



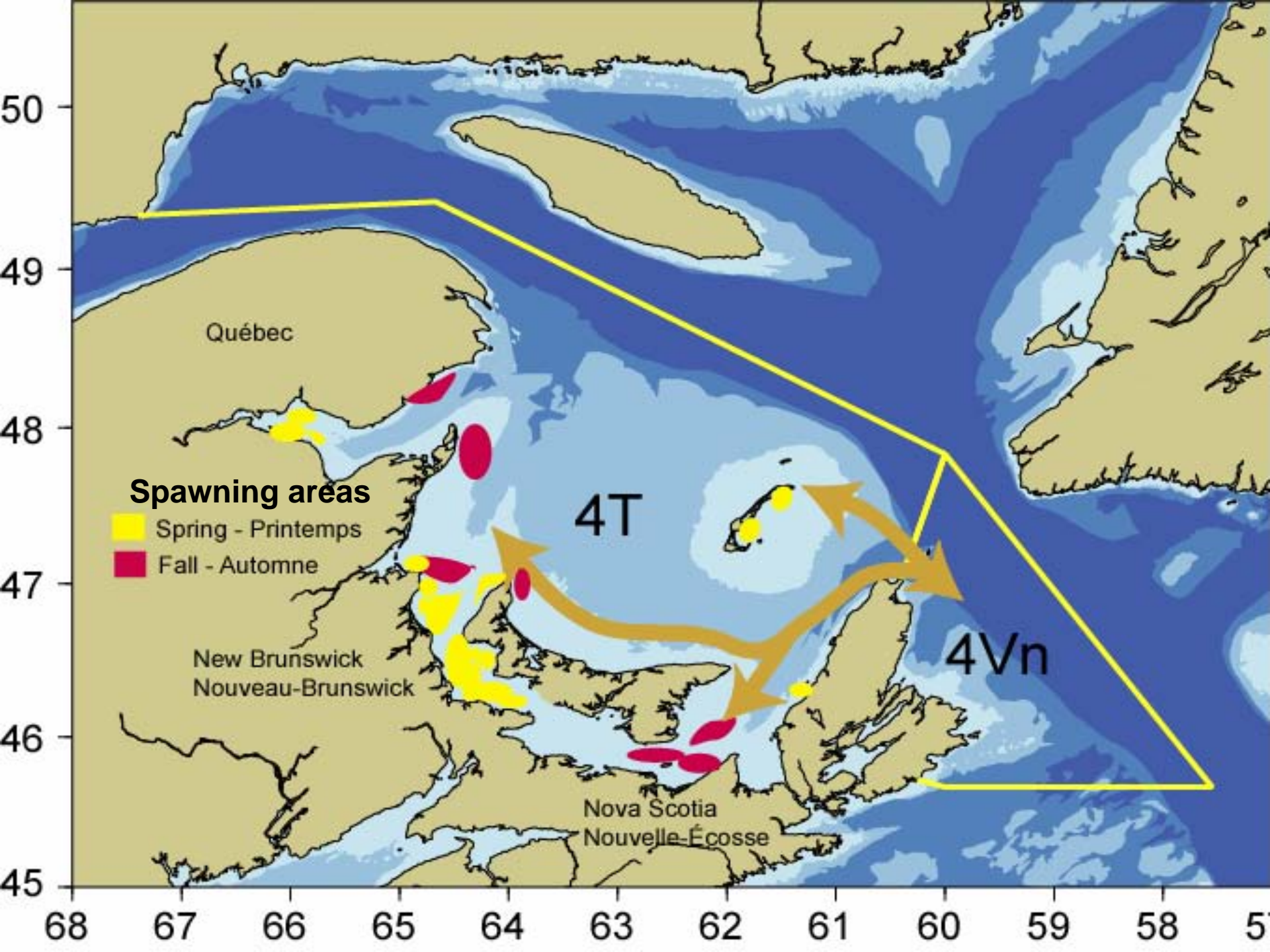
4T Southern Gulf Herring - Science
Hareng du sud du Golfe 4T

Outline

- Stock Overview
 - Stock structure
 - Biological characteristics
 - Fishery history
 - Stock status
- Science program
 - Stock assessment
 - Process
 - Uncertainties
 - Other research activities
- Conservation and sustainability issues

Stock structure

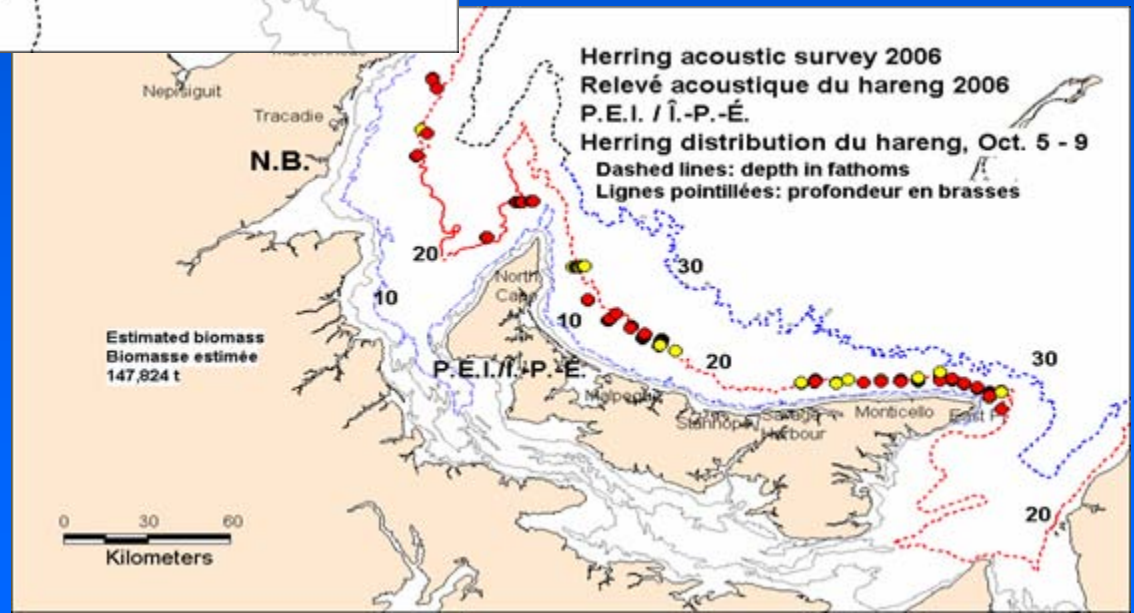
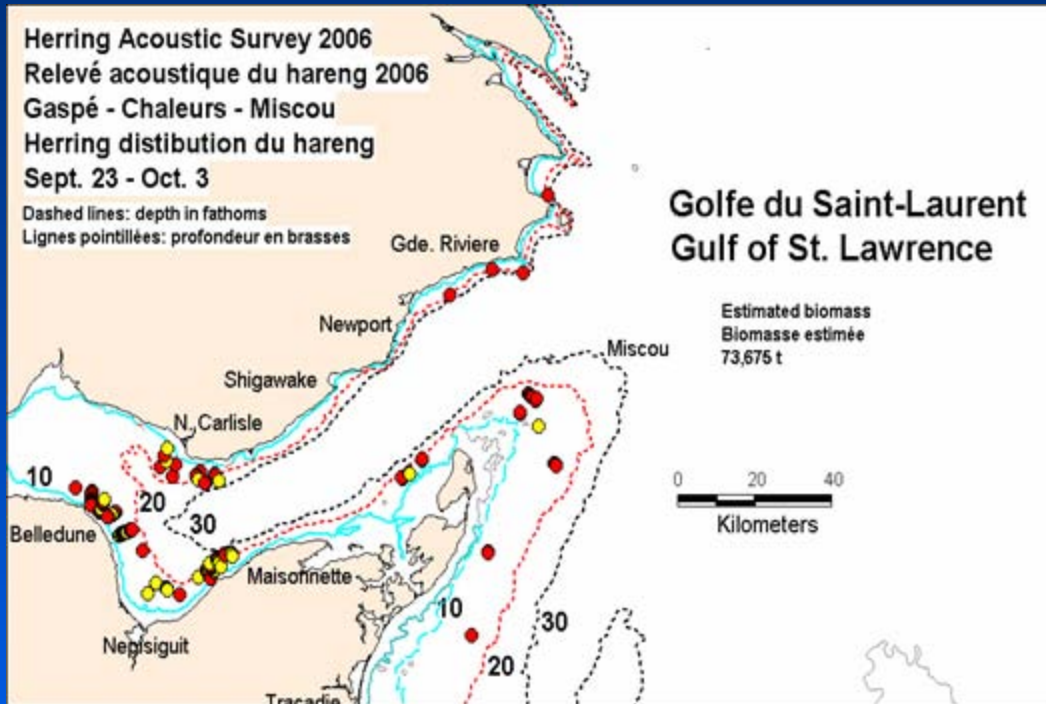
- The SG 4T herring population consists of two spawning components, spring and fall, considered two separate stocks due to their different reproductive cycles.
- The 2 stocks are distinct by their spawning areas and season, but mix during feeding, migration and overwintering periods.
- Spring spawning occurs primarily in April-May at depths <10 m. Fall spawning occurs from mid-August to mid-October at depths of 10 to 25 m.



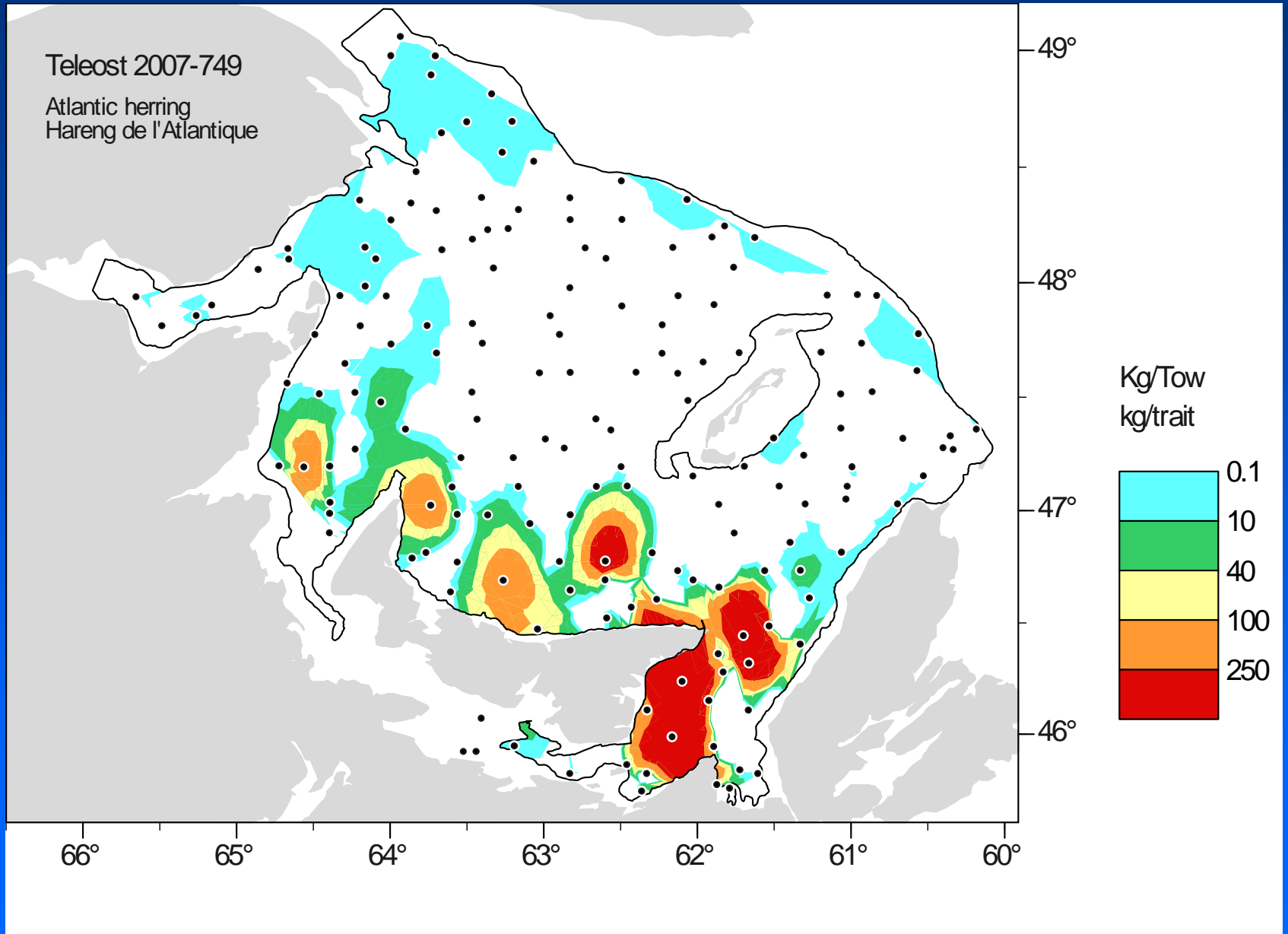
Stock structure

- The stock area for southern Gulf of St. Lawrence herring extends from the north shore of the Gaspé Peninsula to the northern tip of Cape Breton Island and includes the Magdalen Islands.
- Recent survey information suggests that fall distribution of mixed feeding aggregations are in shallow coastal waters mainly between 30 and 60 m depth range.

Fall distribution Acoustic survey

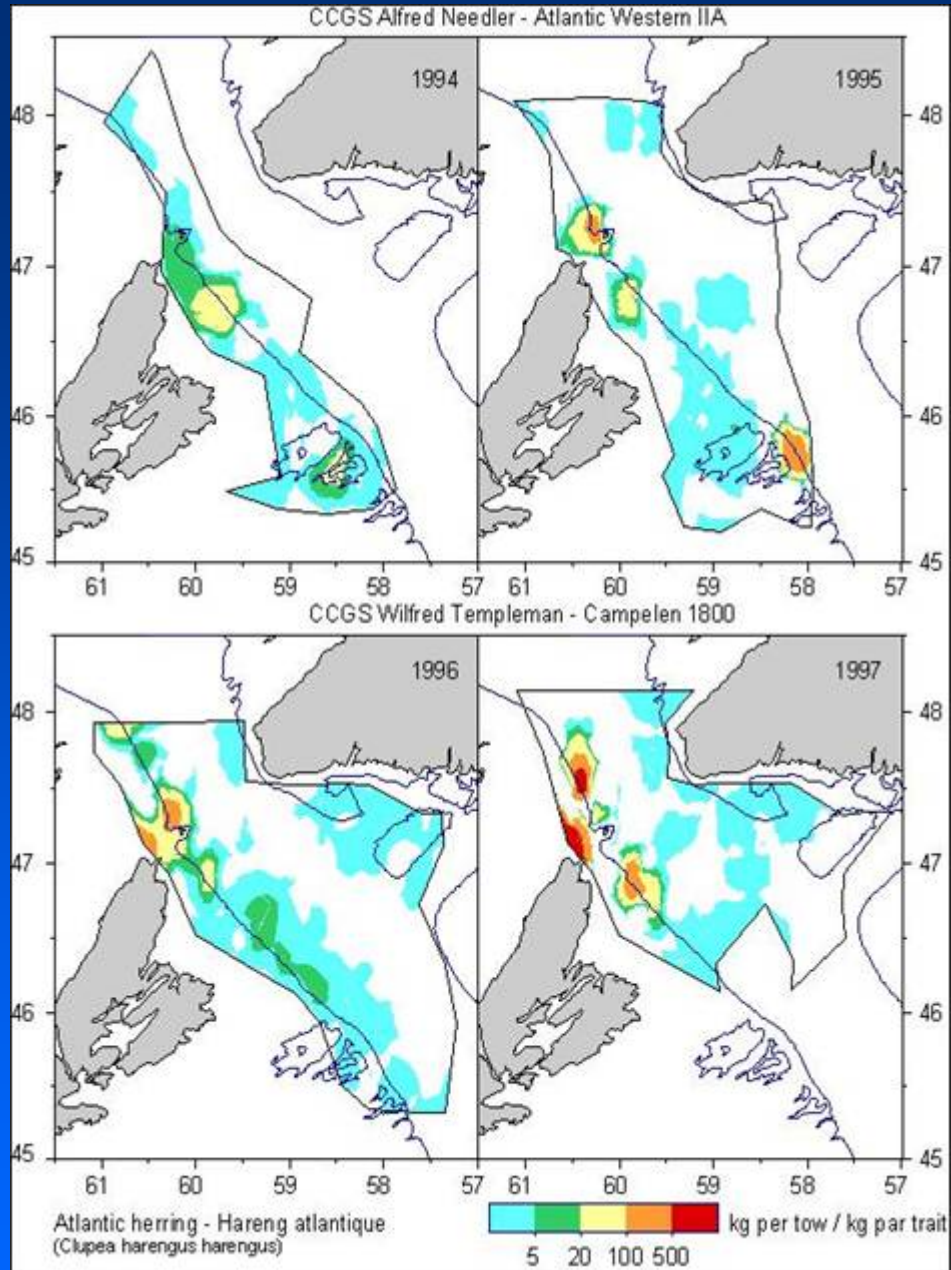


September distribution – Groundfish survey



Stock structure

- Recent survey information suggests that adults overwinter off the east coast of Cape Breton primarily in NAFO area 4Vn.
- Tagging studies in the 1970's also indicated that southern Gulf herring overwintered off the south coast of Newfoundland. Recent exploratory surveys (1995 and 2006) have found no winter concentrations of herring there.

