Risk and Risk Management for feed and seed for carnivorous marine fish aquaculture

Michael Rust
Northwest Fisheries Science Center
NOAA Fisheries Service

Outline

- Risk Assessment Introduction
- Up-steam risks for feed and seed
- Downstream Risks for feed
- Downstream Risks for seed
- Summary

Terms and Definitions

- Hazard - Inherent property of an agent or situation capable of having adverse effects on something (substance, agent, energy source or situation)(Duffus 2001)
- Risk - The <u>probability</u> and <u>severity</u> of an adverse effect/event occurring to man or the environment from a risk source (hazard). (EU 2000)
- Risk Management or Risk Mitigation - Steps that can be taken to reduce or eliminate risks. Can be by reducing probability and/or severity; or totally eliminating the hazard.

Risk Management

- Risk Management or Risk Mitigation -
  - Assumption 1 : Steps that can be taken to reduce or eliminate risks will be easier to adopt if economic gains by industry are in line with environmental risk management choices.
  - Assumption 2: Management that eliminates risks is preferred to management that just reduces risk, however the degree that this is important should be taken in to account.
  - Assumption 3: There are barriers to change that require an industry of some size or government to address.

Outline

- Risk Assessment Introduction
- Up-steam risks for feed and seed
- Downstream Risks for feed
- Downstream Risks for seed
- Summary

Upstream Risk for feed and seed

- Model for both situations is the same if wild stocks are harvested for feed or seed:

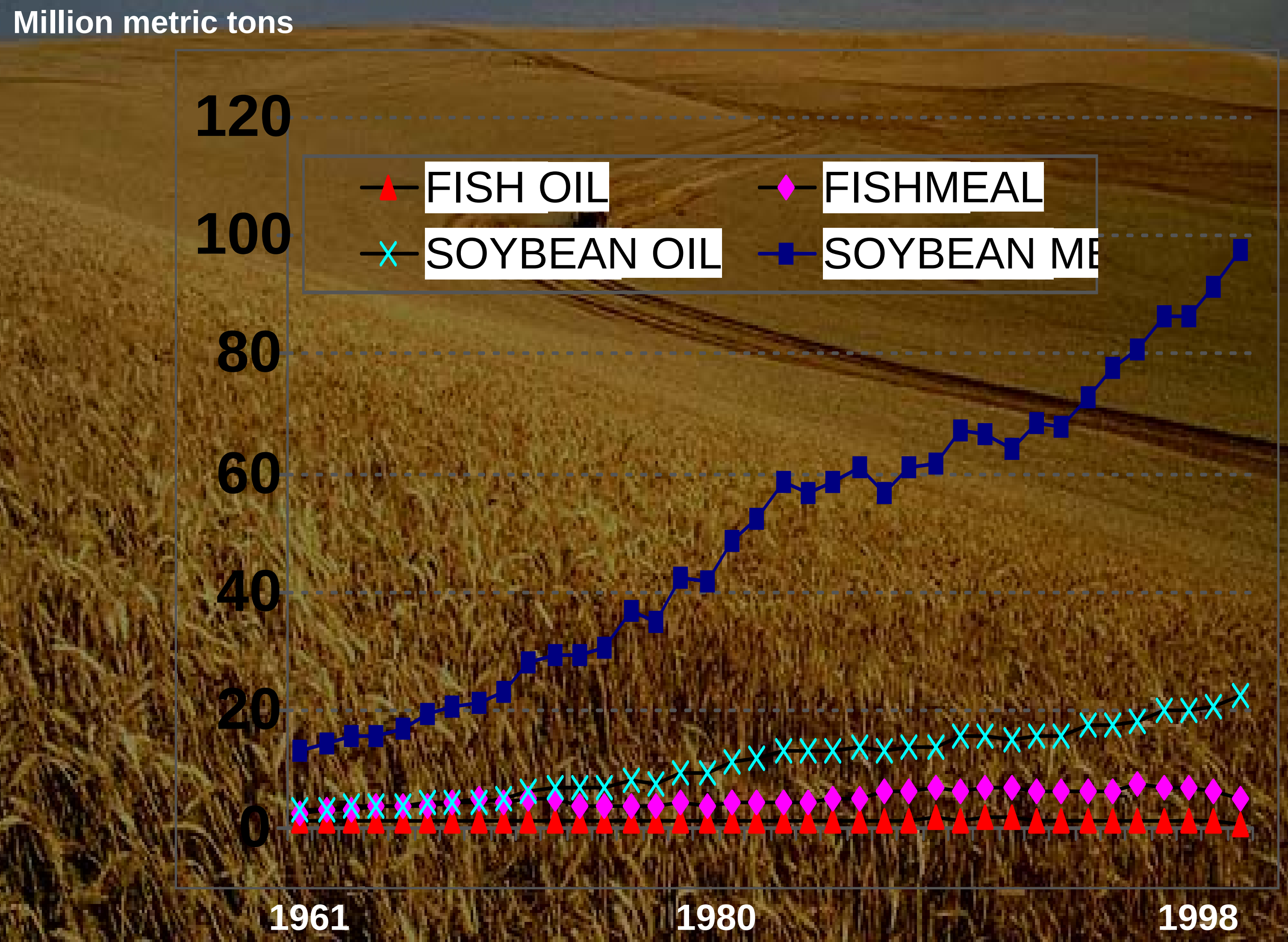
  Risk = F(Fisheries Management)

