Council

WGC(16)5

Presentation of the ICES Advice to the West Greenland Commission

REPORT OF ICES ADVISORY COMMITTEE

ON

NORTH ATLANTIC SALMON STOCKS

TO

NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION

WGC Area

CNL(16)9

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

10.4 With respect to Atlantic salmon in the West Greenland Commission area:

1. Describe the key events of the 2015 fisheries
2. Describe the status of the stocks
3. Compare contemporary indices of salmon abundance in the West Greenland fishery to historical estimates and suggest options for improving future estimates
4. Estimate effects of modifying the timing of the West Greenland salmon fishery, including altering the start date, with regard to harvest and exploitation of contributing stocks
5. Advise on changes to temporal and/or spatial fishery patterns that may provide increased protection for weaker stocks

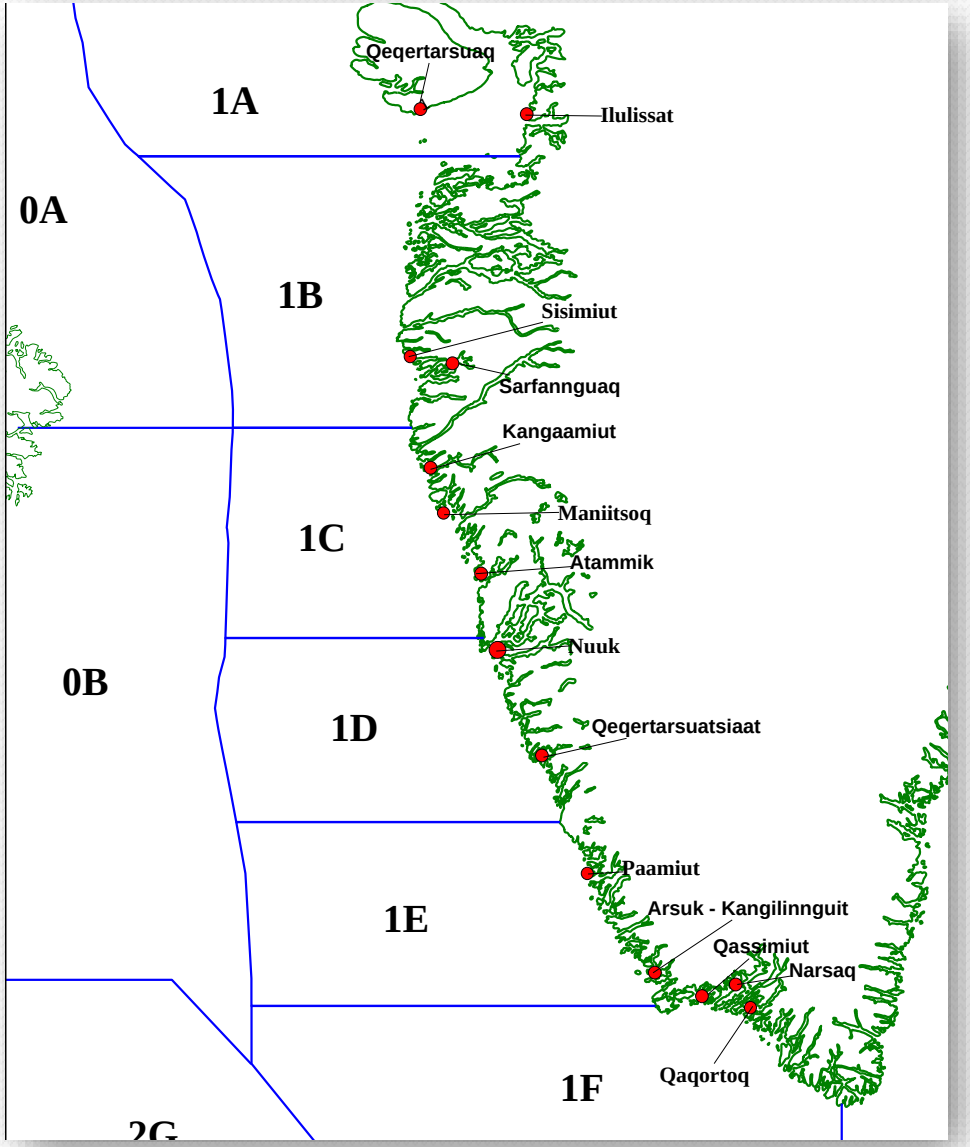
Advice generated by ICES in response to terms of reference from NASCO

10.4 With respect to Atlantic salmon in the West Greenland Commission area:

In the event that NASCO informs ICES that the Framework of Indicators (FWI) indicates that reassessment is required:

6. Provide catch options or alternative management advice for 2016 - 2019 with an assessment of risk relative to the objective of exceeding stock conservation limits, or pre-defined NASCO Management Objectives, and advise on the implications of these options for stock rebuilding
7. Update the Framework of Indicators used to identify any significant change in the previously provided multi-annual management advice

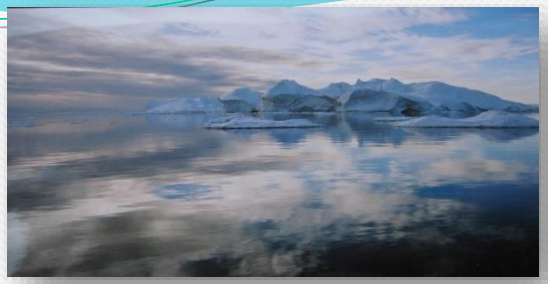
Atlantic salmon in the West Greenland Commission area



- Salmon from NAC and NEAC, in their 2nd summer and autumn at sea go to W. Greenland to feed
- Most are 1SW non-maturing fish, destined to become 2SW (or older) fish if not caught

1. Key events of the 2015 fisheries





- Only hook, fixed gillnets and driftnets allowed to target salmon, min mesh size of 140mm (stretched mesh) since 1985
- 2005–2014: fishing season ran from 1st August to 31st October
- 2015: opening delayed until 15th August, closed 31st October
- 2015: factory landings allowed only from 9th to 31st October
- From 2002–2011 two landing categories reported:
  - Commercial landings - licensed fishers selling to hotels, institutions, local markets
  - Private landings - licensed and unlicensed fishers fish for private consumption
- From 2012–2014 (first time since 2001) licensed fishers allowed to land to factories
- 2012: factory quota set at 35t ► 2014: reduced to 30t

  Applied to only factory landings, not commercial or private landings
- 2015: 45t quota set for all components of the fishery (private, commercial & factory)
- Export ban continues – salmon can only be sold within Greenland

1. Key events of the 2015 fisheries

- 2015 Reported catch of 56.8t (1t in East Greenland)
- Decrease by ~ 1t on 2014 (57.9t)
- Catch breakdown: 89% of landings from licensed fisheries

