Life-Cycle Assessment (LCA) of Salmon Fisheries and Aquaculture in the North-East Pacific

AUTHORS

ASTRID J. SCHOLZ (CORRESPONDING AUTHOR), ASTRID@ECOTRUST.ORG

PETER TYEDMERS - DALHOUSIE UNIV.

ULF SONNESSON - SIK

SARAH KRUSE - ECOTRUST

NATHAN PELLETIER - DALHOUSIE UNIV.

NATHAN AYER - DALHOUSIE UNIV.

ANNA FLYSJO - SIK

FRIEDERIKE ZIEGLER - SIK

INTRODUCTION

According to the United Nations Food and Agriculture Organization (FAO) the global production of seafood from fisheries and aquaculture reached 133 million tonnes, and provided direct employment to an estimated 38 million people, in 2002 (FAO 2004). With many traditional fisheries depleted, over-exploited, or fully exploited, it appears that global carrying capacity for seafood production has been reached or even exceeded (Worm and Meyers 2004), and that restrictive management regimes are imperative. In response to this decline and increasing demand for seafood products, aquaculture has become the fastest growing animal food-producing sector (FAO 2004). At present, approximately 1/3 of all consumed fish and shellfish are farmed, and a 70% increase in aquaculture production by the year 2030 is predicted (FAO 2004).

DECISION - WHY LCA?

While aquaculture has undeniably contributed enormously to economic growth in many regions, poorly regulated development has also had profound socio-economic and ecological consequences (Paez-Osuna 2001, Naylor et al. 1998, 2000). The rapid expansion of the aquaculture sector and the vulnerability of global fisheries to further degradation underscore the urgent need to understand and manage the environmental and social interactions of seafood production systems. Life Cycle Assessment (LCA) provides a convenient means of quantifying and describing these interactions and targeting specific process and product improvements.

ABSTRACT

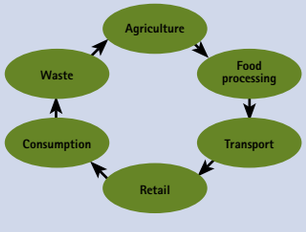
This presentation introduces the North-East Pacific (Alaska and British Columbia) segment of a three-year, international project to rigorously evaluate and compare the major life cycle environmental and social impacts associated with the production of salmon for human consumption. Using a formal Life Cycle Assessment (LCA) framework, the project assesses the relative environmental and social impacts of alternative salmon production systems — both wild and farmed, and from harvest through processing and distribution to final product forms consumers encounter in stores and restaurants. Originally pioneered in Industrial Ecology, the Life Cycle Assessment (LCA) approach can be used to assess the cradle-to-grave impacts of seafood production systems, forming the basis for inter and intra-regional, gear, and product mode comparisons, as well as informing labels and standards, consumer choices, and policy decisions. LCA has been applied to various food systems, including fisheries, and is compatibility with the ISO 14,000 standards and Environmental Management Systems that are increasingly favored by European and other markets. The analysis of salmon products sourced from commercial fisheries will take into account the diversity of harvesting technologies currently employed on the major salmon fishing grounds of the north Pacific (purse seine, gill net and troll). Similarly, the analysis of the environmental and social impacts associated with contemporary farmed salmon production will account for the major differences, e.g. pertaining to feed formulation or stocking densities. The analysis will also include the assessment of the life cycle environmental and social impacts associated with both a certified organic and a land-based farmed salmon system.

WHAT IS LIFE-CYCLE ASSESSMENT?

According to the Society for Environmental Toxicology and Chemistry (SETAC), Life Cycle Assessment is:

> "An objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment, to assess the impact of those energy and materials uses and releases on the environment, and to evaluate and implement opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extraction and processing of raw materials, manufacturing, transportation and distribution, use/reuse/maintenance, recycling and final disposal" (Consoli et al. 1993).

SETAC published the first Code of Practice for LCA studies in 1993 and The International Organization for Standardization (ISO) has also published a series of methodological standards (ISO 2003). An ISO compliant LCA must have four components: goal definition and scoping, life cycle inventory (LCI), life cycle impact assessment (LCIA), and improvement assessment (ISO 2003). For a review of these components see Rebitzer et al. (2004) and Pennington et al. (2004).



