# Aquaculture Task Force Discussion Paper on Bio-Physical Carrying Capacity

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**Issue**

The current aquaculture leasing process considers new proposals on their own merit as prospective aquaculturists identify areas to farm. One could say the process is reactive and fails to consider broader and future use of the public waters. Some have proposed a more proactive approach whereby areas of the coast are pre-identified as suitable for aquaculture based on comprehensive scientific studies that consider cumulative impacts and projected uses. Those areas are where aquaculture would be directed. Determining carrying capacity has been offered as a prerequisite to using such an approach. For the Aquaculture Task Force, the issue at hand is whether or not carrying capacity should or even realistically can be comprehensively determined as a useful long-range planning tool. And if it can, how should it be done?

Here we are concerned with bio-physical or ecological carrying capacity though it should become clear that cultural carrying capacity is integrally entwined. Catton's[1] definition where "an environment's carrying capacity is its maximum persistently supportable load" provides a simple beginning. The operative word is "load." A load is a force or stress and may be positive (e.g. "input" of a nutrient) or negative (e.g. "removal" through harvest). While ecological carrying capacity commonly refers to a system's ability to absorb pollutants, carrying capacity also encompasses other loads including populations of plants, animals and pathogens.

Carrying capacity is dynamic. It continually changes as a system's "load" and cultural norms change. As areas of the coast develop, watersheds may yield higher nitrogen loads to an estuary thus decreasing the carrying capacity of that estuary for nitrogen. Consequently, the estuary's ability to accommodate finfish culture is reduced. Alternatively, as agricultural lands are taken out of production or nitrogen is harvested out of a system in the form of protein (mussels, oysters or seaweeds), it may be possible to increase the system's capacity to assimilate additional nutrient.

**Determining Carrying Capacity**

Imperative to determining ecological carrying capacity is identifying the ecological concern(s) or threat(s). To do so, a management unit and a vision for that unit must be defined. What is the "water body?" What does the public want it to look like? How might this water be compromised? Science can play a role. Physical oceanographers can identify frontal boundaries and patterns of circulation that delineate two water bodies. Some geographical features make sensible boundaries. However, geographic or

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[1] Catton, W. (18 August, 1986). Carrying capacity and the limits to freedom. Paper prepared for Social Ecology Session 1, Xl World Congress of Sociology. New Delhi, India.

oceanographic features may not correspond well to legal jurisdictions (e.g. Cobscook Bay that abuts an international border) or translate to practical management (e.g. Casco Bay that contains uses ranging from industrial to natural areas).

Although science is not in a position to determine the vision for a bay, science can contribute to the vision's formulation. Science can help justify a policy (e.g. that an area is higher risk due to recurrent toxic algal blooms and therefore less suitable for some forms of shellfish aquaculture) as well as predict consequences of one management action over another (e.g. adding 100,000 more farmed salmon may deplete dissolved oxygen). Through monitoring, science can estimate current loads to a watebody and characterize the condition of the waterbody in relation to its carrying capacity for that load. Modeling can project future conditions under different scenarios. Modeling can identify areas suitable for culture and even assist with fine scale aspects such as orientation of pens, cages, and rafts. Trial and error, if cautiously used, has shown to be both effective and safe as long as adequate feedback mechanisms are concurrently employed. Under current law, the Commissioner may reverse a lease if the operation is found not to be in the best interest of the State. The same cannot be said for land based industrial, commercial or residential developments, once constructed.

Other questions are also raised:

- What is the existing condition of the water body?
- What are the existing natural and anthropogenic "loads"?
- What is an acceptable level of change (statutory, philosophical)?
- What is the time element to carrying capacity?
- What level of certainty is necessary? What are assumptions?
- If carrying capacity is exceeded, what are the consequences?
- Is there reasonable opportunity to reverse negative effects, over what time frame?
- Is "maximum ….. load" even desirable?

**Carrying Capacity Use in Maine**

Carrying capacity and cumulative impact have long been considered by DMR and DEP staff when making lease decisions. DMR denied a salmon farm lease in the western side of Blue Hill Bay because bottom waters were already near their carrying capacity for bio-chemical oxygen demand (BOD). At the head of the Damariscotta Estuary, concern exists that the upper estuary has reached its capacity to support shellfish leases. Adding more filter feeders might exceed the carrying capacity, lower phytoplankton supply and result in economic lose to existing aquaculturists. In Blue Hill Bay, expansion of salmon aquaculture was halted for three years awaiting a bay wide nutrient characterization.

Even after a lease is approved, DMR continues to look at carrying capacity. In Cobscook Bay, the DMR and industry are addressing the carrying capacity of the bay for Infectious Salmon Anemia (ISA) virus. The Cobscook example illustrates the diversity of approaches to determining carrying capacity. In this case, capacity is measured not in space (distance or volume) but time; time for water to move between sites. On a more local level, carrying capacity of each finfish lease is re-examined annually through the

Finfish Aquaculture Monitoring Program (FAMP). The above describes a subset of the many types, scales and approaches to addressing ecological carrying capacity.

**Limitations of Carrying Capacity**

Answers to the many questions are not easy but are required in order to determine carrying capacity. Many are public policy decisions for which there may not be consensus. Others require large amounts of field data and some require specific research. Whose responsibility is it to conduct this work? Is it the state, industry, municipality, applicant, or local NGOs? To conduct such work for the entire coast as some propose will be expensive. Even after such an exercise, there may not be an applicant interested in the area. Would we be attracting aquaculture development to areas where people are no more prepared or willing to accept it than those in controversy today? In the late 1970s, a similar planning exercise was undertaken by the State. Maine endorsed a Three Port Development Strategy. Portland, Searsport, and Eastport were selected as commercial cargo growth areas. The expectation was that endorsement by the state would presumably make licensing easier and deflect commercial development from other parts of the coast. This plan sounded sensible in the abstract and was unopposed by environmental groups. The plan unraveled when an actual development proposal was made. What is to prevent the same occurring with proactive aquaculture siting?

Technological advances may modify existing carrying capacity projections is the use of "diapers" under salmon cages. If shown to be effective in collecting solids, then sites and bays where salmon farms may today be at their carrying capacity now may be suitable sites for expansion. In this case, the actual carrying capacity of the site or bay for nitrogen, carbon, and oxygen would remain unchanged but it would be the husbandry that now "fits" within the existing carrying capacity. Polyculture, if developed, offers a similar result. How do we manage integrated aquaculture where one organism offsets the impact of another, or contributes to the other's productivity? Where an area was not suitable for a single species, it may be suitable for a complex of species (e.g. finfish, algae, and shellfish) that offset and balance the impacts of each other.

**Conclusions**

An environment's carrying capacity is not static and neither is aquaculture's. Both are in flux. The coastal system is subject to continual change over seasons, years, decades and so on. Aquaculture is an impermanent use that has the ability to evolve and adapt, not only with its natural environment, but with society. Perhaps most striking, coastal development patterns have intensified along the coast bringing in more people using the land and the water. Hence the dilemma; How do we apriori designate aquaculture sites based on today's conditions, knowledge and culture? Inadequate as some may see it, the current "reactive" approach is up-to-date and adaptive. And to ensure that the industry fits within its environment's carrying capacity, leases are continually re-evaluated and reassessed. Science plays a key role as each lease and activity is evaluated. But is there merit in conducting a comprehensive scientific site suitability analysis of the coast? Short of that, are there measures the Task Force can recommend that address the desire for predictable growth of aquaculture on the Maine coast?