The Social Ecology of Aquaculture in Its New Geographies

Barry Antonio Costa-Pierce

Introduction

Aquaculture is nothing new. It is part of our collective humanity throughout human history (and her-story, as gender issues are vital in all future planning for sustainability). I have hypothesized from anthropological and archeological research and reviews that "When the populations of seafood-eating peoples exceeded the carrying capacity of their natal fisheries ecosystems to support them, they developed aquaculture." We have to break this theory down to test its parts: a) "seafood-eating" peoples, b) exceeded natural limits and c) indigenous abilities.

> There are important orthodoxies that are uncomfortable truths: First, world food production has outpaced population growth by a large margin, including for animal proteins. Second, there is evidence from aquaculture scientists that the enhanced protein and micronutrient contributions from seafood to consumers and households in comparisons to intake from lower-cost plants and terrestrial animals has been overstated. Third, large countries with great potential for aquaculture development advocate the need for it in comparison to other alternatives.

Seafood is an important but minor source of animal proteins throughout the world in most inland nations. There are important regional exceptions: the Great Lakes nations of Africa and the ricefield areas of south and southeast Asia are examples that come to mind. Highest seafood consumption rates exist for coastal and island peoples and actual consumption rates can be underestimated. For example, fish consumption in 613 village meals by Fijians from all ethnic groups in 150 coastal villages on Viti Levu averaged 68.2 kg/capita/year (Rawlinson 1994). This per capita fish consumption rate is similar to that of the Japanese, who are reported to consume 68-70 kg/capita/year, the highest in the world (New 1997). The first Chinese regulations on capture fisheries were published in antiquity and aquaculture pioneers such as Fan Li taught his people how to grow fish like any other farm animal. Aquaculture revolutions happened in coastal and island, indigenous seafood-eating peoples in antiquity (Costa-Pierce 2010).

These were not "Blue Revolutions," however. They were knowledge-based, trial and error farming operations. They were also scientific "Blue Evolutions." Aquaculture in these situations arose within a complex social-ecological milieu. Aquaculture is culture, not just technology and tanks, not just meeting the regulations and obtaining the permits. As such, plans for its future at a larger scale must be comprehensive and consider well not only innovative technologies and economic sustainability but also their ecological and social sustainabilities. In aquaculture's new geographies, will society accept a Blue Revolution in their communities? In many places, the answer is no. If so, how do we step back, plan better, invest smarter and learn from our failures, especially where aquaculture has enormous potential to contribute to human health and environmental sustainability.

But first, there are new orthodoxies arising that as scientists we need to address directly to move forward.

Aquaculture's New Orthodoxies

Costa-Pierce and Chopin (2021) covered much of the hype in some proposals for aquaculture development today. Many aquaculture veterans chimed in to us after the article was published and said "so what else is new"? There are more important additional orthodoxies that affect aquaculture policies and development options that are uncomfortable truths: 1) Does the world need more food? 2) Does aquaculture contribute in an outsized way to nutritional wellness? and 3) Do the new geographies for aquaculture, such as the USA and the EU, import 90 percent or more of their seafoods?

First, world food production has outpaced population growth by a large margin, including for animal proteins (Hazell and Wood 2008, Pingale 2012, FAO 2017). Seafood supply has also outpaced population growth (FAO 2018). The real reason for human suffering is not supply but the dysfunctions in access, distribution networks, income distribution (the yawning gap between rich and poor) and its consequences for increasing poverty, protracted wars and violence and climate-related disasters (FAO *et al*. 2018).

Second, there is evidence from aquaculture scientists that the enhanced protein and micronutrient contributions from seafood to consumers and households in comparisons to intake from lower-cost plants and terrestrial animals has been overstated (Kawarazuka and Bene 2011, Bene *et al*. 2016).

