# Archaeological Aquaculture

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*Before it became the New World, the Western Hemisphere was vastly more populous and sophisticated than has been thought—an altogether more salubrious place to live at the time than, say, Europe.*

C. Mann (2005)

Aquaculture is nothing new. It arose multiple times in indigenous societies where coastal population densities of "seafood eating peoples" increased beyond the carrying capacities of natural, aquatic ecosystems to provide for them. There have been many "blue revolutions" throughout history! Aquaculture has a long, fascinating pre-history with well documented "blue revolutions" occurring throughout (Table 1). The difference is, today, we're in uncharted territory the roles of aquaculture to supply protein foods for an estimated 12 billion people by 2050.

In human history, however, few, if any, of these seminal moments in the history of "aquatic peoples" have been examined to any meaningful extent. The field of "aquaculture anthropology" doesn't exist to formulate a unifying theory of how aquaculture develops, evolves, and fits into the human development equation of seafood-eating peoples. Notable exceptions are the aquaculture scholar Peter Edwards (2009, 2015) and Ken Ruddle (Ruddle and Zhong, 1988) who studied in depth the roots of Asian aquaculture as an important part of our common, historical "food-producing wisdom".

The late pioneering anthropologist, Claude Levi-Strauss, brought the idea of "structuralism" to anthropology (Levi-Strauss, 1958), which is the concept that societies throughout history follow universal patterns of behavior. In tribute to him, I've formulated a simple anthropological theory on the evolutionary, "social ecology" of aquaculture that —

***whenever the demands of seafood-eating peoples exceed the abilities of their indigenous aquatic ecosystems to provide for them, these cultures, throughout the world, develop aquaculture.***

Both modern industrial and community-based aquaculture have few if any connections to, or conversations about, its ancient past. And all too often, there are little or no connections to even its recent past; where are the social-ecological review of 50 years of salmon and shrimp aquaculture?

As a consequence, too many proposals for modern aquaculture developments are frequently marketed as "new" or "pioneering". When this neglect of comprehensive historical reviews occurs, society loses, and the aquaculture profession limps along, losing

many opportunities for aggregating and delivering "teachable moments". And, the world loses important opportunities to "evolve the blue revolution" and to develop the historical, background, baselines, and place-based ecological and social contexts of aquaculture so that informed decisions can be made by politicians, investors, and communities.

The roots of ecological aquaculture are in Asia (Ruddle and Zhong, 1988; Edwards, 2009, 2015). Fast forwarding to the present however, Asia, and especially in China in the period from 1980's to present, Asia has become a global center of industrial aquaculture development. China has chosen to intensify and import vast quantities of feedstuffs and also to become as major global exporter of tilapia and shrimp. As a result, freshwater aquaculture yields in China have increased 10X in just 20 years (FAO, 2009). But these industrial aquaculture developments have also dismantled much of Asia's rich ecological aquaculture heritage.

While there is no neat chronology of evolution of irrigation systems in China, it is clear from the widespread existence of clay models of irrigated agriculture systems recovered from graves throughout southern China that by the Han Dynasty (2300 - 1700 BP) ponds were being widely employed for water storage (Bray, 1984; Li, 1994). To some this indicates the earliest time in which aquaculture might have been developed.

For example, in a single grave over 18 varieties of aquatic plants and animals that are still used by the Chinese today were found within an intact rice-field model. These included lotus flowers, seeds and leaves, water chestnuts, soft-shelled turtles (*Trionyx sinensis*), grass carp (*Ctenopharyngodon idella*), and goldfish (*Carassius auratus*) (Li, 1992). In ancient times, these areas of southern China had high densities of people culturally dependent on aquatic foods as their main protein sources. As population densities increased, demands for fish and other aquatic foods would have increased and the practice of holding and growing fish would become increasingly attractive compared to reliance on increasingly exploited and inconsistent wild stocks. In the floodplains of China and elsewhere in Asia soil is excavated to construct elevated, better-drained areas for establishing homesteads and raising crops. Although the resultant excavations may be referred to as fishponds by aquaculture scientists, farmers referred to them simply as "ponds", an indication of their multipurpose agriculture-aquaculture nature.

Others, however, including the Fisheries Society of China, refer to the short treatise published by the statesman Fan Li some 2500 years ago. It describes common carp (*Cyprinus carpio)* farming in sufficient detail to provide incontrovertible evidence that fish culture had developed well beyond a proto-aquaculture activity, and that aquaculture was well-established by this time (Li, 1994). The monograph details the design and layout of fish ponds, carp breeding, and fry and fingerling rearing techniques. Fan Li's account is of 'semi-intensive' monoculture of carp, although there remains some debate as to the species (Balon, 1995). The integration of fish - presumably carp - culture with that of aquatic plants and vegetables is apparent from written records dating from 2200 - 2100 B.P. while written records of rice-fish culture date from the period 1975 - 1780 B.P. (Yang, 1994).

