Ocean Choice International (OCI) Industrial Research Chair in Fish Stock Assessment and Sustainable Harvest Advice for Northwest Atlantic Fisheries

A key role fisheries science can play in promoting profitable and sustainable fisheries is providing reliable quantitative advice on the impacts and risks of future fishing. Fisheries managers and stakeholders can then use this information to inform their decisions on appropriate levels of fishing. Demonstrating that fisheries are sustainable is increasingly becoming important for industry in terms of maintaining market access and prices, and developing new markets. Organizations such as the international Marine Stewardship Council (MSC) have set standards for sustainable fishing practices and certifying that fisheries meet these standards. To get a fishery certified, industry must provide an evaluation of the state of the stock and management practices with respect to the many criteria of the certification standard. In addition, Fisheries and Oceans Canada (DFO), the regulatory authority for marine fisheries in Canada, has several policy frameworks for fisheries, and sustainability is a leading objective here as well. An integral part of this is demonstrating that there is a reliable stock assessment and harvest strategy in place.

A stock assessment basically involves three questions: 1) what is the size of the stock relative to the past or some reference value? 2) What have been the impacts of fishing? 3) What will the impacts of future fishing be? The first two questions usually involves describing how stock size and harvest rates have changed since fishing began or for the past few decades, with emphasis on the recent trends. Usually fisheries managers and certification and eco-labelling programs require an estimate of the current size of the stock and the harvest rate relative to reference points for optimal sustainable yields (i.e. targets) or conservation concerns (i.e. limits). Estimating stock size and harvest rates often involves biologically and mathematically simple models that are statistically and computationally difficult to estimate reliably because of the data available. Determining reference points is usually biologically complex, and sometimes mathematically complex, because it requires a greater degree of understanding of the stock and ecosystem productivity processes. Stock assessment involves short-term forecasts to evaluate impacts of future fishing and longer-term forecasts to evaluate the sustainability of fisheries and optimum harvest rates.

The basic objective of the research chair program will be to advance the current practice and state-of-the art in fish stock assessment with a focus on the above sustainability objectives and requirements for Northwest Atlantic Fisheries, and specifically those on the Grand Banks of Newfoundland and Labrador (NL). This research will be interdisciplinary and involve advanced knowledge of practical and theoretical marine population and ecosystem dynamics, statistical and mathematical modelling, and computational science. A key objective of the program is to train highly qualified personal (HQP) for stock assessment. This is necessary for sustainable and successful future fisheries. The Marine Institute of Memorial University of Newfoundland (MI) has developed a new graduate program in Fisheries Science, and as part of this the IRC team offers a Master of Science in Fisheries Science (Stock Assessment) and trains Ph.D. students also (https://www.mi.mun.ca/programsandcourses/programs/fisheriessciencestockassessmentmasterofsciencemscdegree/). These training programs are unique in Canada and internationally, particularly in their focus on statistical stock assessment.

State-of-the-art stock assessments involve models that integrate all relevant data on the population dynamics of the stock so that the assessment produces the best advice possible. This could involve data on commercial catches, biological sampling of these catches, trawl and acoustic research surveys, tagging studies, etc. Each source of information may require complex statistical analyses depending on the specific study design and possible confounding factors. For example, not all commercial catches may be reported or there may be measurement error in

the size and locations of catches, etc. Hence, a wide range of statistical expertise is required when combining various types of data in an integrated stock assessment model. Another important consideration is process error. Stock assessment models are approximations of reality and it is important to include this fact as process error in the model. State-space models are now the preferred modelling framework for stock assessments. In the past many assessments have not used all relevant information and as a result the accuracy and precision of results were compromised. The main reason for this is a lack of quantitative and computation expertise in stock assessment groups. Stock assessors could only use standard packages developed for standard data, and additional data sources specific to a stock could usually not be included in the main assessment model. Recent advances in computer software and hardware have greatly increased the scope for more comprehensive stock assessment models.

Better fisheries harvest advice in the future will require better models and data and this has to happen jointly. A key focus of the research chair will be to develop and implement integrated state-space stock assessment models. This will include more holistic modelling of within- and between-species productivity processes (i.e. reproduction, growth and mortality), how they vary over time in response to changes in the environment and ecosystem, and how this variability affects reference points.

A single universal assessment model for all stocks is probably not practical or realistic because of the wide variety of data and life-history characteristics that exist for commercial species. It is more realistic to develop stock-specific models that include model components or modules that have been quality-control tested. It may be difficult to get these state-of-the-art models implemented routinely in DFO and Northwest Atlantic Fisheries Organization (NAFO) stock assessment processes. Hence, it will also be important for the IRC program to produce stock assessment models that can be transferred and used by DFO scientists who have the primary responsibility of providing stock assessments in Canada. It is also very important to provide all the model output in tables and figures that are useful and easy to use for stock assessment, thereby freeing up as much time as possible for DFO assessment staff to focus on assumptions and advice and not the details of running models and creating reports. This will be a focus for the research chair.

There is also a great need to develop more theoretical knowledge of stock assessment models and their estimation. This theory can provide important guidance of what to do with new data or stocks. The present state of knowledge is fairly rudimentary, as evidenced by the scarcity of text books on how to do stock assessment.

In many situations it will often not be clear how to measure the sustainability of current fisheries. This is a problem internationally and it is important to understand how similar problems have been addressed by other countries and regional fisheries management authorities. An important activity of the IRC team will be to participate in NAFO, International Council for the Exploration of the Seas (ICES), and US stock assessment programs to maintain a good understanding of how others do this.

Spatial dimensions have been neglected for the most part in stock assessment although this is important to industry. There is an increasing recognition that incorporating spatial processes in stock assessment and management is important. This will also be a focus of the research chair.

It may still occur that, after using all relevant information in the best possible assessment model, the uncertainty in advice is too large for good fisheries management and to demonstrate the sustainability of the fishery. At this point the research chair will consider, in collaboration with other DFO and university (e.g. CFER) fisheries scientists, what additional data could be most feasibly collect to improve management advice.