Third, large countries with great potential for aquaculture development advocate the need for it in comparison to other alternatives. The US does not import 90 percent of its seafood. It has long been said that "America exports everything it produces and imports everything it eats." I once ate cod at a restaurant in Gloucester, Massachusetts, next to the fish auction. The fisherman I was out to dinner with pointed to my plate and said, "that fish was caught here, exported to be processed in Thailand, now is on your plate." The US and the EU are among the world's largest seafood exporters. Gephart *et al*. (2019) estimate that China imports about one-third of US seafood, processes them, then about 57 percent of that is shipped back to the US where it is counted as imports. As a result, they estimate domestic production accounts for 35-38 percent of America's seafood and that 62-65 percent of seafood is imported. Seafood data are poor everywhere for decision-making and are used to make political points to advocate for aquaculture. Aquaculture is political, of course, but doesn't need poor data to justify its solid merits. (continued on page 44)

This raises a couple of questions: Is a new food systems model of aquaculture needed to reform the seafood system to more comprehensively consider production (aquaculture, fisheries, plant-based seafoods), processing innovations, trade, processing, etc.? How does aquaculture distinguish itself if it cannot use the well-worn political and advocacy platforms it has relied upon for almost 20 years?

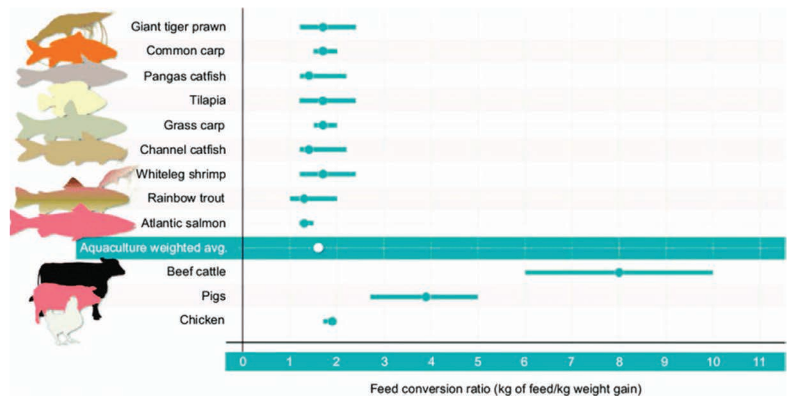

FIGURE 1. *Feed Conversion Ratios (FCRs) for selected aquaculture species compared to terrestrial protein sources (Fry* et al. *2018).*

More on Aquaculture's New Geographies

Almost 90 percent of all global animal aquaculture production is in Asia (60 percent of global aquaculture is in China), with only 3 percent in Africa, 4 percent in Europe, 5 percent in the Americas, and virtually nothing in Oceania. But, aquaculture is not only rare outside of Asia; surprising to many, aquaculture is still quite rare in Asia. Edwards (1993) stated that "Aquaculture is far less widespread in Asia than is widely supposed. Perhaps less than 1 percent of farmers are involved in aquaculture in the region."

Aquaculture has been touted as the world's fastest-growing food production sector for more than four decades (Tveterås *et al*. 2012). Applied science has well documented that fed and unfed aquaculture developments are very efficient food-producing systems in comparisons with terrestrial alternatives (Fig. 1). Aquaculture is by all accounts a very rational investment in the future of food production for governments and entrepreneurs concerned with agriculture's many problems with expansion. However, aquaculture growth globally and regionally has slowed, and the large growth over the past years has been from a very low baseline of near nothing to impressive amounts over 40 years in regions where aquaculture is "new." For example, examine closely the FAO-reported growth (2020, their Figure 12) in Myanmar, Vietnam, Egypt, Brazil, Ecuador and Nigeria from 2003 to 2018.

Where aquaculture has developed outside of Asia, it has been met with social opposition, leading to legal and regulatory complexities slowing or halting its growth, especially when proposed at any significant scale in the "commons" (in public trust resources) such as nearshore oceans and lakes. Opposition is not limited to rich countries in the temperate zone. Notable examples of these conflicts have been (and continue to be): 1) shrimp aquaculture in South Asia and Latin America, 2) salmon aquaculture in cold temperate oceans, notably in the Broughton Archipelago, B.C., Canada, in Alaska and Maine, USA, and in Tasmania, Australia, 3) Nile tilapia in nations of the African Great Lakes and in Brazil. Thus, while growth has occurred, most of these places remain minor aquaculture producers globally. For example, Brazil is ranked 13th and the USA and Canada are 16th and 20th in global aquaculture production 2018 (FAO 2020, OECD 2020).