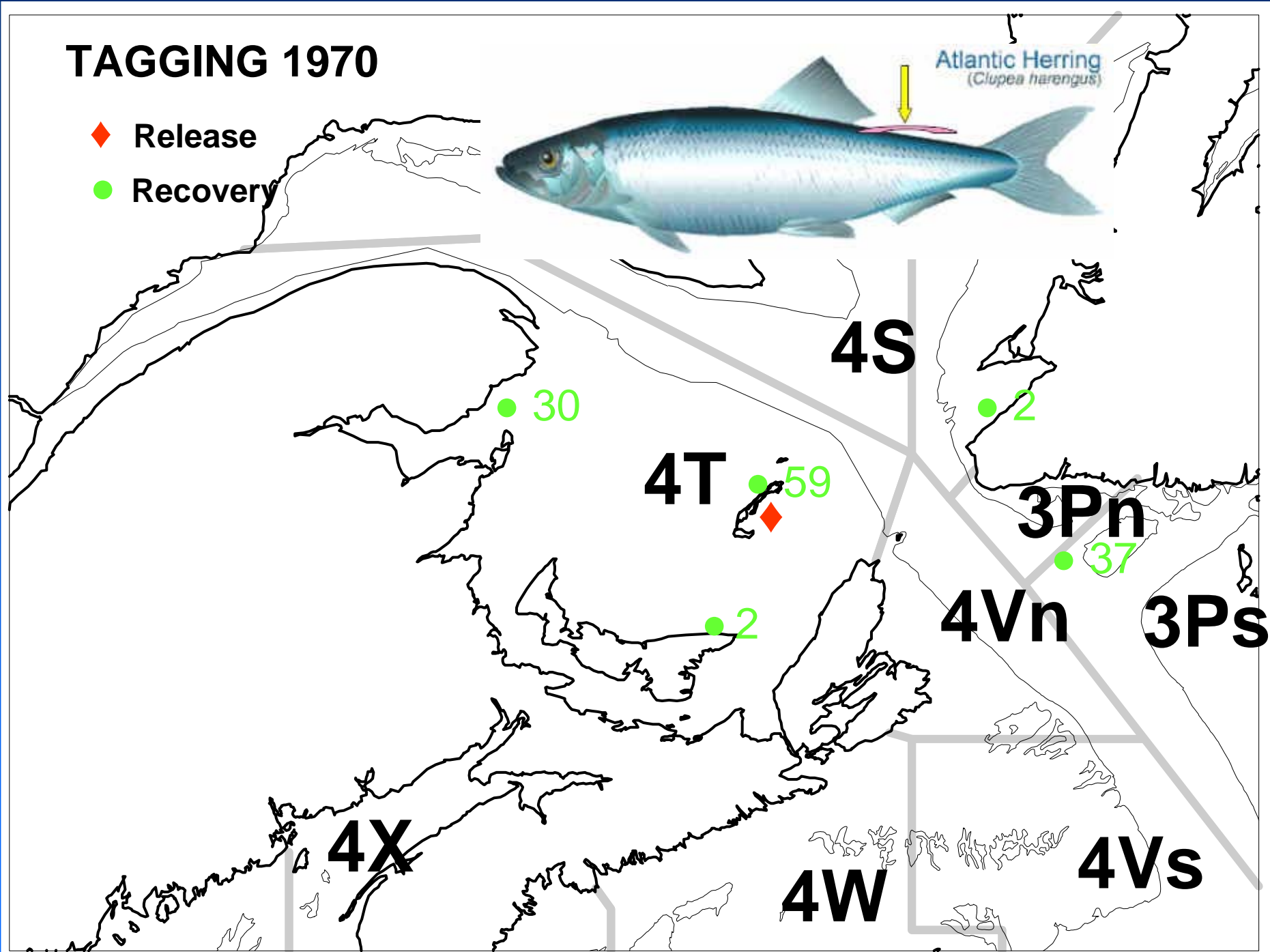
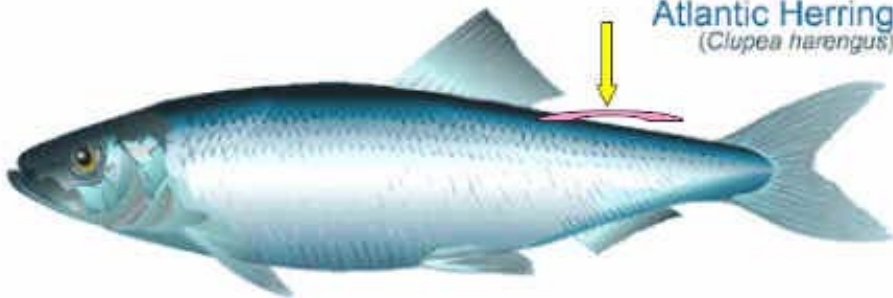


January distribution of herring in Cabot Strait

Distribution du hareng en janvier dans le détroit le Cabot

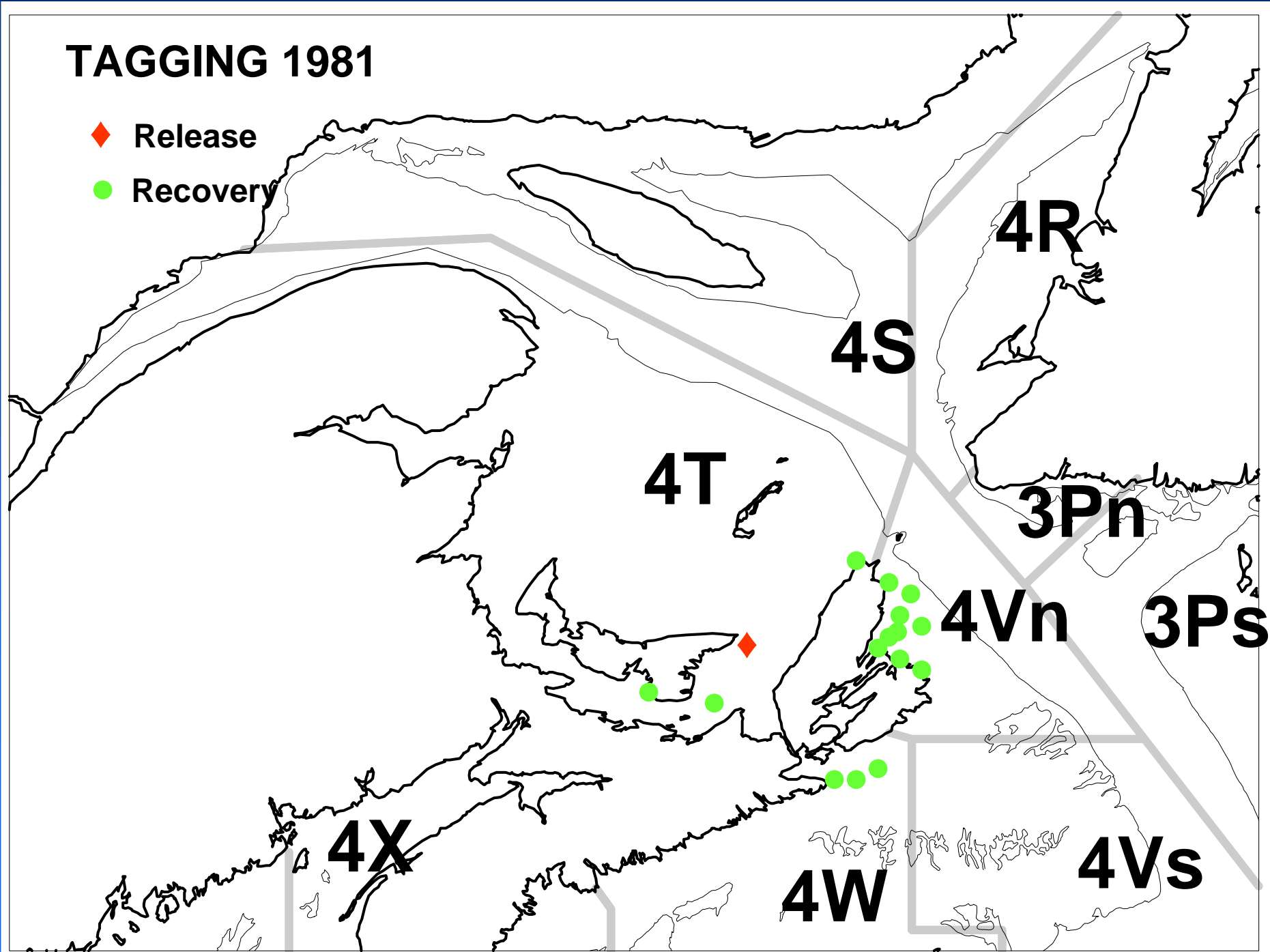
TAGGING 1970

- ◆ Release
- Recovery

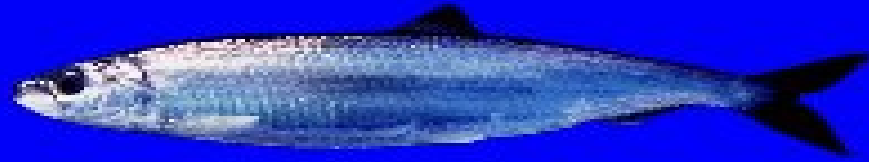


TAGGING 1981

- ◆ Release
- Recovery



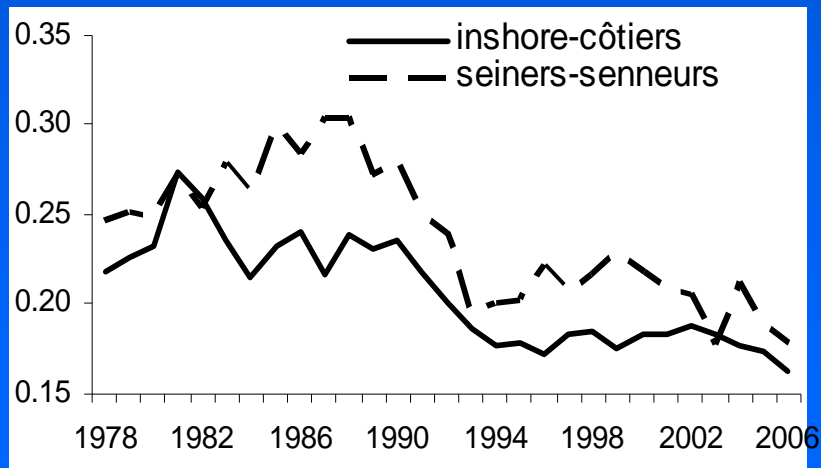
Biological characteristics



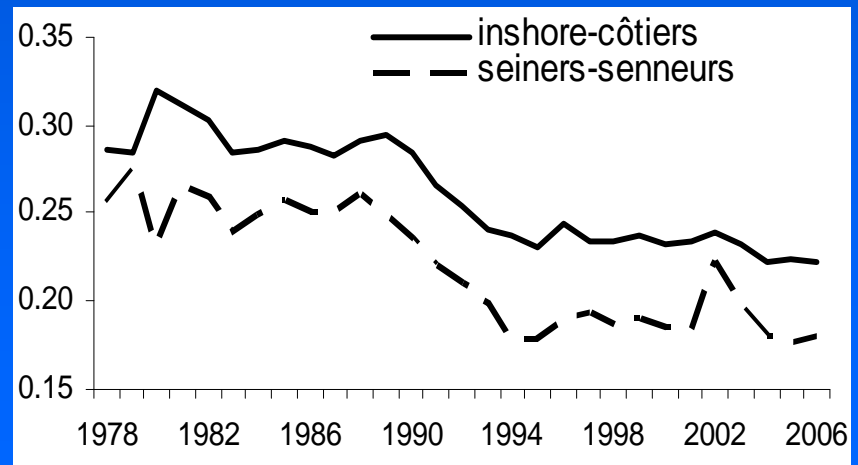
Growth — *Mean weight (kg) of 5-Year-Old herring*

- Growth: since 1990, the average weights-at-age for both the spring and the fall spawner component have been below those observed during the 1980s

Spring - Printemps



Fall - Automne



Spawn on bottom Fisherman's Bank

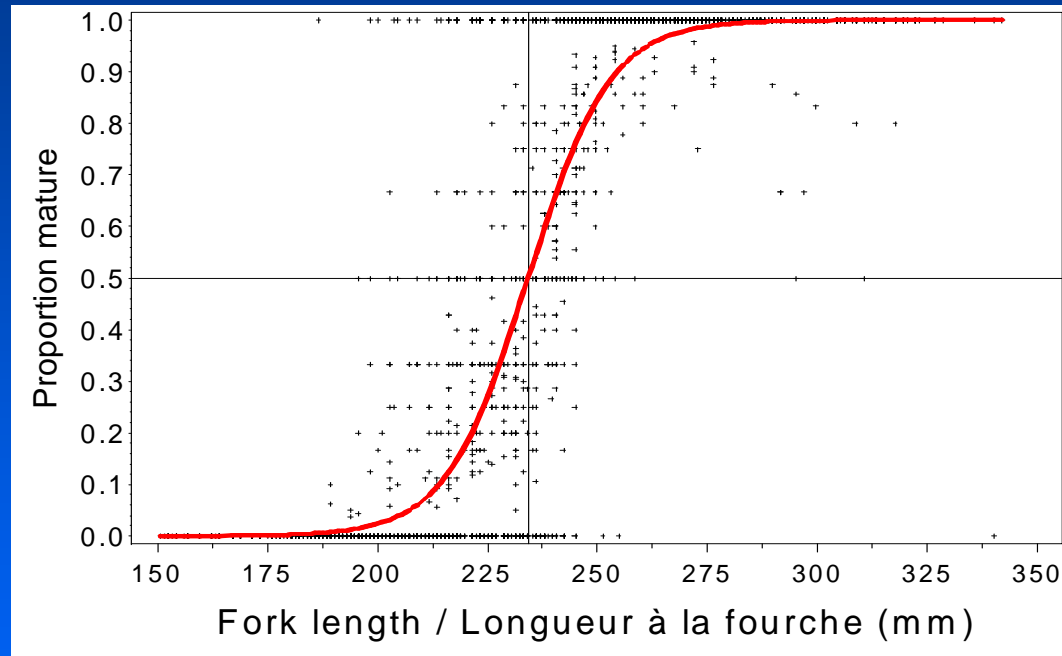


-Spawn on bottom and the eggs remain attached to the bottom.

Maturity – *Size at 50% maturity*

Maturity: First spawning occurs primarily at age four.

Size at 50% maturity was determined to be 23.5 cm fork length (26 cm total length)

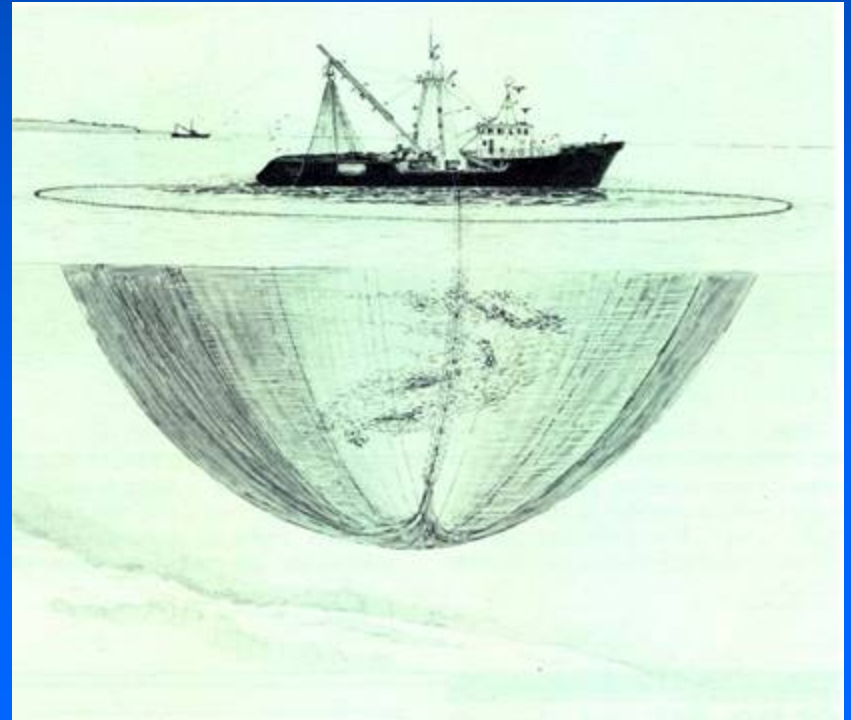


Maturity ogives of 4T herring from acoustic survey data 1999 - 2006.

DFO, 2007. Size at 50% maturity for southern Gulf of St. Lawrence herring (NAFO 4T). DFO Can. Sci. Advis. Sec. Sci. Resp. 2007/019.

