Open ocean aquaculture:

Economics (and policy)

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WHOI Center for Marine Robotics Woods Hole, 11 January 2016

Outline

- Global trends in aquaculture
- Economic drivers of profitability
- Potential for robotics

Context



World Demand is Growing Rapidly



Source: FAO

US Seafood Supply, 2012 80% + of US consumption is imported 50% + of that is farmed



Future Seafood Demand

US population: 2015: 322 million 2050: 440 million

seafood consumption:
12 kg/year live weight; trend?
(US gov't recommends 25% more)

World population: 2015: 7.3 billion 2050: 9.4 billion



seafood consumption: 19.5 kg/year live weight & rising

We'll need another 1-2 million tons/year by 2050 in the USA, and 40 million tons/year by 2050 globally...at least.

Aquaculture...but what kind?

Global trends that will shape food production:

- Concern over C emissions, ecological efficiency of food production
- Constraints on fresh water and arable land
- Trend toward locally produced food, shorter and simpler supply chains



Greenhouse Gas Intensity

Source: Pelletier and Tyedmers (2007)



Aquaculture...but what kind?

- Historically dominated by freshwater finfish
- Recent growth: shellfish
- Future:
 - Marine
 - Open ocean
 - Recirculating



Near-Shore vs. Open-Ocean

Near-Shore

Make full use of permitted site Multiple pens in array Fixed location, multiple anchors Site rotation for fallowing Rely on human intervention

Open-Ocean

Large area, very low-density Independent cages Location less critical Little or no bottom impact Mechanization where possible

• Conventional technologies are suitable only a narrow band of sheltered waters.

Source: Cliff Goudey

Near-shore Technology

Salmon pens, Maine and Washington





OceanGlobe Byks AS, Norway

40,000 m³ design



Source: Byks AS, Norway

Ocean Drifter Conceptual design by Cliff Goudey

- 64,000 m³ design
- Manned or autonomous
- Low-speed selfpropulsion (gyres/reciprocating currents)



Source: Cliff Goudey

Pros and cons of open ocean

• Cons:

- Exposure (structures, vessels)
- Logistics (transport costs)
- Water depth (mooring system)
- Working conditions
- Industry economies of scale
- Operating and regulatory experience

• Pros:

- Water quality
- Availability of sites
- Use conflicts
- Farm economies of scale
- Distance from markets

Some basic economics of aquaculture, courtesy of Gunnar Knapp

Higher production costs at open water sites limit competitiveness with low-cost near-shore sites





What could make open water aquaculture more competitive?

Demand growth

Supply constraints on near-shore sites

Stricter regulation on near-shore sites

Technological change

Figure 2.4. How offshore aquaculture could become competitive with inshore aquaculture.

A. Demand increases. As demand increases, lower-cost inshore sites are fully utilized and farming expands to higher-cost offshore sites. The rise in price to P* makes offshore farming economically viable.



C. Supply of inshore sites declines. As demand for other uses of coastal areas increases, the supply of inshore sites becomes lower and farming moves to higher-cost offshore sites. The rise in price to P* makes offshore farming economically viable.



B. Technological change reduces offshore costs. Offshore farming becomes relatively less costly. Price declines and offshore production expands.



D. Regulations increase inshore costs. Regulators impose new costs on inshore farming to address externalities, making offshore farming relatively more competitive. The rise in price to P* makes offshore farming economically viable.



The role of local production

Open-ocean technology could enable greater US production, even if near shore sites are limited

US-produced open ocean seafood might command a price premium



A. U.S. is competitive offshore. Even though the U.S. is not competitive in inshore aquaculture, it can match costs of foreign producers in offshore aquaculture.

B. U.S. offshore production enjoys a price-premium. Even if foreign offshore costs are lower, U.S. offshore farms may be competitive if they command a price premium over foreign production.



What affects economic viability?

- Capital investment
- Operating cost
- Production density
- Juvenile survival rate
- Feed conversion ratio
- Market price
- Cost of capital

Major cost parameters Major cost components Capital intensity Regulatory factors Farm Operating life design Is farming allowed? Facilities costs Discount rate Technology Regulatory restrictions and requirements Start-up period Scale Permitting process cost and Feed conversion ratio Feed time costs Price of feed Regulatory certainty Taxes and royalties Juvenile survival rate Juvenile Environmental factors Average harvest costs weight Do suitable sites exist? Price per juvenile Site exposure Labor productivity Water depth Other Wage rates Water quality and flow operating costs Distance from shore Economic factors Labor supply & wages Farm cost per pound Infrastructure (roads, ports, energy, etc.) Political & economic stability Is the farm economically viable? Industry factors Availability and cost of iuveniles Farm price per pound Availability of skilled labor and technical specialists Market factors Marine support infrastructure Demand in local, national, & international markets Processing & distribution Supply to local, national & international markets infrastructure Transportation and processing cost differentials Level of farming technology relative to competitors Scale of production Market quality perception differentials relative to competitors Market development Exchange rates

Figure 2.9. Major factors affecting the economic viability of a fish farm.

Production cost: Near-shore vs. Open Ocean

 Increased capital and operating cost of cages, feed system, mooring: 2-3 X near-shore costs

 Increased cost of logistics due to greater distance from port

Cost Effect of Distance from Shore



distance from shore base (km)

Major Cost Components





Kite-Powell et al. (2003)

Summary

- Global aquaculture output will have to grow significantly
- Marine, open water production will be needed
- Key challenges in open water aquaculture: efficient facilities, and operations/logistics
- Robotics/automation can directly address about 15% of cost of current operational model
- Robotics/automation that enables very large autonomous systems can open new possibilities in scale economies