

• A preliminary assessment of the invasiveness of the Indo-Pacific sponge Chalinula nematifera on coral communities from the tropical Eastern Pacific
Avila and Luis-Cabrillo

Reef fish feeding ecology, species checklists, community structure and monitoring techniques

• Population density, distribution and consumption rates of three corallivores at Cabo Pulmo reef, Gulf of California, MX
Reyes-Bonilla et al.

• Fishes of the Cabo Pulmo reef, Gulf of California, Mexico: Systematic checklist, abundance and biogeography
Villarreal-Cavazos et al.

• Community structure of fishes in Cabo Pulmo Reef, Gulf of California
Alvarez-Filip et al.

• Ichthyofauna monitoring using higher taxa in Cabo Pulmo National Park, MX
Saldivar-Lucio et al.

New species, ecology, climate change effects and historical paleo-records

• Coral-reef bleaching at Cabo Pulmo reef, Gulf of California, MX
Reyes-Bonilla

• Anomura from the Cabo Pulmo-Los Frailes reef and vicinity area, Gulf of California
del Socorro Garcia-Madrigal

• Stable isotope paleoenvironmental record of a coral from Cabo Pulmo, entrance to the Gulf of California, Mexico
Bernal and Carriqiry

• Coral Cd/Ca and Mn/Ca records of ENSO variability in the Gulf of California
Carriquiry and Villaescusa

• Effect of tropical storms on sexual and asexual reproduction in coral Pocillopora verrucosa subpopulations in the Gulf of California
Aranceta-Garza et al.

• A new genus of Antiliocorini from Baja California, MX (Hemiptera: Heteroptera: Lygaeoidea: Rhyparochromidae: Rhyparochrominae)
Peredo and Brailovsky

today

More than two decades since Enrique Castro decided to stop the sports fishing at Cabo Pulmo, the recovery of fish biomass inside the Cabo Pulmo National Park has lead to significant local economic benefits. Cabo Pulmo is a high diversity conservation success that highlights community-managed marine reserves and tourism are viable alternative solutions to unsustainable fisheries exploitations. The development of the National Park has benefited from years of scientific research, which continues today. An ongoing challenge is to understand the ecology of the area in a holistic manner; not only studying the ocean and marine life but also how certain processes link land and sea. With the key research topics in the following sections, the Gulf of California Marine Program wants to understand the benefits that this recovered area will have for future generations and how environmental forces will affect it.

Left: Local dive master David Castro is watched by thousands of big eye jack as he takes a photo in the Cabo Pulmo National Park.

LAND AND SEA AT CABO PULMO

BENJAMIN T. WILDER

SULA VANDERPLANK

EXEQUIEL EZCURRA

The terrestrial biodiversity of Cabo Pulmo

AIM

Investigate the transition zones between the succulent coastal vegetation and tropical deciduous forest in the foothills of the Sierra la Laguna. Aiming to answer the questions: What and how many species inhabit this gradient from the desert to the tropics and how many regional- or micro-endemic species are found in this biological hotspot?

METHOD

In order to document the biodiversity of the lands adjacent to the reefs of Cabo Pulmo, 21 researchers from 11 institutions (4 Mexico, 7 United States) have participated in the collection of data from around Cabo Pulmo. Participants from six disciplines (botany, mammalogy, ornithology, herpetology, entomology, and geography) have scoured approx. 14,600 acres (6,000 hectares) noting all of the species found.

