by **Lucas Brotz**

Are jellyfish the food of the future?

Increase in jellyfish populations has given a boost to jellyfish fisheries, promoting the establishment of a multi-million dollar industry. Harvested using a variety of fishing gears, the jellyfish are processed within hours of landing through a time consuming procedure which is more art than science.

Jellyfish are increasing in many places around the globe, including East Asia, Namibia, the Mediterranean Sea, the Black Sea, and beyond. While it is still unclear why jellyfish are appearing more often and in greater numbers over the last several decades, it is likely connected to the continued degradation of the marine environment by an increasing number of humans. Pollution, overfishing, global warming, shipping, aquaculture, and coastal development have all been implicated in increasing jellyfish populations. We still have a lot to learn about these cause-and-effect relationships, but in the meantime, many people are wondering what to do with this newfound jellyfish abundance. Eating jellyfish might strike Westerners as strange, but the act is far from novel.

The Chinese have been eating jellyfish for more than a thousand years and consider it a ceremonial delicacy. Traditional Chinese weddings and banquets usually include a jellyfish salad and other dishes featuring jellyfish. In recent decades, jellyfish consumption has increased, especially in China and Japan, resulting in the rapid growth of jellyfish fisheries and the development of a multi-million dollar industry. The majority of jellyfish fisheries are in Southeast Asian countries including China, Thailand, Indonesia, Malaysia, Korea, Vietnam, the Philippines, Myanmar, and Singapore. Fisheries also exist elsewhere, including India and Turkey, and have recently spread to countries on other continents such as Australia, Argentina, Namibia, Bahrain, Russia, Nicaragua, Mexico, and the USA. This rapid expansion of jellyfish fisheries raises a number of important questions that have yet to be answered. How much jellyfish is being caught? What species are being targeted? How much profit is being made? What are the effects on ecosystems? What are the goals of jellyfish harvesting? How are these fisheries being managed?

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Jellyfish being loaded onto a truck by fishermen at Ryojun Port, China

The art of processing jelly fish

Jellyfish are caught using a variety of active and passive fishing gears including scoop nets, drift nets, trawl nets, set nets, beach seines, weirs, and specialised hooks. Unlike most fisheries, processing of the catch must begin within hours of the initial capture or the jellyfish will begin to spoil. The processing of jellyfish is a time-consuming procedure that has been compared more to art than science. In fact, processing techniques can be highly guarded secrets, protected by coveted "Jellyfish Masters" employed in Asia. Different markets prefer different tastes, colours, and textures, and therefore any facilities preparing to export product must have knowledge of their end consumer. After harvesting, jellyfish are rinsed, cleaned, and treated with a mixture of salt and alum to reduce the water content, firm the texture, and increase the shelf life of the final product. Different

mixtures of salt and alum are used in a stepwise process, and the jellyfish are placed on racks to facilitate the drying process. The entire procedure can take more than a month, resulting in a semi-dried product ranging from 7-15% of the wet weight of the original jellyfish. The shelf life of jellyfish products is usually about 1 year, but can be increased if they are kept cool. Jellyfish product cannot be frozen, as it will spoil.

Preparation of semi-dried jellyfish for eating is varied, but typically they are soaked and rinsed several times to reduce the salt content, and are often scalded before serving. There are also ready-to-use products that can be eaten straight out of the package. Jellyfish have a unique texture that is both crunchy and chewy. There is virtually no flavor, so the taste of the dish is determined by what sauces are used. Jellyfish are a low-calorie food, consisting mostly of water and a small amount of protein. So although jellyfish might be seafood of the future, it is not going to feed the world.

