Canadian Fisheries Research Network
Réseau canadien de recherche sur la pêche

Energy Use in Canadian Fisheries: Perspectives from a Workshop on Research Priorities

S. Paul[1], P. Tyedmers[2], R. Stephenson[3]
Canadian Fisheries Research Network

[1] St. Andrews Biological Station
Fisheries and Oceans Canada
531 Brandy Cove Road
St. Andrews, NB E5B 2L9
Canada

[2] School for Resource and Environmental Studies (SRES)
Faculty of Management
Dalhousie University
Halifax, NS B3H 4R2
Canada

[3] Department of Biology
University of New Brunswick
P.O. Box 4400
Fredericton, NB E3B 5A3
Canada

CONTEXT

Fisheries are highly dependent on fossil fuel combustion, and this reliance presents both economic and environmental challenges. The 2008 spike in oil prices rendered some previously viable fisheries uneconomic and makes the potential return of high prices deeply problematic for many Canadian fisheries and fishing communities. In response, there is renewed interest in fuel saving technologies and strategies throughout many parts of the Canadian fishing industry and a number of projects have been initiated by various provincial governments to address the increased threat of high fuel prices. In addition, global concern continues to grow regarding the probable impacts of increasing greenhouse gas emissions, and in particular those impacts that directly or indirectly undermine aquatic productivity (e.g. ocean acidification, warming, etc.).

Although the general topic of energy use has been a concern within the fishing sector at various times over the last 40 years it is progressively gaining social significance. In parallel with the rise of the sustainable seafood movement, there is increased consumer and large retailer interest in understanding and reducing the carbon footprint associated with fishing and associated seafood supply chains along with all other foods. It appears inevitable that the fishing industry will be increasingly challenged to account for and demonstrate responsibility toward their use of fossil fuels. A proactive strategy will be necessary to effectively respond to this challenge in order to achieve social approval and acceptance. Importantly, evidence suggests that many fisheries appear well placed to compete on the basis of their energy and carbon intensity, particularly when compared to some of the major terrestrial livestock production systems.

THE CANADIAN FISHERIES RESEARCH NETWORK

The Natural Sciences and Engineering Research Council of Canada (NSERC) Canadian Fisheries Research Network (CFRN) is a unique partnership among Canada's academic community, fishing industry and government, with the goal of re-shaping fisheries research in Canada through collaborative research around strategic questions of industry and management while working towards a sustainable fishing industry (www.cfrn-rcrp.ca).

One aspect of the collaborative research is focused on the topic of energy use in Canadian fisheries. Within the CFRN, there is recognition of future implications regarding energy in fisheries and the need for the Canadian industry to be proactive. Collaborators have expressed interest in exploring ways to better understand the scope of initiatives currently being undertaken in Canada. To that end, a workshop was held on April 3-4, 2012 to address the following objectives:

1. To determine the current state of knowledge regarding energy use in Canadian fisheries

2. To identify priorities for research related to energy use in Canadian fisheries in general
3. To consider ways in which the CFRN can uniquely address these issues.

Representatives of the fishing industry, the academic community and members of provincial and federal governments attended the workshop on account of their expressed interest in the topic. Fishing industry representatives included members of both the Canadian Council of Professional Fish Harvesters and the Fisheries Council of Canada, representing diverse fisheries, vessels and operational arrangements.

ISSUES OF GREATEST CONCERN REGARDING ENERGY USE IN FISHERIES

Fuel Use and Operational Efficiency in Fishing

Canadian capture fisheries, together with most of those undertaken throughout the industrialized world, have become highly dependent on the combustion of fossil fuels for vessel propulsion and a range of secondary activities, such as the provision of fishing gear, bait and ice (Tyedmers 2001 & 2004). Reliance on fuel inputs has greatly expanded the distance and depth at which fishing occurs (Tyedmers et al. 2005). It has also improved the quality and price of fisheries products and has markedly improved the conditions under which fishermen work. This reliance, however, comes at both an economic and an environmental cost. Fuel typically accounts for between 10 and 60% of total operating costs (Sumaila et al. 2008, Schau et al. 2009). As a result, the recent spike in oil prices rendered many previously viable fisheries uneconomic and makes the likely return of high prices deeply problematic for many Canadian fisheries and fishing communities.