RESEARCHERS

INSTITUTIONS

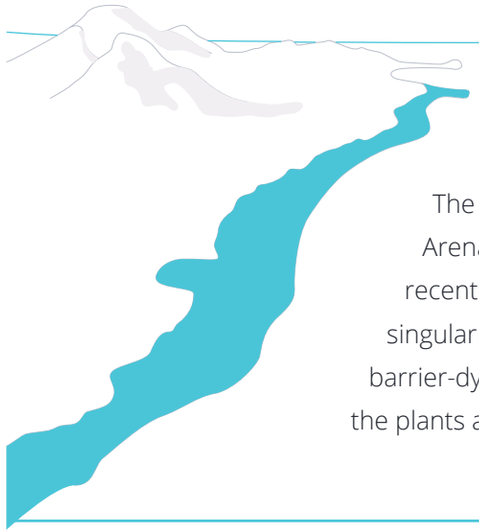
ACRES

The Cabo Pulmo region is surrounded by mountains, criss-crossed by arroyo streams running through desert, and dotted with dunes that grade into the turquoise waters that are rich in sea life. What has been given less recognition is the unique geologic history that sets the foundation for this biologic diversity and aesthetic beauty. Two geologic singularities, the beach ridges of Punta Arena and the coastal barrier-dykes of Cabo Pulmo, have different origins but foundational importance to the plants and animals found there. These have created a region of immense ecological richness and diversity.

As of 2015, a multinational interdisciplinary team of researchers has identified 416 plants, 44 mammals, 29 reptiles, and 95 birds from the lands adjacent to the Cabo Pulmo reef. Forty one of these species have formal conservation recognition as endangered species under Mexican NOM 059. The area of highest conservation importance is Punta Arena, an 11 square kilometer sand spit that contains two unique habitats, several micro-endemic plant species only known to occur within these habitats, threatened species of shorebirds and waterfowl, and nesting sea turtles. Work continues to document and understand the areas of greatest terrestrial diversity.

"We are discovering that it is not just the underwater biodiversity of Cabo Pulmo that is important, the adjacent coast and beach ridges of Punta Arena are home to plants found nowhere else in the world. It is an area of great fragility and endemism, unique locally and globally."

"The biological value of the lands adjacent to the reefs of Cabo Pulmo until recently had remained a mystery. Cabo Pulmo is as much of a biodiversity hotspot on land as it is at sea."



The area of highest conservation importance is Punta Arena, which has been the core development zone of recently proposed large-scale resorts. Two local geologic singularities, the beach ridges of Punta Arena and the coastal barrier-dykes of Cabo Pulmo, have foundational importance to the plants and animals in the area.

EGGS AT CABO PULMO

ANA LUISA M. AHERN

DAVID IVAN CASTRO ARVIZÚ

JAIME GÓMEZ GUTIÉRREZ

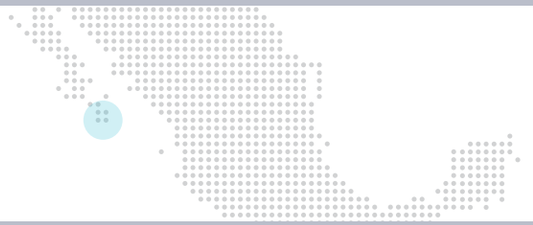
RICARDO J. SALDIERNA-MARTÍNEZ

ARTURO SÁNCHEZ UVERA

Exploring fish diversity and spawning periods through genetic analyses of fish eggs and larvae

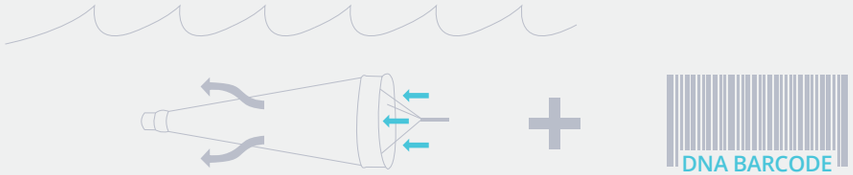
AIM

Identify the species composition, timing, and location of fish spawning in Cabo Pulmo.



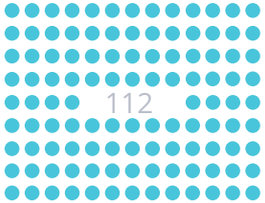
METHOD

Fish eggs and larvae are collected using plankton net tows. They are analyzed using DNA barcoding – sequencing a common gene and comparing it to a database of known species.