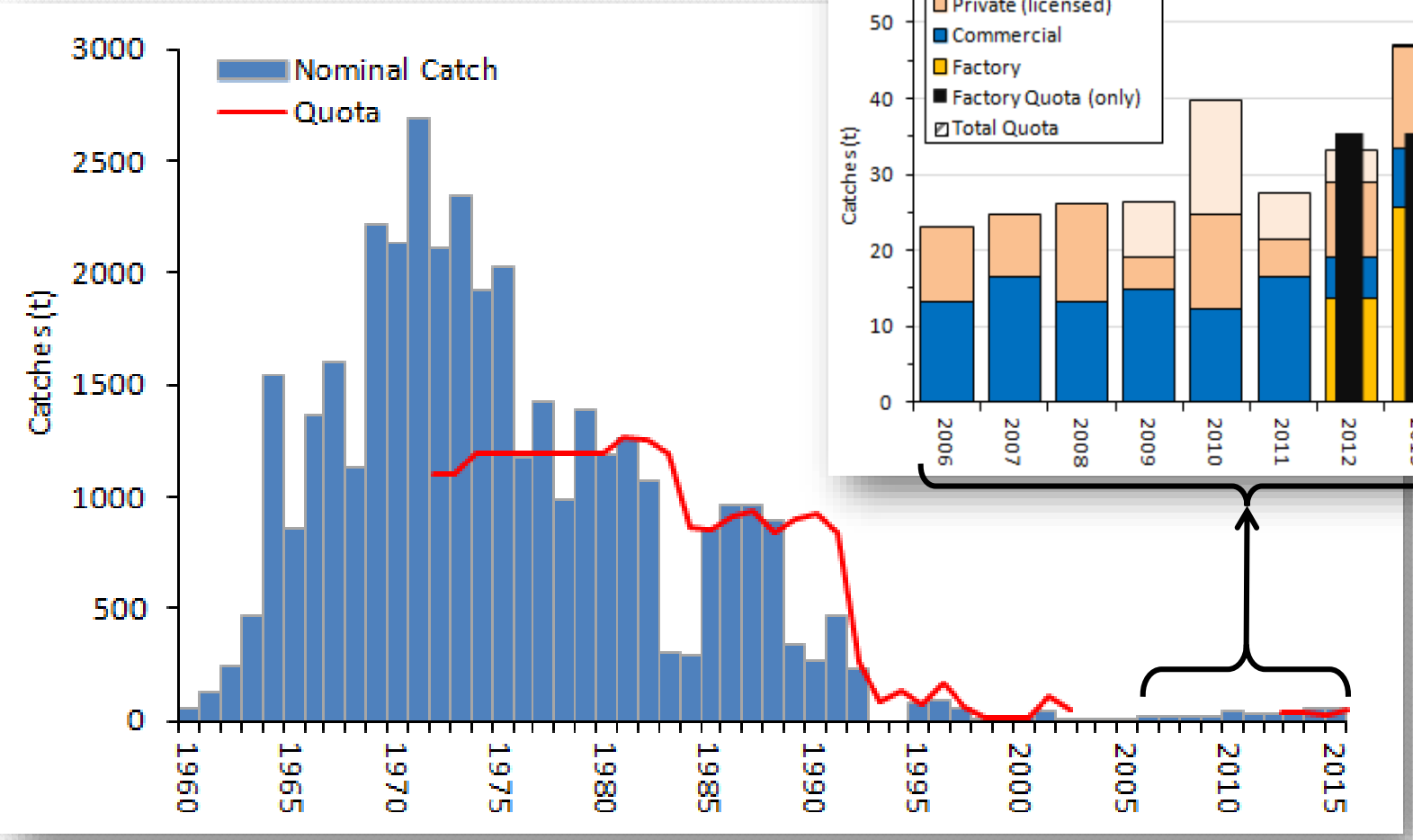
Year	Private		Comm'l	Factory	Total Reported	Landings		Unreported
	non-	licensed				Adjusted	Assmn't	
2014	0.4	10.7	11.6	35	57.7	12.8**	70.5	10
2015	**5.9**	**13.3**	**33.8**	**3.8**	**56.8**	**5***	**60.9**	**10**
Diff.	5.5	2.6	22.2	-31.2	-0.9	-7.8	-9.6	0

Adjusted landings: * survey only; ** sampling & survey)

- Phone surveys were conducted after fishing seasons in 2014 and 2015 – to gain information on catch and effort
- "Adjusted landings (survey)" were added to the reported landings and used in stock assessments (landings for assessment)
- Unreported catch (Adjstd landings (survey)) of 12.2t identified in 2014 and 5t in 2015
- Comparison of reported landings to sample data made since 2002 – to evaluate non-reporting. When non-reporting is identified, "adjusted landings (sampling)" are also included to "landings for assessment".
- Noting: Landings for assessment (including adjusted landings) do not replace the official reported statistics.

1. Key events of the 2015 fisheries

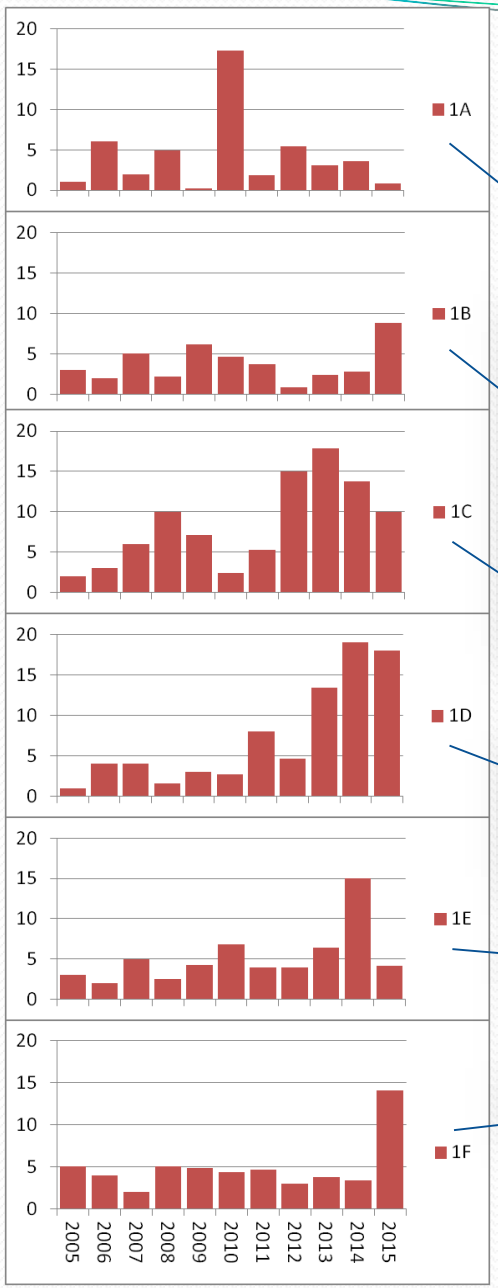
- Despite increased effort to improve in-season monitoring & reporting, total landings exceeded quota (45t) by 11.8t

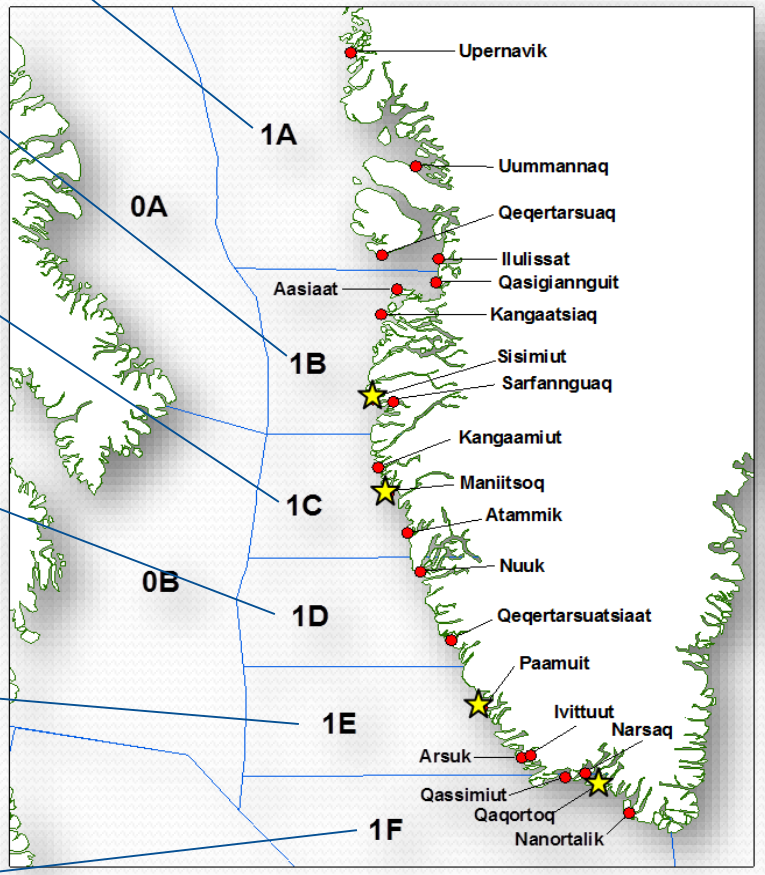


1. Key events of the 2015 fisheries

2015:

- Greatest catch: 1D (18t)
- Two Increases on 2014:
  - 1B & 1F
- Four Decreases on 2014:
  - 1A, 1C, 1D, 1E



