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Aquaculture in Dagupan City, Philippines

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The metropolitan area of Dagupan City, Pangasinan, Philippines (16°00'N, 120°15'E) consists of the chartered city itself plus two municipalities, Binmaley and Lingayen, situated in the river delta estuary system of the Agno River at the head of the Lingayen Gulf, an important commercial fishing area. In the local language of Pangasinan, *dagupan* means "gathering place," and as such was an important marketing and trading center since before Ferdinand Magellan landed and was eventually killed on the islands.[2] Since the 19th century, however, the Dagupan City region has been an important transportation center and fish landing port that was enhanced by the opening of a now defunct railway line to Manila. As a result of good transportation and the fisheries, a number of secondary industries have grown up in the area which include boat and fishing gear manufacturing and sales, as well as fish processing which includes the manufacture and sales of salted fish paste (*bagoong*), fish sauce (*patis*), dried fish (*daing*), and smoked fish (*tinapa*).

The entire economy of the Agno River estuary region is based on fishing and aquaculture. Approximately 20 small "baby trawlers" are based in the Dagupan City area that fish the waters of the Lingayen Gulf. Additionally, commercial boats rigged with either encircling seine nets or longlines fish for pelagic

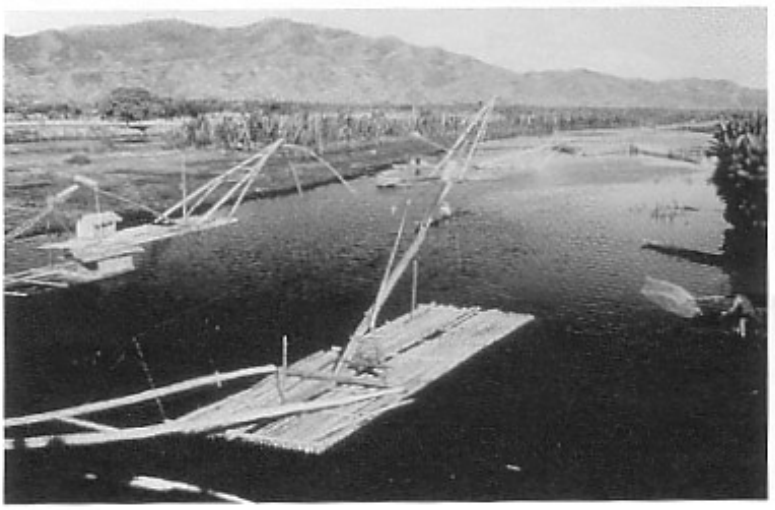
species including tuna outside the confines of the Lingayen Gulf and land their catch in Dagupan City. Since at least 1980, the Lingayen Gulf has been identified as a critical traditional fishing ground at risk to overexploitation.[3] In recent years, however, the Lingayen Gulf has experienced severe overfishing, leading to diminished catches and a reduction in the number of larger boats landing in Dagupan City. In order to restore the commercial fisheries in the Lingayen Gulf, BFAR has been proposing a ban on commercial trawling in the Lingayen Gulf . Public hearings and discussion of such a ban have been ongoing since 1996 with no resolution as of October 1997, but it is clear that the wild harvest fisheries have fallen into hard times. However, many of the owners of commercial fishing vessels are the same individuals or corporations that have active aquaculture enterprises.

Aquaculture systems

In terms of aquaculture, the Dagupan City region is well known for the culture of *bangos* or milkfish, *Chanos chanos* (Forsskal). The milkfish are typically grown in traditional shallow extensive ponds reclaimed from mangrove wetland areas, using techniques widely used in the area since the 19th century.[4] There are about 8700 individual fishponds of this type in the area covering an area of about 11 300 hectares.[5] Stocking of fish in these extensive ponds is typically at 4000 fingerlings/ha and require minimal supplemental feeding as ponds are fertilized to promote the growth of *lab-lab*, a complex of filamentous algae and phytoplankton that serve as food. Fish usually require a three-month growing period before reaching market size of 400-500g, and two or three crop cycles per 9 month growing season are common.[5] Starting in the mid-1980s a number of progressive pond operators have modified their extensive ponds by making them deeper and by adding aeration devices, which for the most part was technology developed in Taiwan.[6] Milkfish in these semi-intensive ponds are typically stocked in excess of 25 000 fingerlings/ha, but typically require input of feeds due to little or no *lab-lab* production. A few of these milkfish pond operators have diversified their crops by growing shrimp, usually the giant tiger prawn (*Peneaus monodon*) in monoculture with crop rotation or as a polyculture species with milkfish. In 1992, pond production of milkfish was

Previous page—typical 5x7 meter net pens used to culture milkfish in the town of Binmaley.