EGGS SORTED TO DATE

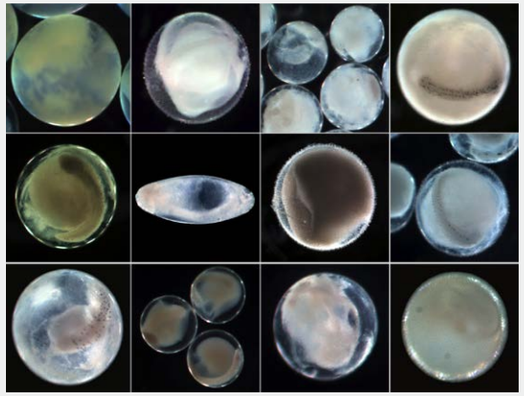
LARVAE SORTED TO DATE



112 SPECIES FROM 12 ORDERS GENETICALLY IDENTIFIED

Identification of fish eggs and larvae complements diver-conducted surveys, which until now have been the primary source of information about the species found in the Cabo Pulmo National Park. Studying fish eggs and larvae reveals a more accurate picture of the true biodiversity of the region than diver surveys alone. The new survey method used can detect the presence of species that would otherwise go unnoticed. This adds crucial information to scientific research and can be used to better inform conservation and management decisions in the area. A large number (approximately 50%) of the species identified in this survey to date are not included on published species lists from Cabo Pulmo, based on more traditional survey methods. Recent surveys have shown the presence of mesopelagic species (including the Giant Oarfish, *Regalecus glesne*) that point to Cabo Pulmo's connection to nearby underwater canyons, and several migratory species (including Mahi Mahi, *Coryphaena hippurus* and Roosterfish, *Nematistius pectoralis*) that are highly prized in recreational fisheries. This new data gives a better idea of what is really going on beneath the waves and will allows the Gulf of California Marine Program to monitor this biodiversity hotspot in the years to come.

"We are monitoring fish spawning activity in the Cabo Pulmo National Park on a weekly basis so we can evaluate the importance of the park as a refuge and as a source of fish eggs and larvae. This will help us understand the importance of the park, the influences of oceanographic conditions on fish spawning and how changes in climate may affect the future fish communities of Cabo Pulmo."



A diversity (12 orders) of fish species spawn in Cabo Pulmo's waters. Findings like these are further evidence of the importance of protecting fragile marine ecosystems and demonstrate that even small areas are worth preserving.

Results have identified species that would have otherwise been missed in traditional diver surveys, such as deep-water oarfish and popular sport fish like mahi mahi and the roosterfish.

DEEP-WATER OARFISH

ROOSTERFISH

MAHI MAHI

PASSIVE ACOUSTICS AT CABO PULMO

TIMOTHY J. ROWELL
JUAN JOSÉ COTA NIETO
BRAD ERISMAN

Cabo Pulmo as a refuge and spawning site for the endangered Gulf Grouper (*Mycteroperca jordani*).

AIM

To determine the importance of the Cabo Pulmo National Park as an area for spawning stock of the Gulf Grouper. It also aims to characterize the spawning behaviors, seasonality, and patterns of adult movement, habitat use, and distribution within the park. Understanding these spatial and temporal dynamics will elucidate how and when Gulf Grouper use the park, which in turn can be used to determine and develop additional refuges for this charismatic species.

METHOD

Currently, 19 Gulf Grouper have been tagged with acoustic telemetry devices that send out acoustic tracking signals to 12 receivers located throughout the National Park. As the fish move within the receivers, their locations are recorded, allowing researchers to see where individuals reside and how often they move from reef to reef. During spring 2015, researchers visited the park to locate a spawning aggregation of Gulf Grouper and document spawning behaviors and sound production associated with reproduction. Hydrophones were installed to record fish sounds and daily dives were conducted to observe and videotape these behaviors.

