REPORT OF ICES ADVISORY COMMITTEE

ON

NORTH ATLANTIC SALMON STOCKS

TO

NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION

June 4 to 6, 2011

CNL(11)45

Advice generated by ICES in response to terms of reference from NASCO

10.1 With respect to salmon in the North Atlantic:

1. **overview of salmon catches and landings**
2. **report on significant new or emerging threats to, or opportunities for, salmon conservation and management**
   - **potential impacts of development of alternative/renewable energy on Atlantic salmon**
3. **report on advances in understanding of associations between changes in biological characteristics of Atlantic salmon and ecosystem changes**

Advice generated by ICES in response to terms of reference from NASCO

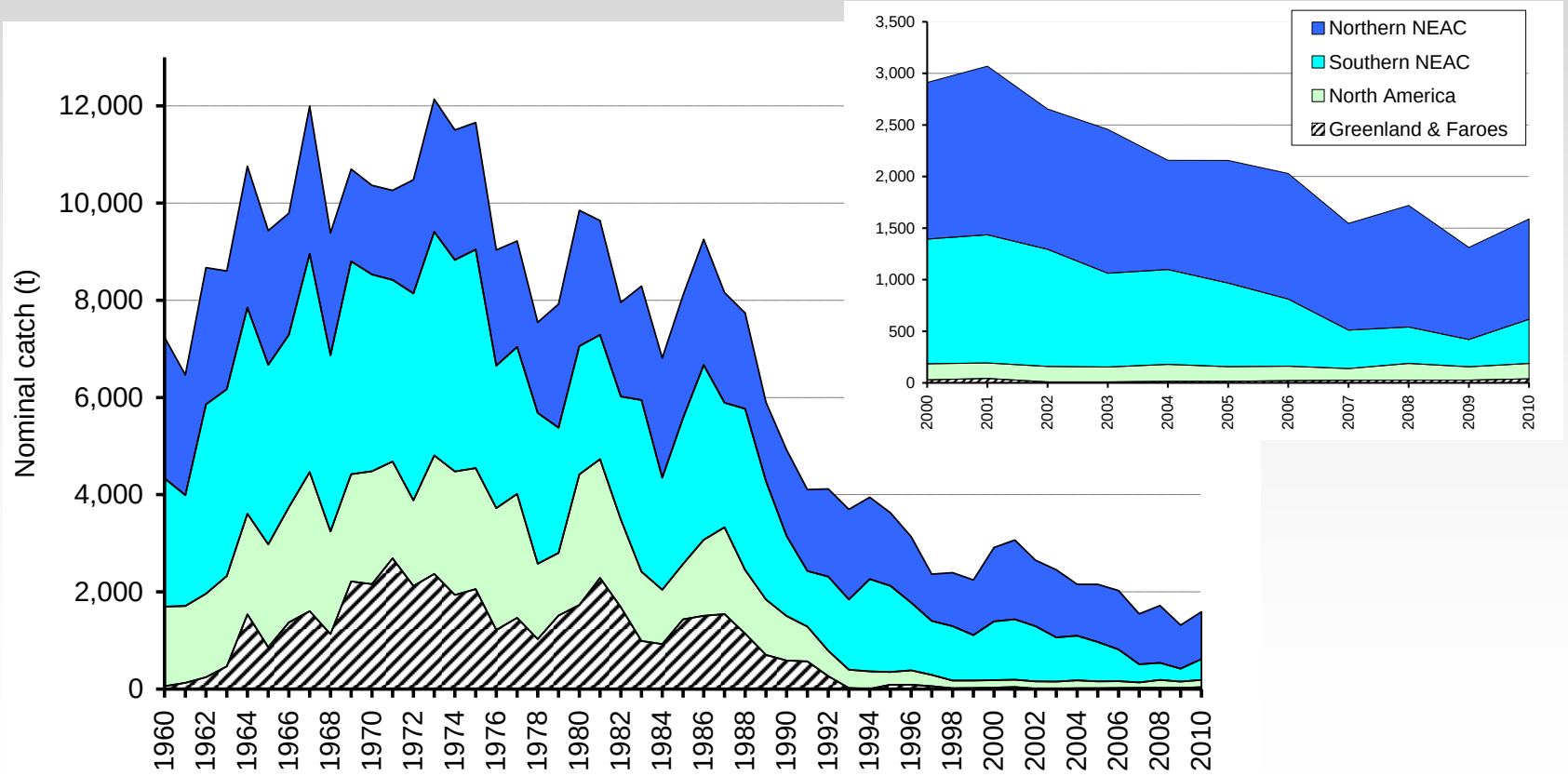
With respect to salmon in the North Atlantic:

4. **further develop approaches to forecast pre-fishery abundance**
5. **provide a review of successes and failures in wild salmon restoration and rehabilitation**
    - **best solutions for fish passage and mitigation efforts**
6. **provide a compilation of tag releases and advise on the utility of maintaining this compilation**
7. **identify relevant data deficiencies, monitoring needs and research requirements**