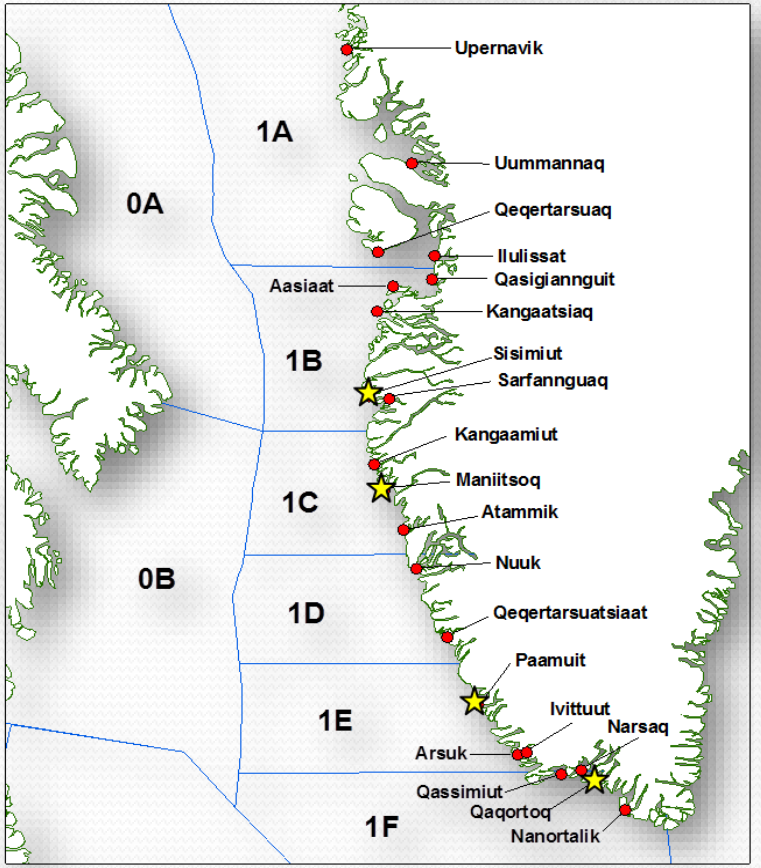


★: Sampling locations 2015

1. Key events of the 2015 fisheries

International sampling programme 2015

- It was initiated by NASCO in 2001, continued in 2015 to provide information needed for assessments
- Samplers from USA, Canada, Ireland, UK (Scotland), and UK (England & Wales), UK(Northern Ireland) supported by Greenland Institute of Natural Resources
- Samples collected at 4 sites: Sisimiut (**1B**), Maniitsoq (**1C**), Paamiut (**1E**) & Qaqortoq (**1F**)
- Sampling undertaken from September to October
- No factory samples were collected in 2015



★: Sampling locations 2015

1. Key events of the 2015 fisheries

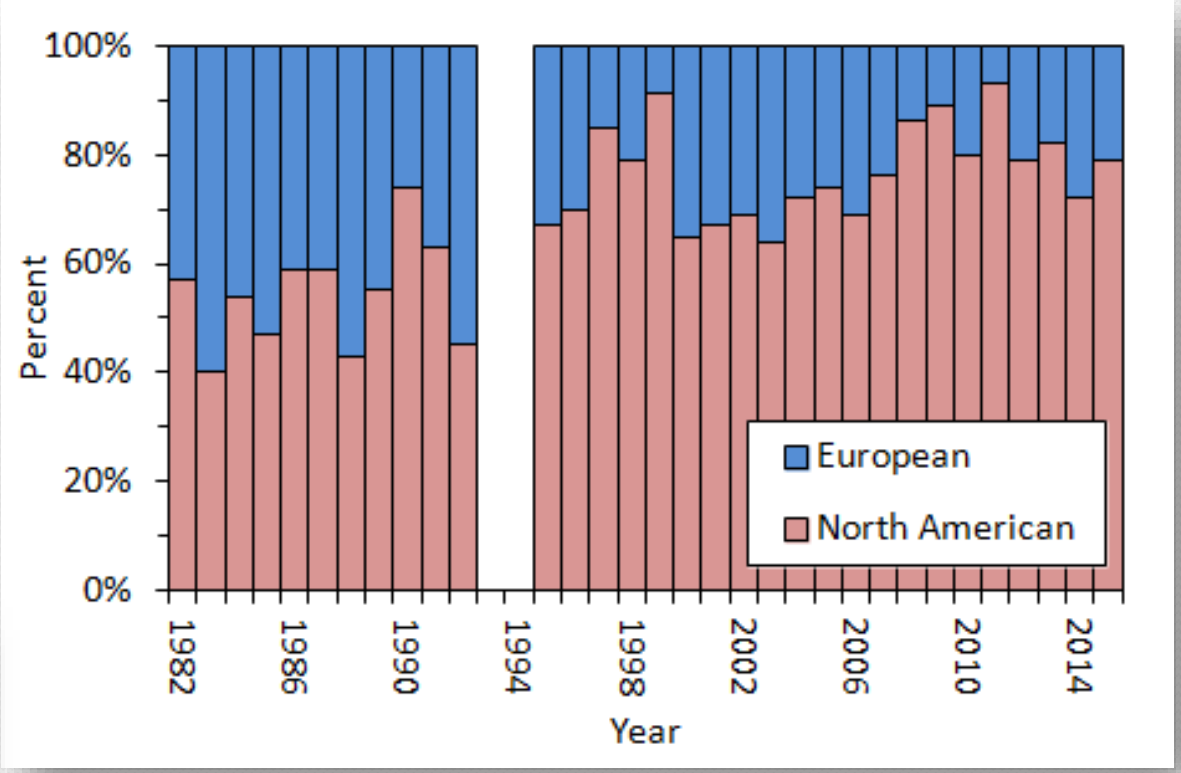
International sampling programme 2015

- 1,964 salmon observed by samplers (~12% by weight of reported landings)
- Of these:
  - 1,708 sampled for biological characteristics
  - 163 only checked for adipose clip
  - 30 finclipped but none carried tags
  - 93 documented but not examined
  - 1,708 fork lengths and weights
  - 1,704 scale samples
  - 1,674 tissue samples for DNA and continent of origin analysis

1. Key events of the 2015 fisheries

International sampling programme 2015

- 79.9% of North American origin, 20.1% European
- North American contribution has remained high since the mid-1990s

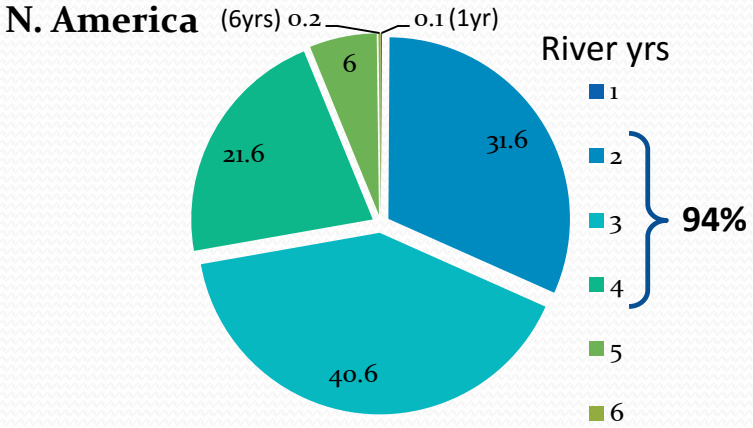


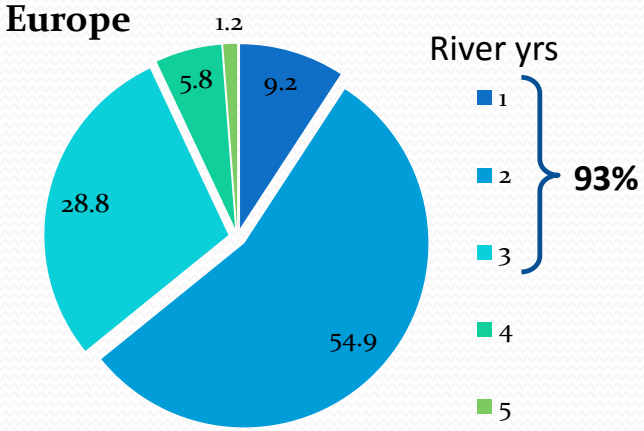
1. Key events of the 2015 fisheries

Biological Characteristics

River age:

- N. America: 94% [3yrs (40.6%), 2yrs (31.6%), 4yrs (21.6%)]
- European: 93% [2yrs (54.9%), 3yrs (28.8%), 1yrs (9.2%)]