In Costa-Pierce and Chopin (2021), we asked, as many have before us, "Why is the public opposing aquaculture's obvious sane and more sustainable food developments/choices in these new geographies that have, according to the experts, seriously exciting, large new areas of potential for accelerated aquaculture developments?" Hargreaves (2021) and many others have posed this as the "social license to operate." There is much to learn in this "evolution of the Blue Revolution." In this article I examine some of important transdisciplinary learning and effective methods being used in community management, conservation and governance that may be helpful in enhancing the social license for aquaculture.

Social Ecology of Aquaculture

"*Perhaps the greatest single role an ecological ethics can play is a discriminating one - to help us distinguish which of our actions serve the thrust of natural evolution and which of them impede it. That human interests of one kind or another may be involved in these actions is not always relevant to the ethical judgments we are likely to make. What really counts are the ethical guidelines that determine our judgment.*" Murray Bookchin (1982)

Ethical and Value Guidelines for Aquaculture

There have been many papers published on the reasons why aquaculture development has been stymied in its new geographies, many emphasizing policy failures. In the USA, aquaculture is seemingly opposed by everyone, according to Knapp and Rubino (2016), who state it is opposed by "local and national interest groups and local, state, tribal or national policies." That should give you pause! But the first ethical guideline emphasized by Bookchin (1982) is that ethics need to be comprehensive to include Nature as well as people and to allow people to speak for Nature. Slater *et al*. (2013) agree that "...to successfully develop in any country, aquaculture must be policy-led." However, they go further and state that "...policy must be built on an understanding of the socio-economic drivers, resources (human and natural), and the constraints of community members intended to be involved." Robertson and Hull (2003) called for a "public ecology" that have both process and content that emphasizes the participation of extended peer communities of a diversity of research specialists, policymakers and concerned citizens. Bailey (1997) defined constituents that are often left out, stating that "Aquaculture must be understood as a human enterprise designed to meet human needs, including the need for economically viable communities, especially in rural areas where most aquaculture production occurs."

I believe we can all agree on one commonsense, ethical principle. Aquaculture is not suitable for all areas of common property resources such as coastal oceans, lakes and preserves, whether or not they are protected by laws and regulations. These special areas of our humanity are protected by our common source of values and ethics. In the terrestrial sphere of Earth, the world's last remaining glorious biodiversity is threatened by agriculture and much is unprotected by any types of laws or enforcement actions. Agriculture's future expansion is projected to consume all of the world's remaining fertile lands (Bruinsma 2009). Despite there being plenty of food, agriculture scientists rely upon a continued expansion of arable lands into what are called "unfavorable agroecological lands and often also unfavorable socioeconomic environments" (Bruinsma 2009); in other words, into the Earth's last remaining natural, terrestrial ecosystems, parks and bioreserves for Nature (Morton *et al*. 2008). Bruinsma (2009) states that about 90 percent of the remaining 1.8 billion ha of available arable lands is in Sub-Saharan Africa and South America, and "half is concentrated in just seven countries (Brazil, Democratic Republic of the Congo, Angola, Sudan, Argentina, Colombia, Bolivia)." These countries are expanding industrial agriculture for non-food exports, e.g., oil palm, biofuels and soybeans.

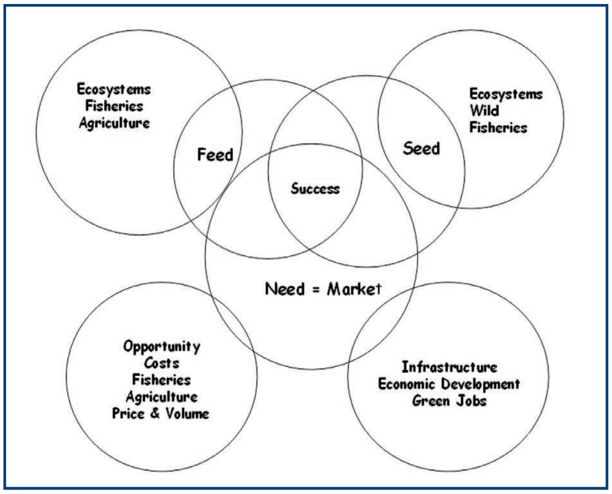

FIGURE 2. *As commercial aquaculture developed over the last 50 years in areas it was "new," the development/regulatory/political agenda shifted from its acceptance as an economically successful business to a social-ecological enterprise answerable to many of society's concerns about its broader impacts.*