Among fishing-based societies, a number of scenarios in which proto-fish or -shellfish farming arose are envisaged: the short-term storage of catches until there were sufficient fish or shellfish to make the journey to market worthwhile; the transport of live fish to market; the holding of catches until prices improved. These strategies are still seen today: modified traps, netted off shallow areas of lakes, bamboo cages in parts of Indonesia (Costa-Pierce and Effendi, 1988) and traditional floating cages used in the Great Lake area of Cambodia (Beveridge, 1996).

Beveridge and Little (2002) describe what is known about the origins of aquaculture in traditional societies in China, Egypt, Europe, and the Americas. Most of these examples are inland, freshwater developments associated with rivers or other water courses indigenous to large continental land masses. The ancient mariculture systems of Hawaii are unique in that they connect an isolated island society with sophisticated ocean harvesting and integrated sea farming activities to an entire watershed management/food production system (the *ahupua'a*) (Costa-Pierce, 1987, 2002).

Ancient Hawaiian mariculture systems are remarkable in terms of their diversity, distinctive management, and sheer extent of development, especially given the small size of Hawaii. Although the Hawaiian systems are relatively recent (about 1500-1800 years old) by Chinese and Egyptian standards, the evolution of ocean fishing to ranching and onwards to true ocean farming systems (mariculture) is notable. Evolution of such sophisticated farming systems may be a natural evolutionary part of societies whose population densities exceed the carrying capacity of natural ecosystems to support them. As a result, rapid evolution of new, innovative ecological mariculture farming systems occurred in Hawaii.

It is evident that the ancient Hawaiians supported a high population density by managing an ecologically complex integrated farming system that connected agricultural watershed ecosystems to nearshore mariculture/fisheries ecosystems—the *ahupua'a* aquaculture ecosystem. These historical developments are remarkably similar in principle to integrated farming systems developed in ancient China and Egypt. Hawaiian society, like other ancient civilizations, was subject to droughts, climatic disruptions, natural disasters, and famines; it may have developed these integrated farming systems in response.

The limited archeological and aquaculture research, as well as exploration in the Pacific Basin, allows no conclusions to be drawn either regarding the uniqueness of the Hawaiian integrated farming systems among the Pacific islands, as some have suggested (Kikuchi, 1973, 1976; Summers, 1964), or their possible relationships to Chinese or other Asian systems. The Hawaiians appear to be one of the originators of mariculture; there is no evidence of another ancient culture using oceanic resources in this manner (Costa-Pierce, 1987, 2002).

There may be three eras of aquaculture development (Figure 1). Modern industrial export-driven aquaculture is very different, being technologically complex. Given the complex social makeup of a society (urban, rural, rich, poor, etc.) communities can either embrace such dramatic changes, and accommodate the necessary social transformations, or reject such changes and continue their social, cultural, and economic evolution without

aquaculture. One of the fundamental problems of aquaculture development is the lack of understanding and planning for the social/community transformations wrought by aquaculture innovations, and the lack of knowledge on how to govern aquaculture innovations.

The divergent and fascinating First Nations perspectives on aquaculture are a case in point, one that has fascinated me for a long time, namely, the evolution of aquaculture in ancient societies, and the use of traditional knowledge to evolve an alternative path for coastal society's worldwide (Costa-Pierce, 1987, 2002, 2010). Yet no matter the sources of the knowledge we use to chart a course for aquaculture – whether traditional knowledge, science, or some blend - well planned, transparent, participatory processes are required; ones that may drag out for longer than decision-makers want, but in the end will lead to some shared visions of more common futures.