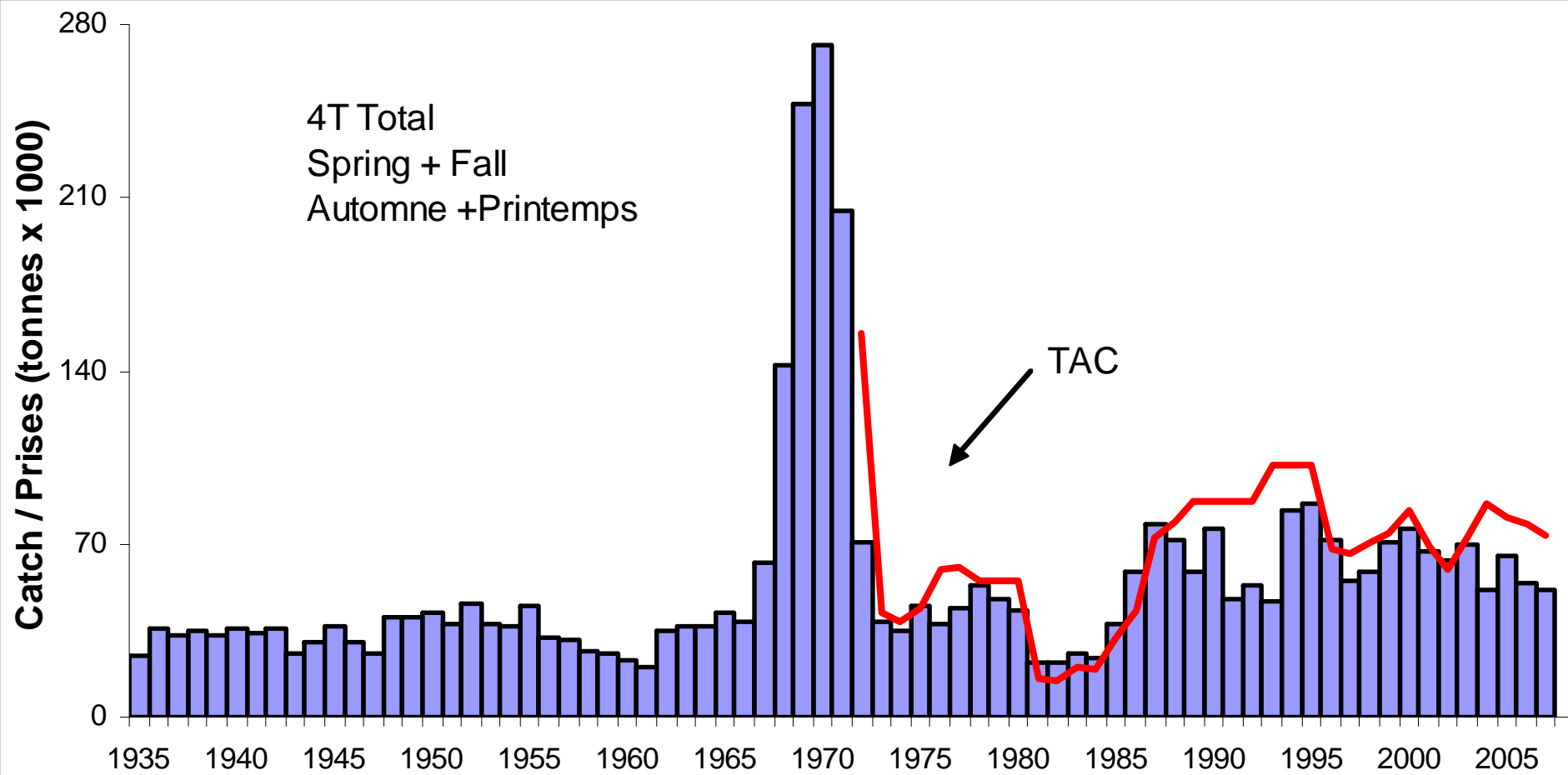
Fishery history

- The fishery for southern Gulf of St. Lawrence herring extends from the north shore of the Gaspé Peninsula to the northern tip of Cape Breton Island and includes the Magdalen Islands. A late fall seiner fishery also used to take place in 4Vn. (4 provinces involved)
- The fishery follows stock structure with a spring and fall season.
- 2 gear types, an inshore gillnet fleet and a purse seine fleet.



Landings by year, all gears and spawning components

Prior to 1967, exploited mainly by gillnets ave. landings 34,000t/year. Epizootic in the mid 1950's. In the mid 1960s, start of purse seine fishery after the collapse of the west coast fishery, ave. landings were 166,000t (1967-72). A TAC was introduced in 1972. Separate allocations for the spring and fall spawner components began in 1985. Recent ave. landings 50,000t/year. Both stocks were at a historically low level in the early 1980's.

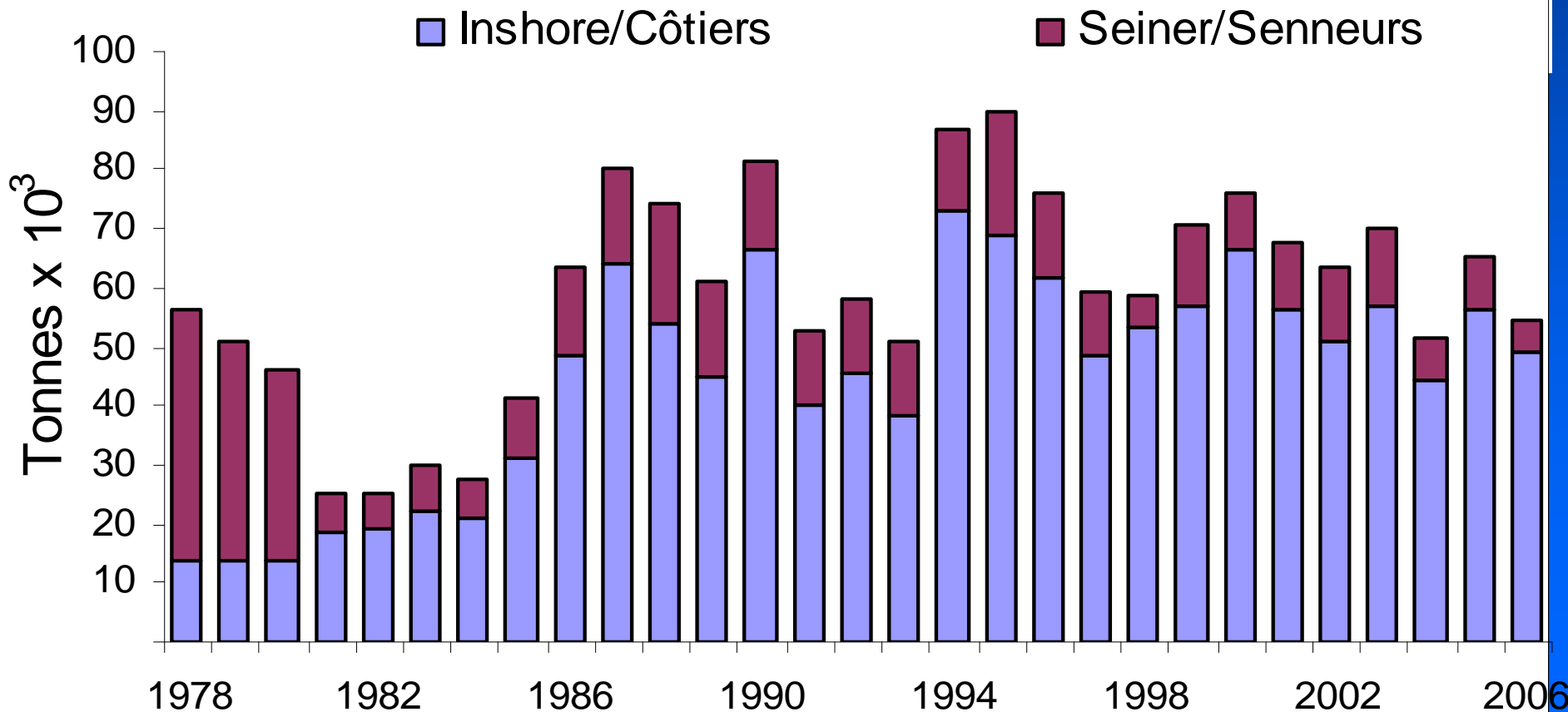


Landings by gear type, all spawning components

Since 1981, the inshore gillnet fleet fishing on spawning aggregations has accounted for most of the catch (77% allocation, 3000 licenses).

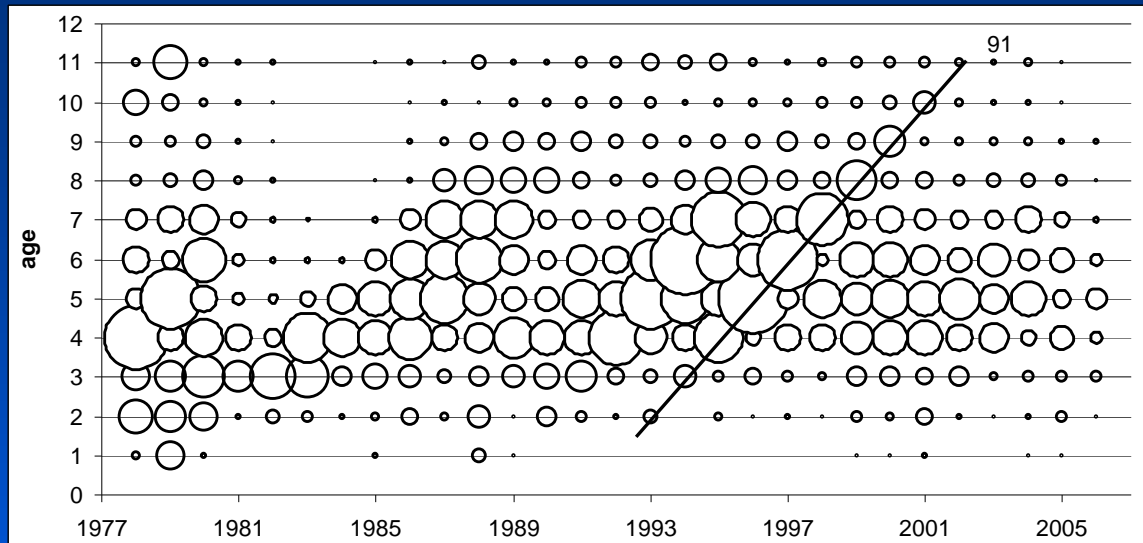
The purse seine fleet fishes mostly on mixed spring and fall component feeding and migratory aggregations (23% allocation, 6 licenses).

Total Spring and Fall Spawners / Total géniteurs de printemps et d'automne

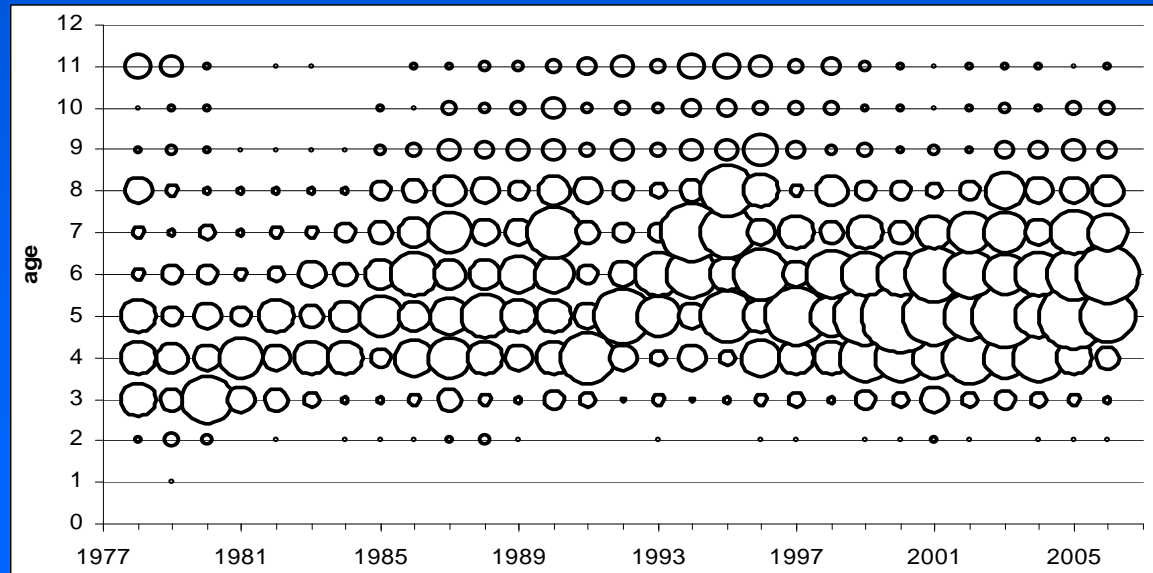


Age structure of fishery catch

Spring - Printemps

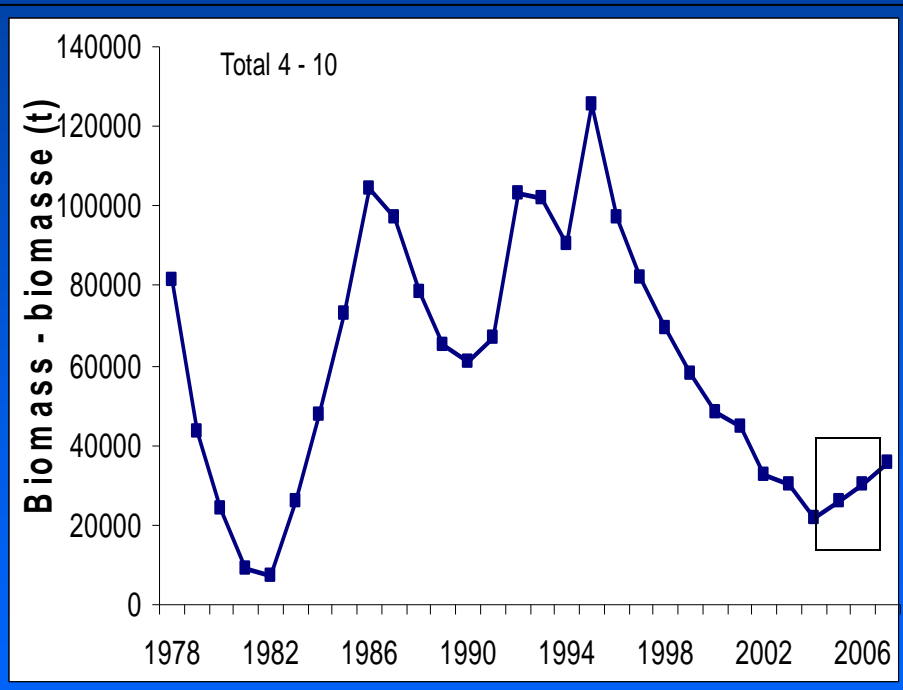


Fall - Automne



Biomass trends / Tendances

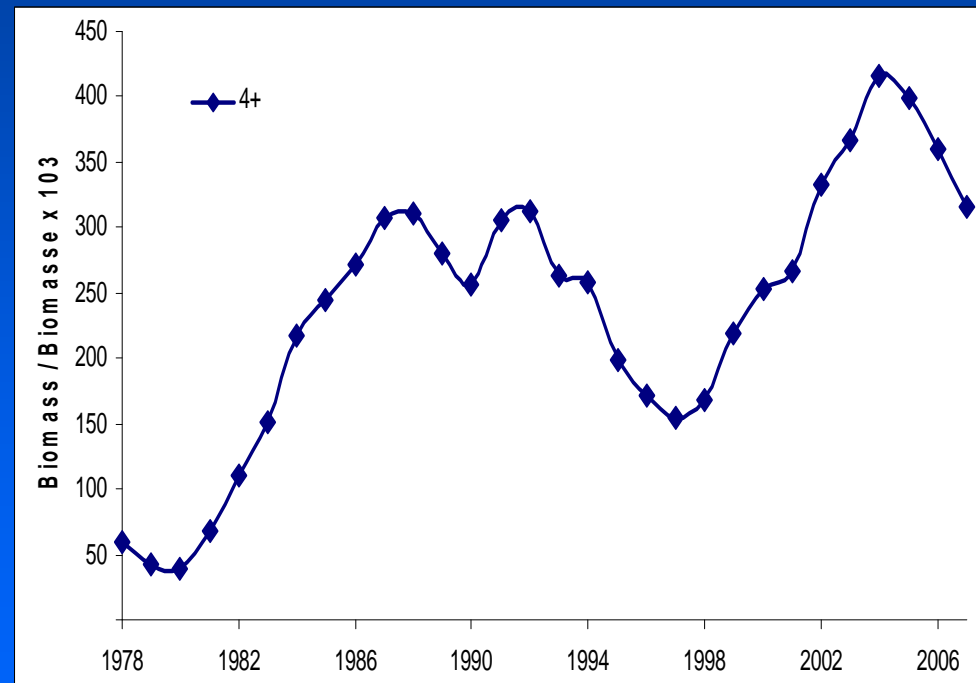
Spring - Printemps



tonnes

Box indicates uncertainty of estimates

Fall - Automne



tonnes

Science Program Assessment

Port sampling

- Length measurements, collection of fish samples from ports in NB, NS, PEI, Québec (aprox 120 samples, 27000 fish measured)

Laboratory sample analysis and determination of spawning component (approx. 7000 fish)

- Dissections, length weight, sex, maturity, otolith, age determination
- Otolith shape, size at capture, gonado-somatic index

Abundance indices

- Analysis of landings data, gillnet catch and effort analyses
- Gillnet fishermen questionnaire: contact about 30% of active fishers and ask questions on stock abundance, effort used, etc.
- Acoustic survey: conducted late Sept to Oct., area from Gaspé to east PEI to be used as an index of herring abundance (17 sea days).