The energy intensity of fishing operations, measured as the amount of energy required to provide a given quantity of product, varies widely depending on vessel construction, the type of gear used, fishing practices, target species, stock abundance and skipper behaviour (Tyedmers 2001, 2004). Technical improvements to fishing vessels and gear, as well as behavioural changes, have potential to improve fuel efficiency and reduce greenhouse gas emissions (Schau et al. 2009, Suuronen et al. 2012) and have been the primary techniques employed over the past 40 years to reduce the fuel consumed in fisheries. Despite our long history of attention to technical and behavioural improvements, further adoption of low-impact and fuel-efficient (LIFE) fishing technologies and practices offer scope for the fishing industry to significantly reduce energy consumption in fishing operations. The transition to LIFE practices poses a challenge to a fishing industry working within tight fiscal boundaries and must be supported by management systems and government policies (Suuronen et al. 2012, FAO 2012). Importantly, fisheries management decision-making at all scales has the potential to substantially affect fuel consumption by vessels and fleets (Driscoll &Tyedmers 2010) and has, to date, been largely unaddressed and unevaluated in terms of the scope for potential improvement.

While fisheries are widely perceived to be amongst the most energy (Wilson 1999) and GHG emission intensive food systems, comparing results of recent analyses of the "life cycle" performance of fisheries and their derived products (Ziegler et al. 2003, Hospido & Tyedmers 2005, Zeigler & Valentinsson 2008) with analyses of terrestrial animal husbandry and aquaculture systems (Foster et al. 2006, Pelletier & Tyedmers 2007, Pelletier 2008, Pelletier et al. 2011) indicate that in many instances, this is not the case. What is clear, however, is that unlike other animal protein systems, in which GHG emissions result from diverse underlying activities and processes, direct fuel inputs to fishing typically account for the vast majority (>80%) of total GHG emissions up to the point at which fish are landed (Ziegler & Hansson 2003, Hospido & Tyedmers 2005, Zeigler &Valentinsson 2008). Consequently efforts to reduce energy inputs to fishing have the potential to pay double dividends. Given the range of technological, behavioural and managerial strategies available to reduce fuel inputs coupled with the general heterogeneity of capture fisheries, the challenge is to identify the most effective strategies to reduce fuel inputs and GHG emissions from various types of fisheries and thereby improve the overall operational efficiency of Canadian fisheries.

Energy Use in Seafood Supply Chains

Fossil fuel use contributes to a range of broad-scale environmental concerns. Chief among these is climate change. With growing concern globally regarding the probable impact of increasing anthropogenic GHG emissions, there is increasing interest in understanding and reducing the "carbon" intensity of all activities, including fishing.

Despite the dominance of direct fishery-related fuel consumption, in some fishery-based seafood supply chains, energy consumption and GHG emissions may be significant after the catch is landed due to fish processing, cooling, packaging, storing and transport (e.g. Thrane et al., 2009; Winther et al., 2009; Vázquez-Rowe et al., 2011), and therefore need to be minimized throughout the seafood supply chain to reduce the environmental cost of fishing (Surronen et al. 2012). An acute example of a 'downstream' supply chain activity that can have a substantial impact on energy use and GHG emissions occurs when air freight is used to move product to markets quickly. In some fisheries, significant energy inputs and GHG emissions can also result from 'upstream' activities. For example, in some baited fisheries, fuel inputs to bait acquisition and the extent of cooling, packaging and transport involved can be a source of substantial energy inputs and GHG emissions.

Product certification and eco-labelling schemes are market-based methods of identifying food products based on their environmental performance. These programs are influencing consumer choices and driving more general awareness to environmental impacts by consumers who wish to support environmentally responsible practices, including sustainable seafood harvesting and production (FAO 2012, Surronen et al. 2012). Regardless of their attributes, certified and eco-labelled food products are one of the fastest growing food market segments and "green products" account for approximately 3% of world trade (Borregaard & Dufey 2005).