"*Continued consumption and degradation of lands for terrestrial agriculture and urban development will destroy the world's remaining terrestrial and coastal biodiversity and novel ecosystems and threaten human health and wellness into the future unless we plan for and invest in the development of ocean foods ecosystems for planetary survival*." Barry Costa-Pierce, Keynote at the World Nutrition Forum (2016)

Aquaculture ethics is embedded deeply into the rise of anti-aquaculture Non-Governmental Organizations (NGOs). While there are areas for aquaculture that are well planned spatially by environmental models (of oceanography, discharges to surface waters, water quality, etc.), there are much fewer area designated as marine/aquatic protected areas (MPAs) illegal to develop aquaculture. And here's where the transdisciplinary complexity comes in as there are MPAs that may be unsuitable for fishing gears of some types but suitable for aquaculture of low trophic level species. The International Union for the Conservation of Nature (IUCN) asked, "Under what circumstances can MPAs and aquaculture come together? How could MPAs boost aquaculture growth? How could aquaculture activities provide financial support to MPAs? And how can we minimize negative interactions?" (Loffoley *et al*. 2019).

There are many suitable sites for producing high quality aquatic proteins globally that add value to people and Nature. When aquaculture locates and dismantles a national park in Thailand (see the cover photo of Pullin *et al*. 1995), or fights for space in national parks of Patagonia (Milazzo *et al*. 2021) or other global treasures, we lose any ability to negotiate for small, well-planned spaces in common property areas. Rachel Carson (1962) said "we are all part of Nature and war against Nature is inevitably a war against ourselves."

Lubchenco (1998) called for implementation in the 21st century of a "new social contract for science" that would "facilitate the investigation of complex, interdisciplinary problems that span multiple spatial and temporal scales; to encourage interagency and international cooperation on societal problems; and to construct more effective bridges between policy, management and science, as well as between the public and private sectors. Most of our efforts to address economic and social problems are as yet devoid of ecological knowledge."

Showing the Great Potential is Not Enough

Moehl *et al*. (2006) estimated that West Africa had a surface water potential of more than 97 billion m^3 with 117,000 ha of surface irrigation schemes suitable for rice-fish farming and fish culture in canals. There were more than 200,000 ha of other types of irrigation schemes and suitable inland valleys. Unfortunately, because of the sectoral nature of political, policy and management regimes, both international and national organizations have developed no specific policies nor carried out research specifically related to the development of integrated aquaculture in water supply, delivery or irrigation schemes (Brugere 2006). She states that "Regardless of how irrigation is practiced, its development is no longer seen in isolation from other issues but in conjunction with broader perspectives of increased food production, environmental sustainability and poverty alleviation."

Meeting the Regulations is Not Enough

Savvy businesses know that their development plans for production may be accepted by permitting agencies but not by the public. Aquaculture can gain more rapid acceptance if its designed plans are more ecological and comprehensive so that they can not only develop but also evolve as an integral part of — not separate from — farmers, fishermen, sustainable community development and the future of working waterfronts. Aquaculture's modern development and future success cannot simply be defined as having simply met the regulations or developed successfully the hatchery, feed (if fed aquaculture) and marketing components important in traditional business plans — the old alignment of the "seed, feed, and the need." Rather, a design for a sustainable, ecological aquaculture development has to nurture society's success for the triple bottom line of economic, environmental and social profits (Dasgupta and Maler 2004) (Fig. 2).

(CONTINUED ON PAGE 46)

To build a social ecology of aquaculture or to advance the culture of aquaculture, increased attention to participatory processes, problem framing and communications is needed. All require the next generation of aquaculture leaders to be trained more broadly, which will be the topic of my forthcoming article in the December 2021 issue of ***World Aquaculture***.