Local workshops with herring fishers to discuss preliminary data and presentation at FAM Gulf Small Pelagic Advisory Committee (Dec).

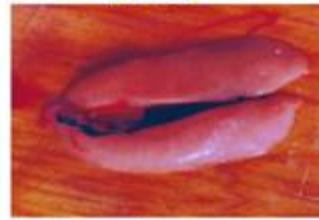
Data analysis and population modeling using SPA with ADAPT.

Annual assessment, preparation of research document, RAP meeting and preparation of Science Advisory report (Feb-March).

Laboratory (fish dissections, length, weight, sex, maturity determination, otolith collection)



Males Herring Maturity Stages Females



3



4



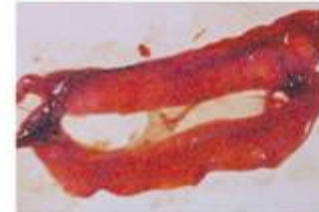
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6



7

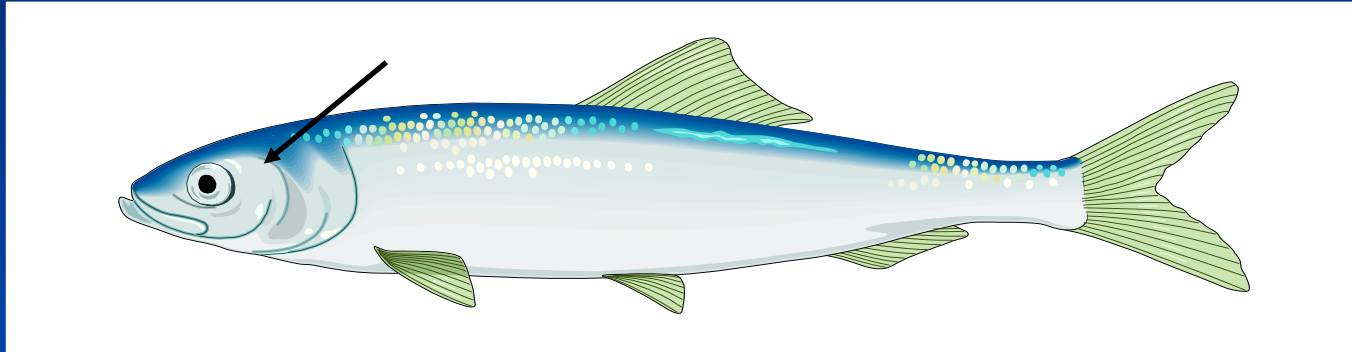


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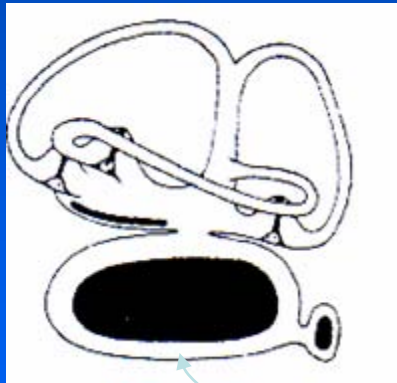


Otoliths (aging, season hatched for juveniles)

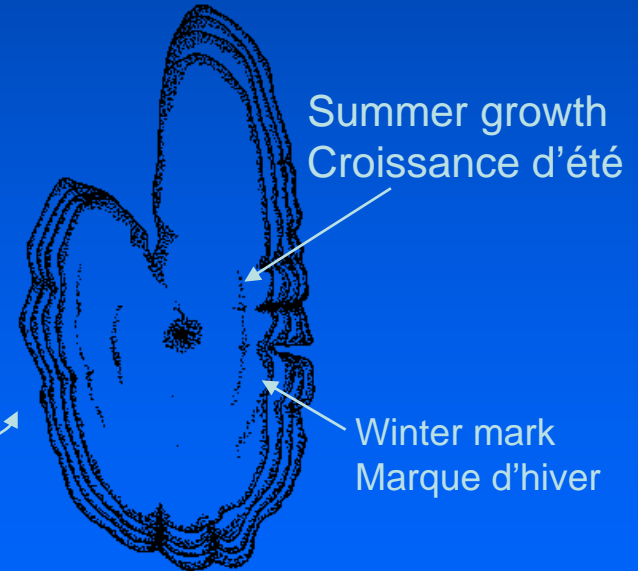
collection and age determination of otoliths (approx 7000 fish)



INNER EAR
OREILLE INTERNE



OTOLITH
OTOLITHE



Summer growth
Croissance d'été

Winter mark
Marque d'hiver

(Herring
Hareng)

Determination of spawning component

The percentage of spring and fall spawner component in the catch and survey samples varies according to season and gear type. As a result, landings during the fall and spring fisheries as well as the survey samples must be separated into the appropriate spring and fall spawning groups.

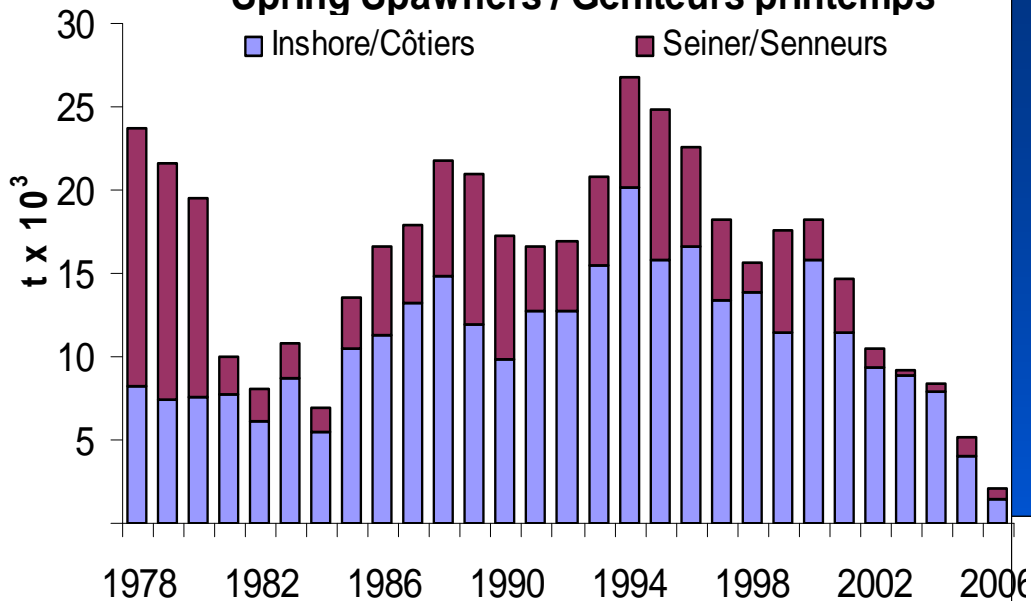
- Spawning group assignment of ripe adult fish (stages 6 and 7) are assigned by macroscopic laboratory examination.
- Spawning group assignment of non-ripe adult herring is done using a gonado-somatic index to assign maturity stage and a monthly key that links maturity stage and month to spawning group.
- Juvenile spawning group assignment is determined by size at capture and otolith shape type.

Landings by year must be divided by spawning component

Débarquements par année doivent être séparés par groupe de géniteurs

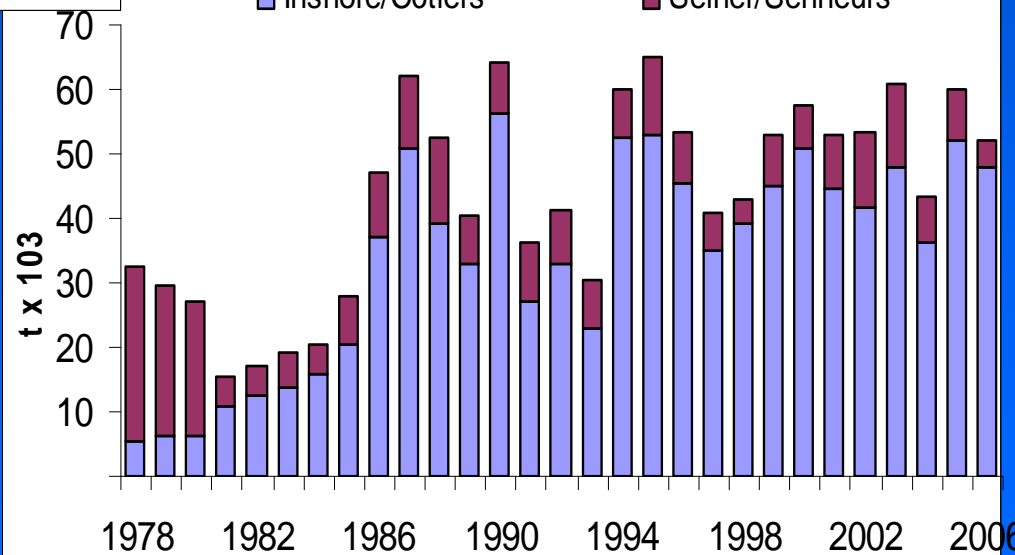
Spring Spawners / Géniteurs printemps

Inshore/Côtiers Seiner/Senneurs



Fall Spawners / Géniteurs d'automne

Inshore/Côtiers Seiner/Senneurs

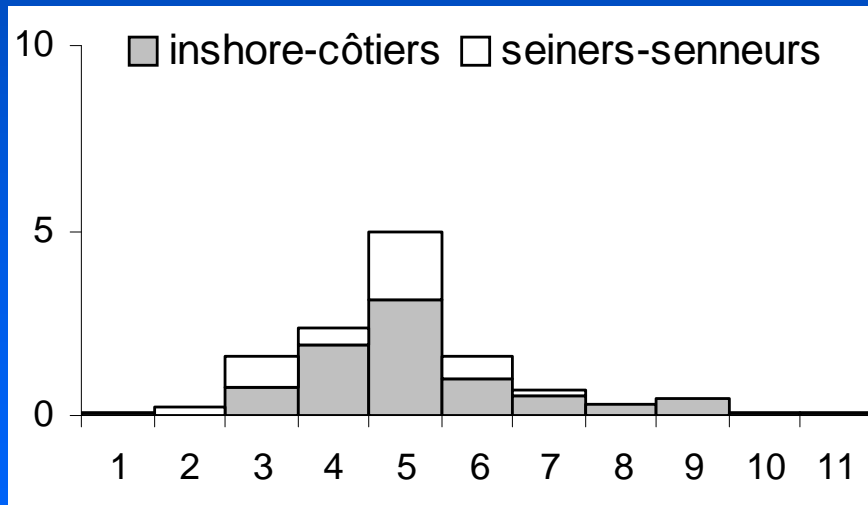


2006 Fishery catch-at-age for each spawning component weighted by the catch per area

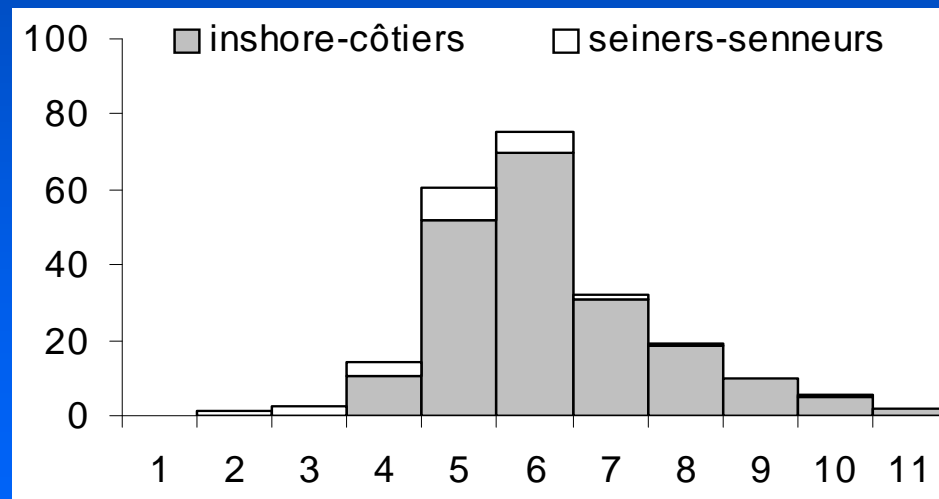
Captures à l'âge de chaque groupe de géniteurs pondérées par les prises en 2006

millions of fish

Spring spawners



Fall spawners



Abundance indices

Gillnet fishermen phone questionnaire of 25 –
30% active licenses

- days fished per season
- hours nets fished per day
- number, length and depth of nets used
(used in CPUE index)
- mesh size
- catch amount and use
- abundance opinion compared to previous year

Abundance indices

Gillnet catch per unit of effort CPUE

Prises par unité d'effort PUE

Effort:

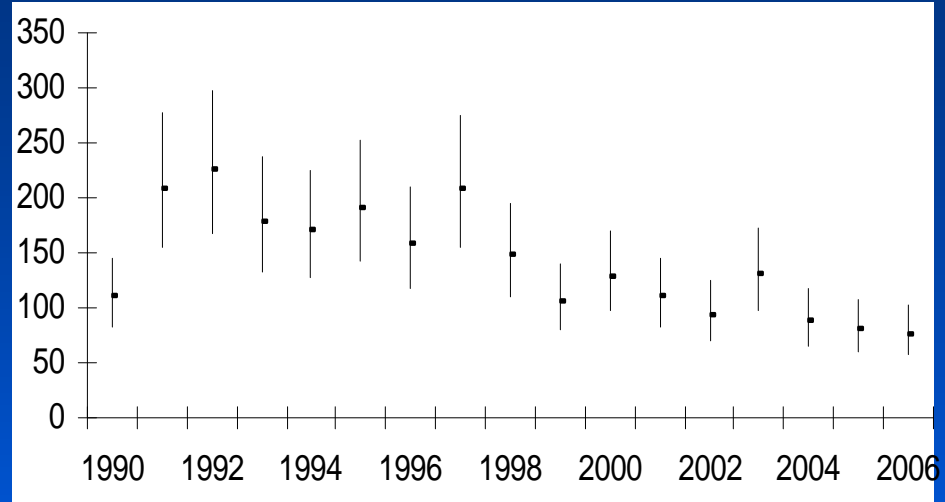
- nets from phone survey or dockside monitoring
- 1 net=15 fathoms
- effort=nets*trips
- $CPUE = \text{catch} / \text{net-trip}$

Effort:

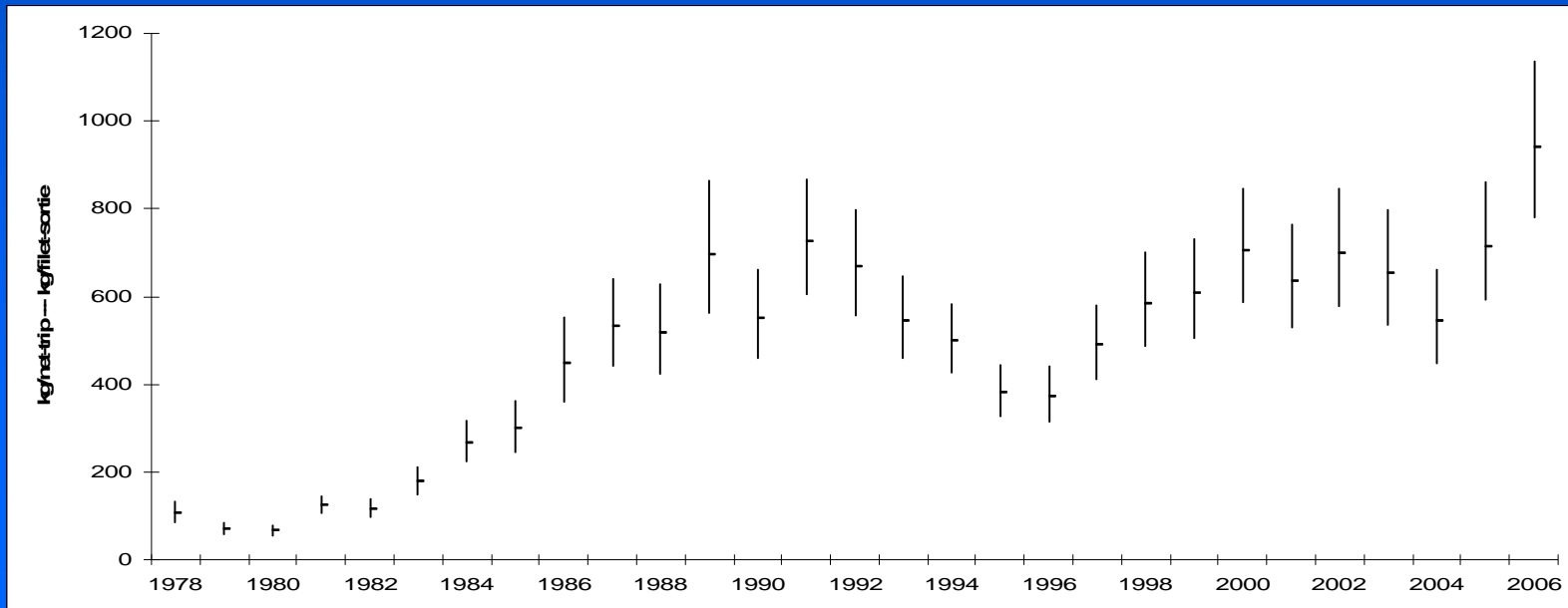
- nombre de filets du sondage téléphonique ou observateurs à quai
- un filet=15brasses
- effort=filets-jours
- $PUE = \text{prise} / \text{filet-jour}$