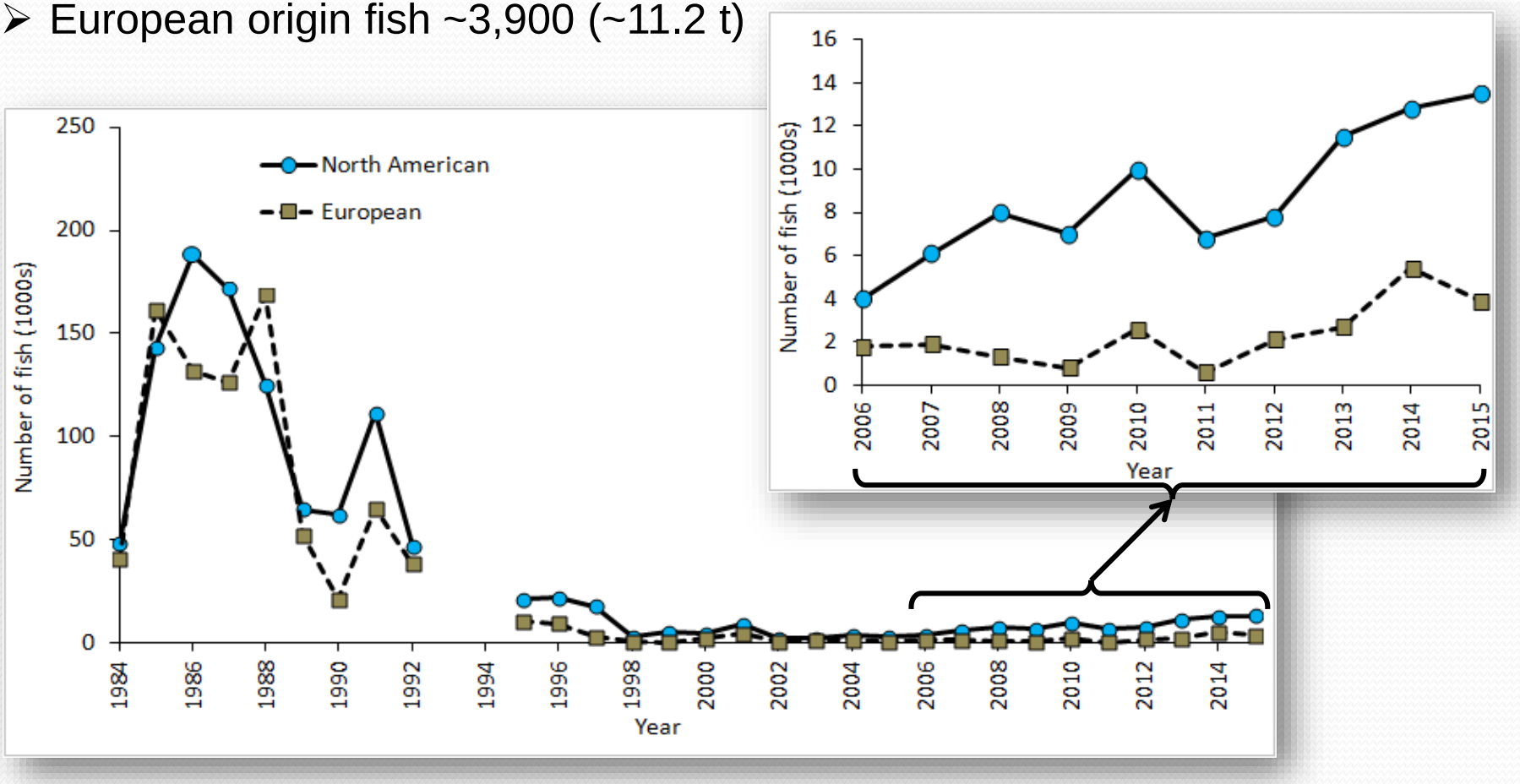
Sea age:

- 1SW age group dominated in 2015 (>95%)

Sea age	1SW	2SW	Prev. Spwnrs
N America	97.0	0.7	2.3
Europe	98.2	1.2	0.6

1. Key events of the 2015 fisheries

- Harvest in 2015:
- Among the lowest in the time-series, although 2nd highest since 1997
  - North American origin fish ~13,500 (~44.6 t)
  - European origin fish ~3,900 (~11.2 t)



2. Stock Status

- A full time series of reliable estimates of wild salmon stock status at West Greenland is not currently available
- Therefore status is inferred from the status of populations in homewaters by:

1. **Pre Fisheries Abundance (PFA):**
   - NAC – non-maturing 1SW
   - Southern NEAC – non-maturing 1SW
2. **Spawning populations:**
   - NAC – 2SW spawners
   - Southern NEAC – MSW spawners

2. Stock Status – PFA

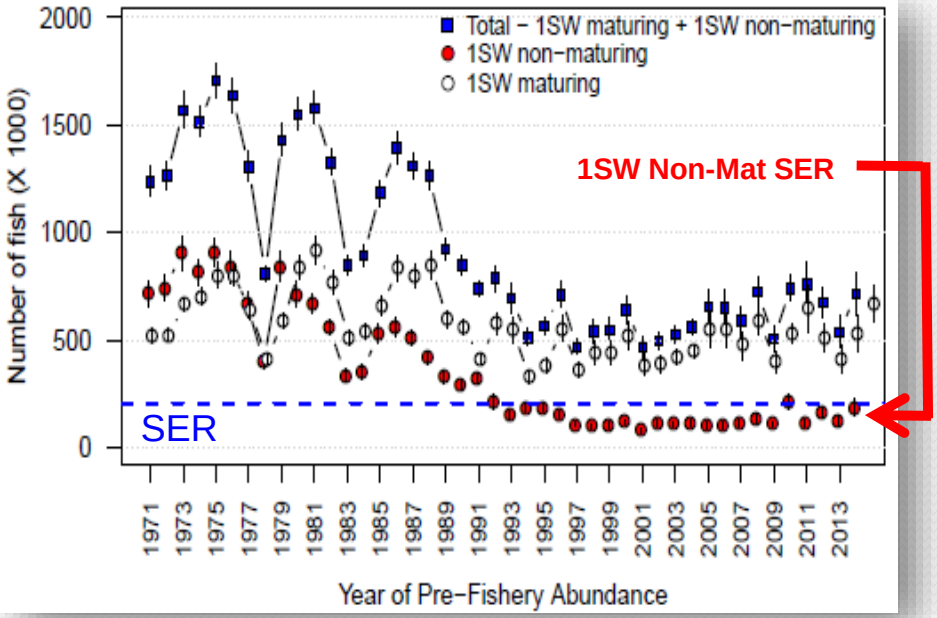
NAC – non-maturing 1SW PFA

- Continued low abundance
- PFA for 2014 above the 2009 to 2013 average
- Below SER, and remains among the lowest in the time series – suffering reduced reproductive capacity

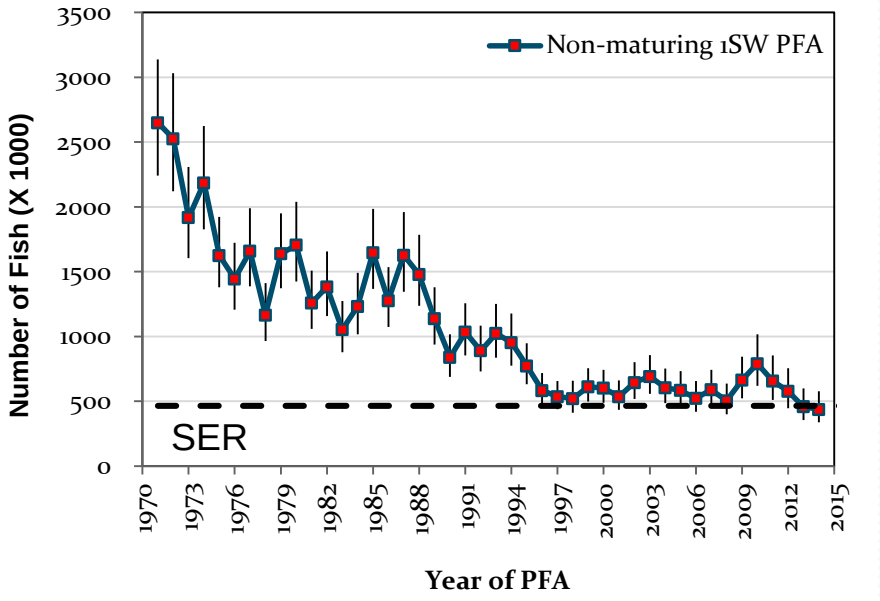
Southern NEAC – non-maturing 1SW PFA

- PFA declined to 1996, since then sustained low levels
- PFA 2013 & 2014 - lowest points in the time series
- Below SER – suffering reduced reproductive capacity