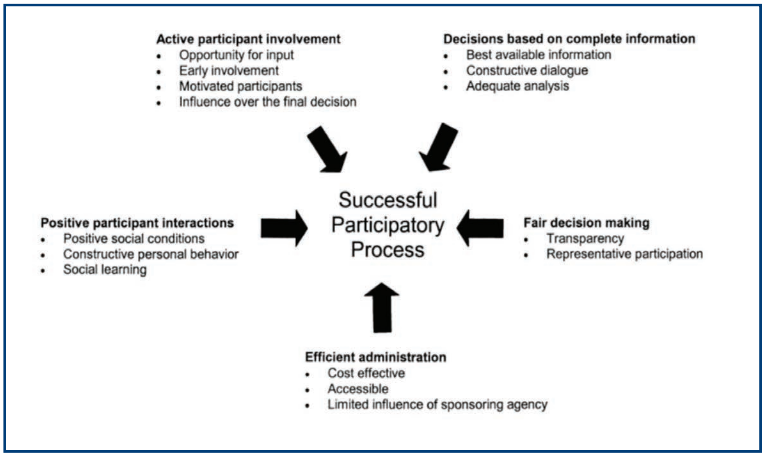

FIGURE 3. *Measuring success of public participation includes active participant involvement, complete information exchange, fair decision-making, efficient administration of the process and positive participant interactions to build trust (Dalton 2005).*

Innovations in Community Science for an Increased Social License for Aquaculture

Nobelist Elinor Ostrom challenged the orthodoxy of Garret Hardin and his tragedy of the commons. She painted a much brighter future for successful participatory processes that result in groups that could agree to better manage common property resources. Ostrom identified the underlying design principles for effective governance: clearly defined boundaries, rules formulated by user and outsider participation, longer-term engagement and monitoring and agreed-upon dispute resolution (Ostrom 2009).

Adversarial processes (conflicts) occur when stakeholders do not recognize each other's interests as legitimate. These increase conflicts and thrive on uncertainty. Adversarial processes are often exclusive, divisive, opaque and closed. They do not build instant trust. When conflicts are intense, scientific evidence is often used selectively, contested or dismissed. Successful processes are inclusive at the start, well planned and facilitated in a professional, neutral and non-advocacy manner. They are well-funded participatory processes over a longer time than just "projects" and stand in contrast to the permitting processes of governments at any level, such as government-led "lease hearings." Shared learning and ownership, creative problem solving, joint fact-finding, all employing adaptive management strategies, are the most successful. Virulent conflicts over grizzly bear management in Banff National Park, Canada were resolved by a problem-solving group that shared responsibilities for interpreting scientific evidence and making management decisions (Gibeau 2012).

Participatory Processes

Participatory processes themselves have to be articulated, vetted and agreed upon at the outset and not as an afterthought, in a transparent way and their success measured (Fig. 3) (Dalton 2005). Setting the table is vitally important. Aquaculture may be the most rapidly growing form of animal agriculture in many nations but most inquiry in aquaculture is still organized and led by biologists and technologists in a top-down, very traditional and compartmentalized manner. Of course, these highly competent, experienced professionals must be at the table.

Neutral, non-advocacy leaders have to be carefully vetted so that it is clear that they have little to no conflict of interest; they must be experienced in dealing with "wicked problems that have few tame solutions"; and they must rewarded (paid well). These are important social investments in aquaculture at the individual level.

Among the most important first steps in establishing a process is problem framing. This establishes from the outset what are the priorities and what are not, what the objectives are, and what questions will be asked and answered by the process. To avoid marginalizing the less powerful, it needs to be diverse in its exploration, start from the local and expand scope to the global context, outline systemic challenges, enhance stakeholder comfort and seek diverse sources of knowledge. Problem farming will identify the need for further expertise, tactics and identify the role of advocacy to "catalyze plans into transformative actions" (Kivimaa *et al*. 2019).