10.1.5 Overview of salmon catches and landings

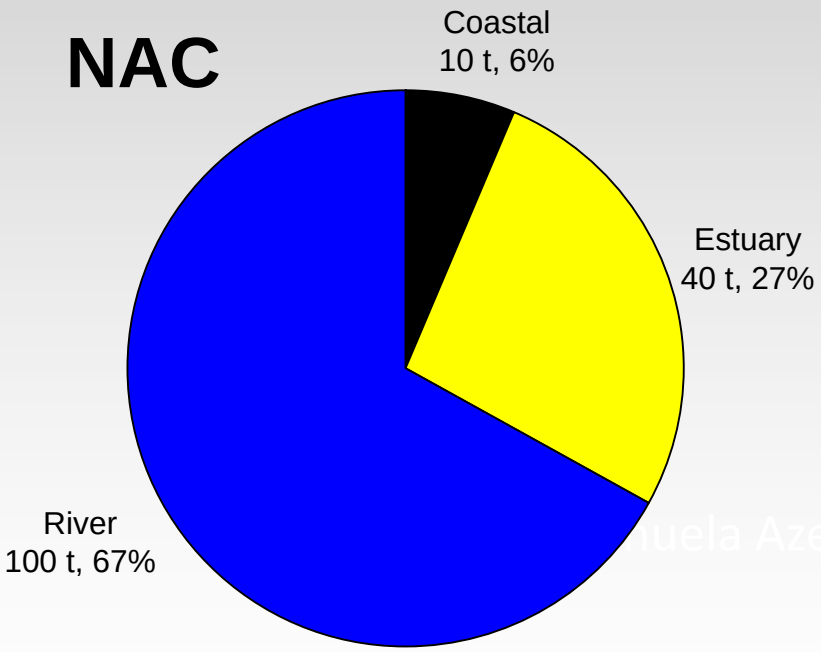
Nominal catch in 2010 in the North Atlantic = 1589 t

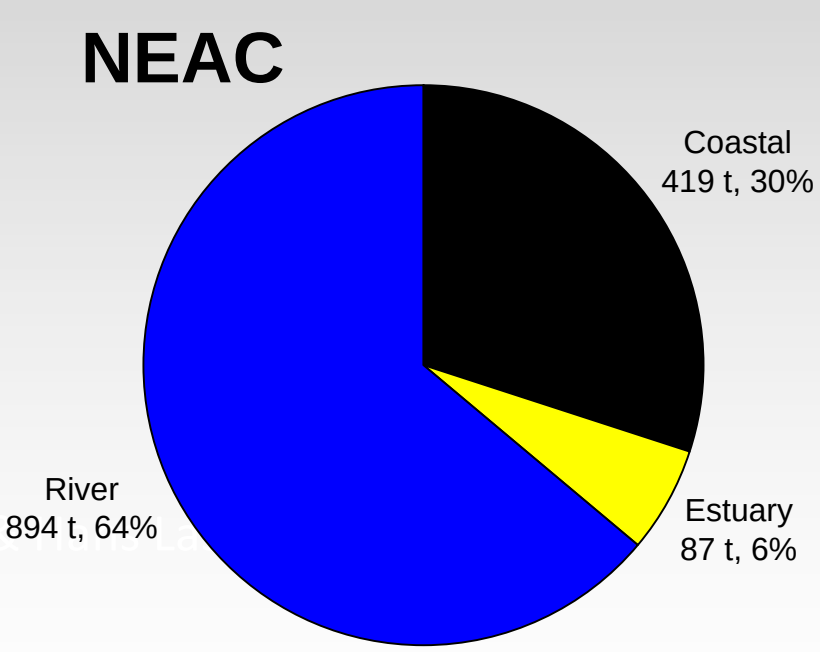
- 3rd lowest of the time series
  - 2nd lowest of time series for NEAC north
  - nominal catch by country, see Table 10.1.5.1



Partitioning of nominal catch into areas fished

- Majority of nominal catch in 2010 was taken in rivers
- Higher proportion of catches from coastal areas in NEAC compared to NAC, higher proportion from estuaries in NAC





Partitioning of nominal catch into areas fished

North American Commission

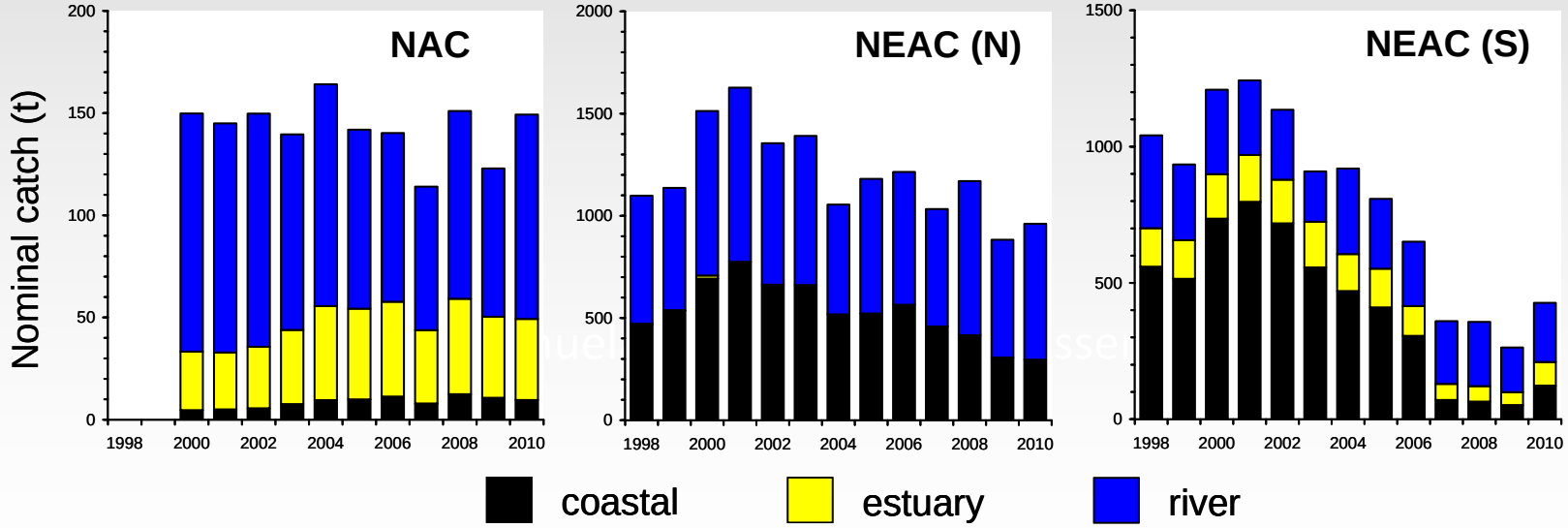
- Total catch relatively constant, majority in river fisheries