- At low levels of production good fishery management can provide a sustainable supply. At high levels of harvest over some maximum sustainable yield fishery management cannot sustain production. Given that wild resources are near maximum yield it is unlikely that future increases can be sustained.

Risk Management for Harvest issues

- Feed - use of alternative protein and oil sources to replace fish meal and fish oil use
  - Cost could be less than for fish meal so environmental goals are in line with economic goals
  - Requires a large investment in research which presents a large barrier to development

WORLD PRODUCTION OF FISHMEAL, FISH OIL, SOYBEAN MEAL & SOYBEAN OIL 1961 - 1998



…Salmon remain carnivores, and raising them in captivity <u>inevitably</u> shrinks the world's supply of edible fish…"

Seth Zuckerman
Bellingham Weekly
Sept 29 - Oct 5, 2005

"…It takes about three pounds of anchovies, mackerel and the like to raise a single pound of farmed salmon."

Do Carnivorous Fish Require Fishmeal?

Mono-gastric (aka Carnivore) fish need protein and fat with a minimum of carbohydrates.

Agastric (aka Herbivore) fish would do better with protein and fat only but can tolerate high levels of carbohydrates.

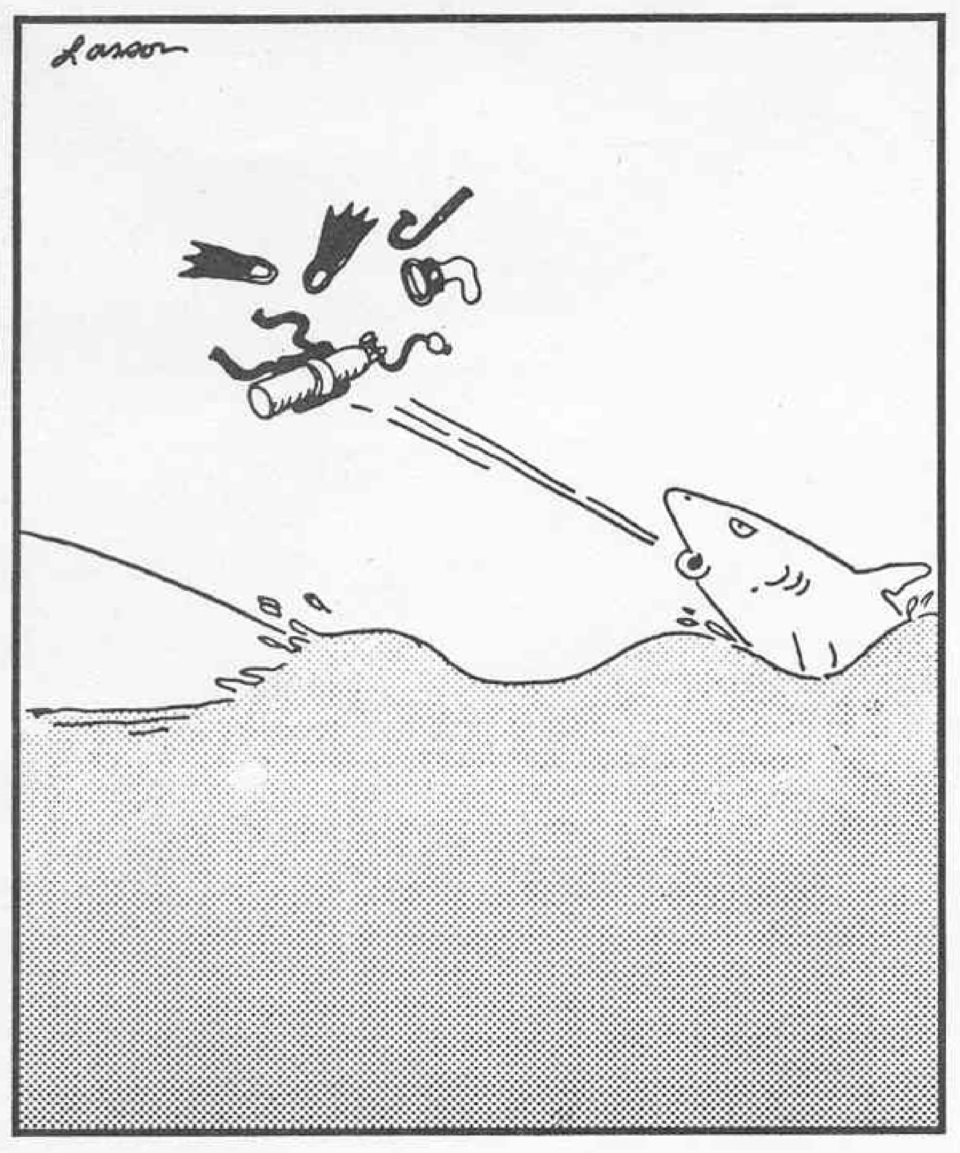
All fish, carnivore, herbivore or omnivore, require about 40-45 nutrients in the correct ratios and need to be protected from anti-nutrients.