Right—extensive milkfish ponds in the Bonuan District of Dagupan City.



The Dagupan-Agno River estuary in 1984 (above). Note the diversity of fishing and aquaculture techniques employed and the proximity of the different activities. Visible in this photograph, taken in the Tapuac Area of Dagupan City, are fish traps (pasabing, shown in greater detail in photograph on left), oyster farms, floating net cages for groupers, and milkfish farms.

Bottom left—a typical floating lever net fishing apparatus (salambaw) common in the Lingayen area of the Agno River estuary system.

A "baby trawler," typical of the Lingayen Gulf commercial fishing fleet, landing at Dagupan City.

reported to be about 12 000 metric tonnes in the estuary.[7]

There are a number of aquaculture species that are cultured directly in the extensive waterways of the river delta-type estuary. Oysters,[8] *Crassostrea iredalei,* have been a very important aquaculture species in the estuary. Oysters are collected by fishermen from mangrove prop roots or are raised on leases granted to individual farmers who put a variety of spat collectors in the water suspended from a plots constructed from bamboo poles.[9] In 1985, there were 40 ha of registered oyster farms using off bottom culture techniques.[10] Typically spat collectors consist of oyster shells treaded onto polypropylene ropes or rubber strips cut from old automobile or truck tires. Data we collected in 1983 showed that oyster production in the Dagupan City area using these off bottom techniques was as high on a per area basis as anywhere in the world, approaching 2.5 kg of shucked oyster meats per square meter of area in the farms,[9] and oyster production in the estuary was officially estimated to be 1760 tonnes of shell-on product in 1985.[8] This may well be a considerable underestimate of the oyster production in the estuary, because the figures only include production from the officially registered farms.

In 1981, a trading company began an operation of depuration or controlled purification of oysters from the estuary, blast freezing them, and exporting the product to Singapore. However this effort was short lived because the gross sewage contamination in the estuary did not allow for an adequately safe product to meet international public health standards.[11] The effort to build an export-oriented industry based on oysters led to the development of a Japanese government funded Philippine government laboratory with a mission to undertake aquaculture research, initially focusing on oyster production and processing,[12] but later expanding interests to other mollusks and finfish. The laboratory is now operated by BFAR as a regional aquaculture disease laboratory.[13]

In 1983, Mr. Jose Ma. S. DeGuzman of JAMA Fish Inc., in Dagupan City introduced the culture of serranid groupers, known locally as *lapu-lapu*. In the early years, the technology for grouper culture closely followed methods developed in Penang, Malaysia beginning in 1973.[14] Fingerling groupers, including the honeycomb grouper (*Epinephelus merra*), the greasy grouper (*E. tauvina*), the marbled grouper (*E. fuscoguttatus*), and the humpback grouper (*Cromileptes ativeles*) among other species were purchased live from fish trap (*pasabing*) operators in the estuary. The fingerlings were stocked at about 2 to 4 fish/m^3 into twelve relatively small (8 m^3) floating fish pens in the estuary. The fish were fed low value trash fish or tilapia from terrestrial fish ponds and reached a marketable size of about 750g in about 9 months. These small scale trials demonstrated the commercial viability of grouper culture, leading to the expansion of production. By 1991, improvements in feed technology led to moist pelleted feeds for groupers and a lowering of production costs. Additionally, markets in Hong Kong and Singapore were developed and by 1993, aquaculture production of groupers in Dagupan City reached about 15 000 kg per annum.[15]

Up until the early 1990s, aquaculture production in the Dagupan City area could be described as having a high degree of species and technological diversity. Most individuals with aquaculture operations were local to the province and to some extent the management of their placement was effective because of local community pressure. Typically, many types of aquaculture, fishing and other uses of the waterway would occur simultaneously in the waterways with a minimum of conflict. For example, oysters which are filter feeders, milkfish which feed low on the food chain, and groupers which are piscivorous were often cultured in close proximity to one another among fixed nets (*pasabing*) placed to capture migrating estuarine fish and crustaceans such as crabs and shrimp.[16] This traditional form of management of aquaculture in the Dagupan City region had the effect of optimizing productive output of the estuary by encouraging a *de facto* form of polyculture. Many fishers in the estuaries reported to have profited as a result of these traditional aquaculture practices.[17] Structures such as oyster farming plots with spat collectors act as miniature reefs or fish aggregating devices. When floating fish pens for groupers or other fish are kept at relatively low densities, excess fish feeds and fish wastes are believed to act to enrich the waters and increase the overall productivity of the estuary.