NAC – 1SW non-maturing



Southern NEAC – 1SW non-maturing



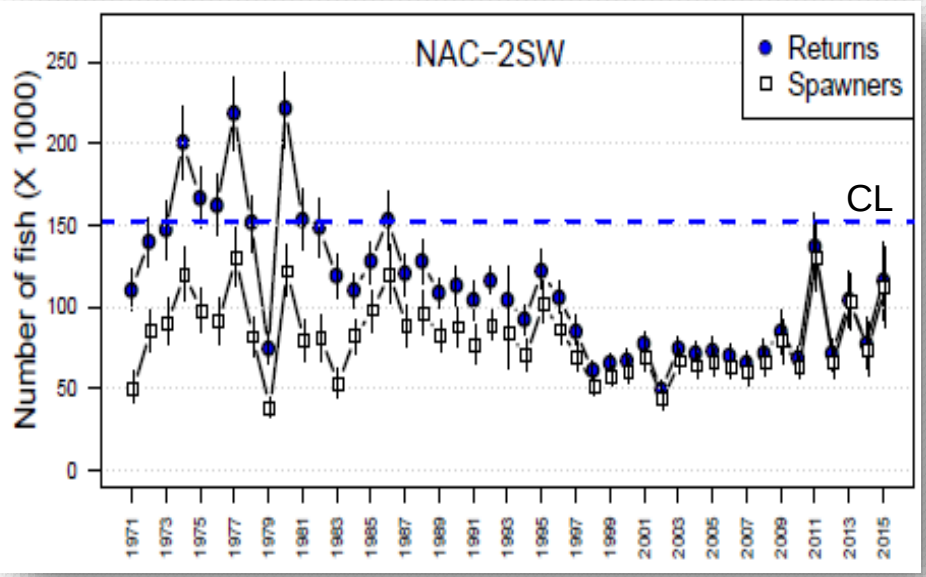
2. Stock Status - Spawners

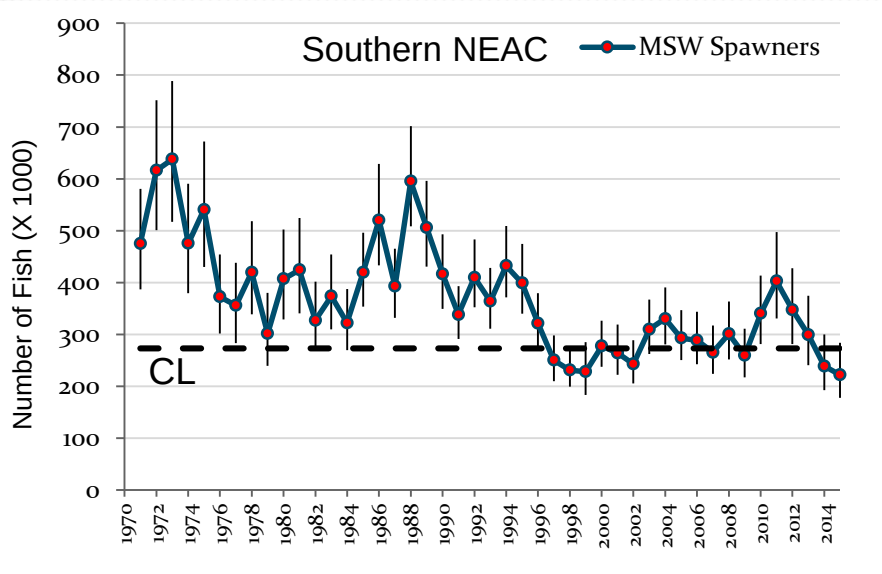
NAC – 2SW spawners

- Complex below CL (and in 4 of 6 regions 2015)
- 2015: 112,100 (6th highest since 1971)
- However, many river stocks are failing to meet CLs, particularly to the south (Scotia-Fundy and USA)
- Labrador, highest on record, and Newfoundland among highest
- Noting: Labrador based on 4 monitored rivers and driven by one – English river

Southern NEAC – MSW spawners

- Decline in MSW spawners
- Since 1997, most years either suffering or at risk of suffering reduced reproductive capacity
- Below CL in 2014 and 2015
- Within countries, many individual river stocks are not meeting CLs



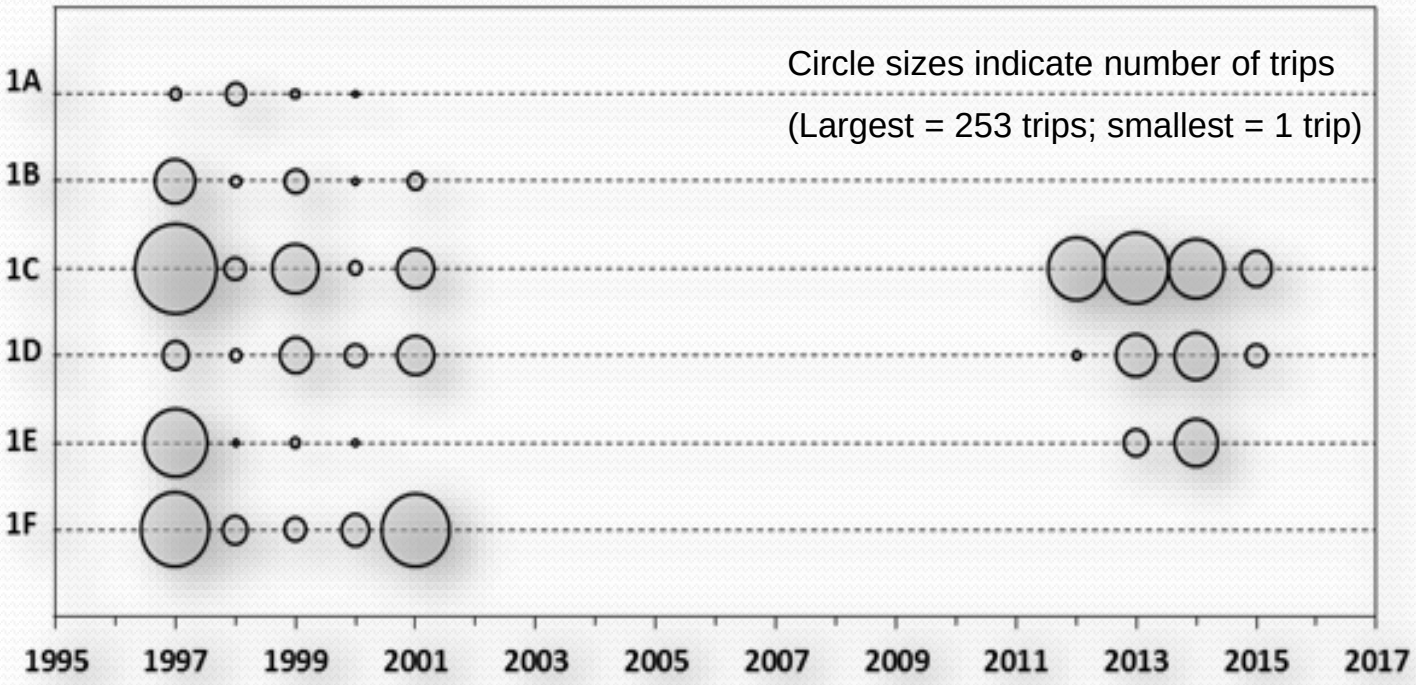


3. Compare contemporary indices of abundance at West Greenland to historical estimates and suggest options for improving future estimates

- 2001: NASCO implemented a programme for in-season adjustments to quota (real time CPUE based)
- 2002: ICES WGNAS examined relationship between CPUE and PFA (1987 to 1992 and 1997 to 2001)
- Despite limitations (ICES-WGNAS, 2002) relationship have been updated (2012 – 2015) to estimate contemporary salmon abundance at West Greenland
- Annual reports of commercial landings varied: 712 to 56 trips (1997 & 2015)
- Spatial and temporal distributions variable (NAFO Divisions and weeks)

3. Contemporary & historical indices of abundance at West Greenland

Distribution of commercial effort by NAFO division
(Number of trips reporting salmon landings)

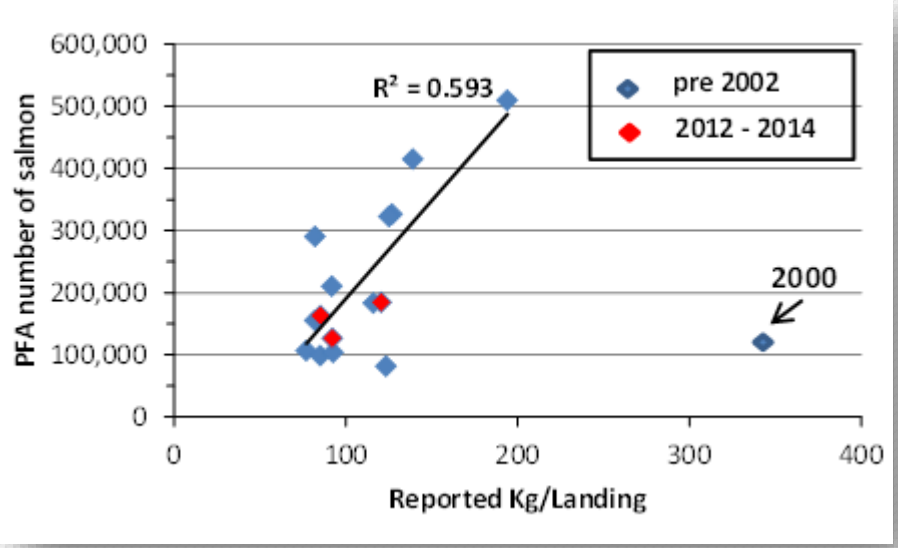


- Number of trips low in some years
- 2000: fishery opened on August 14th, closed four days later – as quota (20t) reached
- 2015: landings to factories occurred late the season (late October)

