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Oceans

LUNAR SEAS ❖ SOVIET OCEANOGRAPHY ❖ BIMINI ❖ WASHINGTON STATE

by Jack Rudloe

ALTHOUGH biology was my first love, it became a meaningless, dull study for me while I was at the university. The thought of taking all those tedious courses that bore little or no relationship to my interests and goals was repugnant.

If I stayed on and suffered through the confines of the educational system, the future appeared dismal, for it was restricted to entering teaching and struggling for research grants. Confinement to an institution until the day I would be compelled to retire was a prospect that grew less and less appealing. So I dropped out of school.

I stood alone on a beach in Panacea, a little fishing village near Tallahassee, Florida—worried, with nothing to do and nothing to look forward to—when I saw some fishermen hauling their seines up on the beach. They were straining against the webbing and against the tremendous water force, holding the lead lines down to keep the school of frothing, beating mullet penned into a walled circle. They were rough, muscular men with big calloused hands and strong backs. Their red-faced, weathered women labored alongside them, holding the cork line up above the waves, helping to beach the seines.

I asked them if they wanted any help, and they were glad to have another back to help pull and strain. Digging our feet into the sand, we pulled up a few yards of webbing at a time, bringing the catch closer to shore.

Finally we dragged the haul onto the white, sandy beach. Among the hundreds of pounds of mullet, speckled trout and mackerel were the inedible stingrays, garfish, sea hares, jellyfishes, sea catfishes, pinfish, puffers and other "worthless" species. I helped the fishermen cull and load the saleable fish into wire baskets. It had been a profitable haul, they said, and they had earned over two hundred dollars in less than two hours. For my help, they gave me two large flounders.

As the boats chugged off, I looked back at the gasping, dying creatures along the sand dunes. Were they really worthless? What a waste of life! There was indeed money to be made from the ocean, but I had no desire to make it by commercial fishing. I wanted to be creative and still earn a living on my own terms. How could I achieve such a goal?

I wondered if the trash fish could be used. They were only a small percentage of the marine life discarded daily. Fishermen had tossed aside fishes like these for centuries. Oceanography as a growing science and potential enterprise has turned Man more and more to the sea. Surely there was a way I could share in its bounty and build my future upon it. These discarded animals could hold the answer.

I had studied many of them in school—specimens from biological supply houses in Chicago, North Carolina, Tennessee and Massachusetts. There were companies that sold dogfish sharks, skates, squids and many other sea creatures, as well as embalmed cats, microscope slides, skeletons and equipment for biology classes.

But I knew of no enterprise that specialized in live sea creatures—and they were all around me for the taking. At low tide multitudes of fiddler crabs seemed to cover every inch of the marsh flats, and at times horseshoe crabs by the thousands scrambled through the churning waves to pile up on the shore. Where to sell them? Why shouldn't I be the one to initiate and establish a market for live sea creatures?

I read assiduously through the biological catalogs and talked with Florida State University researchers, who were pleased with the idea of having a source of living marine organisms. When I had gathered enough small contracts for a start (such as an order for parasites that live in the intestines of sharks and rays), I went to Apalachicola, the largest shrimp port in west Florida, and volunteered to work on shrimp boats without pay, providing I could cull my own specimens.

The shrimpers were glad to get free labor. Another hand to separate the shrimp from the trash was most welcome. Most of them thought me a bit strange—to work that hard just to bring back trash fish. But I enjoyed being with them and listening to their talk.

When I dug through the mounds of myriad creatures that the net brought up from the sea floor, I was overwhelmed. So much color, so many strange and beautiful forms! The midshipman fish, *Porichthys porosissimus,* with its golden skin and jewel-like photophores, glowed at night with an eerie blue light. I was certain it could be useful in teaching or for research.

The purple sea pansies, *Renilla mulleri,* with their delicate polyps, also looked like cold blue fire when the net hauled them aboard. They, too, might be used in schools and laboratories.

As we culled basket after basket of shrimp from the catch, the little purple-striped rock shrimp were tossed overboard as trash, simply because the public is not acquainted with this delicious morsel that tastes more like lobster than shrimp.

There were electric rays, *Narcine brasiliensis,* with dark, mottled marks that resemble Egyptian hieroglyphics on their light gray skin—symbols that seem to spell a warning of their unpleasant little electric jolts. Speckled moray eels with mouths agape, revealing razor-sharp teeth, slithered out from the mound of life. An octopus, flushing furiously, oozed its way from under a sponge, pulling itself along the slimy white deck with its sucker disks.