Aquaculture has an urgent need for developing and engaging leaders who are well trained as "honest brokers of policy alternatives" (Pilke 2007). Keen *et al*. (2005) believe transformation toward more sustainable practices will be much more likely if the individuals who make up society can accept change and modify their personal behaviors. Changes in the behavior of individuals can "scope up" and result in larger changes at the community and societal scales by employing a combination of trust-building, favorable performance in facilitation, accountability, flexibility and innovation and the inclusion of key community stakeholders and "influencers" in strategic planning (Huckle and Sterling 1996, Brehm and Rahn 1997). CHANS (coupled natural and human systems) is a research group that recognizes that resource management successes or failures are a result of the roles of cultural norms and institutions, local knowledge, social learning and decision theory to diversify livelihood strategies and enhance resource sustainability (Johnson *et al*. 2015, Carlson *et al*. 2020).

Knowledge co-production methods have advanced. The UK National Institute for Health Research (2018) has issued guiding principles for knowledge co-production in health care systems. Cooke *et al*. (2020) published a very valuable review of knowledge co-production in fisheries. Co-production methods have been criticized if they intend to structure processes as if all participants in a process have an equal role, while in fact governments, large NGOs and economic interests have disproportionate power and more opportunities for participation (Cangiglia *et al*. 2021). Leveling the playing field by investing in underserved, marginalized and indigenous communities can assist in correcting power dynamics (Cochran *et al*. 2014).

Carrying Capacity Concepts for Aquaculture

Inglis *et al*. (2002) and McKindsey *et al*. (2006) defined four different types of carrying capacities (physical, production, ecological and social). When ecological science is combined with stakeholder inputs, the resulting ecological carrying capacity calculations are used in the management arena, but not necessarily by the public (Byron *et al*. 2011). Science is much more likely to be accepted if there are agreed upon, cooperative aquaculture research frameworks that combine efforts of scientists and farmers as the drivers of a participatory process. Interactions of some differing types of carrying capacities with the scientific approaches and the interest groups who define "acceptability" of aquaculture are outlined (Fig. 4). Regulatory carrying capacity is added as a new type and defined by rigorous risk analysis and communication protocols (GESAMP 2008).

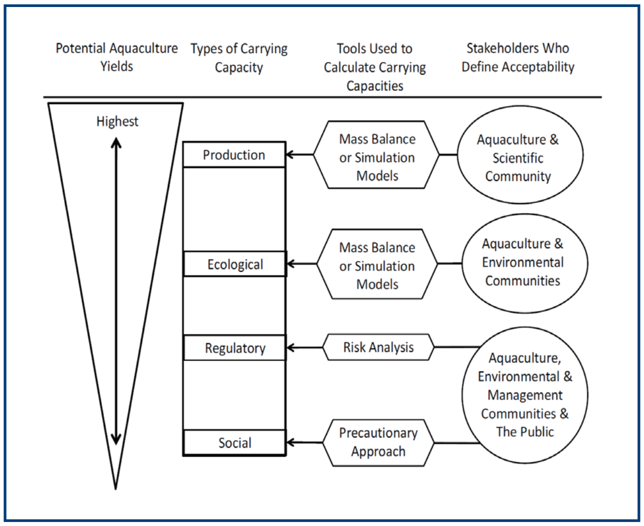

FIGURE 4. *A framework of different types of carrying capacities for aquaculture, scientific tools available and stakeholder groups involved. Greatest aquaculture yields occur when models predict maximum farm production for given input variables and ecological, regulatory and social concerns are less. Potential aquaculture yields decrease as the value of ecological, regulatory and social concerns are equal to or exceed the importance of aquatic food production. In North America and Europe, social carrying capacity drives determinations of production carrying capacity in aquaculture and there is a strong interaction between all types of carrying capacities. Elsewhere in the world, such limits on production carrying capacity are much less but are also increasing.*

Social carrying capacity has been defined as the amount of aquaculture that can be developed without adverse social impacts. Ecological degradation or adverse changes to ecosystems due to aquaculture may inhibit social uses. The point at which alternative social uses become prohibitive due to level, density or placement of aquaculture farms is the social carrying capacity of aquaculture (Byron *et al*. 2011). Gibbs *et al*. (2007) recognized the importance of economics in carrying capacity determinations and defined an economic carrying capacity as the "the amount of money investors are willing to invest, and the monetary value associated with sellable products and ecosystem services." Social carrying capacity was determined for Rhode Island (USA) waters through a stakeholder process (Byron *et al*. 2011) that included commercial fishing, recreational fishing, environmental groups, academia, riparian landowners, policymakers and other groups who agreed upon a level of shellfish aquaculture that would not restrict or inhibit use to any group.