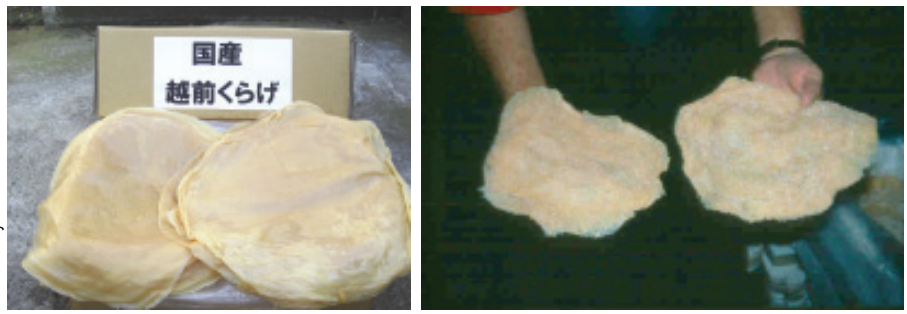
Hermes Mianzan

Fukuda Kaneo

Clockwise from left: (1) Japanese fishermen catch jellyfish in the Ariake sea, Western Kyushu, (2) Jellyfish being sorted in Ryojun port, China, (3) Slicing jellyfish, Ryojun China, and (4) Processed jellyfish.

Health benefits

Interestingly, there is also some evidence to suggest that eating jellyfish is good for you. Traditional Chinese medicine purports a variety of health benefits, such as treatment of high blood pressure, bronchitis, back pain, and ulcers. Consuming jellyfish also allegedly softens skin, improves digestion and circulation, remedies fatigue and exhaustion, and eases swelling. While very few of these claims have been tested scientifically, the findings from one experiment are intriguing. A small number of rats were injected with an arthritis inducing reagent and were separated into two groups – one that was fed jellyfish and one that wasn't. The group of rats that was fed jellyfish showed a significant reduction in the incidence, onset, and severity of arthritis. While the health effects of eating jellyfish remain to be investigated, aluminum used in the curing process has been found in the final product in varying amounts. As the ingestion of aluminum has been shown to be harmful to humans, the health effects from eating jellyfish may not be entirely positive.



Shin-ichi Uye

Kylie Pitt

Processed giant jellyfish in Fukui, Japan (left) and semi-dried jellyfish in New South Wales, Australia (right).

Jellyfish fishery is diversifying

Exactly how much jellyfish is being caught remains unclear. Estimates of fisheries catch statistics compiled by the Food and Agriculture Organization of the United Nations (FAO) put the global harvest of jellyfish on the order of hundreds of thousands of metric tons a year. This exceeds the wet weight catch of many other large fisheries, such as lobsters. But these numbers are likely a dramatic underestimate of the actual tonnage of jellyfish being harvested. The most recent FAO report on the State of World Fisheries and Aquaculture notes that the number of non-reporting countries is increasing, and, on average, the quality of the data being submitted is declining. Numerous countries, including India, Korea, Vietnam, and Singapore have been harvesting jellyfish for decades, but don't appear anywhere in the FAO's jellyfish catch statistics. In addition, customs information from Japan reveals that the

weight of jellyfish imported from some countries is more than what was caught in a particular year according to FAO statistics, highlighting inconsistencies.

Unfortunately, taxonomic resolution is also a problem with the FAO data, as all jellyfish catches are incorrectly indicated as "*Rhopilema* species". While it is true that the most valuable species of jellyfish targeted for consumption is *Rhopilema esculentum*, there are more than a dozen different harvested species. Most belong to the biological Order Rhizostomeae, as jellyfish from this group tend to have the preferred crunchy texture after processing. Such species can include blue jellyfish (*Catosylus mosaicus*) which is the target of test fisheries in Australia, and cannonball jellyfish (*Stomolophus meleagris*) which is the target of developing fisheries in the USA and Mexico. However, species from other Orders can also be harvested and consumed. Jellyfish fishers in China have been catching and processing *Cyanea nozakii* for decades, primarily due to the population crash of the more valuable *R esculentum*. Semi-dried *C nozakii* is sold as a food product in China, but it is not preferred due to its inferior quality and texture, and values can be 100 times lower compared to products from more valuable jellyfish species.