Brick-red and brown slipper lobsters, *Scyllarus americanus,* with their rough shells and monstrous flaps covering their eyes, wriggled out of the yellow urn-shaped sponges, *Iricinia fasciculata.* The vivid pink shrimp, *Penaeus duorarum,* danced and jackknifed about. Small hammerhead sharks, scarlet sea squirts, lumps of pink and purple coral, puffers and spiny boxfish inflating themselves into prickly

Jack Rudloe

The author digs for sea worms in the northern Gulf of Mexico. Sea life others throw away piques his interest, but it took a while to learn where to market it.

round balls—all were so fascinating and different.

It was another world. If I found it so marvelous, surely others would, too. What a delightful way to learn about marine animals! It was much better to see them vivid and alive than to read about them in a book or to handle embalmed specimens. Surely professors would find their teaching chores much easier if they illustrated their lectures with live creatures, and certainly the students would benefit.

Seeing a live dogfish thrashing about on the trawler deck or at the end of the gill net was the real way to acquire an education. Watching schools of these sleek, gray sharks cruising through the shallows in search of prey was a different realm of pleasure and experience, and my interest in the dogfish, its migrations and movements, grew. All at once the anatomy that I had studied at school became meaningful.

University scientists were glad to get specimens of *Mustelus norrisi* for their intestinal parasites. They had never, in all their faunal surveys of Alligator Harbor, recorded that species of dogfish shark.

I knew now, for certain, that I was on the right track. There was bound to be a future for me in utilizing the discards from the nets. After making a few sales—including bullfrogs from the Tallahassee swamps and octopuses from trawlers—I bought an old shack in Panacea and christened it the Gulf Specimen Company.

Such an operation's lifeblood would have to be orders from the universities. During my travels to schools and research laboratories throughout the Northeast, I was urged to put out a list of marine life I could supply.

My first catalog was a mimeographed list and colorful description of the creatures that could be found in the shrimp nets. But it was a step toward the long, drawn-out process of taking inventory—or, as some marine laboratories term it, "making a faunal survey."

I had to determine what animals lived in the Apalachee Bay region, their abundance and whether they were common enough to be supplied on demand. I needed to know where and when to find them, on high tides or low, in dredge hauls, under rocks or by skin diving, and I had to know how to capture them. To make a living from the sea, the collector must know marine animals' seasonal movements—the time of year when hydroids blossom up from the wharf pilings; when the spotted sea hares move into the bays and come off the bottom to swim in the moonlight; when the little nereid worms leave their burrows and wriggle up to the surface to spawn. When these things happen, the collector must "get while the getting is good."

I was dismayed to find no single definitive reference and description of the southeastern United States' marine life. For many invertebrates, no keys were available. The fauna and flora in several southeastern localities, including Alligator Harbor, were only listed in various annotated faunal checklists—like names in telephone directories—and the material and descriptions behind the long Latin names were buried in the scientific literature. Many references were over a hundred years old.

But that problem was soon solved. Few Gulf of Mexico specimens were in the museum collections, hence taxonomists were pleased to identify my specimens. Some creatures turned out to be new species, and nearly all the rest were new distribution records. Many a morning I went to the post office and anxiously opened a letter from one of the major museums to learn the scientific name of the latest beast I had sent them. I could no longer call those bell-shaped

"Trash fish" culled by commercial fishermen like these shrimpers are usually thrown over the side. To author Rudloe, the "trash" is far more valuable than the shrimp itself. To start his Gulf Specimen Company, he once worked on such a shrimp boat without pay in return for the privilege of saving the cast-off sea life.

Florida State News Bureau

jellyfish no more than a centimeter (half-inch) long, with an X-shaped gonad in the umbrella, the "cross jellyfish." They were now *Nemopsis bachei,* a form of hydromedusae.

According to the holothurian specialist at Harvard's Museum of Comparative Zoology, those striped, brownish-pink sea cucumbers that were all over the flats clinging to eel grass were *Pentacta pygmaea.* I learned from the polyclad specialist at the American Museum of Natural History that the orange flatworms that live on *Molgula occidentalis,* the sea squirt, were *Prosthecereaus floridanus.* And those minute, reddish, coiled snails that were parasites on the giant, tube-dwelling scaleworms on Shell Point Reef were identified as *Cochliolepas parasitica* by the specialist at the Academy of Natural Sciences at Philadelphia. The long, sinuous, writhing, speckled scaleworm turned out to be *Polyodontes lupina,* according to a United States National Museum expert.