It is a big challenge trying to understand where animals live and why, especially in the marine environment. A 3D aquatic habitat makes marine species difficult to locate because a whole suite of factors like currents, tides, and lunar cycles can determine movements and residencies. Counting species helps to estimate population sizes and potential areas of preferred habitat, but these inferences are often transitory and can change dramatically over time. Tagging animals is a practical way to solve some of the errors of extrapolation and assumption. Tagged individuals can be followed within a certain area telling researchers about their common movements, specific habitat preferences, and potential social events within a population. By gaining insight into the detailed movements of the endangered Gulf Grouper, the Gulf of California Marine Program and collaborating scientists can begin to locate areas important for spawning and behaviors leading up to these events. This information can be used to advise management and conservation to protect this declining species.

"Our work focuses on understanding the movement and spawning behaviors of Gulf Grouper within Cabo Pulmo, none of which have ever been documented for this endangered species. The outcomes of this project will provide information that can be used to support protection recovery plans of Gulf Grouper throughout the Gulf of California. "

"Cabo Pulmo is one of a few places in the world where one can consistently observe high densities of small and large fishes in shallow waters. The success of the park can serve as a model for the creation of reserves throughout the world, where visitors and residents alike can appreciate the stunning potential of protected marine environments."

A SPAWNING AGGREGATION OF GULF GROUPER WAS DISCOVERED WITHIN THE PARK IN 2015 AND HAS REITERATED THE IMPORTANCE OF CABO PULMO AS A SOURCE OF LARVAE AND RECRUITMENT FOR ENDANGERED SPECIES IN THE REGION.

RESULTS SHOW THAT THE CABO PULMO NATIONAL PARK PROVIDES SEASONAL REFUGE FOR GULF GROUPER.

AS WITH NUMEROUS GROUPER SPECIES, MALE GULF GROUPER PRODUCE SOUNDS AS THEY COURT FEMALES IN AN UNDERWATER DANCE.

ACTIVE ACOUSTICS AT CABO PULMO


JACK PAUL EGERTON


BRIAN URIEL CASTRO ARVIZU

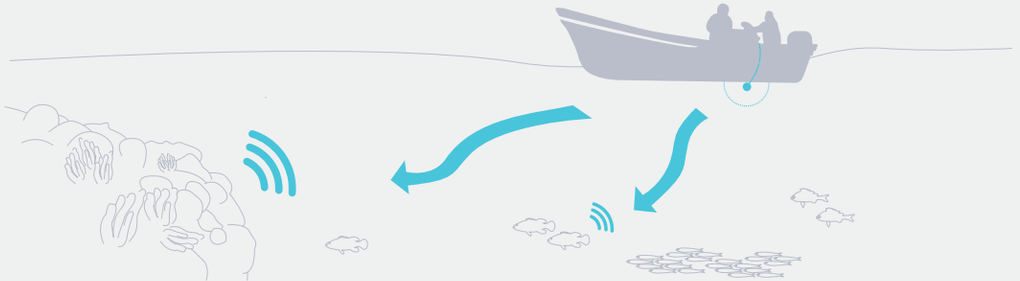

ANDREW FREDERICK JOHNSON

Hydroacoustic fish surveys of the Cabo Pulmo National Park

AIM

To compare acoustic fish abundance with the estimates gained via the Gulf of California Marine Program's annual long-term ecological monitoring program, and to compare fish abundance values inside the park versus adjacent control areas. The effect of habitat type (substrate) on the distribution of fish, and how this needs to be taken into account in the design of acoustic surveys are also part of the objectives of this study.

METHOD



A split-beam scientific echosounder, mounted over the side of a panga fishing boat was used to examine the abundance of fish within the survey areas. The system transmits a ping of sound vertically down through the water column. This ping reflects off any fish present and the strength of the reflected sound tells us about the fish. The echosounder also gives bathymetry and habitat type information. Within the park two separate surveys were conducted to allow comparison. Specific reef surveys were also conducted whereby the skipper used his local knowledge to follow the reefs in the areas.

