Joseph Rossano

BOLD: Moorea

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About the project:

The Ontario Genomics Institute has partnered with renowned Seattle-based artist, Joseph Rossano, and biologists Dr. Paul Hebert, Dr. Chris Meyer, Dr. Hannah Stewart, and Seabird McKeon to engage the public around the science of DNA barcoding and how it is being used to catalog the world's vast – and threatened – biodiversity.

Among the many applications of DNA barcoding is its use as an important tool in modern conservation biology. Indeed, conservation is at the very core of this work, which provides viewers with the opportunity to reflect on the impact of humankind on our environment.

The species featured in BOLD: Moorea have been catalogued using DNA barcoding technology as part of the Moorea Biocode Project, which aims to create the first comprehensive inventory of all non-microbial life in a complex tropical ecosystem. The Moorea Biocode Project is based at the University of California Berkeley's Richard B. Gump South Pacific Research Station and France's Centre de Recherches Insulaires et Observatoire de l'Environment (CRIOBE) in Moorea.

About the sculptures: A note from the artist, Joseph Rossano

As an artist, I strive to distil ideas, concepts, and reality into their bare essence. My resulting minimalist sculptures, I hope, convey an emotion, ask a question, or direct the viewer on a path of introspection and investigation, as they explore man's impact on the environment.

My series "BOLD" is named for the acronym for the Barcode of Life Data Systems (BOLD) database. The subject of each specimen box is neither real nor is it an accurate representation of the creature it is designed to represent. The subjects of these sculptures are a jewelled representation of reality that draw the viewer in for a closer inspection. As the viewer shortens the distance between himself and the sculpture, the specimen becomes increasingly difficult to discern. The viewer, now confronted with the frustration of being unable to make out exactly what is in the box, discovers the clear and legible text surrounding the specimen.

What is the text on the side of each piece? The text is the 100% accurate representation of the specimen that attracted you. The text is the FASTA file, a textual representation of the DNA barcode that identifies the unique species.

What is the story of this specimen? What is a DNA barcode? I'm not a scientist; my role in this interactive collaboration is to distil reality into a visual hook that leads you to the answers.

Welcome to BOLD.

Introduction:

One way to think of a head of *Pocillopora* coral is as a storybook castle. It is the center of a community, and a defensible fortress. Soaring towers and turrets reach high above the coral reef structure, while dungeons and catacombs may plunge many feet below. And as with any castle, corals exist under threat from outside forces: there are dragons in this world in the form of coral eating seastars, and crabs like heavily armoured knights to chase them off. Beautiful and mischievous damselfish flit about, while sombre coral crouchers and gobies plot and scheme to find the next meal or mate. The coral may stand for centuries, or fall into ruin.

This project was meant to provide insight into the fauna of a coral head - and to introduce some of the characters that are frequently overlooked, but play important roles in the survival of the coral. In a community such as this many of the relationships are ***symbiotic*** - intimate arrangements between players. Some of these relationships are ***obligate*** - where the participants have little choice but to remain associated, while others are ***facultative*** meaning that the relationship is optional. Some symbioses are ***mutualistic,*** where both partners benefit. Others are ***parasitic,*** where one of the partners is exploiting the other. And some are ***commensal,*** where one partner benefits, while the other is neither aided nor harmed.

These arrangements are intricate and political - they may change with a higher temperature, as day goes to night, or with the addition of another character. Our role in the story is still being played out. From our actions onshore and in the atmosphere we are changing the environmental conditions that affect the entire reef community. Our removal of large reef predators such as groupers, the addition of sediment to the reef, or the increase of CO_2, have cascading effects. We simply do not know how these changes will affect the careful balance of power within the castle of *Pocillopora*.

BOLD-15

***Tetralia ocucaerulea* – Zorro crab**

It wasn't the crabs that I noticed on my daily swim over corals near the Gump Station in Moorea - it was their handy work. Small corals just off the shore were either healthy and thriving, or dead covered in silt and sand. The difference? Found between the branches of healthy corals are small white crabs with black masks, madly cleaning away any debris that lands on the coral. These are *Tetralia ocucaerulea*, commonly known as Zorro Crabs.