I was not only learning the inventory that the bay had to offer, but also where to find chitons and keyhole limpets; when to catch the pulsating, pink jellyfish, *Chrysaora quinquecirrha,* that swarmed in the bays, and where to dredge for the pointed white tusk shells, *Dentalium pilsbryi.* I found out that when sporadic or pelagic animals were not inshore, no amount of searching, dredging or trawling would produce them. I was accumulating valuable information that subsequently turned into the basis for an ecological survey.

Listing these creatures in a catalog not only brought me into taxonomy, but into physiology and biochemistry as well. To sell these specimens to research laboratories, I had to first learn if they had any use. Physiologists had never studied many sponges, coelenterates and other creatures, and so the market was distinctly limited. Most had never heard of *Xestospongia,* the orange and green sponge that encrusts a hermit crab and grows to massive size, finally engulfing the whole crab. They hardly knew the burrowing gray sea anemone, *Bunodactis stelloides,* that peppers the flats and, when touched, contracts down to what looks like a boiled onion. But when I started shipping this anemone to laboratories, it proved to be a splendid experimental animal in neurophysiology.

However, many animals that are traditionally used in biochemical studies were abundant in my collecting vicinity. The electric organs from the electric ray contain one of the highest concentrations of acetylcholine esterase (a compound that regulates nerve firings) found in a single biological system. The ancient brachiopod, *Glottidia pyramidata,* whose fossil relative, *Lingula,* dates back over four hundred million years, is a good source of the respiratory pigment, hemerythrin. Biochemists, paleontologists and geologists use this strange little mud-flat animal, with its bivalve-like shell and long white foot.

As word spread, orders started pouring in. Scientists never before had the opportunity to get living *Strombus alatus,* the Florida fighting conch that madly twists its foot and wriggles away when confronted by danger. Gulf Specimen Company now made *Thyonella gemmata,* the brownish-green sea cucumber containing hemoglobin red blood pigments, available for laboratory study.

Most orders led into new and interesting phases of collecting, such as seeking out and digging up the mud shrimp, *Upogebia affinis,* needed for an experiment in hormone regulation of color changes. They were nowhere to be found in the daytime, but a midnight trip with a gasoline lantern to the end of a mud flat produced the required dozen in short order. I dug lugworms on the flats, too, and dredged for the elusive *Amphioxus*—a little worm-like creature that may link invertebrates and vertebrates.

Orders for some of the inhabitants of the rocky outcrops that even the lowest tides never exposed brought me into the world of skin diving. Lumpy brown coral, *Siderastrea radians,* covered by thousands of knobby polyps, grew in scattered patches, as did the wiry sea whips, *Leptogorgia* and *Lophogorgia,* and the fuzzy rock clams, *Pseudochama.*

Through my diving mask I saw great loggerhead sponges, forests of brown *Sargassum* seaweed and chunks of pink, green and blue sea pork. As I swam along the bottom, I stuffed orange starfish, *Echinaster spinulosus,* into my diving bag and plucked *Pennaria* hydroids from their holdfasts, learning quickly how severely they sting.

Brown stone crabs, *Menippe mercenaria,* with black-tipped claws, peered from their burrows and ducked out of sight at my approach. Featherduster worms yanked their maroon, branching tentacles into their tubes at the appearance of a shadow. Schools of black-and-white-striped spadefish and greenish-yellow menhaden swam by. Skates, stingrays and flounders wallowed in the sand. This was a different, enjoyable way of collecting creatures in their natural habitat.

Working from an outboard skiff, I experimented with many different tools—dredges, plankton nets and small otter trawls. The Gulf squid, *Lolliguncula brevis,* died after being captured in a standard shrimp net, so I tried a lighter net that brought them in faster without hurting them. After a

few weeks I abandoned that technique in favor of dipping them up at night after attracting them with a strong light shone upon the dark waters.

When I had few orders, it was easy to gather enough specimens to meet the demand. But when business picked up, things were not so simple. If an order came in for an oyster sponge, *Stelletta grubii,* I could not drop everything to run down to Leonard's Landing in Alligator Harbor, collect a sponge, pack it in seawater or freeze it, and put it on a plane the same day. There were too many animals to collect from too many places, and bad weather or unfavorable tides often interfered.