Analytical methods for determinations of social carrying capacity remain in development. Kite-Powell (2009) placed a monetary value on various ecosystem uses and calculated the social carrying capacity at which relative value for all uses was maximized. This included assigning value not only to commercial products but also to ecosystem services and other intrinsic and tacit values associated with the system or use of the system. If aquaculture is constrained by social values, an index of social values needs to be developed that can be as scientifically credible as any ecological or water quality suitability index. Fortunately, scientists who study the human dimensions of resource use have developed such an index for the social context of grey wolf reintroduction in Colorado, USA (Manfredo *et al*. 2021). They developed state and county maps that represented public interest in policy decisions that informed management actions that targeted identified human behaviors. These techniques are broadly applicable to aquaculture.

Agricultural extension services and NGOs continue to lead in developing innovative participatory processes. The Healthy Food Policy Project (healthyfoodpolicyproject.org) is a notable example. They have developed a template to measure "authentic resident engagement" that will drive transformational change in food policy (Table 1). The Project defines authentic resident engagement as an "inclusive process for informing, designing, implementing and evaluating food access policy changes that centers around residents… moving beyond participatory practices and acknowledging the deficiencies of policy and advocacy organizations, government officials and others to embrace the capacity, knowledge and experience already present in dynamic and resilient communities."

Conclusions

"*However far modern science and techniques have fallen short of their inherent possibilities, they have taught mankind at least one lesson; nothing is impossible*." Lewis Mumford (1934)

"*Most of the work still to be done in science and the useful arts is precisely that which needs knowledge and cooperation of many scientists and disciplines. That is why it is necessary for scientists and technologists in different disciplines to meet and work together, even those in branches of knowledge which seem to have least relation and connection with one another*." Antoine Lavoisier (1793)

We can increase the social license for aquaculture in common property resources in aquaculture's new geographies. To do so, aquaculture natural and social science needs to tie together community knowledge and industry-relevant outreach with applied academic scholarship to create transdisciplinary, knowledge-based infrastructures and support systems for aquaculture development in common property areas. Aquaculture's evolution towards social, economic and ecological sustainability depends on innovative farmers, supportive policymakers and social institutions, educators, researchers, bankers and consumers all working together in well-designed participatory groups to influence adoption. Pioneering research in agroecology, agroecosystems and farming systems and the use of participatory technology development frameworks and methodologies provide a roadmap for achieving an accelerated social license for aquaculture.

Farmers everywhere experiment, adapt, innovate and observe the results of their work — and they have been doing so for centuries. Farmers must be able to adapt to continuously changing conditions to evolve sustainability. Farmers have invaluable indigenous

(CONTINUED ON PAGE 48)

Community Engagement Stances	Ignore	Inform	Consult	Involve	Collaborate	Defer To
Goals	No access to decision-making	Provide diverse, up-to-date information	Gather community input	Community needs and assets are integrated into the planning and processes	Community plays a lead role in the implementation of decisions	Full decision-making is in the hands of the community allowing a bridge between the community and governance
Messages	"Your voice, needs and interests do not matter"	"We will keep you informed"	"We care what you think"	"You are making us think differently about the issues"	"Your leadership and expertise are critical to how we are addressing these issues"	"You have unlocked the collective power for transformative solutions"
Activities	Closed door committees meetings of working groups	Publications, Fact Sheets, Presentations (virtual and non), Videos, Experts	Public comments, Focus groups, Community forums, Surveys	Community organizing processes (forums), interactive workshops, polling	MoUs with community-based organizations, formation of Citizen Advisory Committees, Open planning forums with citizen polling	Community led planning and investment in consensus-building, participatory action budgeting and research, investments in cooperatives
Impacts	Marginalization	Placation	Tokenization	Voices Heard	Power Delegated	Community Ownership
Social-Ecological Ranking	0	1	2	3	4	5

TABLE 1. *Authentic community engagement for aquaculture in its new geographies. Modified from the Healthy Food Policy Project document on Food Access Policy Change Through Authentic Resident Engagement. healthyfoodpolicyproject.org*

knowledge and experiment using scientific principles oftentimes without recognizing their experimentation as science. They design, implement and evaluate farm trials by gathering background information, select sites, identify variables, monitor and evaluate trials. It therefore critical that farmers be included in the process of evolving the sustainability of aquaculture to analyze, monitor, adapt and innovate in collaborative aquaculture research to evolve sustainable aquaculture ecosystems.