Korean cuisine featuring jellyfish

Even jellyfish species from other taxonomic Classes can be the target of fisheries. Cubomedusae, also known as box jellyfish, are consumed by aboriginal peoples in Taiwan. In addition, hydromedusae, or water jellies, were heavily fished for several decades starting in the 1960s. Rather than being processed for consumption, these jellies contain naturally occurring luminescent and fluorescent proteins that have proven extremely valuable in biomedical research. While these proteins are now typically synthesised in laboratories, it is estimated that hundreds of thousands of *Aequorea victoria* jellies were harvested each year at a single location in USA's Washington State. It is clear that there is diversity in the assemblage of jellyfish species that are directly targeted for harvesting. Unfortunately, we know virtually nothing about many of these species - a point underscored by the fact that some species of edible jellyfish still lack proper scientific descriptions. As such, it is important that all jellyfish catches are reported with as much detailed information as possible.

Jellyfish fisheries are extremely difficult to manage, as jellyfish tend to be short-lived and exhibit dramatic variations in abundance. In fact, changes in biomass of edible jellyfish are potentially greater than

***Aequorea* jellyfish.**

any other fishery, resulting in high uncertainty for those involved. Some jellyfish stocks appear to be overfished, creating conflict and forcing fishers to switch to less valuable species. In the case of *Rhopilema esculentum* in China, there is now a hatchery programme which releases hundreds of millions of juveniles in Liaodong Bay each spring, with the hope of harvesting them in the fall.

Difficulties in fishery management

As jellyfish stocks are highly variable, vulnerable to overfishing, and profitable for many fishers, one would expect an emphasis on collecting comprehensive catch statistics. This is currently not the case. As we continue to fish down the food web, the continued expansion and diversification of jellyfish fisheries appears inevitable. Detailed catch statistics are necessary in order to formulate proper management strategies, understand the implications of fishing, and make predictions about future recruitment. This is especially true for jellyfish, as their peculiar life histories make predicting the magnitude and timing of blooms particularly difficult. Many jellyfish have a unique, two-phase life cycle. The pulsing, swimming "medusa" phase, which is the target of fisheries, is actually the adult form. These adults release their eggs and sperm into the water column, which fertilise to form a "planula". These planulae settle on the sea bottom or other substrate within hours or days, and grow into a polyp, much like a coral polyp or tiny sea anemone. If suitable habitat is found, these polyps can survive for years, feeding on drifting plankton and detritus. When conditions are right, these polyps transform and begin to asexually bud off "ephyra" or baby jellyfish. Each polyp can potentially create dozens of tiny jellyfish which can grow rapidly, eventually leading to a bloom. Scientists are still unclear about the environmental cues that initiate this process called "strobilation", but light, temperature, and food availability may all be important. In some cases, polyps can survive after strobilating, creating a seed population for future blooms. Clearly, there is a need to develop a better understanding of the factors regulating jellyfish populations in order to implement proper fisheries management strategies.

While it has been suggested that we should adapt to increasing jellyfish populations by harvesting more of them, such a strategy is unlikely to be a success. Prices for jellyfish products are generally quite low, as only a couple of species are highly sought after for consumption. For the thousands of other species of jellyfish, many of which appear to be increasing, fisheries have yet to prove economically viable. As an example, several mt of moon jellyfish (*Aurelia* sp) were caught and processed by Canada's Department of Fisheries and Oceans (DFO) in 1984, and were given to local Asian restaurateurs with the hope of establishing a market. The test fishery ultimately failed due to complaints that the processed product had "no crunch". In Japan, attempts to adapt to more jellyfish are also proving ineffective. Blooms of the giant jellyfish (*Nemopilema nomurai*) used to occur roughly every 35-40 years, but since 2002, an infestation of these massive creatures is almost an annual event. Products derived from these behemoths have so far been added to candy, cookies, and even ice cream. However, the demand for this species is low, as they are not preferred for direct consumption. In some parts of China, India, and the Philippines, once-abundant and profitable stocks of jelly fish appear to be declining. In some locations, these declines are likely the result of overfishing, despite desperate attempts for jellyfish conservation that include seasonal closures, trawling bans to protect polyps, and aforementioned hatcheries. Thus, as numerous populations of jellyfish appear to be increasing around the globe, so it seems we will be left with increasing amounts of non-desirable species and decreasing amounts of those of higher value. Without efforts to collect detailed catch statistics and develop proper management strategies, the situation is sure to deteriorate further.

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