Northern North-East Atlantic Commission

- Approx. 50:50 river to coastal, increasing in rivers (69% river in 2010)

Southern North-East Atlantic Commission

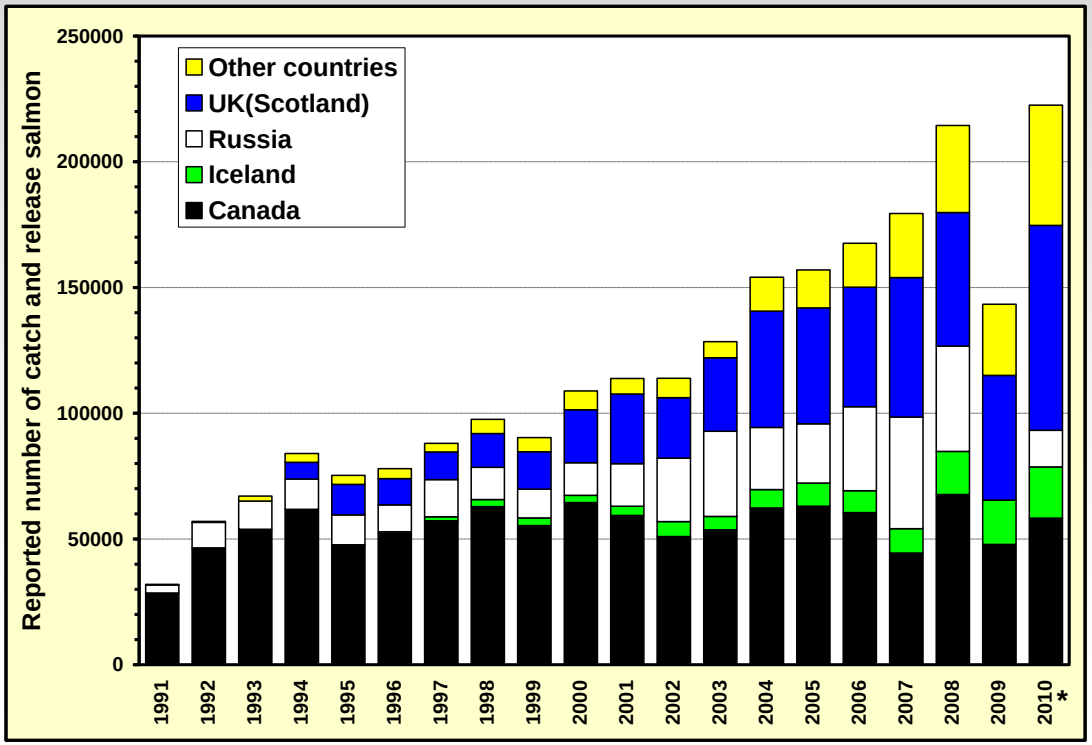
- Large declines in coastal fisheries, majority of catch since 2007 taken in rivers (only 51% in 2010)



By country, see Figure 10.1.5.2

10.1.5.2 Catch and release fishing (by country Table 10.1.5.2)

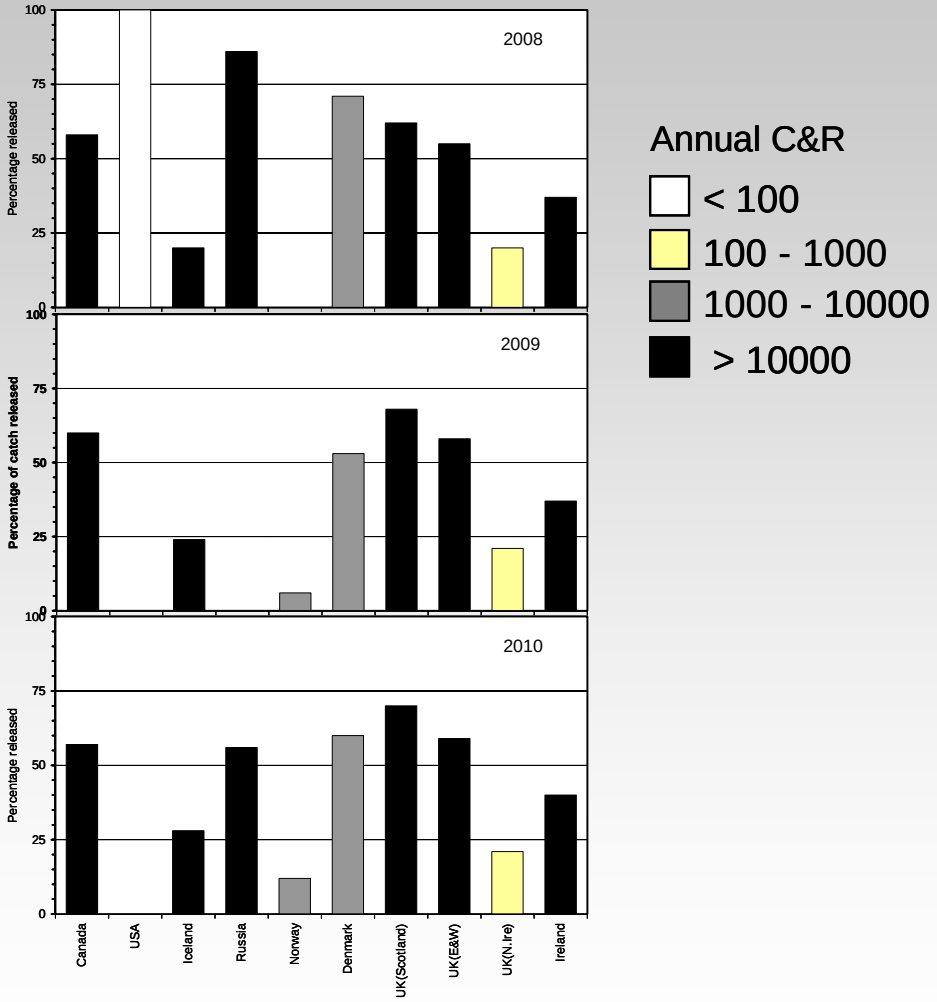
- **Occur in river rod fisheries, not included in nominal catch**
- **Increasing number of countries are reporting (10 in 2010)**
- **Often incomplete reporting**
- **Practice is increasing in popularity**
  - 222 000 released fish in 2010