The energy and related environmental impact of seafood production can be measured by considering the energy consumption during each stage along the supply chain from the point of production to the final consumer. Currently, the dominant methodology for quantifying the energy and related environmental performance of production systems is Life Cycle Assessment (LCA). As described by Pelletier and Tyedmers (2008) LCA is "an International Organization for Standardization (ISO)-standardized accounting framework used to develop life history profiles of the potential environmental impacts associated with energy intensity of products or processes." Over the last 15 years, over 30 fisheries or fishery product-related supply chains have been analysed using LCA (Vázquez-Rowe et al. 2012). Results of LCA's have been useful in "planning and evaluating changes in fisheries management and in guiding seafood consumers to make more sustainable choices." (Ziegler 2007).

In instances where there is a narrow focus on the GHG implications of production systems, a number of LCA-derived or related 'carbon-footprinting' techniques or standards have recently been developed to expedite analyses. The Publicly Available Standard (PAS) 2050 (http://www.bsigroup.com/en-GB/standards) and the Greenhouse Gas (GHG) Protocol Standard (http://www.ghgprotocol.org/standards/product-standard) encourage users to understand, quantify and manage greenhouse gas emissions of goods and services. Any association or group, both for the benefit of their industry and to help promote their expertise, can use these standards for their products. Importantly, given seafood-industry concern regarding the unsuitability of general provisions of the PAS 2050 to seafood supply chains, a seafood-specific PAS – PAS 2050-2 - has recently been developed (http://www.bsigroup.com/en-GB/about-bsi/media-centre/press-releases/2012/12/new-standard-published-to-help-the-seafood-industry/). While this new seafood-specific carbon footprinting standard will largely affect products destined for the UK market, over time it is likely that similar GHG quantification standards will be developed for North American bound products.

Policy Planning and Management Decisions regarding Energy use in Canadian Fisheries

The Code of Conduct for Responsible Fisheries, adopted in 1995 by 80 countries, including Canada, recommends the development of guidelines and standards for energy optimization in harvest and post-harvest activities, and the development and transfer of technology to improve energy efficiency within the fisheries sector (FAO 1995). Led by fishers, Canada became the first country to develop its own Code of Conduct for Responsible Fishing Operations in 1998 (DFO 1998). Protection of the environment is referenced throughout the document, and two guidelines specifically call for the optimization of energy consumption in fishing operations where possible, and to work with regulatory agencies to establish energy conservation policies and procedures.

In spite of the reference in the Canadian Code of Conduct for Responsible Fishing, Canada has no policy regarding the use of energy or the reduction of greenhouse gas emissions in fisheries, and there is no explicit consideration of energy use in fisheries management or policy planning. Given that the price of oil is forecast to increase in the coming years (http://www.nrcan.gc.ca/energy/publications/sources/crude/issues-prices/1329), there is real potential for failed fisheries, economic hardship and increased environmental impacts without proactive planning and policy development (Abernethy 2010).

Management decisions can strongly affect the energy intensity and associated greenhouse gas emissions of a fishery through long-term effects on fleet structure and dynamics (Driscoll & Tyedmers, 2010). These unintended consequences of particular management decisions must be understood and taken into account during the decision-making process in order to minimize the factors that contribute to reduced energy efficiency in a fishery.

The transition to more efficient operations will depend heavily on creating the appropriate incentive for change, such as supporting and implementing an ecosystem approach to management (EAM) (Suuronen et al. 2012, FAO 2012). Canada employs an EAM; however, to date it is largely focused on conservation objectives. A broader view of ecosystem objectives would have to be considered in the future to incorporate ecosystem objectives related to energy use.

WORKSHOP PERSPECTIVES AND RESEARCH PRIORITIES IN CANADA

Roundtable discussions at the workshop focused on two questions asked of participants, which were designed largely to garner thoughts and opinions on issues of greatest concern and research priorities relating to energy use and GHG emissions in fisheries, as well as the methods used to date to overcome some of these issues.