Traditional fish survey techniques are often destructive or invasive (e.g. trawling/fishing) and therefore difficult to conduct within protected areas. There are also additional problems due to catchability and selectivity of fishing gears. Methods such as visual census via scuba diving are hampered by other issues such as depth limits, water clarity, and are labor and time intensive in general. Further, these methods often miss the pelagic component of the ecosystem. Active hydroacoustic techniques offer many solutions to some of these problems. They allow for rapid autonomous data acquisition, enable estimation of population sizes, and all raw data are retained instantaneously. Although it can be difficult to get species information for a diverse community such as Cabo Pulmo, the acoustic data can be manipulated and processed to give numbers of fish, an indication of fish sizes, proxies for biomass, and can be ground-truthed using in-water camera systems or diver evaluations. Hydroacoustics have been found to be a cost efficient way to monitor marine reserves but to date this has very seldom been put into practice.

"Cabo Pulmo is a great example of how marine systems can recover from overexploitation when appropriate management decisions are taken. It is important that areas like Cabo Pulmo continue to be protected and used as case studies to further conservation science and investigation."

"We are using Cabo Pulmo as a test ground for acoustic methods, which offer a way to rapidly assess the health of marine protected areas based on fish abundance."

10X

MEAN FISH ABUNDANCE WAS OVER TEN TIMES HIGHER IN THE CPNP COMPARED TO THE ADJACENT CONTROL AREAS.

4X

THE REEFS WITHIN THE PARK HAD OVER FOUR TIMES HIGHER FISH ABUNDANCE THAN ADJACENT SANDY AREAS.

THE VALUES FROM THE TWO SURVEYS WITHIN THE PARK DID NOT DIFFER SIGNIFICANTLY INDICATING GOOD REPEATABILITY OF THIS METHODOLOGY.

LONG-TERM ECOLOGICAL MONITORING AT CABO PULMO

Gulf of California long-term ecological monitoring program

AIM

To determine the health status of the reefs in the Cabo Pulmo National Park by collecting biological and ecological information on the fish and invertebrate communities inhabiting them. The information generated through this program helps researchers understand more about the evolution of the park and also provides information that may be relevant to other related coastal areas.

METHOD

Monitoring surveys are conducted once a year during summer. At least two pairs of divers are needed to conduct the visual census surveys at any particular site. One person from each team carries out the fish monitoring, while the other person surveys the invertebrates. The fish data is collected along a 50 meter, 5m wide long belt transect and for the invertebrates, the monitored area is 30 meters in length and 1 m in width.

Distinguishing anthropogenic change from natural trends in the environment is difficult. To help overcome this challenge, the Gulf of California Marine Program has conducted annual surveys—since 1998—to record changes in the structure, function, and overall health of the marine ecosystems in the Gulf of California. Divers quantitatively measure changes in fish and invertebrate abundance and density along mangroves, fishery regions, Sargassum (brown macroalgae) beds, rocky reefs, and other coastal habitats. Trends in these populations are continually tracked and analyzed to better unravel the complex human-environment interactions within the region. Patterns in diversity, density, size, and biomass of species indicate which sites fulfill larger ecological roles and demand greater protection or improved management. Overall, Cabo Pulmo has consistently shown high reef health, species richness and diversity and acts as a useful baseline to compare other reefs to throughout the Gulf of California.

"To determine the health status and track annual changes in the structure and function of marine ecosystems in the Gulf of California, we undertake annual surveys of the fish and invertebrate communities throughout the Gulf. We focus on habitats of ecological importance including rocky reefs, mangroves, sargassum beds and seamounts in order to understand how pressure from fisheries, pollution and climate change is affecting these systems. "

"The rocky reefs in Cabo Pulmo harbor an incredible richness, diversity and biomass of marine fish and invertebrate species. It is important that we continue to monitor this success story to describe the effects of long-term protection."

463%

THE ABSOLUTE INCREASE OF FISH BIOMASS IN CPNP BETWEEN 1999 AND 2009 IS THE LARGEST MEASURED IN A MARINE RESERVE WORLDWIDE (463%).

11X

THE BIOMASS OF TOP PREDATORS AND CARNIVORES INCREASED 11 AND 4 TIMES RESPECTIVELY IN THIS 10-YEAR TIME FRAME.