Changes in the estuary

Beginning in the early 1990s, a number of events and changes in the Dagupan City region and the Philippines as a whole began to change the way fisheries

An oyster farmer tends his spat collectors in the Salapingao District of Dagupan City

and aquaculture was to be conducted in the estuary. Firstly and quite dramatically on July 16, 1990 an earthquake with an intensity of 7.8 on the Richter Scale struck the region with devastating consequences. The commercial center of the city which was largely built on unconsolidated silty, riverine delta deposits was heavily damaged and subsided by approximately one meter. Many low lying fishponds were inundated. A considerable amount of local capital was expended in the recovery and rebuilding of the city, which included its fisheries and aquaculture infrastructure.

A second event affecting the way aquaculture was to be done in the Dagupan City region began in the major Philippine shrimp culture region of Negros Occidental, about 600 km to the south of Dagupan City. During the 1980s, the shrimp industry grew considerably due to innovations in hatchery and feed technologies. Unfortunately due to over-intensification, less than optimum management, and disease outbreaks the industry fell into decline in the early 1990s.[18] This decline in shrimp production led to a situation of an over-capacity in terms of aquaculture feed production. To maintain markets, a number of aquaculture feed manufacturers started to develop and promote forms of aquaculture that would diversify their product lines away from their heavy reliance on marketing of shrimp feeds.

In the Dagupan City region, the form of aquaculture to expand rapidly was the net pen culture of milkfish, *Chanos chanos*, directly in the estuaries. This practice began slowly in 1991 with only a few operators. Typically, the net pens are placed in the estuaries after a municipal permit is granted. The net pens average 7 m by 5m in length and width and are 2 meters in average depth. These net pens would then be stocked with fingerlings at a rate of 36 fish/m^3, or 2520 fish/pen. The fish would then be held through a 3-month growing period on a commercially prepared diet containing 29% crude protein, and then marketed as they reach a size of about 500g each. In the initial years between 1991 and 1993, the short term profitability of the fish pens *vis a vis* the traditional extensive ponds was astounding to local and outside investors alike. Returns on investment of 200 to 300 percent or more in just a few months were not unheard of. In just one 35 m^2 net pen as many fish could be reared as in a 0.5 ha extensive fishpond, without the expenses or taxes associated with real estate development or the rebuilding efforts due to the earthquake induced floods.

News of the success of pen culture of milkfish precipitated a rapid expansion of the industry between the years of 1994 and 1996 capitalized largely by investors from metropolitan Manila. By 1996, just in the town of Binmaley alone, municipal and BFAR records showed that there were in excess of 800 registered fish pens,[19] producing an estimated 1600 tonnes of fish per annum. This may well be an underestimate of the actual number of fish pens because estimates of the actual number of the fish pens in the estuary vary due to a known problem of unregistered and unlicensed operations.[19]

The rapid growth of pen culture of milkfish in the estuaries around Dagupan City was not without it's down side. The nearly unrestrained establishment of the milkfish pens led to degraded water quality conditions, which has forced operators using the relatively sound traditional multi-species approach to suffer economic losses. After a more than a decade of production of groupers in floating net pens, hypoxic conditions resulted in killing some of the groupers, which tend to be more sensitive to low oxygen than the milkfish. This led to a business decision to cease all grouper culture in the estuary in 1995.[15] Likewise between 1993 and 1995, production of oysters in the estuary declined by nearly 50% according to BFAR statistics.[20]

Eventually, the degradation of water quality began to affect the milkfish pen operators themselves. By 1996, overnight fish kills started to occur regularly in the fish pens in the town of Binmaley. Unpublished data collected by BFAR personnel showed that surface waters in the Binmaley section of the estuary around the fish pens often went below 1 mg/L,[21] which is the presumed lower limit for the survival of young milkfish.[22] There is also some preliminary evidence of shifts in phytoplankton species composition in the estuary during hypoxic events.[23]

Emergency government action

The economic effects of the fish kills have been severe enough to draw the attention of the national government. In early October, 1997 the House of Representatives of the Republic of the Philippines passed a resolution directing an inquiry into the causes of the fish kills.[24] The severity of the situation precipitated an Executive Order[25] by the

Floating net pen for serranid groupers in the Tapuac District of Dagupan City

President of the Philippines on October 17, 1997 which mandated the removal of all fish pens from the estuary until the cause of the fish kills is determined and that an adequate procedure for limiting the density of fish pens is instituted. This effort to dismantle fish pens is administered by the Lingayen Gulf Coastal Area Management Commission, an umbrella organization of coastal experts reporting to the Office of the President set up in the early 1990s with the mission of advising local officials and coordinating inter-jurisdictional coastal zone management initiatives.