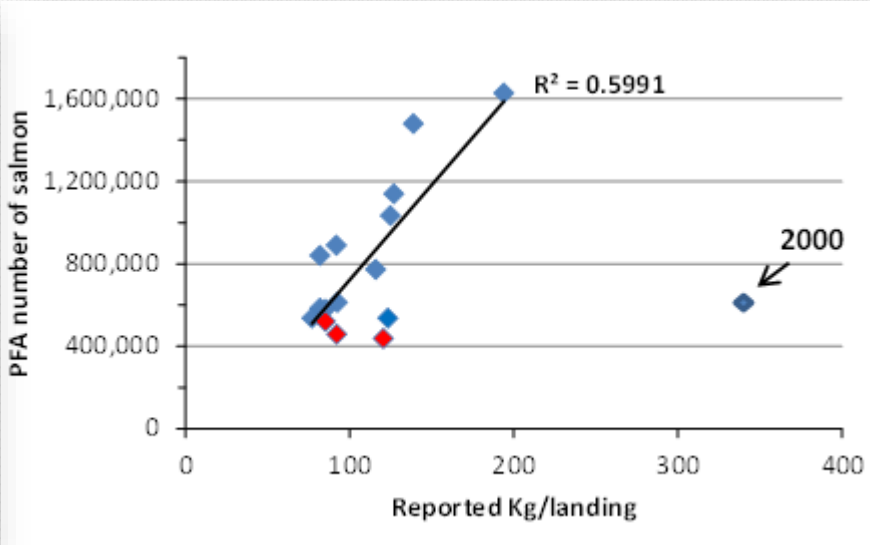
3. Contemporary & historical indices of abundance at West Greenland

West Greenland CPUE and PFA estimates

North American stock complex PFA



Southern European stock complex PFA



- Red points indicate available contemporary data (2012–2014)
- As in 2002 strong relationship between commercial CPUE and PFA (again with exception of outlying point of 2000)
- Regression relationships exclude the outlying point for 2000
- Position of red points indicate current low stock abundance

3. Contemporary & historical indices of abundance at West Greenland

Conclusions

- Previous conclusion (ICES, 2002) that CPUE reflects overall PFA remain valid when updated
- Recent CPUE values are low compared to historical estimates – supporting conclusions of ICES (2015) that stock abundance is low at West Greenland
- Anecdotal reports of high salmon abundance at Greenland may be the result of localized concentrations of abundance, localized catch success or a shifting baseline of perception
- Despite concerns about using CPUE, WGNAS endorses the general approach to infer stock abundance

3. Contemporary & historical indices of abundance at West Greenland

Options for improving future abundance estimates

- Comprehensive reporting of data characterizing fishing effort (e.g., vessel size, gear type, amount of gear deployed, soak time, documentation of zero landings trips and private sales trips) would allow for a more detailed analyses of CPUE data
- Development of alternative in-season measures of abundance should also be explored (e.g. relationships between 1SW returns to rivers from the same cohort)
- Scope to explore alternative fishery-independent methods to estimate stock abundance at Greenland, such as:
  - Hydro-acoustic surveys at West Greenland
  - Standardized gillnet surveys or test fishing
  - Open-trawl surveys (open codend with video camera observation for surveying large areas without harvest)

4. Estimate effects of modifying the timing of the West Greenland salmon fishery, including altering the start date, with regard to harvest and exploitation of contributing stocks

Premise:

- Atlantic salmon at West Greenland grow rapidly - August to November
- With increases in weight of individual fish, could increased returns to homewaters be realized by fishing later in the season for a comparable TAC option established in weight of fish harvested

- Analysis examined:
  the relative consequence on predicted returns to homewaters of a fixed TAC according to variations in opening and duration of the fishing season at West Greenland

4. Effects of modifying timing of the West Greenland fishery on harvest and exploitation

Examined by modelling:

- Moving fish at the PFA stage through the fishery
- Adjusting their size (in weight) over time (standard weeks) (based on >18 000 salmon sampled at W.Greenland, 2002–2015)
- Removing fish based on weekly catches (at a proportion of the TAC)
- Correcting for natural mortality (approx. 3% per month, from PFA stage, through the fishery, and return to homewaters)
- Relative changes in returns were compared against a base line scenario
- Base line fishing season: from 30th July (week 31) to 11th November (week 44)
- Uncertainties in PFA values and fishery characteristics were simulated by 5000 independent Monte Carlo draws

4. Effects of modifying timing of the West Greenland fishery on harvest and exploitation

Scenarios:

- A base fishing season scenario
- 10 "experimental" season scenarios, split into three groups:

30th July ↓ 11th November ↓

Standard week:	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**
Pred. weight (kg)	2.59	2.68	2.78	2.88	2.99	3.10	3.21	3.33	3.45	3.58	3.71	3.85	3.99	4.14
Scenario:	Number of weeks													
Base	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A1		1	2	3	4	5	6	7	8	9	10	11	12	13
A2			1	2	3	4	5	6	7	8	9	10	11	12
A3				1	2	3	4	5	6	7	8	9	10	11
A4					1	2	3	4	5	6	7	8	9	10
A5						1	2	3	4	5	6	7	8	9
B1	1	2	3	4	5	6	7	8						
B2			1	2	3	4	5	6	7	8				
B3					1	2	3	4	5	6	7	8		
B4							1	2	3	4	5	6	7	8
C1									1	2	3	4	5	6

4. Effects of modifying timing of the West Greenland fishery on harvest and exploitation

Relative change from base fishing season:

Catch and the pre-fishery abundance are simply scaling factors:

- 1SW non-maturing catches: NAC and southern NEAC
- 1SW non-maturing surviving post-fishery to week 45: NAC and southern NEAC

Metric of interest: 2SW returns to homewaters – NAC and southern NEAC

Fishing season scenario	Tonnes harvest'd	Relative change from base fishing season (percentages): Catches 1SW n-m		PFA 1SW n-m surviving to week 45		2SW Returns		
		NAC	S.NEAC	NAC	S.NEAC	NAC	S.NEAC	
Base	**102.5**	24 230	4911	112 200	339 800	**90 980**	**275 500**	**(No. fish)**
A1	102.5	−1.9	−1.9	−0.1	0.1	**−0.1**	**0.0**	
A2	102.1	−4.2	−4.2	0.6	−0.1	**0.6**	**−0.1**	
A3	101.7	−6.4	−6.4	1.0	0.1	**0.9**	**0.1**	
A4	101.9	−8.0	−8.0	1.1	0.1	**1.0**	**0.1**	
A5	102.4	−9.4	−9.3	1.2	0.2	**1.2**	**0.2**	
B1	102.2	10.3	10.3	−1.7	−0.1	**−1.7**	**−0.1**	
B2	102.2	2.6	2.6	0.0	−0.1	**−0.1**	**−0.1**	
B3	102.2	−4.5	−4.5	0.7	0.1	**0.6**	**0.1**	
B4	102.0	−11.3	−11.2	1.7	0.0	**1.7**	**0.0**	
C1	102.2	−14.5	−14.5	2.6	0.2	**2.5**	**0.1**	

4. Effects of modifying timing of the West Greenland fishery on harvest and exploitation

- Number of harvest non-maturing 1SW salmon decreases as season opening is delayed
- Highest catch (No. of fish) – from a short fishing season that opens early (scenario B1)
- Lowest catch (No. of fish) – from a fishery that opens latest and is of short duration (scenario C1)
- As predicted, catch (No. of fish) decreases as the fishery opening is delayed
- Relative gain in returns to homewaters (2SW salmon) is reduced by natural mortality over the migration period

4. Effects of modifying timing of the West Greenland fishery on harvest and exploitation

- Largest increase in returns for NAC (2.5%) – result from the shortest and latest opening (scenario C1)
- As the fishery effect at West Greenland on NEAC fish is small, there is little effect on 2SW NEAC salmon returns to homewaters

- Analysis indicates that relative gains in returns to homewaters associated with a delayed fishery are dependent on the exploitation rate experienced by the stock
- The more heavily exploited NAC component benefits most from a delay in the opening

- Realized gains are dependent on growth and natural mortality rate
- If growth rates were lower or natural mortality higher, relative gains to escapement would be lower than estimated and,
- If growth rates were higher or natural mortality lower, relative gains would be more important