Catch and release fishing

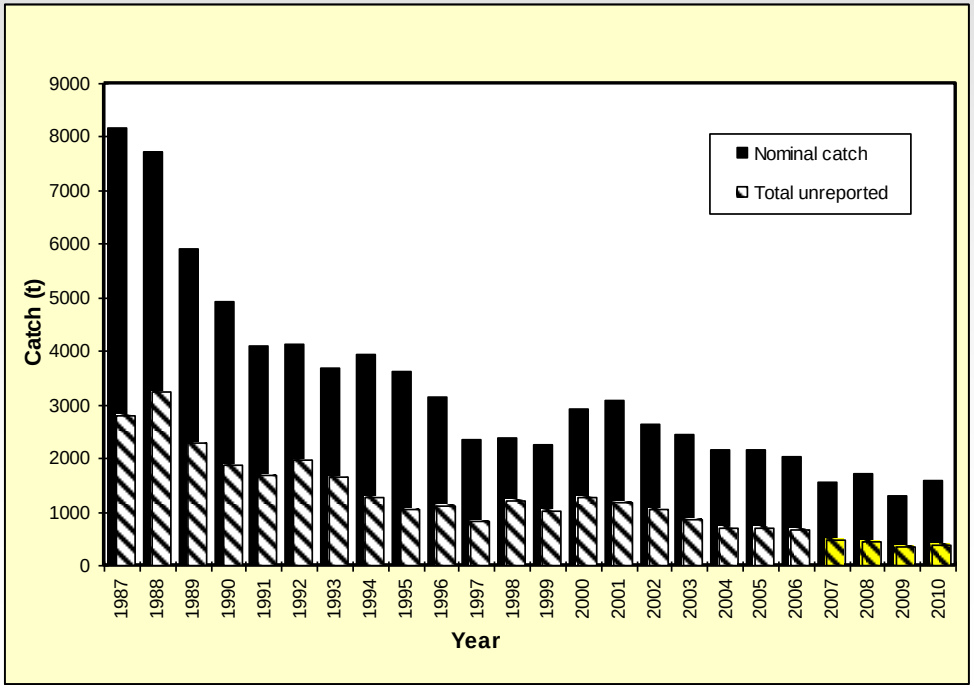
- **Percent released varied from 12% (Norway) to 70% (UK Scotland) in 2010**

- **There is mortality associated with catch and release fishing**
  - in 2009, ICES reported to NASCO on effects of C&R fishing on salmon survival
  - in 2010, ICES reported on how C&R mortality is incorporated in assessments

