International Atlantic Salmon Research Board

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Summary of the ICES / NASCO Workshop for North Atlantic Salmon at Sea Mortality (WKSalmon)

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ICES and NASCO agreed to convene a series of workshops that explore how best to integrate available data on salmon, specifically data on marine survival, with the appropriate ICES and other database(s) for use in models to advance the conservation of wild salmon at sea. This work would also support the further development of the Likely Suspect Framework, an initiative that will link patterns in at-sea mortality of Atlantic salmon to appropriate geographic and temporal scales and to provide a comprehensive understanding of the key mortality factors affecting the entire life cycle of Atlantic salmon. Ultimately the workshops would result in an improvement in the ICES advice for Atlantic salmon through enabling the provision, collation and standardisation of salmon data that are currently unavailable to ICES and other interested researchers.

The objectives of the proposed workshops are:

a. Identify data sources that could inform estimates of at-sea salmon mortality and the associated available data, including data from North Atlantic salmon as well as ecosystem data (such as oceanographic time-series, plankton surveys, International Ecosystem Summer Survey in the Nordic Seas (IESSNS), pelagic or demersal fish surveys);

b. Develop a data call that will integrate these sources with existing ICES databases;

c. Evaluate the appropriateness of data and methods used to estimate at-sea salmon mortality;

d. Identify data gaps and develop recommendations for future data acquisition; and

e. Evaluate modelling approaches to integrate marine data fully to cover the whole life-cycle of Atlantic salmon in the context of the 'Likely Suspects' Framework.

The first of the three planned workshops (Workshop for North Atlantic Salmon At-Sea Mortality; WKSalmon) was convened June 24-28, 2019 at ICES headquarters in Copenhagen, Denmark. The terms of reference for WKSalmon were to identify data sources that could inform estimates of at-sea salmon mortality as well as ecosystem data including oceanographic time-series, plankton surveys, pelagic or demersal fish surveys that describe the marine ecosystem occupied by Atlantic salmon.

The workshop, co-chaired by G. Chaput (Canada) and N. Ó Maoiléidigh (Ireland), was attended by 24 participants from the North Atlantic countries (including non-government organisations and two with expertise on Pacific salmon). Most of the participants contributed information on Atlantic salmon data sets and four participants provided background, overviews and information on available data within ICES and associated with the North Atlantic physical and biological oceanography. The draft report of the workshop is presently under review by the report drafting team, with an anticipated completion date by end of June 2020.

Atlantic salmon data sets for the North Atlantic, covering all aspects of life history, are diverse and generally not available from a single database. The ICES Working Group on North Atlantic Salmon (WGNAS) maintains time series of various data sets of catches, returns, spawners, at country or jurisdiction spatial scales. Time series of return rates at individual river scales are also maintained by WGNAS. ICES has through a series of workshops and expert groups compiled and analysed several data sets including tag and recapture data from the North Atlantic and analyses of biological characteristics. ICES maintains various databases

containing spatial and temporal distribution of fisheries catches and effort for the Northeast Atlantic that could be of interest for the pelagic fish community and fisheries interactions with salmon.

The Likely Suspects framework emphasizes the need to develop testable hypotheses based on candidate life history regulatory processes acting within specific domains (represented by locations/areas or periods in the life cycle). Empirical data are required, termed life cycle audit points, to confirm or invalidate the hypotheses and processes. In a summary of examples of research to date, the most common audit point and metric is the abundance of salmon when they return to homewaters, based on catches in fisheries, run reconstructions of abundances for regional groups, and return rate metrics derived from the ratio of smolts going to sea and the abundance of adults returning. Other examples of audit points include life history processes such as weight at age of salmon at Greenland, and variations in relative proportions at sea age.

There are few audit points for Atlantic salmon at sea and the spatial by temporal (season) matrix for these is very sparse. Current and potential audit points identified in the WKSalmon report include:

- The return rate time series from monitored rivers in the North Atlantic. Smolt output is an important audit point for understanding the freshwater regulatory processes.