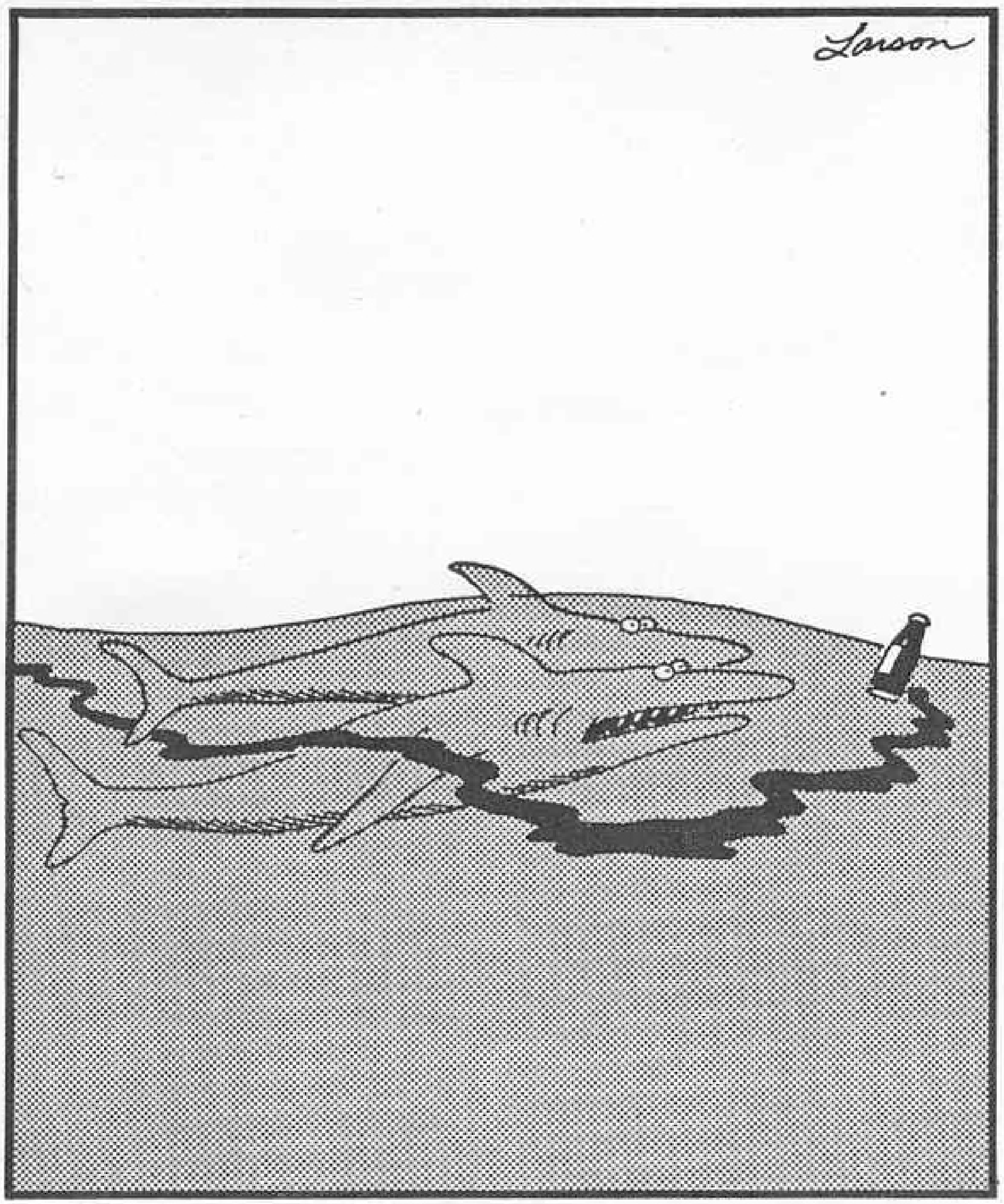
It does not matter where the nutrients come from. There is no requirement for fishmeal for farmed Salmon or any other fish.