Named from the Latin '*oculus'*, meaning eye, and '*caeruleus*' for the sky blue lines on its eyestalks, it's the distinctive black Zorro-like mask which reflects the spirit of *Tetralia ocucaerulea*. They are the fierce protectors of *Acropora* corals, defending them from the dangers of sediment build-up that would otherwise damage and smother coral tissue. This protective tendency is not unique to this species – others do it, but none with the same fervor as *Tetralia ocucaerula.* Young and old, these crabs are adamant about keeping their host corals clean.

Tetraliid crabs are dorso-ventrally flattened – making it easier to move laterally between tight coral branches. Color patterns on the 'face' of these crabs are key taxonomic characteristics and important in advertising their species identity to other coral symbionts.

Tetraliid crabs are found throughout the Indo-Pacific region from the Red Sea to the east coast of Africa and to French Polynesia. *Tetralia ocucaerula* has been recorded in Guam, Moorea and the Northwestern Hawaiian Islands.

BOLD-16, BOLD-17

***Acanthaster planci* - Crown-of-Thorns Seastar**



There are very few natural forces that can destroy something as structurally complex as a coral reef - a large typhoon or storm, perhaps an earthquake or volcano. The scale is usually geological, not biological, withs one notable exception: *Acanthaster planci,* the Crown-of-Thorns seastar. No one knows exactly the circumstances that made this seastar lineage into the most voracious of coral predators. Its closest relatives are deep-sea sediment-feeders, but just a short time ago (...short in geological time, perhaps 3 million years) Crown-of-Thorns seastars came out of the mud and onto the reef.

The Crown-of-Thorns seastar is the second largest seastar in the ocean. It's a bizarre-looking animal! It has a general seastar shape with multiple legs radiating from a central disk, but this seastar is covered with sharp, venomous spines resembling thorns, giving this seastar its name. Making contact with a Crown-of-Thorns seastar is extremely painful, as these spines are long and sharp enough to puncture wetsuits and skin. A wound from a Crown-of-Thorns seastar can be painful for many hours, and a piece of a spine lodged in your skin can produce a nasty infection. It's no wonder that adult Crown-of-Thorns seastars have very few predators, though some large wrasses, the Giant Triton (a large marine snail) and a large anemone-like polyp have been reported to feed on adult Crown-of-Thorns seastars.

Crown-of-Thorns seastars feed on coral. They consume it by climbing on top of a coral head, everting their stomachs, secreting digestive juices onto the live coral tissue and slurping it up. They are primarily noctural, so it's rare to see one feeding in the daytime - they spend daylight hours hidden under ledges and bommies - but you can see where they've been by the feeding scars of white coral skeleton where the tissue has been removed. It's easy to forget that Crown-of-Thorns seastars are a natural part of a reef ecosystem - areas of coral that they clear provide space for settlement of new organisms. As reef systems are increasingly threatened by anthropogenic activities, however, the impact of outbreaks of Crown-of-Thorns seastars becomes more severe.

BOLD-18

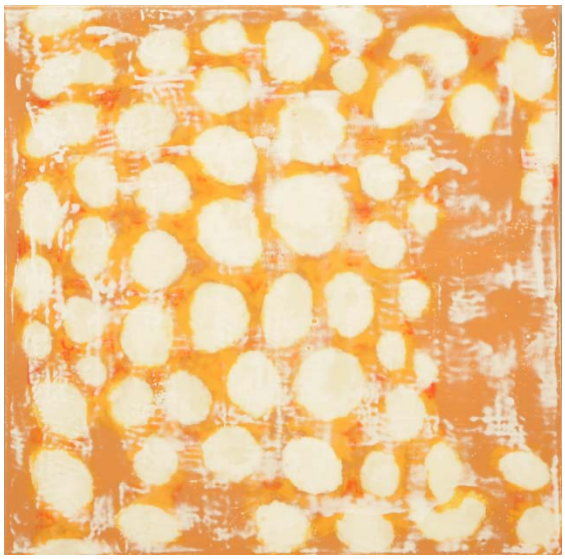
Trapezia rufopunctata

China white with bright red spots and green eyes, there is little mistaking *Trapezia rufopunctata*. This is the best known of the Guard Crabs associated with *Pocillopora,* with a range from French Polynesia in the Pacific Ocean all the way to the East Coast of Africa in the Indian Ocean. Like other *Trapezia*, *T.rufopunctata* is an aggressive guard of its host coral, and will do it's best to chase away coralivores that might eat the coral.

