Interactions between Offshore Aquaculture and Fisheries

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Photo: NOAA
Potential interactions and concerns

- Loss of access to fishing grounds
- Pollution
- Interactions between escaped farmed fish and wild fish
- Attraction of wild fish to cage sites
- Disease transmission
- Fisher responses to altered fishing opportunities
- Market interactions between products
Potential interactions and concerns

- Loss of access to fishing grounds
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Interactions between Offshore Aquaculture and Fisheries

Hatchery

Fisher response

Attraction

Disease transmission

Escapees
Much can be learned from the practice and science of fisheries enhancement: hatchery fish and artificial habitat.
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- Hatchery
- Escapees
- Disease transmission
- Fisher response
- Attraction
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Interactions between Offshore Aquaculture and Fisheries

Escapees

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Interactions between Offshore Aquaculture and Fisheries

Escapees

- Fisher response
- Attraction
- Disease transmission
Interactions between farmed and wild fish

Lorenzen, Beveridge & Mangel *Biological Reviews* 87: 639–680, 2012
Key factors: relative abundance and conservation status of the wild population

- Most interactions* are strongest when farmed fish are abundant relative to wild fish.
- Small/declining wild populations may be particularly vulnerable to such interactions.
- Consider Atlantic salmon in Norway vs. Almaco jack or red drum in the Gulf

* Exceptions: introduction of invasive fish or parasites/pathogens
Cultured fish undergo a process of domestication

Domestication involves (Price 2002):

- **genetic changes** occurring over generations and
- **developmental effects** (phenotypic plasticity) recurring during each generation

→ Improved performance in culture
→ Reduced performance (fitness) in the wild
### Natural vs. aquaculture environment

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Natural habitats</th>
<th>Aquaculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall extent</td>
<td>Large, often open</td>
<td>Small, confined</td>
</tr>
<tr>
<td>Complexity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Resource availability</td>
<td>Lower than uptake capacity,</td>
<td>Matching or exceeding uptake capacity,</td>
</tr>
<tr>
<td></td>
<td>unpredictable</td>
<td>predictable</td>
</tr>
<tr>
<td>Predation risk</td>
<td>High</td>
<td>Very low</td>
</tr>
<tr>
<td>Disease risk</td>
<td>Variable</td>
<td>High (but controllable)</td>
</tr>
<tr>
<td>Population density</td>
<td>Low</td>
<td>Very high</td>
</tr>
<tr>
<td>Disturbance</td>
<td>Rare</td>
<td>Very common</td>
</tr>
<tr>
<td>Selection</td>
<td>Natural, sexual</td>
<td>Artificial, natural</td>
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</table>
Comparative survival of fish

Based on data from Lorenzen 1996, 2000

In aquaculture

In wild populations

Escaped farmed fish in the wild
Genetic loss of fitness—in-the-wild vs. number of generations in captivity

How do escapees interact with wild conspecifics?

Population model for enhanced fisheries

Some generic results

Strongest interactions when:
- farmed fish abundance is high relative to wild
- maladaptation to life in the wild is only moderate and genetically based.

→ When farmed fish abundance is very low relative to wild fish, interactions are minimal.

→ When farmed fish abundance is high, alternative husbandry and genetic management approaches can give very different outcomes.
Impacts of farm escapees on wild populations: effects of survival and reproduction

**Total biomass**

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<th>Wild-like survival, no reprod.</th>
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**Wild type biomass**

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Impacts of farm escapees on wild populations: effects of survival and reproduction

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Minimizing risks from escapes: alternatives

1. Reduce escapes (review when and where escapes occur and improve facilities/management)
2. Produce sterile fish (triploids)
3. Advance domestication: benefit aquaculture and reduce performance in the wild (multiple traits?)
4. Preserve wild attributes in cultured fish (stock structure, adaptation)
5. Multiple measures (1–3) may be most effective
Minimizing risks from escapes: alternatives

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Attraction of wild fish to cages

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Fisher response

Attraction

Disease transmission

Escapees
Attraction and aggregation of wild fish

- Cage aquaculture operations have impacts on the behavior of wild fish
- Attracting and aggregating fish in ways similar to fish aggregation devices or artificial reefs
- Enhances the scope for certain biological interactions such as disease transmission
- Enhance harvesting opportunities for fishers.
Interactions between Offshore Aquaculture and Fisheries

Disease (parasite) transmission

Fisher response

Attraction

Escapees

Disease transmission
Disease (parasite) transmission

- Formulated feed & low predation in culture largely eliminate transmission of **macroparasites** with complex life cycles
- High density in culture enhances transmission of **microparasites** with direct lifed cycles (e.g. bacteria, viruses, sea lice) an may lead to evolution of higher virulence
- Open nature of cage farm allows transmission of microparasites to wild fish
- Health management (vaccination, treatment) on the farm is key to minimizing risk of transmission to wild stocks but is not always sufficient
Interactions between Offshore Aquaculture and Fisheries

Fisher responses

Hatchery

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Fisher responses

- Fishers may seek out harvesting opportunities provided by escaped farmed and aggregated wild fish.
- Can reduce interactions between farmed and wild fish
- Can affect the exploitation level of wild stocks in ways similar to fish aggregating devices.
- Potential for complex interactions with fisheries that require concerted attention from both sectors
Velella Epsilon cage as a FAD/AR
Conclusions and outlook (I)

- Good conceptual understanding of potential interactions between offshore aquaculture and fisheries
- Increasingly sophisticated quantitative models and tools for risk assessment and management planning
- Learning from fisheries enhancements
Conclusions and outlook (II)

- Small-scale pilot projects for the culture of native species that are abundant in the wild pose limited risks.
- Provide important empirical information on interactions with fisheries that can help to test and refine models, risk assessments and management plans.
- Fisheries interaction studies should complement pilot aquaculture projects.
- Studies should be accompanied by a stakeholder process involving fisheries and aquaculture stakeholders.
Conclusions and outlook (III)

Some issues and approaches are likely to change when/if the industry expands and develops, due to:

- Increase in numbers of facilities
- Increase in number of farmed fish and escapees
- Advancing domestication
- Emerging diseases