Age-disaggregated abundance index - gillnet catch and effort CPUE

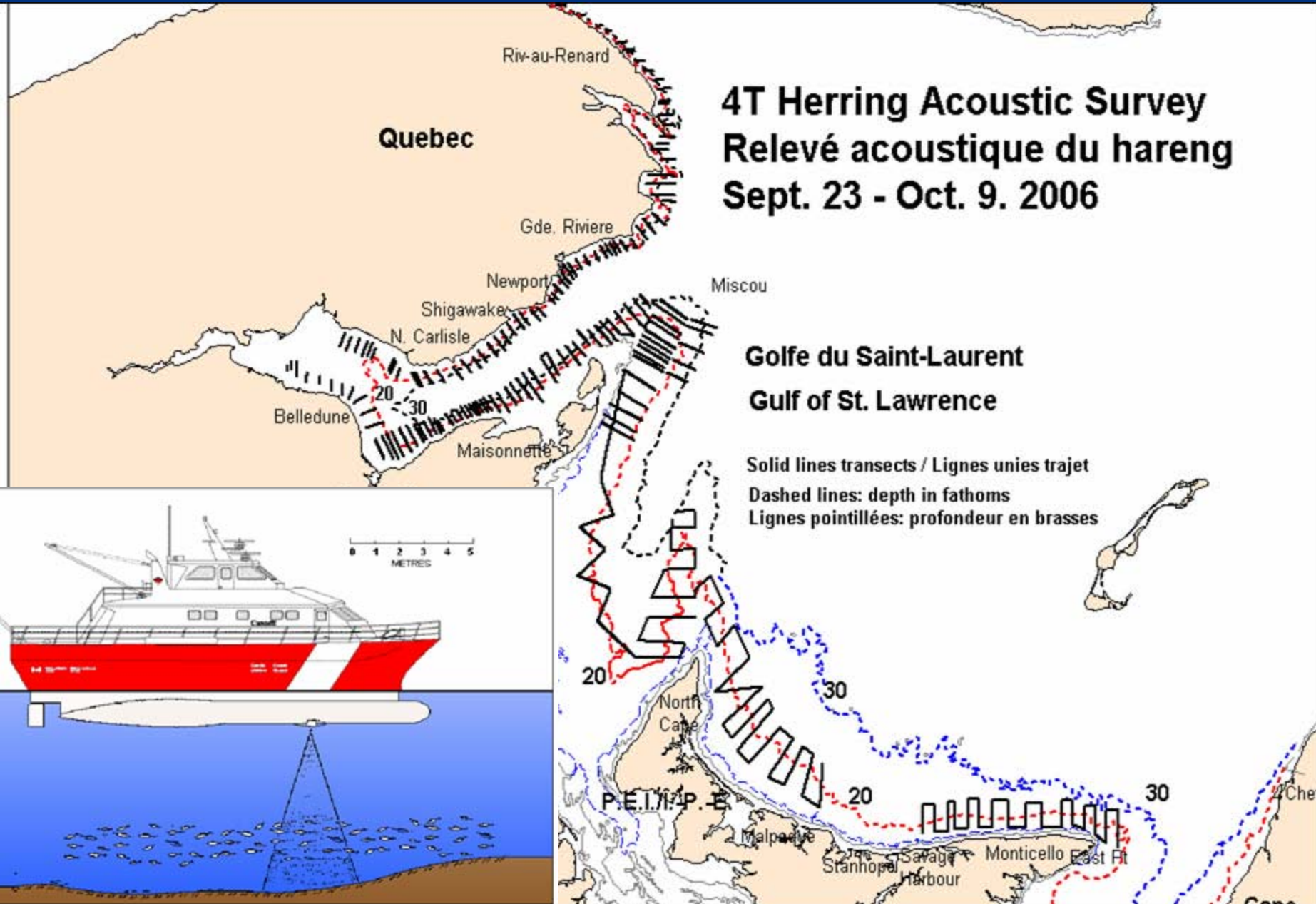
Spring - Printemps



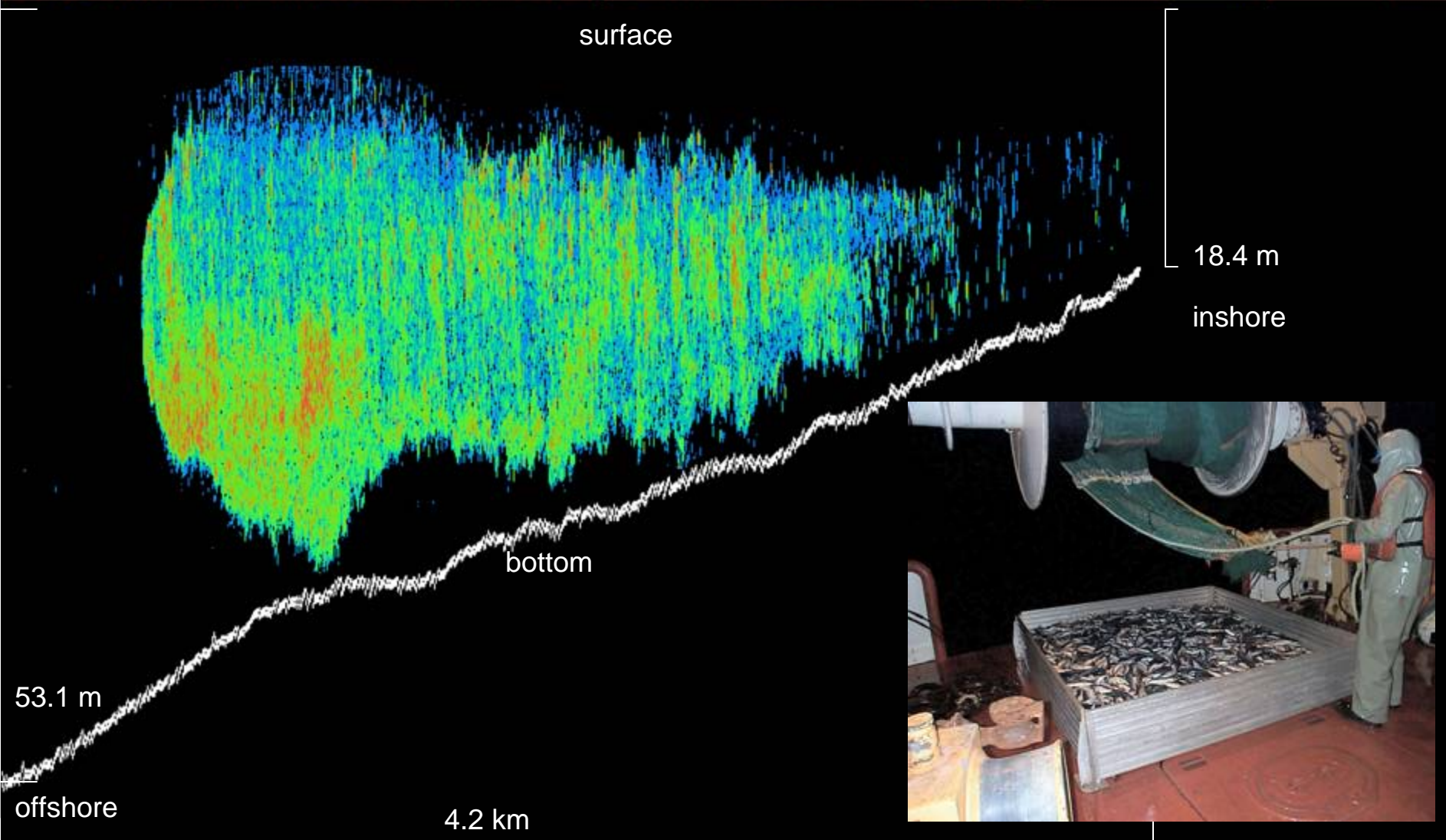
Fall - Automne



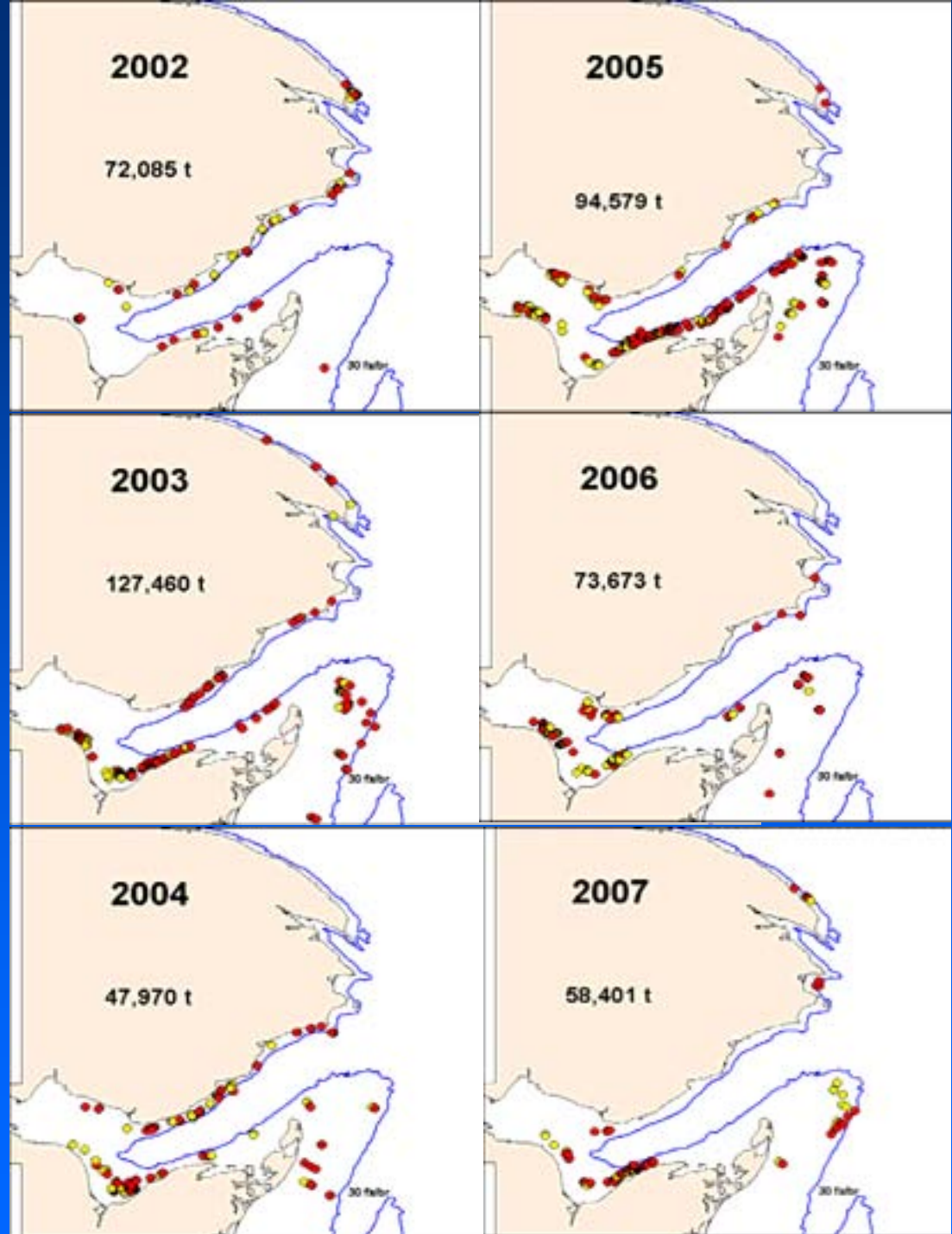
Age-dissagregated abuundance index - Acoustic survey catch-at-age weighted by biomass estimate (over 2000 kms of transects)



Acoustic Survey transect with herring school

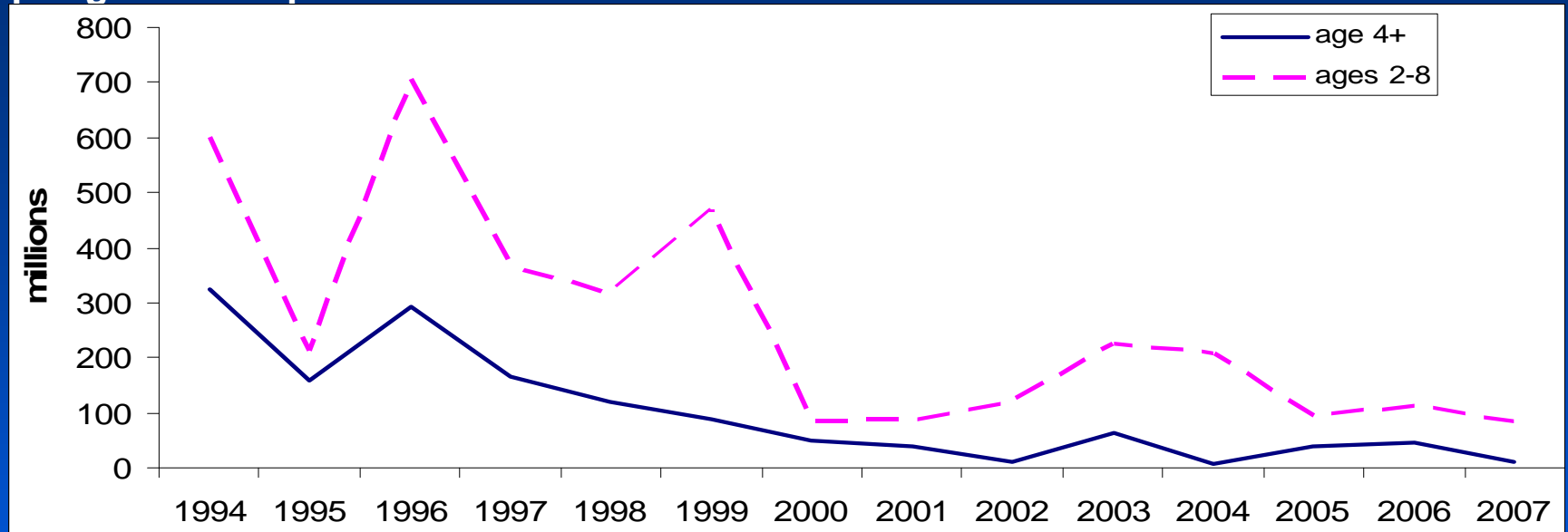


Chaleur Bay –
Miscou Bank fall
distribution from
acoustic survey
used in the acoustic
age-disaggregated
abundance index