The fish kills caused by this unrestrained expansion of fish pens in the estuarine waters around Dagupan City is yet another example of the 'tragedy of the commons,[26] in which the environmental costs of the project are borne by the public in general and there is no direct technical solution or quick fix. Sadly, the milkfish kills in Binmaley are not unprecedented in the Philippines. Hypoxic fish kills occurred in fish pens in the Laguna de Bay, the Philippines' largest freshwater lake during the mid-1980s,[27] resulting in an outpouring of considerable public concern and the formation of the Laguna Lake Development Authority to oversee future development plans in the lake.

Picking up the pieces

Ironically, the overall economic productivity of the estuary may be increased by aquaculture growth restriction policies which promote the "old fashioned" multiple species methods with managed densities of fish cages and fish pens. With concerted effort, a number of actions can be taken by the academia, local and national government regulatory authorities, the agricultural extension community, and the aquaculture industry itself to prevent similar problems from occurring in the future. The key is a cooperative effort, and in some instances requires a re-evaluation of priorities and changes in the way business is done.

In general, the academic community in the Philippines has done an excellent job of solving the production related problems of the aquaculture industry such as feeds and nutrition and reproductive biology of fish and other cultured species, but there is a weakness in the area of research on environmental and economic impacts. There is a pressing need to begin an effort to establish quantitative criteria for determining the carrying capacity of fish pens or cages in a particular river or estuary based on hydrographic, carbon and nutrient loading considerations. Such data would be invaluable to policy makers in their decision making process. The amount of wastes from the milkfish pens deposited into the estuary is around 3200 tonnes per annum,[28] but no data are available

in regard to actual increases of biological oxygen demand (BOD), total sediment carbon around the fish pens or the hydrographics of the estuary. Actual measurements of dissolved oxygen dynamics in the estuary are spotty at best. Expanded research capabilities in the broad area of physical oceanography, water chemistry and hydrographic modeling are a necessary prerequisite in the effort to understand and predict environmental impacts. Likewise, efforts need to be undertaken by natural resource economists to quantify the effects of the loss of diverse aquaculture production methods on the overall economic yield of the estuary.

Ever since the 1986 Constitution of the Philippines along with the Local Government Code and devolution of powers to local officials, the responsibility for management of the estuary rests primarily with the local government units in Binmaley, Lingayen and Dagupan City. Each of the three towns are now in the process of developing local ordinances regarding the management of fish cages and fish pens. National agencies with fisheries responsibility including the Agricultural Extension service of the Department of Agriculture and BFAR have become strictly advisory to the local governments. In rare instances however, such as the promulgation of the executive order instructing the removal of all fish pens, the national government can act on an emergency basis when national interests are threatened. BFAR can make a major long term contribution to finding a solution to the problem of managing the various forms of aquaculture in the estuary by boosting their environmental and aquatic disease research and extension capabilities at their newly acquired seafarming research center in the Bonuan Binloc District of Dagupan City.

In the past, local ordinances regarding fish pens and fish cages were based upon the local government's desire to maximize tax revenues to fund worthwhile civic projects. It is recommended that any future ordinances aiming to restrict the number or sizes of fish pens reflect this past priority by setting a hard and fast top number of allowable pens as well as their sizes and then initiating an annual open auction system. Such an auction system will allow the market forces of demand for permits to simultaneously maximize municipal income while serving as a means to protect the estuary.

Finally, the aquaculture industry members themselves can help their overall long term economic situation by organizing a local producers organization. Industry organizations of this type can set professional standards, define customary and best management practices and bring their concerns to government agencies with a stronger, unitary voice. More importantly, a professional aquaculturists association in the Dagupan City area can restore the process of informal self-policing by peer pressure. Industry pressure may be the most effective means for controlling unregistered and unlicensed operations that have been alleged to be a key villain in this version of the "Tragedy of the Commons."

Notes and References

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