118

TO DATE WE HAVE RECORDED 118 FISH AND 81 INVERTEBRATE SPECIES INSIDE THE CABO PULMO NATIONAL PARK.

NEW EXPLORATIONS IN CABO PULMO

Exploring the deep waters around Cabo Pulmo

AIM

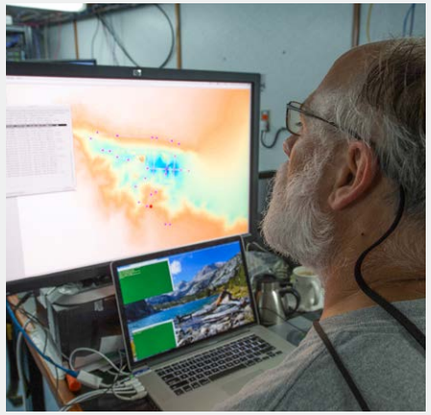
To map a deep coastal canyon that begins just 50 meters from the shoreline, south of Cabo Pulmo at Los Frailes. In addition to this new canyon exploration, the Gulf of California Marine Program wanted to see which species lived in the waters inside the canyon as well as the oceanographic conditions that exist in these deep waters.

METHOD

In order to draw a high resolution, textured bathymetric map of the canyon MBARI's Autonomous Underwater Vehicles (AUV) was launched from the RV Rachel Carson in March 2015. The AUV measured physical characteristics of the water (temperature, depth, salinity, dissolved oxygen) whilst mapping the seafloor and walls of the canyon travelling along a pre-programmed route. To see (in real-time) what life lay beneath the surface, the Gulf of California Marine Program used MBARI's mini-ROV to explore the canyon walls.

Cabo Pulmo is famous for its shallow reefs and incredible species diversity, but still very little is known about the deeper habitats surrounding the park. Complex bathymetry, underwater canyons and cliffs surrounding the park may help explain some of the patterns and populations seen there. It is therefore important that research efforts are expanded to included areas that cannot be surveyed using divers. In collaboration with scientists from MBARI, for the first time the Gulf of California Marine Program explored the deep Cabo Pulmo Canyon situated to the south of the park as well as a deep 200m contour running North-South along the parks boundary. Using MBARI's technologies, collaborating scientists produced a high-resolution map of the canyon floor and video transects exploring the canyon's steep walls. In addition to this new exploration, MBARI visited Cabo Pulmo at the end of their Sea of Cortez cruise leg and explored waters from 1000m to 200m running directly into the park. This gave researchers new information about how species and water characteristics (oxygen, salinity, turbidity, pH) change with depth moving towards Cabo Pulmo. The Gulf of California Marine Program hopes to continue these deeper water explorations using remote cameras and baited video to see what lurks outside of this incredible national park.

"Although the shallow reefs of Cabo Pulmo have been explored and documented for almost 20 years, very little is known about the deep waters surrounding the park that are out of reach of conventional SCUBA divers. For the first time exploration in the deep waters of Cabo Pulmo has begun to record species and habitats outside of one of the world's most important Marine Protected Areas."



"Cabo Pulmo is well known for its high diversity underwater life. This biological complexity is likely driven by the equally incredible geology of the region, from basaltic dykes to deep coastal canyons, which form complex habitats for a wide array of local species."

500m

THE CANYON AT LOS FRAILES EXTENDS TO ALMOST 500M DEPTH JUST 1KM FROM THE BEACH.

4km^2

OVER 4 KM^2 OF SEA FLOOR WAS MAPPED DURING THE EXPEDITION USING THE AUV.

?

VERY FEW ANIMALS WERE OBSERVED IN THE CANYON WHICH MAY BE RELATED TO THE PHYSICAL CHARACTERISTICS OF THE WATER WITHIN IT.

The Gulf of California Marine Program would like to thank the Walton Family Foundation, The Leona M. and Harry B. Helmsley Charitable Trust Foundation, David and Lucile Packard Foundation, International Community Foundation and the WWW Foundation for their support of the Gulf of California Marine Program that has allowed field research and information dissemination to take place in and around the Cabo Pulmo National Park.

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