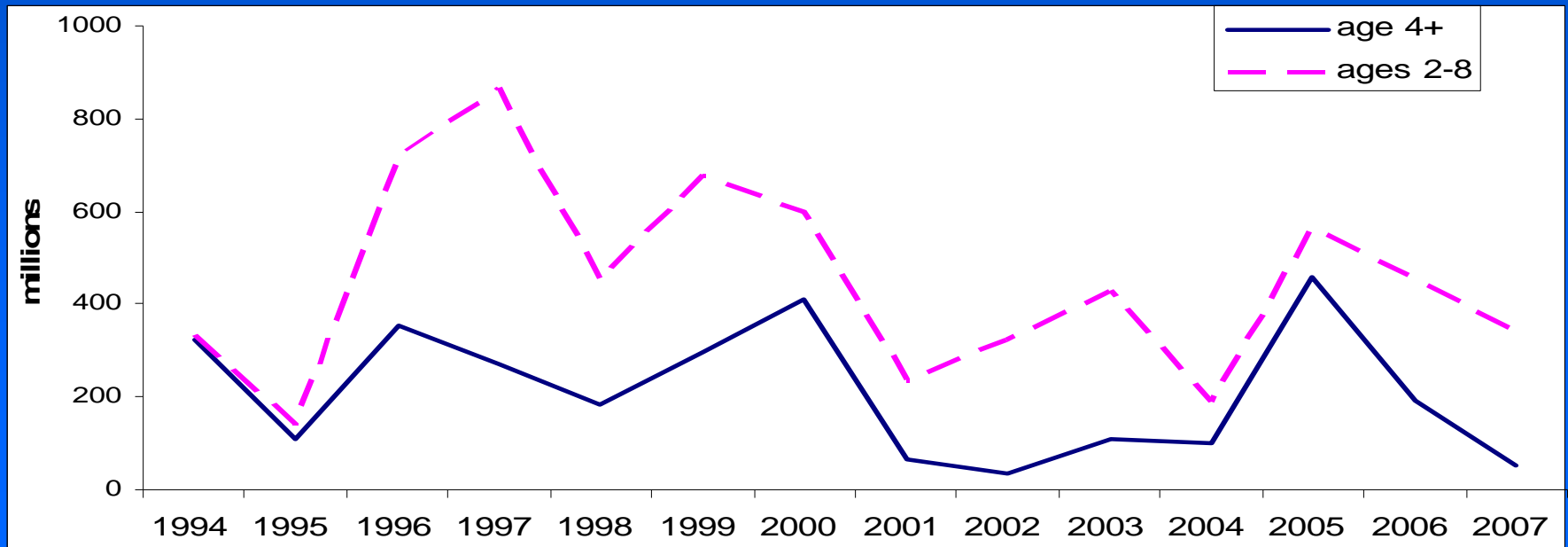


Age-disaggregated abundance index – Acoustic survey

Spring - Printemps

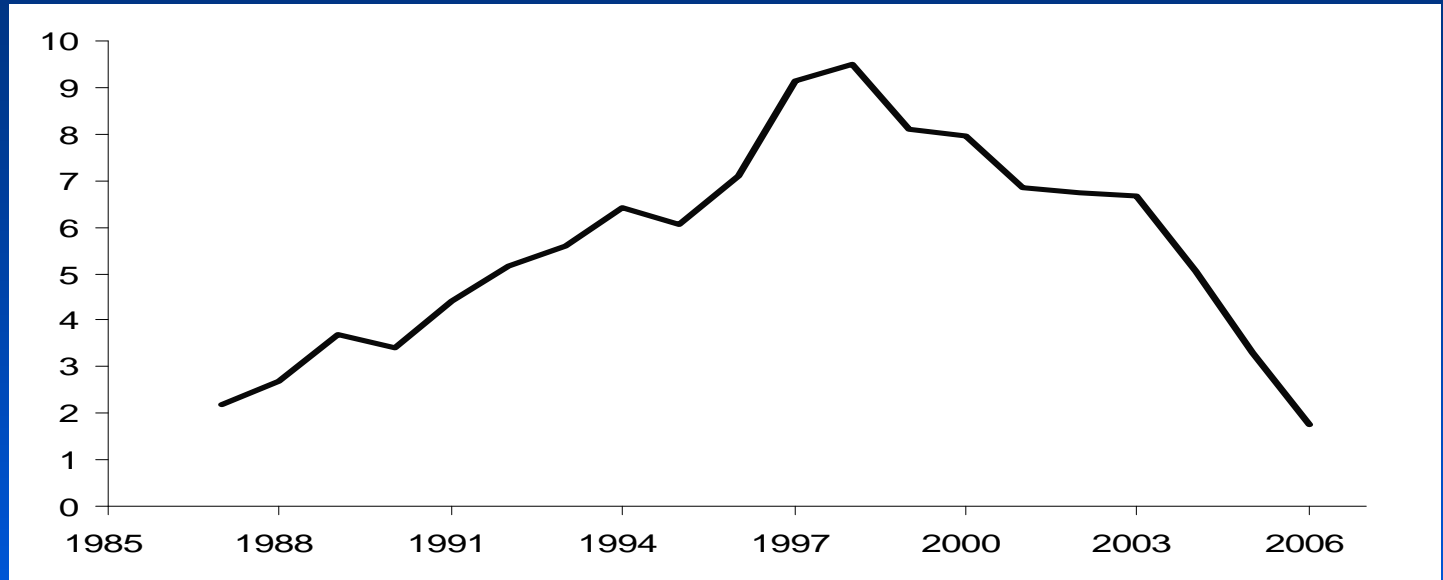


Fall - Automne

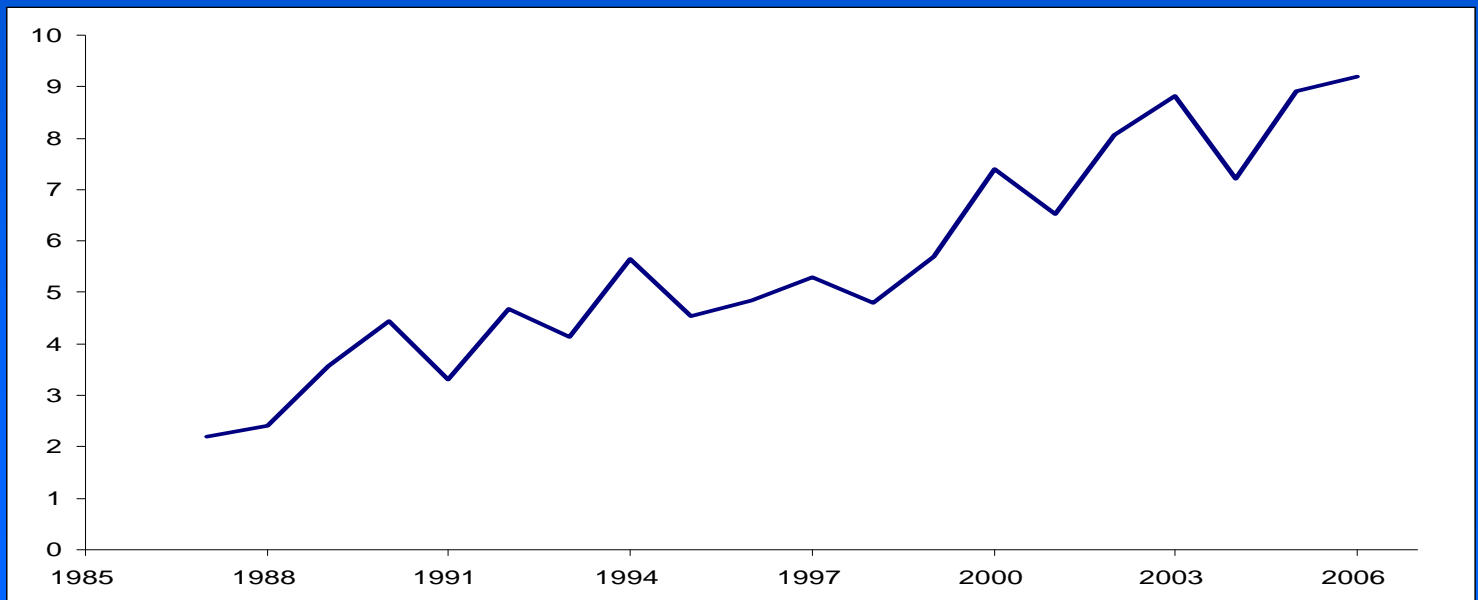


Fishermen questionnaire age-aggregated index opinion of abundance

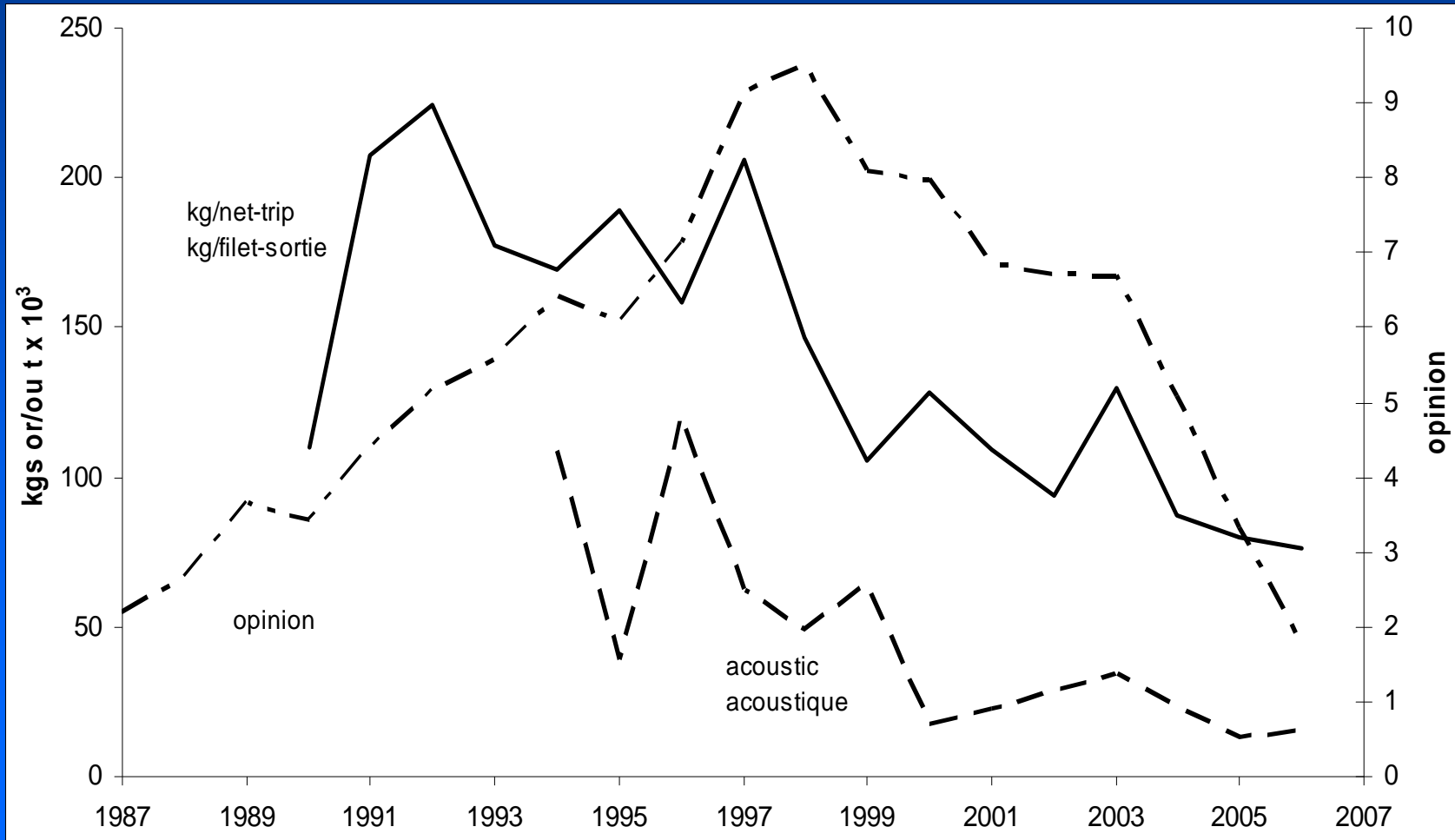
Spring –
Printemps



Fall –
Automne

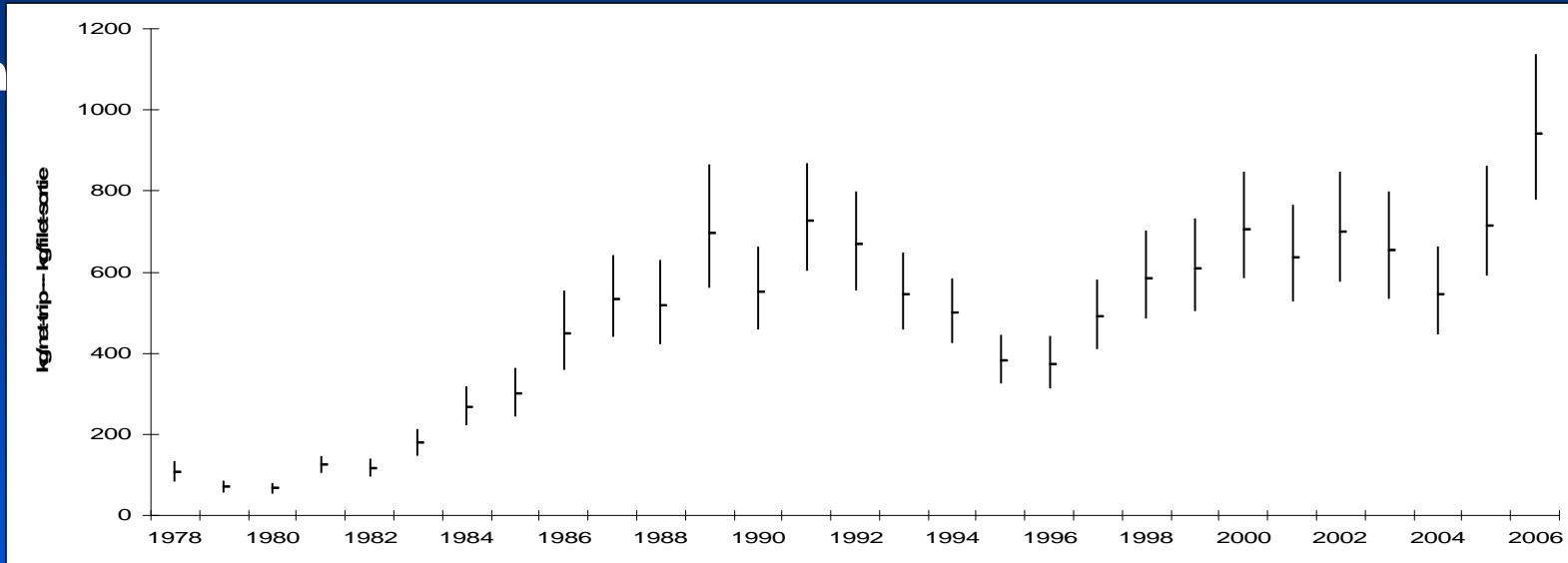


Spring current abundance indices used

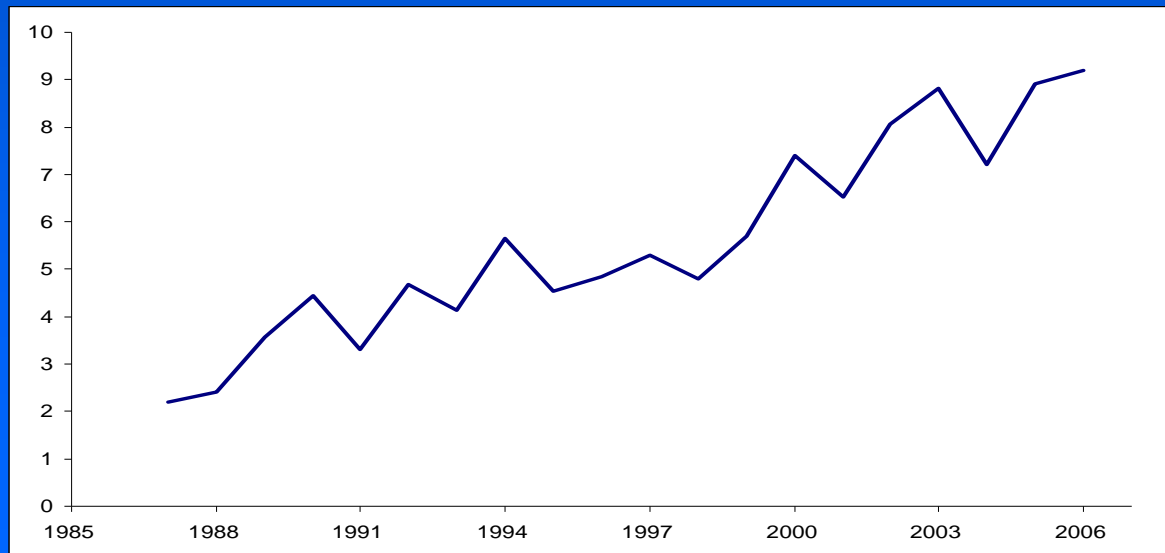


Fall current abundance indices used

Gillnet catch
per net

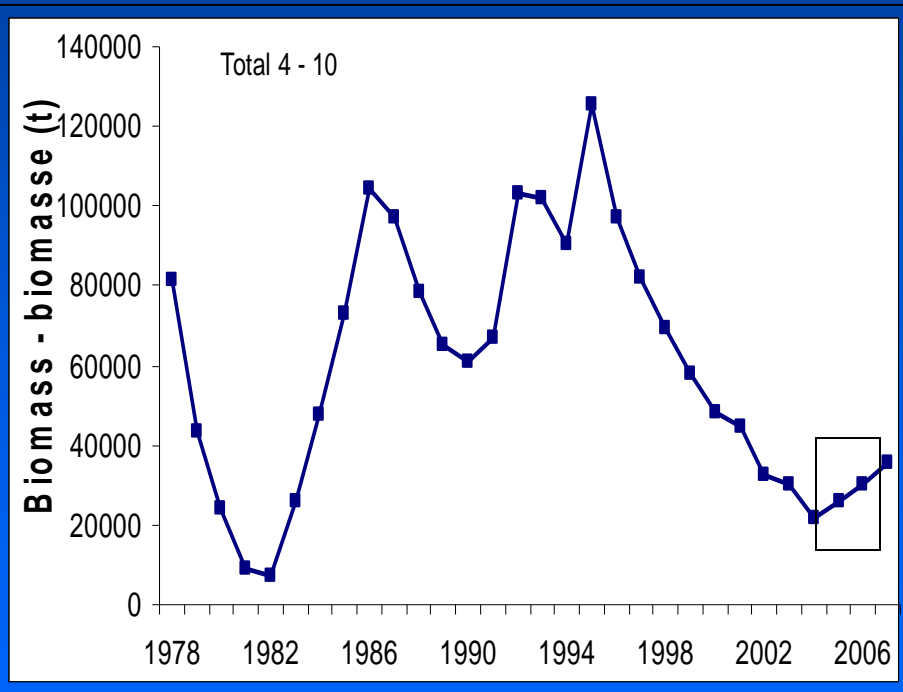


Phone survey
abundance opinion



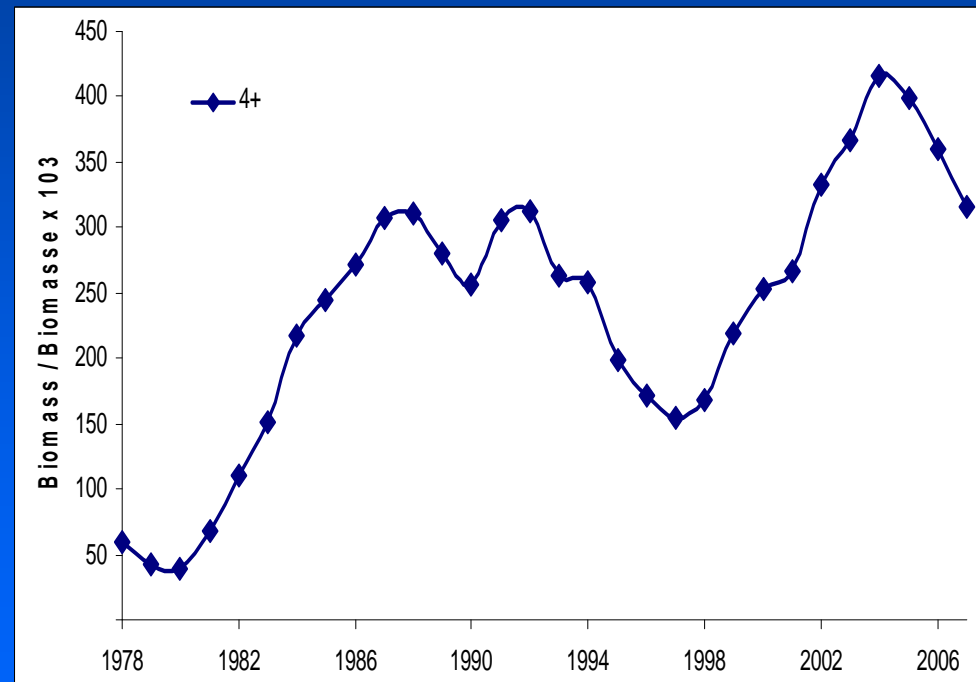
Population modeling using ADAPT

Spring - Printemps



tonnes

Fall - Automne



tonnes

Box indicates uncertainty of estimates

Science Assessment Output

- Annual assessments of spring and fall spawning components
- Most recent assessment: March 2007
- Current stock status
- The F0.1 estimation of catch for coming year and resulting projected changes in stock biomass.
- Estimate of uncertainties regarding stock size and use these in risk analysis.

- DFO, 2007. Assessment of Herring in the Southern Gulf of St. Lawrence (NAFO Div. 4T). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/005.

- LeBlanc, C.H., G.A. Poirier, C. MacDougall, C. Bourque and J. Roy. 2007. Assessment of the NAFO 4T southern Gulf of St. Lawrence herring stocks in 2006. CSAS Res. Doc. 2007/016.

Current Stock status

Spring - Printemps

- Recent gillnet catch rates are the lowest in the time series that starts in 1990. Views from fish harvesters in the traditionally important areas in terms of landings are that catch rates may represent an overestimate.
- The amount of effort used may be underestimated as trips with no catch do not have to be reported.
- All three abundance indices indicate a continued decline in abundance from 2005 to 2007 contrary to the population model estimates.
- It is believed that the model is overestimating the spawning stock biomass and underestimating the fishing mortality.

Fall - Automne

- Catch rates from the gillnet fishery continue to be among the highest in the series. There is concern that catch rates may not accurately track population biomass because of the nature of the fishery.
- Overall, the stock appears to remain at a high level relative to the late 1970's and early 1980's. Estimated recruitment at age 4 was above average from 1999 to 2004.
- The current estimate of spawning stock biomass (316,000t) is well above the upper stock reference point of 172,000t.