4. Effects of modifying timing of the West Greenland fishery on harvest and exploitation

- Based on characteristics of fish in the fishery (estimated changes in weights over the period and assumed natural mortality):

  By delaying the opening of the fishery, to at least mid-September, there would be small gains in escapement (2.5% for NAC)

- However, the number of fish harvested would be reduced by almost 15% from the base scenario, resulting in lower exploitation on the stock overall, and could favour protection of weaker stocks assuming equal availability to the fishery

- Scenarios for season closures after week 44 were not examined:
  (no contemporary samples from the fishery to indicate increased weight)

5. Advise on changes to temporal and/or spatial fishery patterns that may provide increased protection for weaker stocks

1. Literature review

- ICES previously provided information on catches at West Greenland by stock origin and described spatial and temporal distributions
- Available data from genetic sampling used to determine:
  - Continent of origin by standard week and NAFO division (2006–2015)
  - Division-specific sub-continental (regional) numbers and proportions for both European (2002, 2004–2012) and North American (2011–2014) fish
- These represent the most robust estimates available describing composition of W. Greenland harvest (sub-continent level)
- Could be used to evaluate options for temporally / spatially focused management aiming to protect weaker stocks
- Unfortunately genetic assignments previously reported on (ICES 2015) were not available

5. Changes to temporal / spatial fishery patterns

1. Literature review

- Mixture analysis (Bradbury *et al.* accepted), provides some insight:
- European harvest: Three regional groups accounted for 90%:
  - North Scotland and North and West Ireland
  - Irish Sea
  - South and East Scotland
- North American harvest: Three regional groups accounted for 75%
  - Central Labrador
  - Gaspé
  - Southern Gulf of St. Lawrence
- Weaker performing stocks from more southerly regions
  - North America: Nova Scotia, Inner Bay of Fundy, and USA
  - Europe: France and Spain

  Generally contributed less than 2% of the harvest

5. Changes to temporal / spatial fishery patterns

1. Literature review

- Historical tag returns suggest salmon from the USA were more prominent in southern portions of the fishery than Canadian (Reddin *et al.*, 2012)
- Bradbury *et al.* (accepted) explicitly tested for differences in spatial distribution of salmon from different regions, detecting no significant structuring
- Cluster analysis indicated no structuring
- None of the variance in catch composition was attributable to location or year
  - Further supporting the suggestion that contributing stocks are mixed off West Greenland

    (power to detect spatial or temporal patterning may be influenced by small sample size)
- A tendency for salmon from southern regions to arrive slightly earlier was detected – though was not significant
- Further analyses of European regional stock structure were not undertaken, though no evidence to suggest dynamics deviate from those of North America

5. Changes to temporal / spatial fishery patterns

1. Literature review

- Given that temporal estimates of stock composition at West Greenland (ICES, 2015; Bradbury *et al.,* accepted) and the modelled estimates of MSW stock abundance (ICES, 2015) are highly correlated, the genetic estimates appear to be accurately resolving stock composition in the harvest
- In view of their low representation it is difficult to ascertain if there are spatial or temporal patterns to the harvest of the weaker performing stocks, but unlikely considering lack of patterns for the larger contributors
- As such, there does not appear to be any obvious temporal and/or spatial patterns in regional contributions of harvest that would allow for management options to provide increased protection for weaker stocks

5. Changes to temporal / spatial fishery patterns

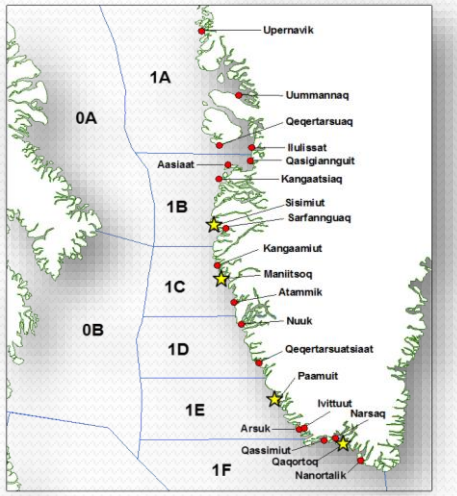
2. Analysis

- Continent of origin association with river age
  (river age as a proxy for latitude of origin)
- ~11 000 samples available (2006–2015)
- Data included:
  - Origin (North American or European)
  - River age (1–6)
  - NAFO division (1A–1F)
  - Standard weeks (31–44) sampled
    (week 31 = 30th July to 05th August each year, increasing sequentially by one every seven days)

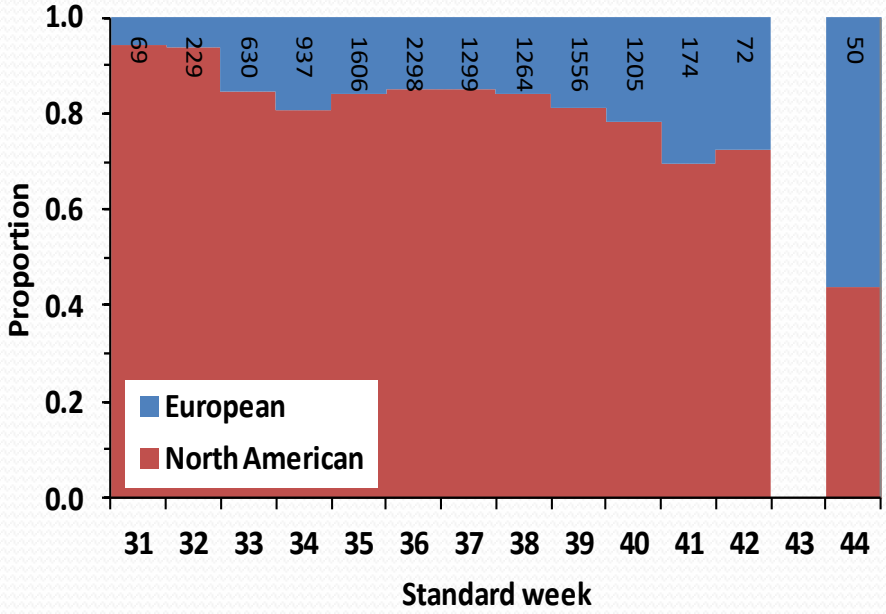
5. Changes to temporal / spatial fishery patterns

2. Analysis

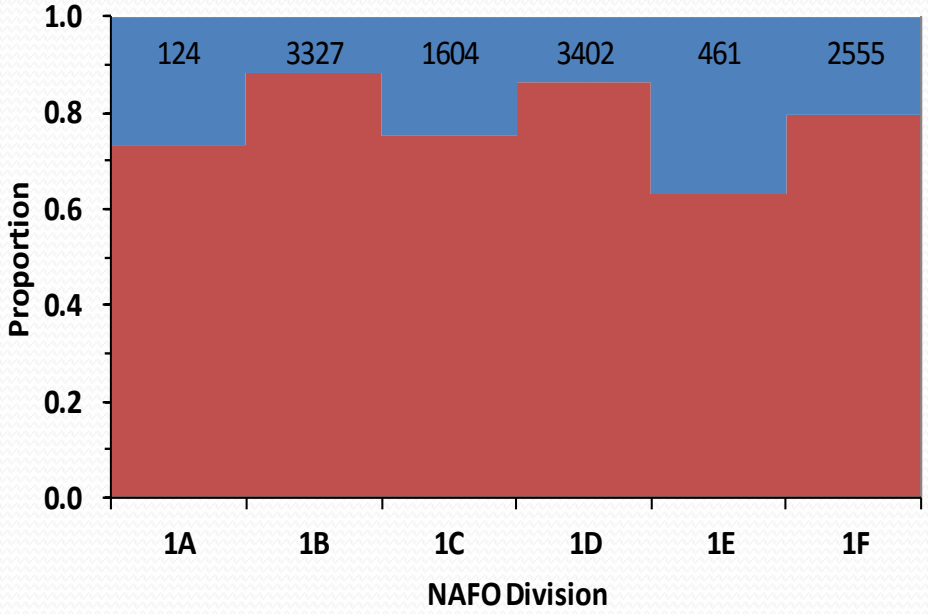
- Appears to be slight increase in European fishing as the season progresses
  (~6% weeks 31–32: 28% & 44% weeks 42 & 44)
  Care – sample sizes over these four weeks <5% total
- No clear pattern across NAFO divisions
- Two divisions with greatest European contribution also had lowest sample sizes (1A and 1E)