Participatory processes promote empowerment and accountability. They lead to institution building, market reforms and the advocacy needed to secure policy reforms, scaling appropriately, and prioritizing rural economic development. They elicit evolutionary change towards sustainability in aquaculture by using ecological principles as the basis for new designs for aquatic food production systems and by incorporating people into holistic systems analyses of production and natural systems. The approach is to use the wisdom of ecology and its underlying principles of hierarchies, complementarity, redundancy, cycling, and diversity to not only meet environmental goals but also to improve farmer livelihoods by increasing whole farm efficiencies and product values.

In designing participatory processes that will lead to an increased social license for aquaculture in common property resources, clear, unambiguous linkages between aquaculture and the environment must be created and fostered and the complementary roles of aquaculture in contributing to environmental sustainability, rehabilitation and enhancement clearly articulated to a highly concerned, increasingly educated and involved public. But isn't this the democracy we want?

Recommendations

Recommendations to increase the social license for aquaculture that new aquaculture operations must plan, at the outset, to:

- Use inclusive, transparent and long-term transdisciplinary approaches that results in new aquaculture developments becoming an integral part of a community and a region,
- Plan for community development by working with leaders to provide needed inputs and recycle wastes as much as possible at the outset, and continuing to evolve to become leadership innovators in resource use, management, developing new circular, recycling economies, and
- Get beyond endless user conflicts that view the global expansion of aquaculture as a "blood sport" by creating stakeholder processes with ethics and values and true meaning. For example, a local NGO, a community, and a shrimp aquaculture company negotiated a deal with the following conditions: 1) all shrimp ponds were to be located 50 m behind the mangroves; 2) no alteration of mangrove cover would be allowed; 3) no alteration of natural water flows by dams, walls, or diversions was permitted; 4) traditional uses and access to mangrove areas would be guaranteed to the local peoples; and 5) ecotourism activities and collaborative research were developed (Ochoa 1997).
- Adopt the pedagogy of ecological aquaculture as a "new" (actually ancient) and exciting, knowledge-based creative challenge. Integrate aquaculture planning with communities to maximize job creation and training for displaced "sea workers" or new entrants.
- View aquaculture in the context of rural and urban planning and community development. Develop planning mechanisms for aquaculture to fit as a good community citizen. Create community pride by creating a diversity of processed and unprocessed products and provide local market access for both, not only export value-added products catering to the wealthy.
- Incorporate aquaculture models and metaphors to help increase math and science standards in coastal schools.
- Use market and tax incentives to enhance aquaculture's efficiencies, eliminate wastes, and improve aquaculture's economic and social returns to protect ecosystems and ecosystem services.

- Accelerate the ecolabelling of fishery products and product certification to encourage development of niche markets and small business development.
- Use participatory processes to stabilize the aquaculture regulatory environment and decrease the societal costs for ecological aquaculture to evolve rapidly.

In the 21st century, aquaculture developers will need to spend as much time on the technological advances coming to the field as they do in designing ecological approaches to aquaculture development that clearly exhibits stewardship of the environment. In developed nations, aquaculture products are discretionary and can be rejected by the public, making the enterprise economically fragile. In developing countries, aquaculture development is a vital issue for future food and economic security. However, for aquaculture development to proceed to the point where it will be recognized worldwide as the most efficient contributor to new protein production, clear, unambiguous linkages between aquaculture and the environment must be created and fostered and the complementary roles of aquaculture in contributing to environmental sustainability, rehabilitation and enhancement must be developed and clearly articulated to a highly concerned, increasingly educated and involved public.

Notes

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