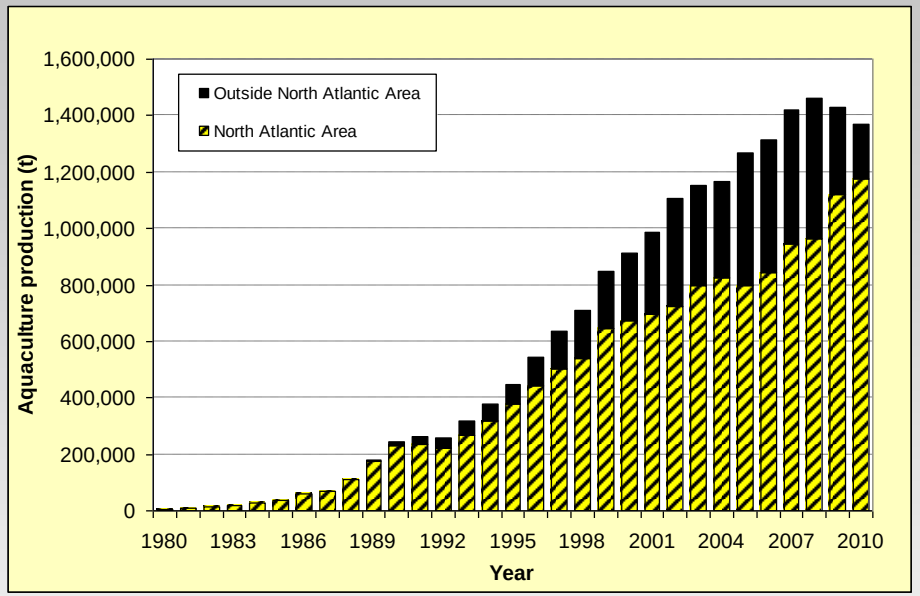


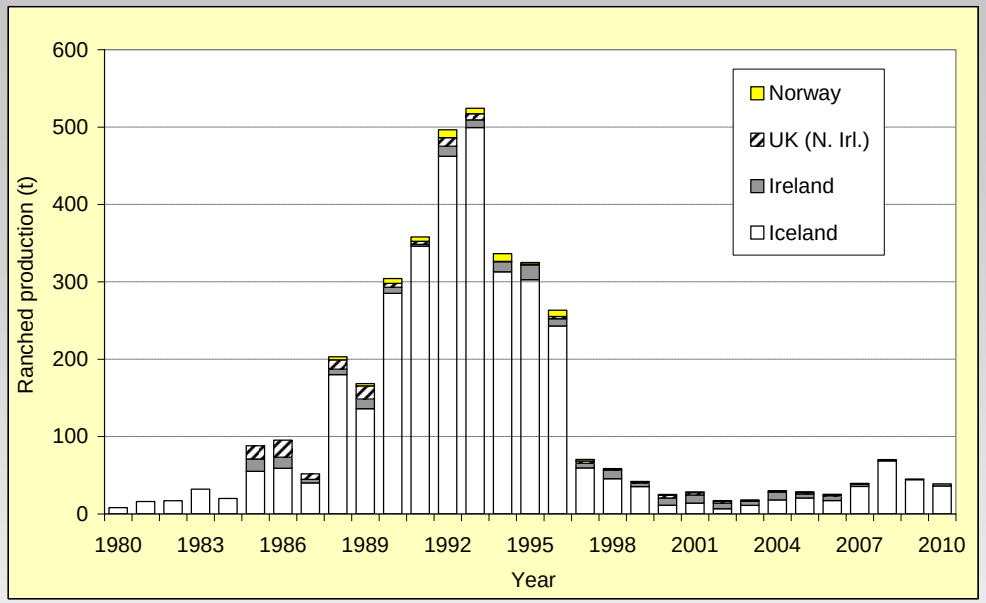
10.1.5.3 Unreported Catches

- **382 t in 2010** (incomplete, partial report Canada, no report from St. P&M, Russia, Spain)
  - 357 t from NEAC (partial, 2nd lowest of time series)
  - 10 t from West Greenland (same value as previous years)
  - 15 t NAC estimate (partial; value in 2006 was 56 t)
- **Unreported catch has been 23% to 34% of nominal catch, over the period 1987 to 2006**



10.1.5.4 Farming and Sea Ranching





Farmed production in 2010

- **North Atlantic = 1 188 kt**
  - **78% from Norway**
  - **13% from UK(Scotland)**
- **Worldwide = 1 368 kt**
  - **above 1 million t since 2002**
  - **> 850 times the nominal catch in 2010**

Sea ranching in 2010 = 39 t

- **36** t from Iceland as ranching to rod fisheries

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.1 Workshop on Age Determination of Salmon

Objective: reviewing assessing, documenting, and making recommendations on current methods of ageing Atlantic salmon

- **Recommendations** from the Workshop:
  - standardising digital scale reading,
  - compilation of a digital image reference collection,
  - detailing of characteristics and reference points on scales, and
  - itemising scale marks and issues in their separation.
- Approaches to future sample and data collection to address questions of changing life histories and proposals for future data analyses were also made.
- **ICES recommends** further work be undertaken to address protocols, inter-laboratory calibration and quality control as they relate to the interpretation of age and calculation of growth and other features from scales

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.2 Potential impacts of the development of alternative / renewable energy on Atlantic salmon)

• Reports from several countries of a marked increase in the number of hydropower schemes and an anticipated increase in response to government targets on renewable energy and the introduction of financial incentives to support this growth

• ICES noted apparent contradictions between the objectives of different EU Directives: Renewable Energy Directive (2009/28) seeks to promote the development of hydroelectric schemes, while the Council Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (1992/43) and the Water Framework Directive (2000/60) seek to protect the functionality and resiliency of rivers and require habitats to achieve good ecological status

10.1.6.2 Potential impacts of the development of alternative / renewable energy on Atlantic salmon)

• The potential impacts of in-river and estuarine structures on Atlantic salmon are relatively well known given the long history of hydropower development and barrage construction in rivers supporting salmonid and other migratory fish species.

- loss of juvenile habitat due to impoundment
- creation of barriers to migration (upstream and downstream)
- delay of movements of migratory fish
- water abstraction depletes habitat
- turbines (used to generate power) result in fish mortalities
- construction of high dams in the lower sections of rivers and estuaries and the potential cumulative impact where a number of schemes are created in the same catchment

10.1.6.2 Potential impacts of the development of alternative / renewable energy on Atlantic salmon)

- Difficulties posed by current salmon restoration programmes highlights the importance of establishing robust standards at the outset and not relying on inadequate mitigation/compensation provisions

- ICES concluded that great care must be taken to minimise the impact of renewable energy schemes on salmon (and other species) through careful development, design and site selection

- ICES highlighted that the pressures to expand renewable energy raised additional concerns, particularly given unresolved difficulties in establishing and maintaining appropriate safeguards for aquatic biodiversity in previous hydropower developments, and the risks posed by individual and cumulative developments within a catchment