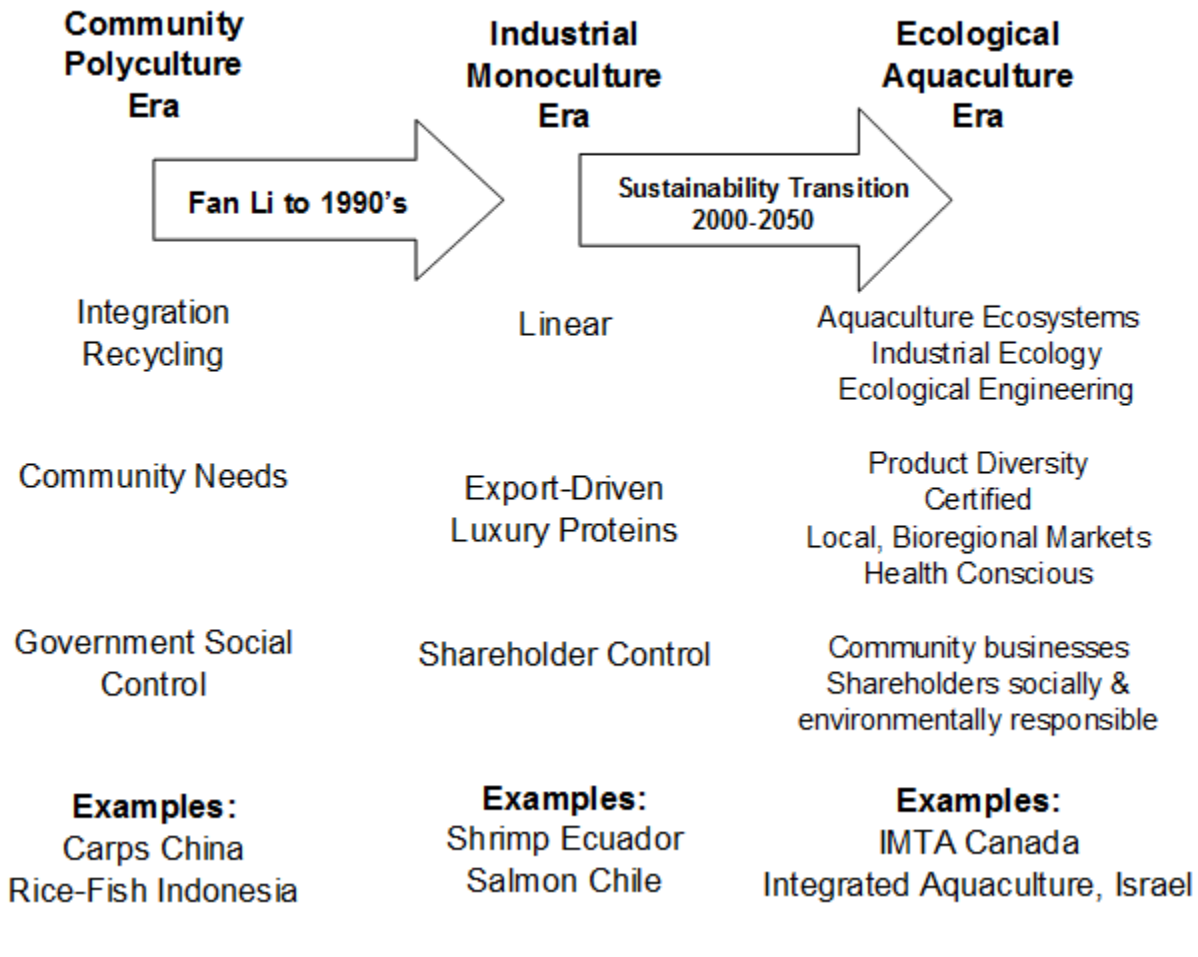
**Table 1**

Documented "blue revolutions" in aquaculture societies from antiquity to historical times. There have been many blue revolutions throughout human history (updated from Costa-Pierce, 2010)

| **Places, Regions & Approximate Dates** | **Aquaculture Social Ecologies & Ecohistories** | **References** |
|---|---|---|
| Egypt (New Kingdom, 4000 years ago) | Tombs show tilapia being cultured in drainable fishponds integrated with agriculture | Chimits (1957) |
| China (Zhou Dynasty at least 2300 years ago) | Aquaculture monograph by Fan Li published; evidence of integration of fish and rice 8000 years ago; in Tang Dynasty, sophisticated multispecies carp polycultures are developed resulting in significant increases in food (fish & crops) per unit area | Beveridge and Little (2002); Edwards (2004, 2006); Lu and Li (2006) |
| Europe (Etruscans and Romans 2100-2200 years ago) | Start of "vallicoltura" coastal aquaculture by the Etruscans on Adriatic and Tyrrhenian coasts; Roman literature describes that fish in ponds was commonplace | Beveridge and Little (2002) |
| Bolivia (Beni Province, 2000 years ago) | The Beni is ~30,000 square miles of raised agricultural fields integrated with fish/irrigation canals | Mann (2005, 2008) |

| | | |
|---|---|---|
| Cambodia (more than 1000 years ago) | Traditional integrated agriculture/aquaculture system may have developed first in Cambodia | Edwards et al. (1997) |
| Mexico (Valley of Mexico City, 1000-1400 AD, but could stretch back 6000 years ago) | Chinampas floating garden islands in lakes that were separated by channels where fish were grown | Aghajanian (2007) |
| Indonesia (West Java, 1200-1400 AD) | Milkfish in coastal ponds | Schuster (1952) |
| Hawai'i (from Polynesian settlement to 1778) | The ahupua'a aquaculture ecosystems sustained a high population density of islanders until European contact | Kikuchi (1973, 1976); Costa-Pierce (1987, 2002) |
| Australia (over 8,000 years ago) | Gunditjmara people around Lake Condah farmed eels in an artificial system of ponds connected by canals which covered over 75 $km^2$ | Lambert (2014 ) |
| British Columbia Canada | Ancient First Nation clam gardens in the Broughton Archipelago cultivating butter clams | Williams (2006); Groesbeck et al. (2014) |

**Figure 1**
Three Eras of Historical Aquaculture Development (Costa-Pierce, 2010)



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