- Monitoring of adult salmon returns to rivers is an important auditing task, from which other life history metrics including size, condition, lipid content, sea age and sex ratio can provide data for testing hypotheses.

- Audit points for abundance at sea include catch indices of Atlantic salmon derived from the three large scale ecosystem surveys in the Northeast Atlantic: IESNS in the Norwegian Sea in spring, IESSNS in the Norwegian Sea and surrounding areas in summer and an ecosystem survey in the Barents Sea in the autumn.

- The fishery at West Greenland, and any historical and contemporary data on relative abundance from catch rate indices, could serve as an audit point for salmon from North America and southern Europe at the high seas feeding grounds in their second summer and autumn at sea.

- Biological characteristics data from salmon captured and sampled at West Greenland could be used as audit points for hypotheses related to for example bottom-up regulatory processes for growth, survival, maturation, as well as migration and distribution at sea of regional groups of salmon (with genetic stock identification tools).

- Acoustic technology tracking programs have been initiated to monitor the migrations and estimate area specific survival rates of salmon post smolts from four populations migrating through the Gulf of St. Lawrence to the Labrador Sea. This program provides a unique auditing opportunity to examine variations and candidate regulatory factors of marine survival and migration phenology during the first two months and approx., 1000 km of post-smolt migration. This time series now extends from 2003 to 2019.

- The cumulation of individual salmon distribution and migration data from archival transmitting tags, if sufficient tagging was conducted over a wide range of populations and years, could provide migration and distribution (and mortality rate) data for hypothesis testing.

The WKSalmon report summarizes data from a large number of sources but important data gaps remain.

- There are large-scale multi-disciplinary initiatives in ocean modelling that were not described during the meeting of WKSalmon. Ocean circulation is complex, and descriptions of sea surface temperature and primary production may be relatively accessible for inquiry, however the complex dynamics of the deeper ocean layers is a gap in this report.

- There was no expertise at the WKSalmon associated with the diverse avian, marine mammal and ectotherm fish community that interacts with salmon. The report summarizes the information on these components based on a review of literature but sources of data regarding variations in abundance, seasonal distribution at sea, and diet data are incomplete.

- The mesopelagic community, those macroplankton (krill) and fish (non-commercial) that serve as prey for salmon, are poorly to not monitored throughout the North Atlantic.

- Outside monitoring of surface conditions by remote sensing, the ecosystem during the winter period (November to April) is poorly to not monitored at all in the North Atlantic. This period has been identified as a key regulatory period of Atlantic salmon at sea.

- Genetics of Atlantic salmon and the capacity for adaptation and evolution of salmon populations is not covered in this report.

Very few of the salmon data sets described in the WKSalmon report are readily available as open data or from websites. The salmon data, although referred to in a number of studies and reports, requires some work to access and would involve contacting individual institutions and governments.

The most readily available information is from climate indices and physical oceanographic features. The physical features that are monitored by remote sensing, such as sea surface temperature and indices of primary production, have the broadest spatial and temporal domain coverage that encompasses the entire North Atlantic. The indices of secondary production, for example obtained from Continuous Plankton Recorder monitoring, have a broad but lesser spatial and temporal coverage than remote sensing indices whereas the pelagic fish community is sparsely sampled, with the best coverage in the Northeast Atlantic for May, and July-August (with coverage in the autumn for the Barents Sea) and no coverage in the Northwest Atlantic.

The options for testable hypotheses within the 'Likely Suspects Framework' will be constrained by the availability and representativeness of monitoring data of the components of the marine ecosystem occupied by Atlantic salmon. There is a large amount of information compiled and maintained within a diverse community of scientific experts with to date limited cross-fertilization and networked analyses. The time scales and spatial scales of observations are variable, of differing complexity requiring a range of analytical skill sets, but seemingly extractable with some concerted effort.