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

- River connectivity is vital in maintaining biodiversity
- Maximising the production of juvenile salmon in freshwater is particularly important at a time when salmon survival at sea is low

- ICES noted that there are several national and international manuals and comprehensive guides on both upstream and downstream fish passage (extensive reference list is provided)

- The technology available for upstream fish passage is more advanced than that available for downstream passage

10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

Examples

- Temporary opening of barriers
- River Rhine, Germany
  - ➢ temporary and periodic openings of the Haringvliet Sluice gates in the Netherlands to allow passage of smolts and migrating adults

10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

Examples

- Technical fish ladder for upstream passage
- River Ätran, Sweden
  - 1946 the dam was equipped with a ***Denil fishway***
  - 3000 to 5000 Atlantic salmon and sea trout passed annually in 2000-2010

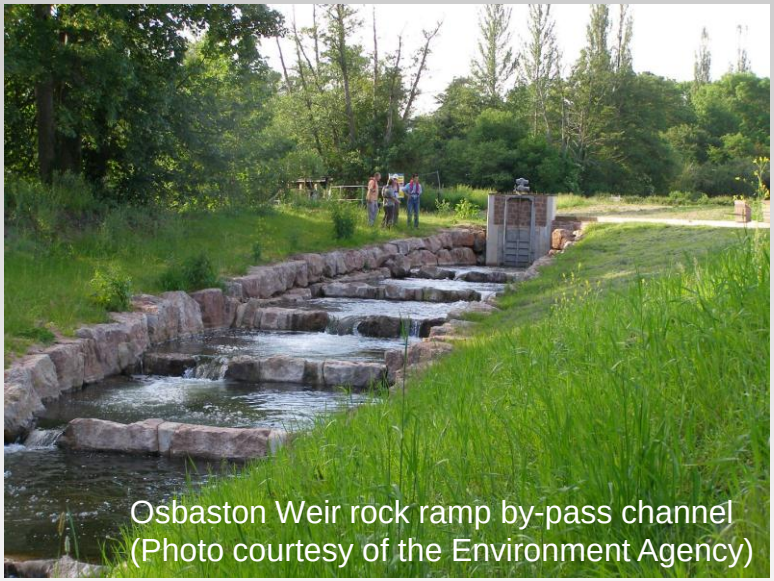
- Downstream passage of fish in the river remains a problem

- Denil fishway is functioning well for strong swimmers (salmon and sea trout) but other species (eel and sea lamprey) are hindered

10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

Examples

- Bypass channel
- River Monnow, UK (England and Wales)
  - rock ramp by-pass channel opened up 200 km on the River Monnow (one of the largest tributaries of the River Wye in Wales) to a wide range of species



Osbaston Weir rock ramp by-pass channel
(Photo courtesy of the Environment Agency)

- Salmon have since been seen spawning upstream of the weir

10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

Examples

- Multiple fish passes
- River Taff, UK (England and Wales)
  - three fish passes have been installed (2003, 2005 and 2009)
  - prior to the installation of the passes, there were no salmon upstream
  - there has been progressive recolonisation of the newly accessible areas since this time, with over 70% of the sites surveyed for juvenile salmon containing salmon fry in 2010

10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

Examples

- Dam removals
- River Himleån, Sweden
  - In the 1980's, salmon were lost due to migration hindrances, acidification in the upper parts, eutrophication in the lower parts combined with canalisation for drainage of agricultural areas
  - First dam and small-scale hydropower plant in the main stem removed in 1996
  - Second power plant and dam removed in 1999
  - 38 km of the river is passable for salmon after removal of three dams
  - Salmon stock is above conservation limits (lost salmon population to a healthy river in 23 years)
  - Eel has increased in the system due to improved passage facilities

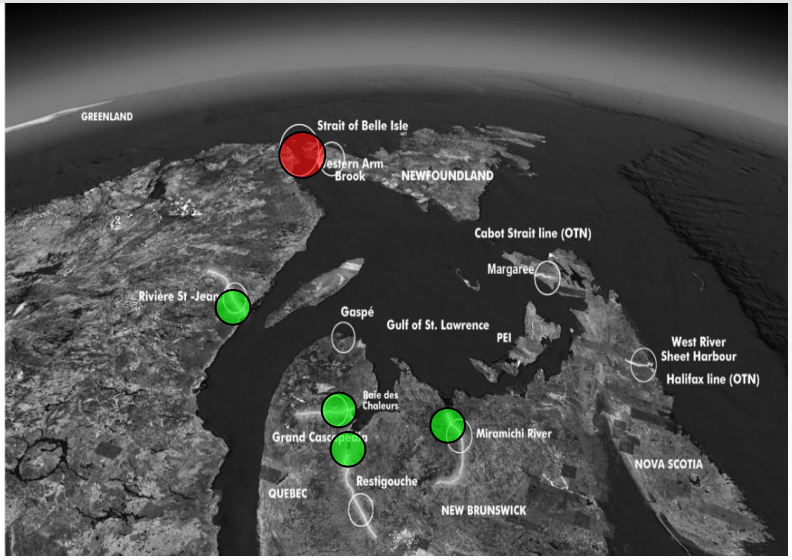
10.1.6.3 (TOR a.v) NASCO asked ICES to provide information on best solutions for fish passage and associated mitigation efforts with examples of practices in member countries

- Fishways are never 100% effective
- In rivers with multiple passes/barriers, there can be substantial negative cumulative effects resulting in few spawners reaching the nursery areas and/or few smolts reaching the sea.
- Careful design, adequate water supply and proper maintenance are crucial to well functioning fishways
- Where possible, complete removal of obstructions offered the best solutions for upstream and downstream movements of aquatic species without delays or mortality
- Many more examples of poorly designed and inefficient technical fishways where problems persisted and insufficient studies on the effectiveness of such structures.