The priorities and issues of greatest concern can be summarized as follows:

- The cost of fuel and operational efficiency of fleets
- The cost-effectiveness and economic viability of fleets as they relate to energy issues
- The need for education on the topic of energy consumption and conservation – for skippers, processors and consumers
- Environmental responsibility – to customers, shareholders and the next generation
- Increased consumer sensitivity to carbon intensity issues
- Energy aspects of market certification.

Indisputably, the cost of fuel and its impact on the economic viability of fisheries were of utmost concern among Canadian stakeholders at the workshop. In recent years the fishing sector has been seriously constrained by variable and increasing fuel prices, a strong Canadian dollar which impacts exports, and a general slowdown in the global economic market.

Many Canadian fishermen have been experimenting with changes to their operations in order to reduce fuel consumption and operate more efficiently and cost-effectively. These efforts have met with varied success. Adjustments to reduce impacts of high fuel costs are diverse and include modifications to gear, improved engine harmonics and vessel design, new fishing technologies, as well as behavioural changes to fishing operations such as adjusting speed during steaming or towing and reducing fishing effort.

Some provincial governments have responded to the problem by conducting fuel consumption audits on vessels, supporting workshops, and experimenting in more fuel efficient gear and vessel designs. In general, Canada's fleet of fishing vessels is aging and in need of modifications to improve fuel efficiency and energy performance. Replacing vessels in the current economic environment poses a challenge, but new improved hull and system designs will be required in the near future.

The documentation, evaluation and dissemination of information such as effective strategies to reduce fuel use and recent initiatives taken to address energy consumption are required to facilitate successful modifications to gear, vessel design and fishing behaviour, as well as adopting new technologies, within and between fishing fleets. The need for education of harvesters, processors and consumers on the topic of energy consumption and conservation was widely expressed by meeting participants, as was the necessity of seeking opportunities to network and share such information with experts in the broader fishing community outside of Canada. Additionally, establishing benchmarks of fuel consumption by particular classes of vessels in Canadian fisheries is a priority in order to measure the effectiveness of fuel-saving changes in the future.

A less significant immediate concern among workshop participants, although one that the group agreed was on the horizon, is the growing social concern regarding fossil fuel use and resulting GHG emissions. It appears inevitable that the Canadian fishing industry will be increasingly challenged to account for and demonstrate responsibility toward their use of fossil fuels. A proactive strategy will be necessary for the Canadian fishing industry to effectively respond to this challenge in order to maintain social approval and acceptance; however, a baseline understanding of certain aspects of Canadian seafood products is first necessary. For instance, there is a need for greater clarity regarding the scale and relative importance of energy inputs and GHG emissions associated with Canadian-based fisheries. Although numerous LCAs of fishery-based supply chains have been undertaken to date and can be used as first-approximations of a potential Canadian reality, due to the substantial differences that are likely to exist between fisheries (e.g. in stock availability and catchability, size of vessels and engines, gears deployed and skipper behaviour), analyses based on local conditions will be essential. In addition, alternate supply chain GHG implications must be compared to understand how locally caught and processed seafood products compare to those from elsewhere.

Throughout the dialogue on issues of greatest concern at the workshop, the matter of unintended consequences of policy and management decisions was broached. Tradeoffs among objectives occur in the decision-making process and there was wide agreement among workshop participants that energy performance must be considered along with other objectives in a broader view of fisheries sustainability and in policy and management strategies. Workshop participants were passionate regarding the implications of past, current and future management decisions on energy use in Canadian fisheries. Participants referred to the need to develop tools and approaches for evaluating past decisions such as the impact of conflicting regulations for adjacent management areas and fleet rationalization, on energy performance of fleets. It was also strongly expressed that the Canadian fishing industry is currently ill-prepared to deal with many of the energy-related issues that were discussed at the workshop and maintain that some basic information needs to be compiled to help guide the industry and assist in policy development, such as a list of existing GHG accounting processes and standards.