METHODS

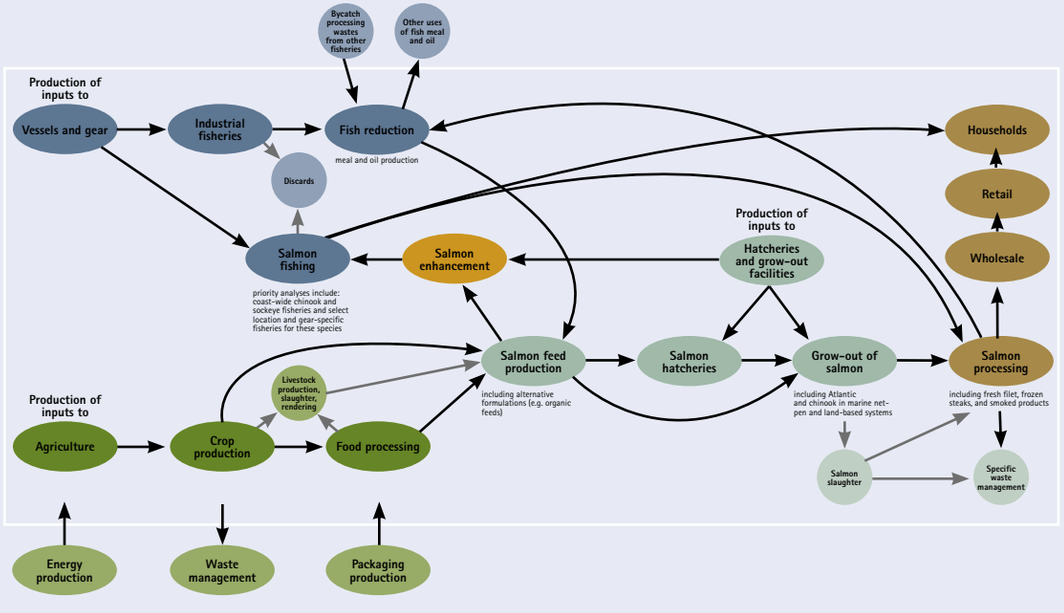
In this project we use a formal LCA framework to address the following question: What are the quantitative, life cycle environmental and socio-economic impacts associated with the provision of salmon for human consumption from the North-East Pacific?

Salmon were selected as the primary focus of this study because:

- Salmon have become one of the most widely consumed seafood products in the industrialized world, it is an international super-commodity — a uniform food product available fresh on demand around the globe (Eagle et al. 2004);
- Many of their derivative products are highly substitutable, i.e. they compete directly in the marketplace (Anderson and Fong 1997, Clayton and Gordon 1999);
- Production from the two industries (capture fisheries and aquaculture) is currently broadly of a comparable scale globally;
- There is significant public interest at present regarding the relative environmental impacts associated with both salmon fishing and farming, driven in part by research on the health risks and environmental impacts of these activities (Hites et al. 2004, Krkosek et al. 2005), and
- Detailed data from both of these industrial activities are relatively readily available from local, state and federal agencies, as well as from industry.

The analysis will proceed in the following four stages:

1) Defining the functional units for analysis, the boundaries of the systems under consideration, and the impact categories that will be assessed. For the production phase of each system, we will use live weight tons of salmon; for the consumption phase we will use commonly found product forms such as frozen steaks, smoked portions, or sashimi-grade raw salmon. During this phase we will also develop a suite of socioeconomic impact categories in conjunction with the biophysical ones.
2) Inventory analysis — the compilation and quantification, to the extent practicable, of relevant inputs and outputs associated with the activities within the system boundaries, including the use of resources and emissions to air, water and soil. Data used ranges from published sources such as agency statistics to primary data from businesses involved in the capture, culture, and distribution of salmon.
3) To understand and evaluate the magnitude and significance of the resulting environmental impacts, raw resource inputs and emissions associated with the provision of the functional unit are classified and converted into standardized indicators based on standardized characterization factors; e.g. all greenhouse gases are expressed in terms of CO_2 equivalents.
4) Interpretation: This phase entails the analysis and reporting of results, limitations and implications of the research along with the contextualization of the results. With respect to the latter, comparisons will be made with the results of prior published LCAs of both production systems and finished seafood products from other species — including pickled herring, frozen cod fillets and canned tuna.