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.4 Recent results from acoustic tacking investigations in Canada

- Atlantic Salmon Federation (ASF) acoustic telemetry collaborative programs to assess estuarine and coastal survival of Atlantic salmon in Canada
- Smolt survival increased through the Strait of Belle Isle for all rivers in 2010 compared to 2009
- Best survival was for Cascapedia River (five year average of 20%), followed by Miramichi (five year average of 19%), and Restigouche (five year average of 14%)



- More complete results at Salmon Summit conference, October 2011

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.5 Assessing the impact of common assessment procedures on smolt physiology, behaviour and adult return rates

- Various studies have indicated that marking/tagging can have negative impacts on survival of salmon
- Investigations conducted in UK (England and Wales) to assess the impact of trapping, handling, anaesthesia and tagging (CWT) of Atlantic salmon on smolt physiology, smolt migratory behaviour and subsequent adult return rates

  - Physiology of wild smolts - River Frome
  - Physiology of hatchery-reared smolts – laboratory study
  - Wild smolt migratory behaviour - River Ceiriog
  - Adult return rates - River Frome

- Additional mortality associated with the handling and tagging of wild smolts should be taken into account when assessing marine survival

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.6 Red Vent Syndrome

- Reports from a number of countries in the NEAC and NAC areas of salmon returning to rivers with swollen and/or bleeding vents (red vent syndrome; RVS) noted since 2005.
- Linked to the presence of a nematode worm, Anisakis simplex
- No indication that RVS affects survival or spawning success
- Affected vents showed signs of progressive healing in freshwater

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.7 Reduced sensitivity and development of resistance towards treatment in salmon louse (*Lepeophtheirus salmonis*)

- ICES previously highlighted concerns from Norway regarding the development of reduced sensitivity of the salmon louse (*Lepeophtheirus salmonis*) to oral treatment (ICES 2009a, ICES 2010b).
- Average number of adult lice on salmon in January and February 2011, for Norway as a whole, was at the same high level as seen in the previous year (www.lusedata.no).
- Throughout 2010, levels were on average higher than the previous year in January to March and August to November. Together with the increase in geographic spread of incidences of treatment failure and resistance, gives ongoing cause for concern.

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.8 Atlantic salmon genetics - in relation to management of mixed stock coastal fisheries in northern Norway

- Collaborative initiative between Norway and Russia
- Presently, around 50% of the samples from coastal fisheries can be reliably assigned to river (probability >90%)
- Spatial coverage of the baseline should be expanded, and additional sampling should be conducted in a number of rivers to improve the precision of the assignment of individuals
- Norway, Russia and Finland project:
  - model of coastal migration of spawners to the northern rivers will be developed
  - up to 100 northern rivers will be added to the genetic baseline, and
  - up to 18000 samples from coastal fisheries in Norway and Russia to be analysed
- provide a foundation for implementing river-specific management regime for coastal and riverine fisheries of these northern populations

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.9 SALSEA West Greenland

- Update provided on SALSEA West Greenland 2010
- Data collected will be combined with data from the same cohorts of salmon sampled during concurrent oceanic surveys and subsequent in-river sampling programs in home waters
- In 2010, 358 fresh whole salmon were purchased directly from individual fishermen for detailed sampling
- List of tissues collected provided in report, similar to the tissue collections from the marine surveys
- ICES recommends that SALSEA West Greenland be conducted in 2011 and that efforts continue to integrate the results from this sampling program with results obtained from both SALSEA-Merge and SALSEA North America

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.10 Salmon by-catch in the Icelandic mackerel fishery

- Programme to investigate the incidence of salmon by-catch in a new mackerel fishery that began in Icelandic waters in 2010

- Monitoring of landings for salmon by-catch in land-based sorting facilities
- Sampling rate was 40 kg per 100 t of landed catch
- Total by-catch sampled was 170 salmon
    - most were less than 60cm in fork length (first sea-year)
    - four of the salmon were tagged (three from Norway, one from Ireland)

- Most of the by-catch occurred in areas off eastern and northeastern Iceland during the early summer months.

- ICES welcomed this opportunistic assessment of the incidence of salmon by-catch in this pelagic fishery and also the opportunity to collect samples from the salmon caught.

10.1.6 Report on significant new or emerging threats to, or opportunities for, salmon conservation and management

10.1.6.11 Reintroduction of salmon – developments on the River Rhine

- Re-introduction of Atlantic salmon to River Rhine began 20 years ago
- Naturally produced juvenile salmon first observed in 1994
- Since the start of the programme more than 6200 adult salmon, mainly from stocking, have been recorded in the Rhine and its tributaries
- Downstream migration of Atlantic salmon hatchery smolts has been monitored in the River Rhine since 2007
    - Number of smolts reaching the sea has been low (highest in 2007 at 47%)
- ICES noted that following a change in government in 2010, the plans to partially open the Haringvliet sluices were dropped
- This raises serious concerns since this will affect the main migration route for salmon and other diadromous fish

10.1.7 Report on significant advances in our understanding of associations between changes in biological characteristics of all life stages of Atlantic salmon and ecosystem changes with a view to better understanding the dynamics of salmon populations

- ICES previously considered a preliminary report from the second meeting of the Study Group on the Identification of Biological Characteristics for Use as Predictors of Salmon Abundance [SGBICEPS]
- Final Study Group report had since been published (ICES 2010c).
- No other new information was presented to ICES.