I had to learn about marine animal husbandry, seawater systems and the techniques of keeping creatures alive. Then I could do my harvesting when the animals were most abundant—and in good weather and calm seas—and have them on hand when the orders came in.

The Gulf Specimen Company had reached a threshold. It was too big for me to handle alone. It could either collapse from failure to meet its commitments, or it could expand, take on a staff and purchase professional collecting equipment. Several big orders from the National Institutes of Health decided me. The NIH wanted hundreds of marine animals in pound quantities, freshly ground and preserved in alcohol, for a vast cancer research program. To supply the specimens, I purchased a small shrimp boat.

In the beginning I never dreamed that commercial shrimping operations would interest me. I planned to use the trawler only to collect specimens. But the captain who came with the trawler had been a commercial shrimper and fisherman all his life and was outraged at my intentions to toss the valuable shrimp overboard and only keep things like spider crabs, electric rays and puffers.

He took a firm stand. "As long as I'm captain of this boat, we're going to save what shrimp we catch." So to keep him happy, we saved the shrimp along with the edible fish.

The captain was right. The shrimp turned out to be a good source of major capital. They helped offset the salaries and operating costs yet were fully compatible with the business of supplying specimens. We renamed the trawler PENAEUS—the scientific name of the commercial penaeid shrimps—and established ourselves with the local fish companies.

The PENAEUS required modification to keep animals alive. We installed holding tanks, extra pumps and oxygen cylinders, and used insulation to control temperature. Some of the most delicate animals have to be placed in plastic bags of seawater and given oxygen the minute they pour out of the net.

Keeping marine animals alive is far from simple. How do you maintain a big watery jellyfish or a bonnethead shark? How can you keep a captured squid from becoming frantic and going into irreversible shock? How should you treat the bacterial rot that kills many confined sea creatures?

We eventually solved some of these problems. After experimenting three years, we can now keep a multitude of fishes in our tanks and also certain species of sponges, coral, flatworms and crabs. Even octopuses are maintained with little difficulty. But their close relatives, the squids, remain a problem. One reason for so much interest in keeping squids alive is because their giant axonic processes have proven to be a most valuable tool in neurological research. Biological and medical scientists from all of the United States as well as Europe come to the Marine Biological Laboratory in Woods Hole, Massachusetts, just to study squid.

The laboratory charters a large vessel that drags its trawls for short intervals and catches squids, blushing, squirting ink and forlornly flapping their tail fins. The crew dumps them into vats of seawater, which is rapidly pumped from the ocean and exchanged through the tanks. The squids are trucked to the laboratory holding-tanks and distributed to the awaiting scientists, while the boat goes out for more.

The commercial concern that develops the techniques of keeping squid, culturing them and shipping them alive to inland laboratories, will do well. The capability would save the scientific community much time and expense.

Shipping other creatures live was also a problem for us and involved another research and development phase. When we began, many creatures arrived dead at the laboratories or died before they could be used for teaching and research. This meant dissatisfied customers and the duplication of orders with the subsequent loss of income. Overheating, freezing and delay generally caused the deaths.

By painstaking control of temperature and oxygen saturation in sealed containers, we developed efficient shipping methods. Less than five percent of our shipments now encounter trouble. An express or freight agency has even left a box of specimens on a loading ramp for days before delivering it, and all the specimens have still arrived in good condition. As a result of such techniques, live blue crabs, *Callinectes sapidus,* can be shipped far inland and served at restaurants.

Our research and development phase continued, financed by the sale of specimens and additional capital. Would sea creatures from the Gulf survive in artificial salt water? There was a constant demand for fertile sea urchins, *Arbacia punctulata,* which are so essential for embryological study because the entire cell division process can be observed within a few hours. But they did not do well in some closed aquarium systems. In artificial seawater, their spines drooped; they quit moving and soon died.

The short-spined sea urchins, *Lytechinus variegatus,* survived beautifully for long periods, enabling researchers and teachers to extract sperm and egg from aquarium specimens, inseminate them and watch the entire cell division process. But the *Lytechinus* eggs were fertile only from April to September, and then *Arbacia* filled in and were fertile from October to March.

Later we learned to increase the fertility span in both species through temperature control and proper diet. But how could the sensitive *Arbacia* be kept alive in a Chicago or Michigan laboratory? That problem we finally solved by shipping carboys of natural seawater along with the *Arbacia.*

Other difficulties arose. Many burrowing animals survive only in mud, but mud in a closed aquarium tends to build up hydrogen sulfide, which causes the soft-bodied, delicate organisms to deteriorate. We had to develop a filter for a mud-flat aquarium.