DISCUSSION

Results from this research will provide new insights into the environmental and social impacts associated with contemporary commercial salmon fisheries in the NE Pacific, up to and beyond the point at which salmon are delivered to the dockside — including any differences that result from the three dominant fishing gears used in the region (purse seine, gillnet and troll). The research will provide rigorous information on the life cycle impacts associated with contemporary farmed salmon production in the North-East Pacific, including net-pen, land-based and "organic" systems. Both capture and culture salmon will be traced, in terms of the environmental and social impacts, through processing, storage, transporting, handling, retailing and consumption of commonly found, consumer-ready product forms

The analysis will afford numerous comparisons, both within the North-East Pacific region, and eventually internationally — across all three primary salmon production areas, which in addition to Alaska and British Columbia include Chile and the North-East Atlantic.

REFERENCES

Anderson, J. L. and Fong, Q. S. W. 1997. Aquaculture and international trade. *Aquaculture Economics and Management* 1(1), 29-44.

Clayton, P. L. and Gordon, D. V. 1999. From Atlantic to Pacific: price links in the US wild and farmed salmon market. *Aquaculture Economics and Management* 3(2), 93-104.

Consoli F, D. Allen, I. Boustead, J. Fava, W. Franklin, A. Jensen, N. de Oude, R. Parrish, R. Perriman, D. Postlethwaite, B. Quay, J. Sequin, and B. Vignon. 1993. *Guidelines for Life-cycle assessment: A "Code of Practice"*. Society for Environmental Toxicology and Chemistry, Brussels and Pensacola.

Eagle, J., R. Naylor and W. Smith. 2004. "Why farm salmon outcompete fishery salmon." *Marine Policy* 28(3): p. 259-70.

Food and Agriculture Organization (FAO). 2004. *The State of World Fisheries and Aquaculture 2004*. Rome, United Nations.

Hites, R. A., J. A. Foran, D. O. Carpenter, M. C. Hamilton, B. A. Knuth and S. J. Schwager. 2004. "Global Assessment of Organic Contaminants in Farmed Salmon." Science 303 (5655): p. 226.

International Organization for Standardization. 2003. ISO 14041, Geneva, Switzerland. www.iso.org (accessed October 19, 2005).

Krkosek, M., M.A. Lewis and J.P. Volpe. (2005) Fish Farms, Sea Lice, and Infestations of Wild Salmonids. *Proceedings of the Royal Society of London, Series B.* 272(1564): 689-96.

Naylor, R., R. Goldburg., H. Mooney, M. Beveridge, J. Clay, C. Folke, N. Kautsky, J. Lubchenco, J. Primavera, and M. Williams. 1998. Nature's subsidies to shrimp and salmon farming. Science 282(5390):83-884.

Naylor, R., R. Goldburg, J. Primavera, N. Kautsky, M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of aquaculture on world fish supplies. Nature 405: 1017-24.

Paez-Osuna, F. 2001. The environmental impact of shrimp aquaculture: a global perspective. Environmental Pollution 112(2):229-31.

Pennington, D., J. Potting, G. Finnveden, E. Lindeijer, O. Jolliet, T. Rydberg, and G. Rebitzer. 2004. Life Cycle Assessment part 2: Current impact assessment practice. Environment International 30:721-39.

Rebitzer, G., T. Ekvall, R. Frischknecht, D. Hunkeler, G. Norris, T. Rydberg, W. Schmidt, S. Suh, B. Weidema, and D. Pennington. 2004. Life Cycle Assessment part 1: Framework, goal and scope definition, inventory analysis, and applications. Environment International 30:701-20.

Worm, B. and R. Myers. 2004. Managing fisheries in a changing climate – No need to wait for more information: industrialized fishing is already wiping out stocks. Nature 429(6987):15.

ACKNOWLEDGEMENTS

THIS PROJECT IS MADE POSSIBLE BY FUNDING FROM THE LENFEST OCEANS PROGRAM AT PEW CHARITABLE TRUSTS.