Manuela Azevedo & Hans Lassen

10.1.8 Further develop approaches to forecast pre-fishery abundance for North American and European stocks with measures of uncertainty

Study Group on Salmon Stock Assessment and Forecasting (SGSAFE) was set up to further develop Atlantic salmon stock assessment and forecast models and to assist ICES in providing catch advice to NASCO for management of the North Atlantic high seas salmon fisheries

- Terms of reference:
  - update and further develop stock and/or catch forecast models for salmon stocks in the NAC and NEAC areas
  - evaluate options for developing forecast models which include all sea-age classes
  - evaluate methods for incorporating uncertainty in the assessments
  - develop risk analyses for the provision of salmon catch advice
  - explore the possibility of incorporating physical and biological variables into the models that may explain variation in salmon survival

Manuela Azevedo & Hans Lassen

10.1.8.1 Update and further develop stock and/or catch forecast models for salmon stocks in the NAC and NEAC areas

- NAC: PFA of 1SW non-maturing salmon is modelled for each region proportionally to lagged spawners
  - model to be used in 2012 for forecast and catch advice for NAC and WG

- Revised NEAC model:
  - combined sea-age group model
  - discussed further in Section 10.2 and is applied to develop catch advice for the NEAC stock complexes.

Manuela Azevedo & Hans Lassen

10.1.8.2 Evaluate options for developing forecast models which include all sea-age classes

- Combined sea-age class models have been developed for the NEAC stocks
    - combined sea-age group model not developed for NAC but model structure similar to NEAC could be considered.

- Issues: heritability of age at maturity in the two differing assumptions for NAC and NEAC

    - NEAC: assumption is that an egg is an egg regardless of its sea-age origin

    - NAC: assumption is perfect heritability. 2SW salmon spawners are the only contributor to 1SW non-maturing salmon (potential 2SW)

10.1.8.3 Evaluate methods for incorporating uncertainty in the assessments

- Inference and forecast models in a hierarchical Bayesian framework are the most appropriate
- NAC and NEAC models are developed in that framework

10.1.8.4 Develop risk analyses for the provision of salmon catch advice

- Catch advice in a risk analysis framework within the Bayesian structure is complete for the NAC model
- Similar approach for NEAC was proposed by ICES in 2010, further developed at the Study Group and is being completed by ICES (Section 10.1.12)

10.1.8.5 Explore the possibility of incorporating physical and biological variables into the models that may explain variation in salmon survival

- Literature review of environmental and biological factors associated with biological characteristics and survival of Atlantic salmon is available in the SGBICEPS Study Group report (ICES 2010)

- Factors vary between NAC and NEAC and even within areas of NEAC

- Progress on this term of reference requires the development of models at scales below the stock complex level (is developed for NAC, is being developed for NEAC)

- Study Group began constructing the spawning and recruitment dynamic into the specific salmon life stages associated with freshwater and marine environments.

10.1.8.6 Next steps

- The Study Group report (both meetings) to be finalized July 2011

- Models developed by the Study Group have been presented to ICES and are being used to develop catch advice for both NAC and NEAC.

- Further work on the question of incorporating environmental variables in assessment and forecast models is expected by collaborators in a new EU funded project – Effective Use of Ecosystem and Biological Knowledge in Fisheries (ECOKNOWS) - and one of their deliverables is reporting to ICES.

10.1.9 Provide a review of examples of successes and failures in wild salmon restoration and rehabilitation and develop a classification of activities which could be recommended under various conditions or threats to the persistence of populations

- Study Group on Effectiveness of Recovery Actions for Atlantic Salmon [SGERAAS] intended to work by correspondence to make progress on this issue

- Study Group has not been able to address this question and there was no progress to report

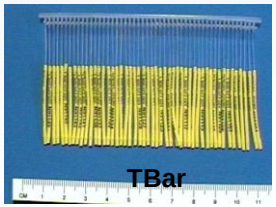
- ICES recognised that the issue of the restoration and rehabilitation of salmon stocks remains a concern

- Study Group is the best way to provide this review

10.1.10 Provide a compilation of tag releases by country in 2010 and advise on the utility of maintaining this compilation

10.1.10.1 Tag releases and fin clips in 2010

- compiled as a separate report (ICES 2011)
- 4.89 million salmon were marked in 2010, an increase from the 3.45 million fish marked in 2009
- most marks were applied to hatchery-origin juveniles (3.34 million)
- since 2003, marks have been applied to farmed salmon. Such CWT tagged farmed fish are included in the compilation
- broad range of tag types and increasing numbers of PIT, acoustic, radio, and DST tags being used



10.1.10 Provide a compilation of tag releases by country in 2010 and advise on the utility of maintaining this compilation

10.1.10.2 Utility of maintaining the tag compilation

- ICES concludes there is value in maintaining the tag compilation, in particular while such large numbers of salmon are being tagged annually and while the return of tags can add to the knowledge about salmon at sea

- preparation of the tag compilation can be carried out during the annual meeting of the Working Group

- ICES recommends continuing with the annual compilation of salmon tags and encourages further use of the scientific information gathered from tagging programmes.

Acknowledgements

Members (24) of participating countries (14, including Iceland) to Working Group on North Atlantic Salmon, March 22-31, 2011

Manuela Azevedo & Hans Lassen