Sources of uncertainty / Sources d'incertitude

CPUE Abundance indices from gillnets used in the assessment model could overestimate biomass

- CPUE from gillnets might not be proportional to population abundance
- Does not include nul or 0 catches
- No reliable estimate of bait catches

Indices d'abondance PUE des filets maillants utilisés dans le modèle d'évaluation surévalueraient la biomasse

- Les PUE des filets maillants ne sont peut-être pas proportionnelles à l'abondance de la population
- N'inclue pas les sorties sans prises
- Pas d'estimés fiables des prises pour appât

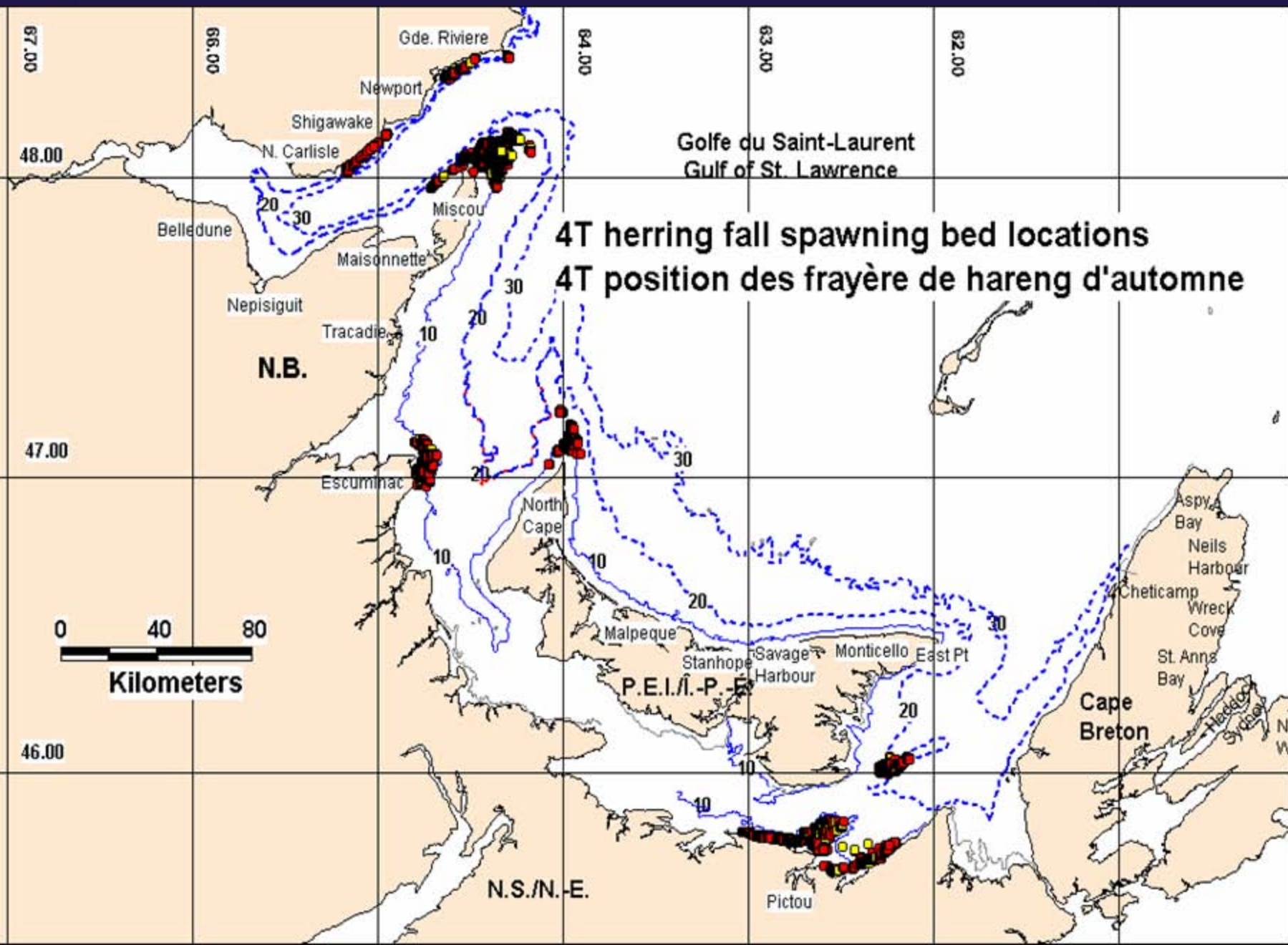
Science Research activities

- Methods for local stock assessments: 5 collaborative projects with fall inshore fishers to collect acoustic data from local fall spawning areas and fish experimental nets to determine local abundance and spawning bed dynamics (since 1997 in some areas). How to use in the overall 4T stock assessment?
- Methods to identify herring from local spawning areas and season: two methods have been investigated by DFO Science in collaborative projects with fish harvester associations. Methods tested were analysis of trace elements from 1017 otoliths and otolith shape analysis. Preliminary results indicate that it could potentially distinguish between seasons but spawners from same season overlap. Review and publication of analysis pending.
- Methods to identify herring from local spawning areas and season: yearly samples have been collected since 2005 for analysis of genetic differentiation among herring spawning areas as part of a collaborative project with Dalhousie University.

Science acoustic echocounder installation onboard a gillnet fishing vessel

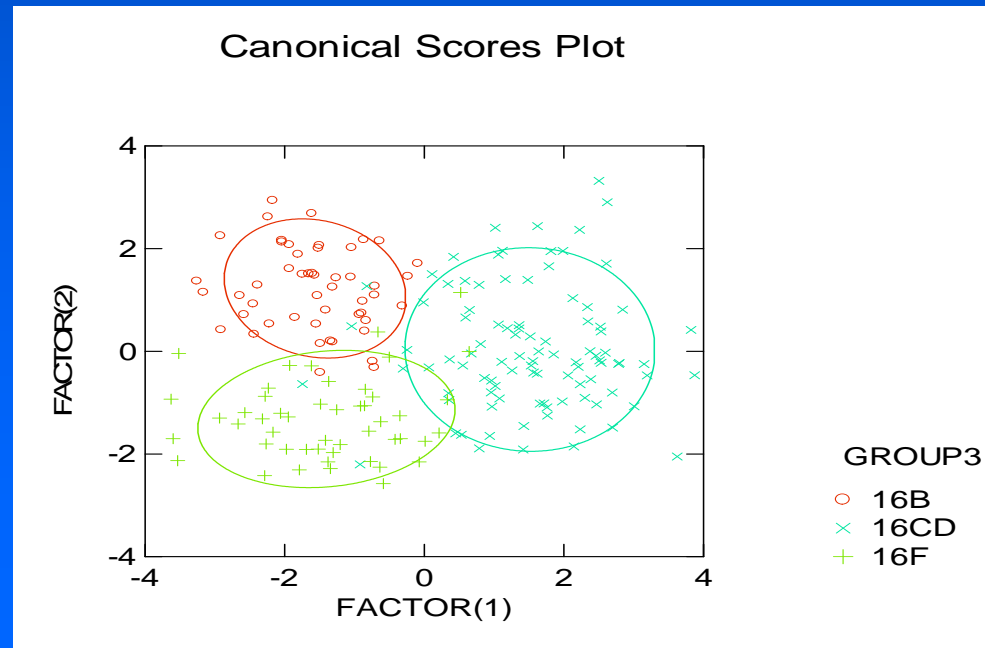


Fleet acoustic projects fall spawning beds (15-40 km² each)



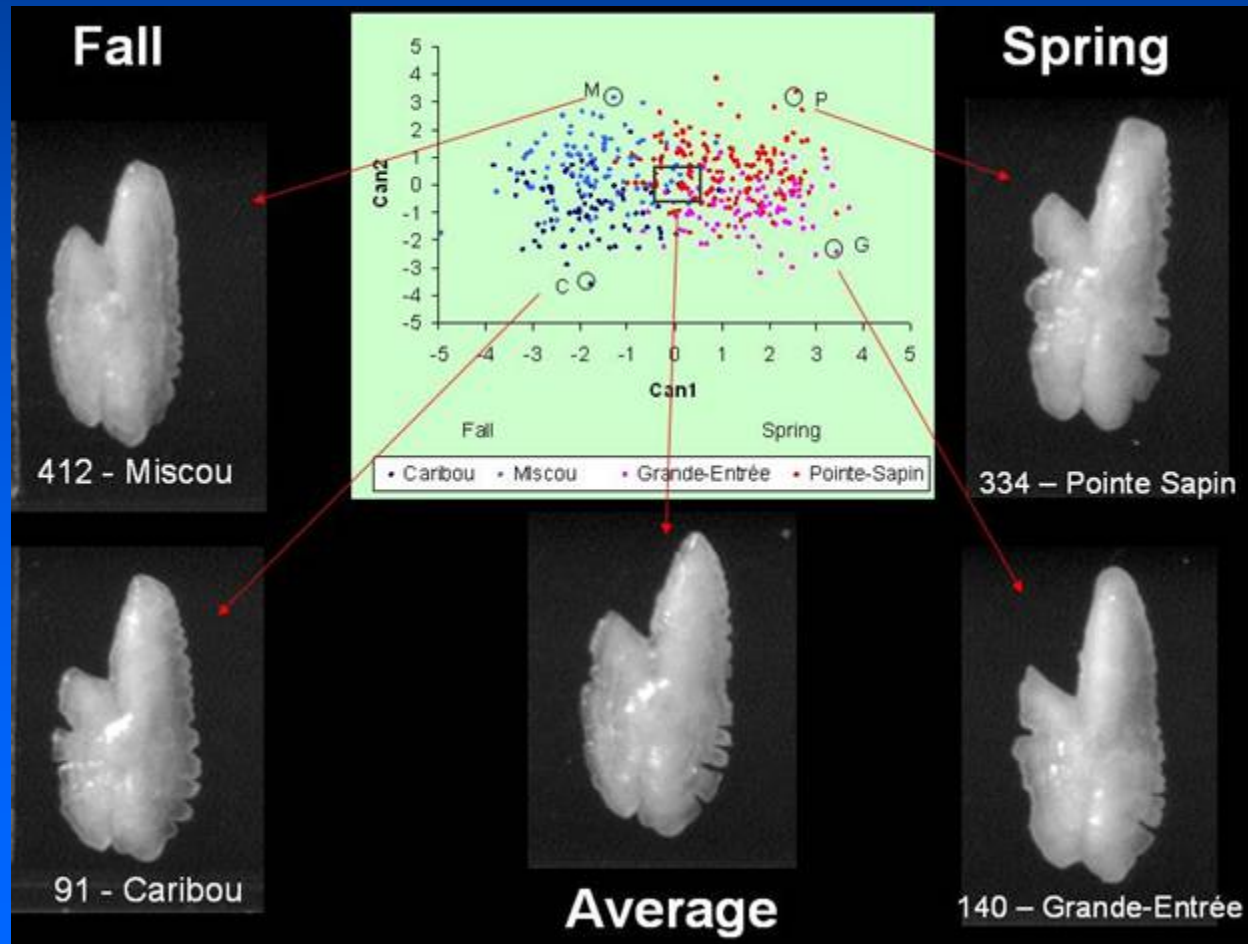
• Otolith trace elements

- Trace elements: elements that are contained in sea-water in small quantities are absorbed in bones and can act as a tag to identify fish from different areas.
- Pilot study in 2003/2004 looked at approx. 200 otoliths. Since then another 817 otoliths have been analysed from both spawning seasons and within areas.
- Some elements showed promise in distinguishing herring from different spawning seasons but not within areas of the same season .



- Otolith shape analysis

- Otolith shape analysis: Pilot study suggest that it can be used to distinguish spring and fall hatched but spawners from same period overlap.