NEXT STEPS

Although the mix of workshop participants was diverse, consisting of representatives from smaller, owner-operator fisheries as well as larger, vertically-integrated industries, the group as a whole recognized the magnitude of the issues as they relate to all fisheries in Canada, and the potential implications of being ill-prepared in the future. Regardless of the type of fishery, the issue of energy use in Canada affects all fishing fleets to various degrees.

Workshop participants articulated six topics for future research:

1. Undertake a compilation of energy reduction strategies, experiments, and technologies, both internationally and domestically. Projects have been undertaken by some groups, including the provinces. There were expressions of interest in documenting what is being done in order to consider how work can be linked.

2. Facilitate the development of a strategic meeting related to vessel hull evaluation and optimization

3. Evaluate energy use and profitability implications of historic, current and future management in key fisheries

4. Facilitate the development of a strategic meeting related to fishing gear design, utilization, operational aspects, evaluation and optimization

5. Develop fishery/fleet specific operational efficiency metrics and benchmarks

6. Conduct an evaluation of bait use and options across a range of Canadian baited fisheries.

The following workshop participants agreed to form a reference committee on the CFRN energy profile, which will meet again to further deliberate on the research topics and plan the next steps toward a strategic initiative.

Name	Affiliation
Brian Johnson	NL Department of Fisheries and Aquaculture & Canadian Centre of Fisheries Innovation
Bruce Osborne	N S Department of Fisheries and Aquaculture
Claude d'Entremont	Inshore Fisheries Ltd.
Damien Grelon	Merinov, Quebec
Dany Jabbour	Clearwater Seafoods
Darryl MacIvor	Maritime Fishermen's Union
Donat McGraw	N B Department of Agriculture, Aquaculture and Fisheries
Jean Lanteigne	Fédération Régionale Acadienne des Pêcheurs Professionnels (FRAPP)
Jeff Simms	Newfoundland Resources Ltd.
Lewis Clancey	N S Department Fisheries and Aquaculture
Paul Winger	Memorial University of Newfoundland
Peter Tyedmers	Dalhousie University
Rick Ellis	Ocean Choice International
Rob Stephenson	University of New Brunswick / DFO St. Andrews
Ron Heighton	Gulf Nova Scotia Fleet Planning Board
Ruth Inniss	Maritime Fishermen's Union
Shaun Allain	Fishermen and Scientists Research Society
Sheena Young	Fundy North Fisherman's Association
Stacey Paul	Canadian Fisheries Research Network / DFO St. Andrews
Vern Shea	N S Department of Fisheries and Aquaculture
Wayne Matheson	N S Department of Fisheries and Aquaculture.

REFERENCES

Abernethy, K.E, P. Trebilcock, B. Kebede, E.H. Allison and N.K. Dulvy. 2010. Fuelling the decline in UK fishing communities? ICES Journal of Marine Science, 67: 1076-1085.

Borregaard N, and A. Dufey. 2005. Challenging preconceptions about trade in sustainable products. Towards win-win-win for developing countries. International Institute for Environment and Development, London

DFO. 1998. Canadian Code of Conduct for Responsible Fishing Operations—Consensus Code. Secretariat, Code of Conduct for Responsible Fishing Operations, Department of Fisheries and Oceans, Ottawa, Canada. Cat. No. Fs23-347/1998.

Driscoll, J. and P. Tyedmers. 2010. Fuel use and greenhouse gas emission implications of fisheries management: the case of the new England Atlantic herring fishery. Marine Policy, 34: 353-359.

FAO. 1995. Code of Conduct for Responsible Fisheries. Rome, FAO. 41 p.

FAO. 2012. The State of World Fisheries and Aquaculture. Rome, FAO. 230p.

Foster, C., K. Green, M. Bleda, P. Dewick, B. Evans, A. Flynn, and J. Mylan. 2006. Environmental Impacts of Food Production and Consumption: A report to the Department for Environment, Food and Rural Affairs. Manchester Business School, Defra, London. pp. 199.

Hospido A, and P. Tyedmers. 2005. Life cycle environmental impacts of Spanish tuna fisheries. Fisheries Research 76:174–86.