Nutrients: what do they do for Organisms?

- Protein (actually specific Amino acids - some essential) - used for building blocks, tools, and energy
- Fat (aka - lipids or fatty acids - some essential) used mostly for energy but a few for building blocks and tools (n-6 and n-3 FA)
- Carbohydrates - (none essential) energy
- Vitamins, minerals and the like (all essential but very small amounts needed) - mostly tools, but some building blocks (choline)

<u>Caveat</u> - Flavor is important





"What the—? Ketchup? We followed a *ketchup* trail for three miles?"

But there are ways around the taste issue, and in fact some plant meals have very little palatability problem with mono-gastric fish

Crops that have shown to be fish meal replacement feedstuffs for mono-gastric fish

- Soy
- Peas
- Flax
- Sunflowers
- Canola
- Rape
- Barley
- Lupine
- Corn
- Wheat
- Cottonseed
- And so on….

Risk Management for Harvest issues

- Seed - use of hatcheries to replace need for wild seed collection
  - Cost per seed is lower and reliability is higher at high levels of production so environmental goals are in line with economic goals
  - Requires a large investment in research which presents a large barrier to development
  - Allows for selective breeding which creates an additional risk due to genetic impacts of escapes (we will look at this in a minute)

Outline

- Risk Assessment Introduction
- Up-steam risks for feed and seed
- Downstream Risks for feed
- Downstream Risks for seed
- Summary

Downstream Risks for feed

- Feed provides the nutrients that are released into the environment
- Risk Model:

$$\text{Risk} = F(\text{diet})$$

- Greater nutrient retention in animal leads to less feed needed and less nutrients released so practices which improve nutrient retention will both improve farm economics and environmental risk.

Downstream Risks for feed

- Change from raw fish diets to formulated feeds
  - Changing from raw fish diets to formulated feeds decreases loss by more than 90%
    - Typical FCR for raw fish - 6:1
    - Typical FCR for pellets - 1-2:1
    - Reduction of potential for disease transfer
    - Allows easier mechanization of feeding

Downstream Risks for feed

- Improve estimates of nutrient requirements
  - FCR in fish that are well studied (salmon) is low relative to species that have not been studied
    - Typical FCR for salmon - 1:1
    - Typical FCR for "new species" - 2-3:1
    - Higher health in animals when requirements are met
    - Allows easier least cost formulation making diets cheaper
    - More uniform production of fish when diets are well matched to requirements.
    - Diet can be used to minimize other risks such as disease and so on.

Outline

- Risk Assessment Introduction
- Up-steam risks for feed and seed
- Downstream Risks for feed
- Downstream Risks for seed
- Summary

Downstream Risks for seed

- Risk results from hatchery fish escaping
- Risk Model for genetic change of wild population

$$Risk = F(P_e/P_w)(\Delta G)(F_e)$$

P_e = Population size for escapes

P_w = Population size for wild population

ΔG = Difference in genetic structure between wild and escapes

F_e = Fitness of escaped fish to live in the wild

$Risk = F(P_e/P_w)(\Delta G)(F_e)$

- If wild fish were harvested for seed risk would be zero because $\Delta G = 0$, so it is the hatchery which creates the risk.
- If genetics are managed so that $\Delta G = 0$ then risk is also zero but this does not allow for economic gains due to selective breeding
- Reducing escapes or increasing wild population size has the same effect on risk (P_e/P_w). Thus there is good reason to preserve wild stocks and risk is less for healthy stocks.
- Selective breeding will increase ΔG but decrease F_e so highest risk is at intermediate levels of selective breeding.
- Technologies that sterilize fish reduce risk by making $F_e=0$. They may or may not have economic benefit.

Outline

- Risk Assessment Introduction
- Up-steam risks for feed and seed
- Downstream Risks for feed
- Downstream Risks for seed
- Summary

Summary

- The development of alternative feedstuffs and hatcheries can eliminate the risk of overfishing wild stocks to supply marine aquaculture industries. These technologies have high cost and research barriers to develop but in the long term are more economically beneficial than wild harvest.

Summary

- The development of modern formulated diets can reduce greatly the risk of nutrient enrichment relative to raw fish diets. These technologies have high cost and research barriers to develop but in the long term are more economically beneficial than raw fish diets.

Summary

- Hatcheries should begin programs of selective breeding for better economic and environmental efficiency. This will increase risk in the short term due to increased genetic difference between cultured and wild fish so an additional strategy will be needed to protect wild stocks during this time.

Summary

- The aquaculture industry should be supportive of efforts to increase wild populations of the species they culture. This will lower the risk that escapes from their facilities will have.
- Risk assessment can be a powerful tool to focus research efforts and make decisions on sustainable industry development.