What does the crab get from this arrangement? The first benefit is shelter - *Trapezia* are found nowhere other than in live Pocilloporid corals. The second is food - the coral produces fat that is pushed up into the tentacles of the individual polyps. These tentacles are grazed on by the crab, reducing its need to ever leave the coral for food. This type of relationship, where both partners benefit, is a mutualism. You may know about "cleaner fish" and "cleaner shrimp", or clown fish and anemones, all of which are involved in mutualisms. As reef scientists explore and study the biodiversity of tropical oceans, we find more and more of these positive relationships.

BOLD-19

Trapezia flavopuncata



The idea that crabs may be able to defend their host corals from predators has been around for some time. That said, there have always been lingering doubts; how could such a little crab - about the size of two thumbnails - chase off something as large and scary as a Crown-of-Thorns seastar? And not just one seastar, but many, because when there's an outbreak of seastars, they frequently come in huge numbers.

When the most recent Crown-of-Thorns population outbreak was underway on the island of Moorea, French Polynesia, an interesting pattern emerged - as many corals were consumed by these voracious predators, the ones that survived belonged to a single species, *Pocillopora eydouxi*. What made this coral different from all the rest was the presence of the largest species of Trapeziid crab, *Trapezia flavopunctata*. It was a shocking display of how little things can make a big difference, and how important symbioses are in reef systems.

BOLD-20

Pocillopora woodjonesi

We have a tendency to think of corals much the same way we think about rocks, or plants. They don't really move, they can look a bit like flowers, and they provide structure and habitat to many other organisms. The reality is quite different - corals are animals, or really, many animals living as a single colony. Each one is an anemone-like polyp connected to adjacent polyps by a thin film of tissue. The polyps are largely identical on a genetic level, but retain autonomy when it comes to things like eating or reproduction.

Corals continue to masquerade as plants in another important way - they are able to harness the energy of the sun to make food. They do this through a symbiosis, a partnership, with a tiny single-celled alga called *Symbiodinium*. When the partnership is working properly both the coral and the algae benefit - the algae are protected inside the coral tissue and receive 'fertilizer' in the form of coral waste, and the coral is provided with all of the excess sugars the alga makes through photosynthesis. Sometimes the relationship doesn't work, due to high temperatures, or UV, or changes in salinity, all of which can stress this symbiosis. When this happens, the alga is expelled from the coral tissue. This is what causes "coral bleaching" and it is a major problem on reefs today. The animal part of the coral is still alive after bleaching, but they are much weaker without all the free food from the algae, and if they don't regain an algal symbiont they will eventually die.

BOLD-21

Sebastapistes fowleri **- Fowler's Scorpionfish**

When one says "scorpionfish", what comes to mind? Often conjured up are images of showy lionfish with their frilly displays or camouflaged stonefish lying in wait for their prey. More importantly, one should think, "Stay away" or "Be careful", for these guys are poisonous. These three groups of fishes (lionfish, stonefish and scorpionfish) have venomous spines capable of inflicting a nasty sting, thus the name. Some, like the lionfish, are more extravagant, while others are almost impossible to see – often it is the eye that is noticed before the body.

All scorpionfish are carnivorous - some slowly stalk their prey, while others are ambush predators – they dart out quickly, opening their wide mouths to create suction, and draw the prey in. You can find representative species all over the reef. The Fowler's scorpionfish is the world's smallest scorpionfish, residing deep within the branches of coral, almost imperceptible. Sampling in Moorea has shown them to be much more common than one might think, since they are not often seen lurking about. They take advantage of the structural protection of the coral and opportunistically feed on small crustaceans and other invertebrates that also hide among the branches. No place is safe from these ambush predators....