Pelletier, N. 2008. Environmental performance in the US broiler poultry sector: Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions. Agricultural Systems. 98: 67-73.

Pelletier, N., E. Audsley, S. Brodt, T. Garnett, P. Henriksson, A. Kendall, K.J. Kramer, D. Murphy, T. Nemecek and M. Troell. 2011. Energy Intensity of Agriculture and Food Systems. Annu. Rev. Environ. Resour. 36: 223-246.

Pelletier, N. and P. Tyedmers. 2008. Life Cycle Considerations for Improving Sustainability Assessments in Seafood Awareness Campaigns. Environmental Management. 42: 918-931.

Pelletier, N. and P. Tyedmers. 2007. Feeding farmed salmon: Is organic better? Aquaculture 272: 399-416.

Schau, E.M., H. Ellingsen, A. Endal, and S.A. Aanondsen (2009) Energy consumption in the Norwegian fisheries. Journal of Cleaner Production. 17(3): 325-334.

Sumaila, U. R., Teh, L., Watson, R., Tyedmers, P., and D. Pauly. 2008. Fuel price increase, subsidies, overcapacity, and resource sustainability. – ICES Journal of Marine Science, 65: 832–840.

Suuronen, P., F. Chopin, C. Glass, S. Lokkeborg, Y. Matsushita, D. Queirolo and D. Rihan. 2012. Low Impact and fuel efficient fishing – Looking beyond the horizon. Fish. Res. 119-120: 135-146.

Thrane, M., F. Ziegler and U. Sonesson. 2009. Eco-labelling of wild-caught seafood products. Journal of Cleaner Production. 17: 416-423.

Tyedmers, P. 2001. Energy consumed by North Atlantic fisheries. In Zeller, D., R. Watson and D. Pauly (eds.), Fisheries Impacts on North Atlantic Ecosystems: Catch, effort and national regional datasets. Fisheries Centre Research Reports 9(3): 12-34.

Tyedmers, P. 2004. Fisheries and Energy Use. In Cleveland, C. (ed.), Encyclopedia of Energy. Elsevier, San Diego, vol (2): pp. 683-693.

Tyedmers, P., R. Watson and D. Pauley. 2005. Fueling Global Fishing Fleets. Ambio. 34(8): 635-638.

Vázquez-Rowe, I., A. Hospido, M.T. Moreira and G. Feijoo. 2012. Best practices in life cycle assessment implementation in fisheries. Improving and broadening environmental assessment for seafood production systems. Trends in Food Science & Technology 28: 116-131.

Vázquez-Rowe, I., Ma Teresa Moreira, Gumersindo Feijoo. 2011. Life Cycle Asessment of fresh hake fillets captured by the Galician fleet in the Northern Stock. Fisheries Research 110: 128-135.

Wilson, J. D. K. (1999). ‘‘Fuel and Financial Savings for Operators of Small Fishing Vessels.’’ FAO Fisheries Technical Paper 383. FAO. Rome, Italy. 46.

Winther, U., Ziegler, F., Skontorp-Hognes, E., Emanuelsson, A., Sund, V., & Ellingsen, H. (2009). Carbon footprint and energy use of Norwegian seafood products. SINTEF Fisheries and Aquaculture Report SFH80 A096068, Trondheim, Norway.

Ziegler, F. 2007. Environmental Life Cycle Assessment of Seafood Products from Capture Fisheries. Int. J. LCA 12(1): 61.

Ziegler F., and D. Valentinsson. 2008. Environmental life cycle assessment of Norway lobster (Nephrops norvegicus) caught along the Swedish west coast by creels and conventional trawls – LCA methodology with case study. International Journal of Life Cycle Assessment 13: 487–497.

Ziegler F., and P-A Hansson. 2003. Emissions from fuel combustion in Swedish cod fishery. Journal of Cleaner Production 11: (303–14).

Ziegler F, Nilsson P, Mattsson B, and Y. Walther. 2003. Life cycle assessment of frozen cod fillets including fishery-specific environmental impacts. International Journal of Life Cycle Assessment 8(1): 39–47.