We tried to maintain a balanced ecology in our tanks and to keep incompatible specimens isolated. The pinching blue crabs readily devoured the scallops, and so did the conchs and sea urchins. The octopus would peer from his lair—a short piece of sewer pipe—and then pounce upon a hapless blue crab and drag it off. In a short while a pile of crab shells would spew out of the pipe. We learned that sea urchins were eating the batfish, and the stone crabs were dining on sea urchins. We were always removing skeletons, empty mollusk shells and sea urchin tests. Even the inconspicuous grass shrimp, *Palaemonetes pugio,* was feeding on the precious *Amphioxus,* which sold for five dollars apiece.

To keep the animals from eating all our profit, we isolated

The Gulf Specimen Company's collecting boat at left, PENAEUS, *is named for a genus of common, edible shrimp. Knowledge of seasonal movements of marine life is vital for the successful specimen collector.*

The left-handed (or lightning) whelk, Busycon contrarium, *is a large predatory snail that must be kept away from other specimens.*

This spider crab, a master of camouflage, has covered itself with the calcareous plates of the alga Halimeda *for protection.*

William M. Stephens

These "flowers of the sea" —tubeworms—are abundant in rocky areas and are easy to keep alive for shipment.

Jack Rudloe

Squids are always in great demand for research. These are the common reef squid, Sepiateuthis sepioidea.

the filter-feeders—oysters, clams, and scallops—and the soft, burrowing animals from predators such as starfishes and carnivorous snails. Certain predators could be mixed together—the mantis shrimps, *Squilla empusa,* thrived with the sea urchins and whelks. We kept the voracious spider crabs, which had been eating animals ten times their worth, in solitary confinement.

But all the animals, no matter how small and insignificant-looking, required feeding. The healthier they were, the longer they lasted in our tanks and the more profit we made. So we set about learning their nutritional requirements. As we gained knowledge and developed more sophisticated techniques of collecting and maintaining plants and animals, the Gulf Specimen Company began to evolve in other biology-oriented areas.

The bait business started almost by accident. Whenever we went to the aquariums to fill an order for mantis shrimp, we were dismayed to find that the rock bass and speckled trout had eaten them. This was surprising, since the commercial fishermen consider mantis shrimp, with their cutting, jagged uropods, disagreeable pests. They call them sea lice because they inflict painful cuts. Every year shrimping fleets cull many tons of *Squilla* overboard with curses.

We tried *Squilla* on hook and line and met with astonishing success. The groupers, snappers and rock bass were just as pleased with the mantis shrimp as they were with the expensive penaeid shrimp. So we had found a new use—and eventually a new market—for an abundant and easy-to-catch crustacean.

Another bait—sea worms—was also an accidental discovery. It was a by-product of our rearing of specimens. While checking our filter system, we found under the gravel nearly one hundred worms, *Arenicola marina,* that had been nurtured and had grown side by side with the long, pink Southern clam worms we had been raising. The sea worms growing in our tank were worth money. A good day of hard digging on the Apalachee Bay flats would produce only a handful of them. If we could raise them in just three square meters (thirty square feet) of tanks, who could tell what farmed acreage could produce? Anglers purchase over one million dollars worth of sea worms each year, furnished by professional collectors in Maine who dig them from their natural habitats.

The fiddler crabs, *Uca pugilator,* that we herded and sold to schools and universities by the thousands, also had a potential use in the bait industry. Sheepshead and other bottom fishes could not resist them. But they were highly seasonal, and with the approach of cold weather (and the start of the sheepshead season), they vanished into their burrows.

Previously we had tried to keep fiddler crabs alive in wooden vats, Usually, though, we failed dismally and thousands died. But after we developed a sub-sand filter fed by the effluent of our seawater tanks, we could successfully keep hundreds of thousands alive.

With the increased use of the biomass found along the bottom of the bays and estuaries, on the beaches and in our nets, our business expanded rapidly. Other phases are beginning to evolve in formulating mariculture techniques and using marine organisms for pharmaceutical purposes.

The time will come when Man will learn to use all the resources of the sea and use them wisely. Nothing will be wasted or considered trash, and everything that comes up in the net will be valuable. Man will finally learn to use the sea as he uses the land. Hopefully he will take better care of it.