BOLD-22

Neocirrhites armatus **- Flame Hawkfish**

Look closely as you swim by the *Pocillopora* colonies - your eye is likely to catch a vision of a red sentinel perched among the branches of the colony. Most likely this is a hawkfish, one of two obligate species that live among *Pocillopora* colonies. These guys dart out and grab unsuspecting prey or flit about among the colony catching unwary creatures. They can brace themselves in among the branches with their thick pectoral rays so that even crashing waves have a hard time moving them. The two species commonly encountered in Moorea are the arc-eye and the flame hawfish. The arc-eye usually is poised at the top of the colony whereas the flame hawkfish likes to dart among the branches.

The details of the relationships between the two hawkfish species and other members of their community are unknown. Do they have the same menu? If so many species in these coral heads are obligates, do the hawkfish cut the residents a break? Are they eating the guard crabs or other species that provide some benefit to the system, or do they avoid these species and concentrate efforts on the more transient species that are not part of the network of usual players? Examination of these types of ecologic interactions helps us to understand how reef diversity is built. The use of snippets of DNA from the guts of the two species of hawfish allows us to determine exactly who they are eating. Turns out that the two hawkfish species each have a somewhat different diet - the larger arc-eye tends to feed on larger prey items, while the flame hawkfish eats smaller kinds of animals.

BOLD-23

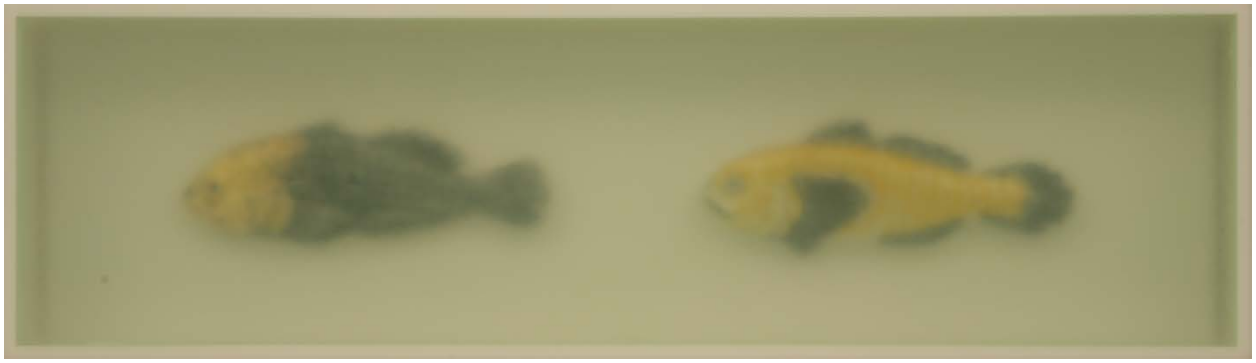
***Plectroglyphidon johnstonianus* – Blue-eyed Damselfish**

Perhaps the most visible fishes on coral reef are damselfishes. Small colorful and bold, they will sometimes even come out and nip a snorkeler that gets too close to their patch of algae, or clutch of eggs. The 'Blue-eyed Damselfish' displays these characteristics, and can be seen zipping in and out of the branches of large colonies of *Pocillopora* corals. Generally yellow with a bright blue eye and a dark bar across the base of the tail, these small fish are active defenders of their home coral from other fish. Coralivores such as butterfly fishes and filefish are quickly chased off, as are wrasses that might dart in to grab a shrimp or crab. This makes the relationship between the damselfish and the coral a mutualism - the coral gains a protector and the fish gains a place to live.

As with many partnerships, everything may look happy on the surface, but underneath a conflict lurks. The fish defends the coral, but is also feeding on it, nipping off polyps and tentacles as its own living larder, while the fish waste fertilizes the algae within the coral, aiding the growth of the coral. One thing is certain: the amount of 'benefit' that each partner receives is under continual negotiation, and both the fish and the coral are looking out for their own best interests. Just a slight change in the circumstances and a mutualism becomes a parasitism, where one partner benefits at the expense of the other. How and why these symbiotic relationships work is the subject of much of the research that is being conducted on coral reefs today.