Weeks



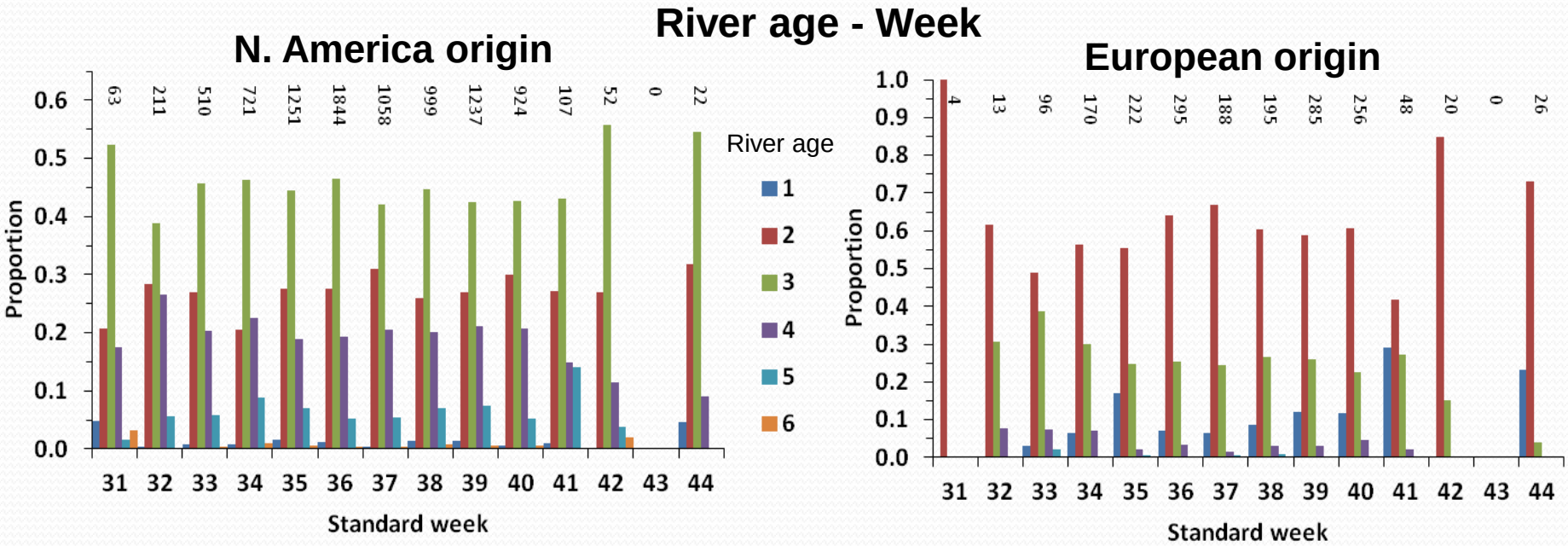
Divisions



5. Changes to temporal / spatial fishery patterns

2. Analysis

- No clear patterns in river-age across weeks (N. America or Europe)
- N.American river-age 1fish ranged from 1% to 2% across weeks, with the exception week 31 (5%), though this consisted of only three fish, all sampled in a single year/community/day
- European river-age 1 fish appear to increase over time, however, week42 contained only one river-age 1 fish; the six 1yr fish in week 44 all from a single year/community/day

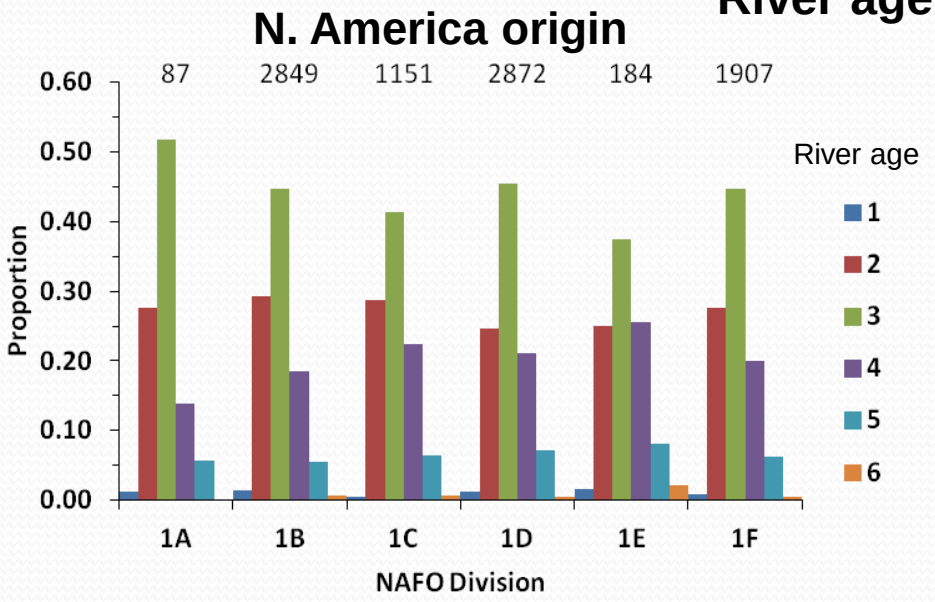


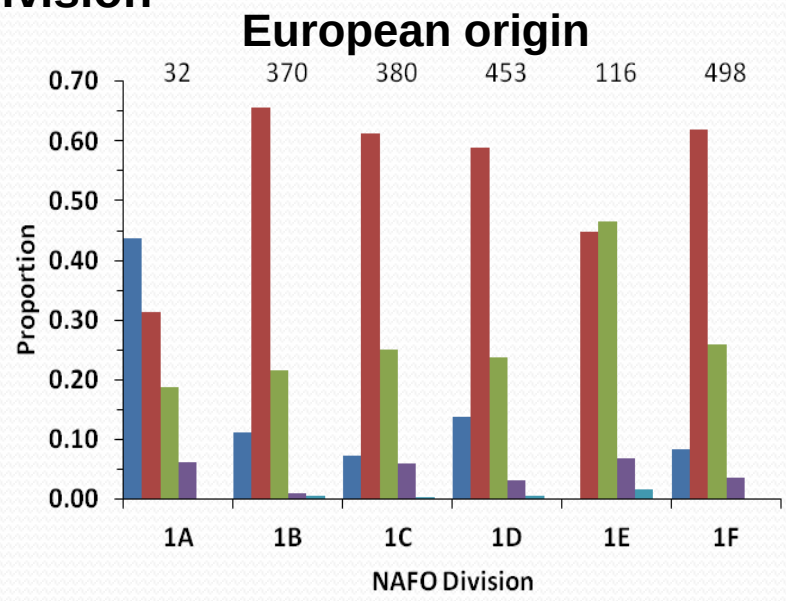
5. Changes to temporal / spatial fishery patterns

2. Analysis

- No clear patterns in river-age across NAFO divisions (N. American or European origin)
- N. American river-age 1 ~ 1% across all divisions; river-age 2 ranged from 25% to 29%
- European river-age 1 fish had a larger contribution in NAFO Division 1A (44%), but small sample size
- Remaining divisions ranged from zero to 11% with no clear patterns

River age - Division





5. Changes to temporal / spatial fishery patterns

Conclusions

- Neither the results presented (ICES, 2015), or by Bradbury *et al.* (accepted) provide clear evidence of temporal and/or spatial management options for the fishery at West Greenland that would provide increased protection for weaker stocks
- Although sample sizes may not be optimal, the best available information suggests that the contributing North American and European stocks mix sufficiently along the coast of West Greenland and across the fishing season
- Contributions to the harvest by regional stock groupings closely mirrors modelled estimates of MSW stock abundance, further supporting the suggestion that the stocks are well mixed
- Although some weak relationships were identified, these remain preliminary and further analysis of these data, increased genetic sampling of the fishery, and further refinement in the genetic baselines used for regional assignments may be needed to investigate these patterns further

Recommendations

- ICES recommends for future activities:

1. Further analysis of the resulting data and continuation of the phone survey programme in the Greenland fishery. this will provide for a more accurate assessment of the status of stocks and assessment of risk with varying levels of harvest

2. Efforts to improve Greenland catch reporting continue and detailed statistics related to catch and effort should be made available for analysis

3. A continuation and potential expansion of the broad geographic sampling programme at West Greenland (multiple NAFO divisions including factory and non-factory landings) to more accurately estimate continent and region of origin and biological characteristics of the mixed-stock fishery

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

Supporting information and details in the report of the ICES Working Group on North Atlantic Salmon available at:
http://www.ices.dk/publications/library

Acknowledgements

Members (23) of participating countries (10) to the Working Group on North Atlantic Salmon, 30 March–8 April 2016, in ICES HQ, Copenhagen, Denmark

Section coordinator: Tim Sheehan (USA)