BOLD-24

Paragobiodon modestus ***Paragobiodon lacunicolus***

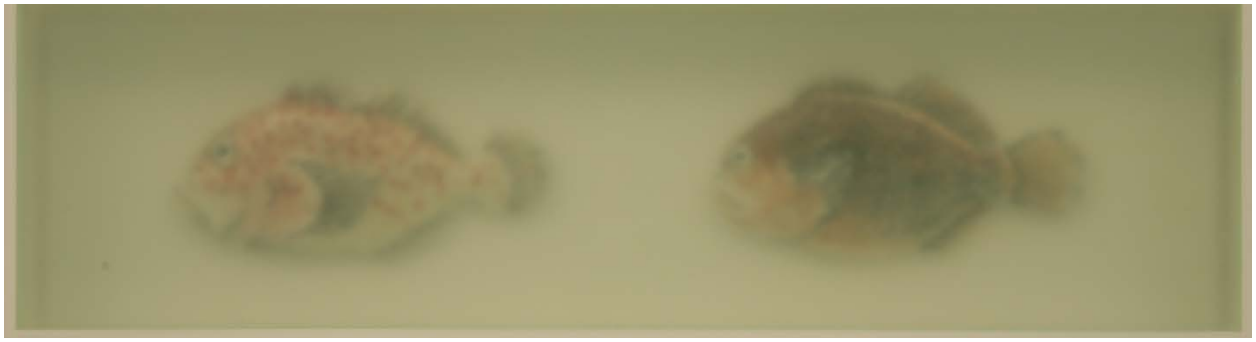


Gobies are among the most diverse group of fishes. They include the smallest species of known fish, bizarre forms like the mudskippers, and are the largest group of marine species of any family of fish. That said, they have a distinctive look - sometimes they appear to be "all head". It's a diverse, impressive group that has evolved to live in all sorts of strange places - like in the branches of coral!

The *Paragobiodon* species are parasites of coral. They live on it, lay their eggs on the underside of its branches, and eat it. No one knows very much about them because they are never seen outside of their coral hosts. They are what we call an "obligate" symbiont - this fish is only found in a particular species of coral. That level of intimacy between two different species has costs and benefits. The goby gain a precise ability to use the *Pocillopora* corals as a source of energy and shelter, but if a goby finds itself on a reef without *Pocillopora*, it is out of luck. This is a pattern seen over and over again in coral symbionts - many are specialists limited to a very narrow range of hosts. This "fine tuning" of the relationships between the organisms on the reef is part of what allows for such tremendous biodiversity.

BOLD-25

Caracanthis maculates ***Caracanthus unipinna***



Caracanthis unipinna, the Pygmy Coral Croucher, is easily overlooked within the branches of coral, and that is part of its plan. Looking like a harmless blob, this fish wedges itself between coral branches in the depths of the corals, preying on other coral-dwellers who come for shelter. It's covered with papillae, giving it a fuzzy appearance and a sponge disguise, but with venomous dorsal fin spines nothing about this fish is warm or soft. They can however, be nice to each other – males and females form monogamous pairs, and small groups of crouchers develop what may be complex social interactions within the depths of host corals. They are true to their corals, and once settled into one, spend the rest of their lives in that same coral head.

Caracanthis maculates, the Spotted Coral Croucher, is the good-looking, friendly cousin of the Pygmy Coral Croucher. It is light grey/tan in color with reddish spots, and its body is covered with papillae, giving it a furry appearance similar to *C. unipinna*. Like the other Coral Crouchers, it lives down in the depths of its host corals, eating unsuspecting invertebrates that venture into the coral branches. Because species of *Caracanthis* are hard to see, we know little about the ecology of these fishes, and the role they play on the reef - we think that they play an important role in regulating densities of coral-associated organisms. Despite all that is unknown about *Caranthis*, one thing is certain: When we peer into a coral head, whether we seem them or not, Crouchers are in there looking back out at us!

Acknowledgements

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To learn more please visit: http://www.ontariogenomics.ca/JosephRossano/bold-moorea