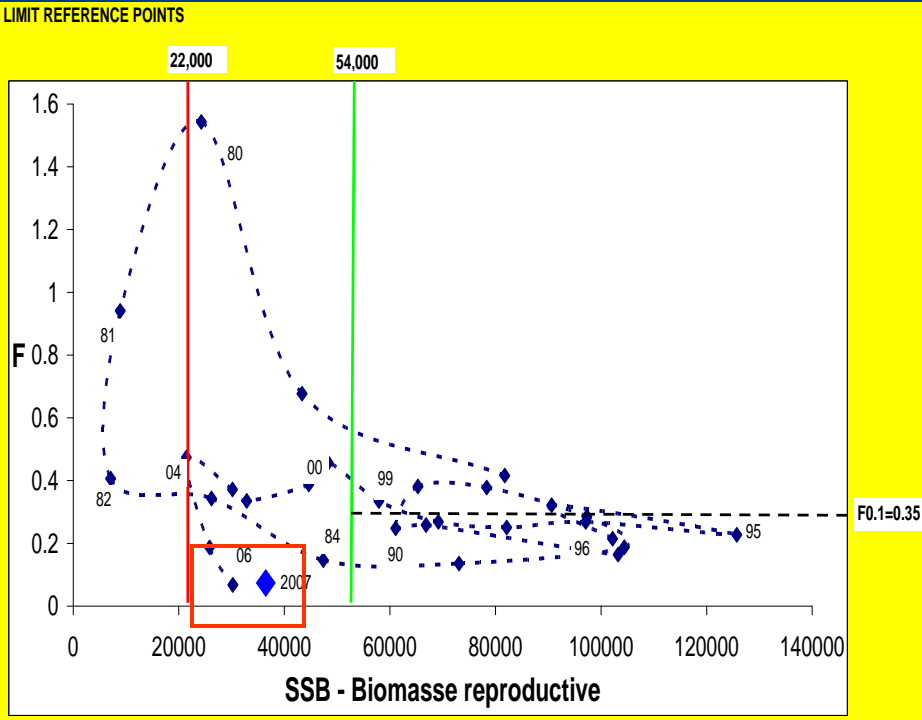


Conservation and sustainability issues

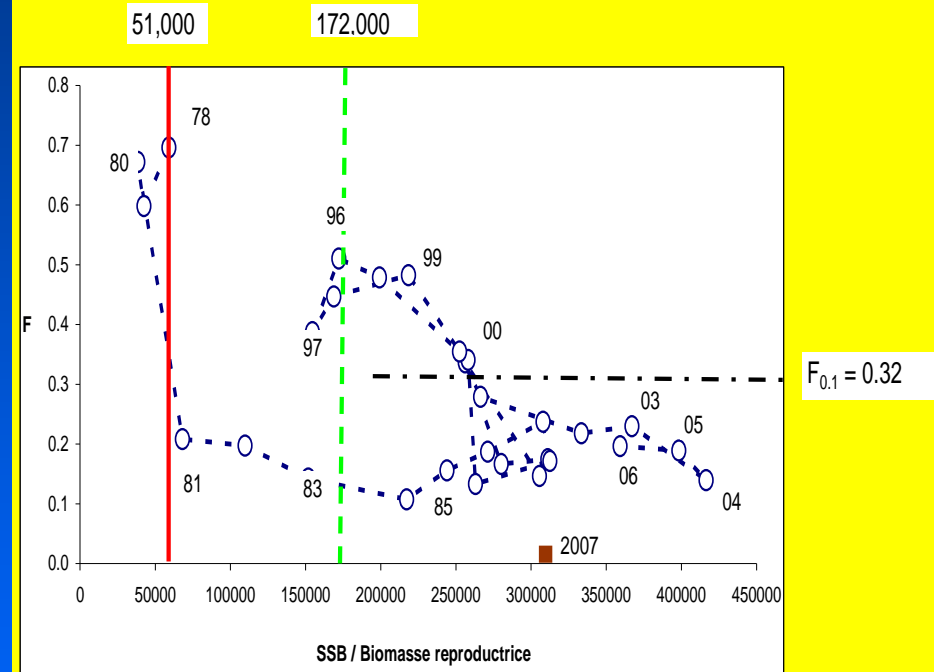
- Spawning stock biomass reference points
- Stock mixing and migration
- Good estimate of catch and effort
- Estimation of natural mortality
- Turnover rate on spawning beds
- Fidelity to spawning bed (homing)
- Ecosystem approach

4T reference points / Points de référence 4T

Spring - Printemps



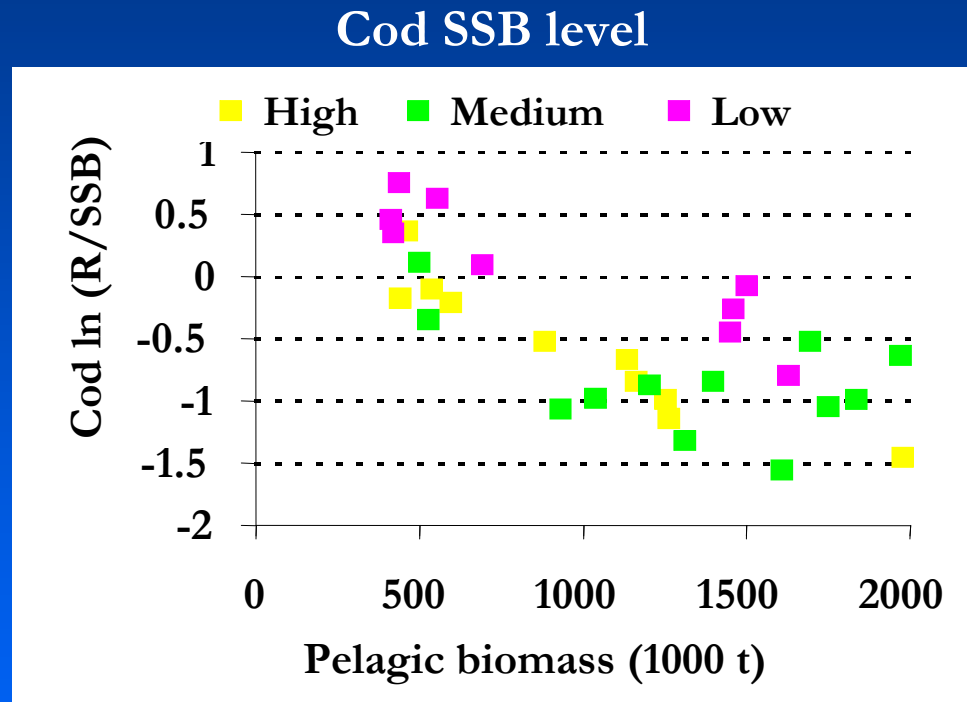
Fall - Automne



DFO, 2005. Spawning Stock Biomass Reference Points for Southern Gulf of St. Lawrence Herring. DFO Can. Sci. Advis. Sec. Advis. Rep. 2005/070.

Ecosystem consideration

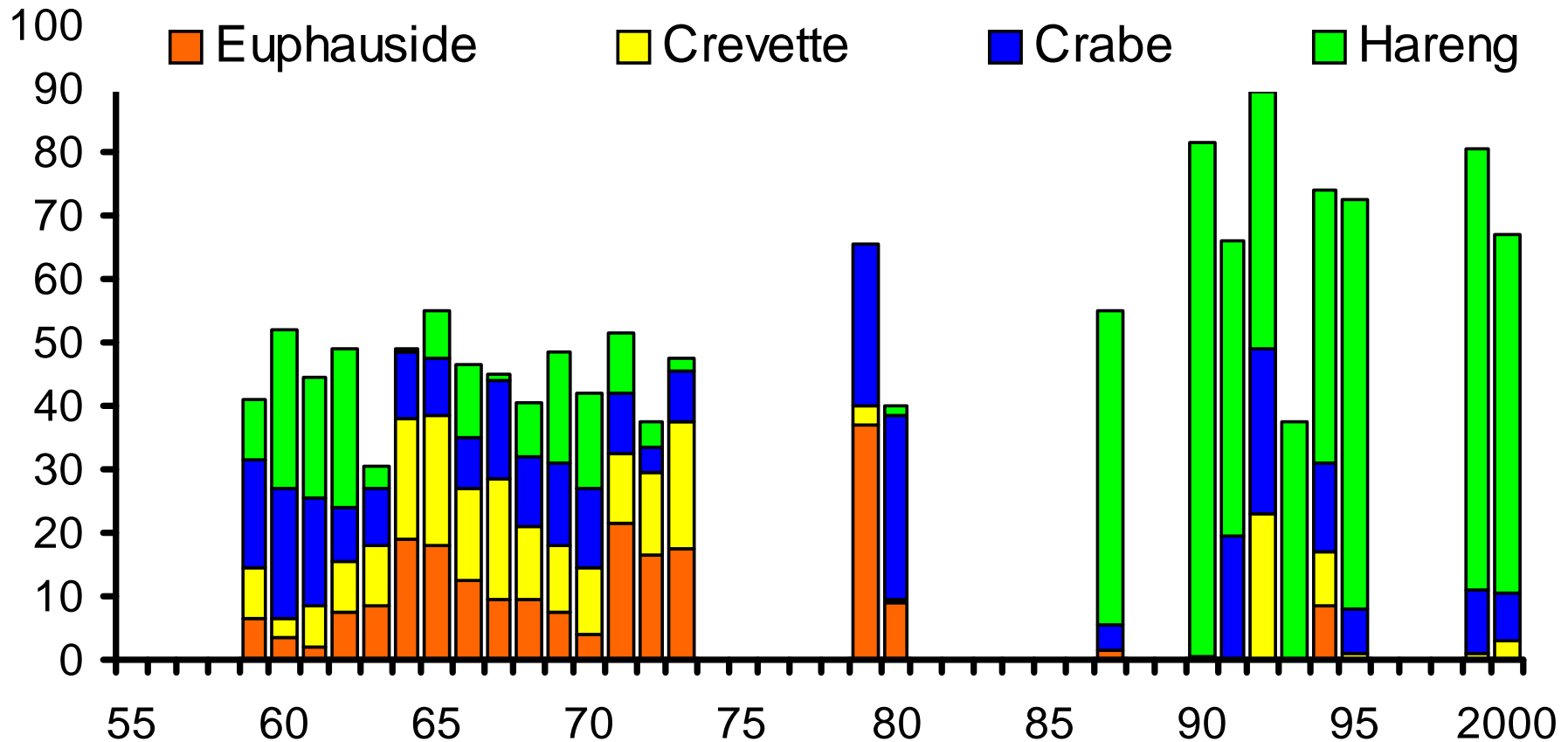
Cod recruitment rate and pelagic biomass



- Trends in cod recruitment rate ($\ln (R/SSB)$) negatively correlated with pelagic biomass. (Swain and Sinclair 2000)
- Pelagic biomass includes herring and mackerel

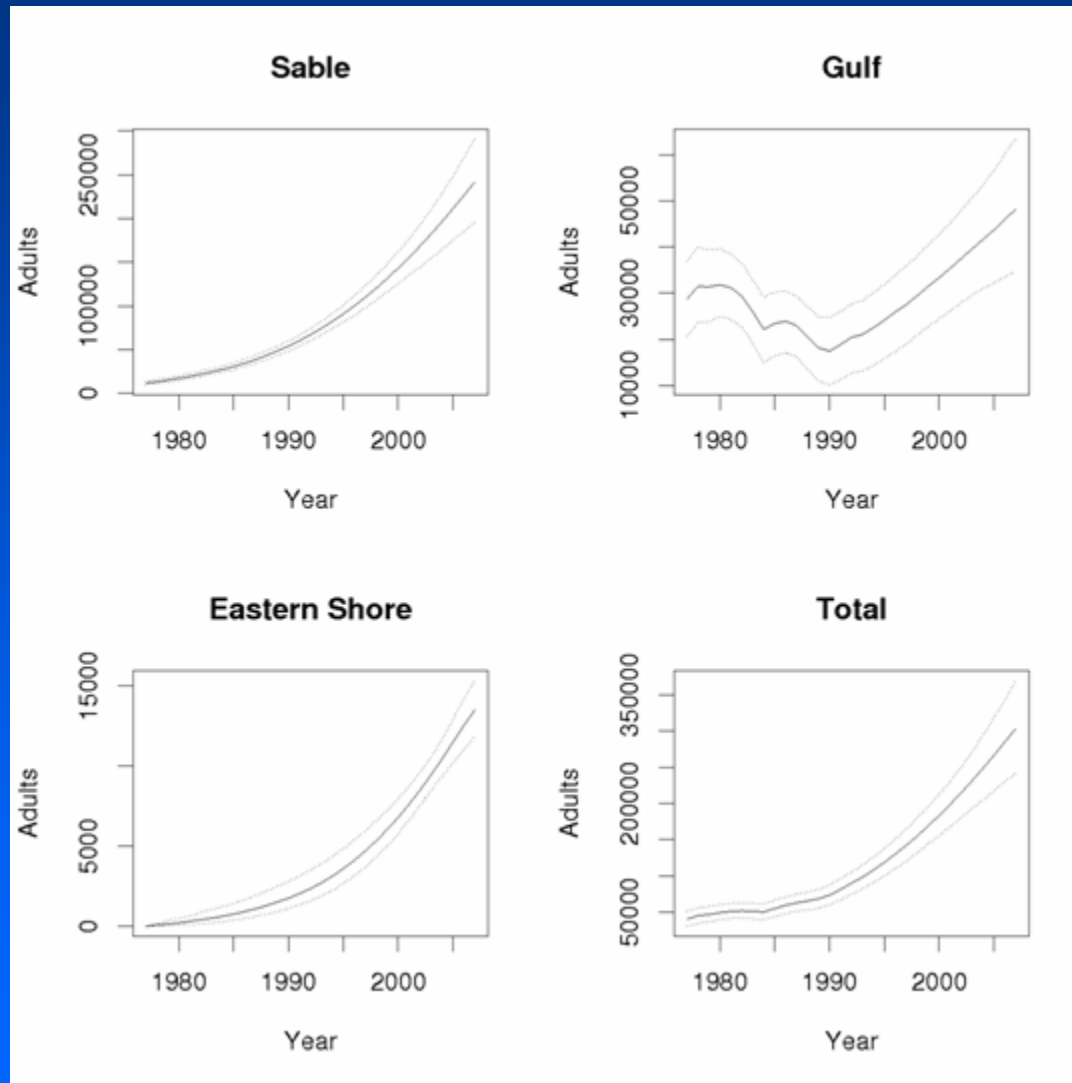
Ecosystem considerations

Stomach content of cod in the Southern Gulf



Natural mortality - Mortalité naturelle

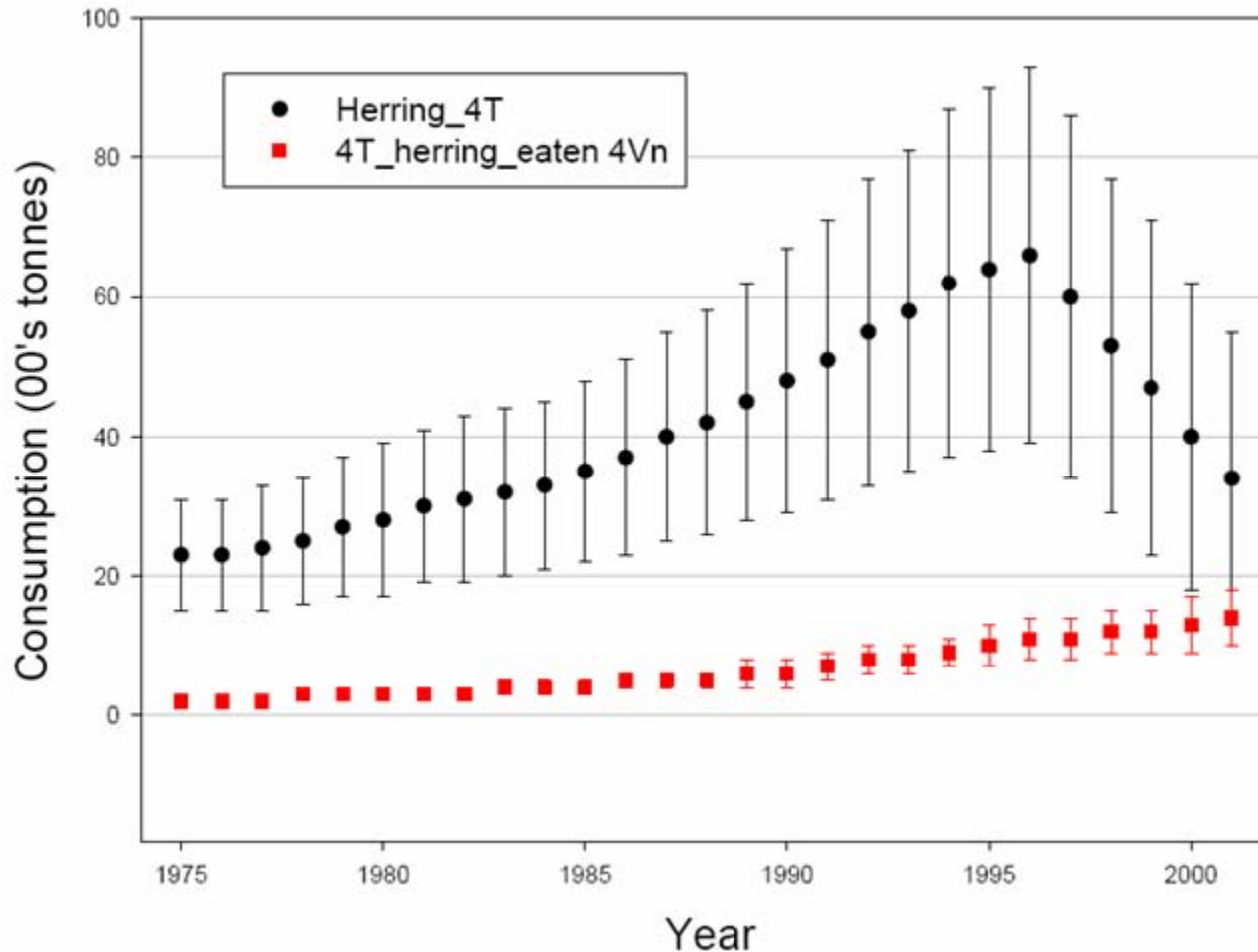
Predators - Prédateurs



Abundance of Atlantic grey seals (Thomas, Hammill and Bowen in prep.).

Natural mortality - Mortalité naturelle

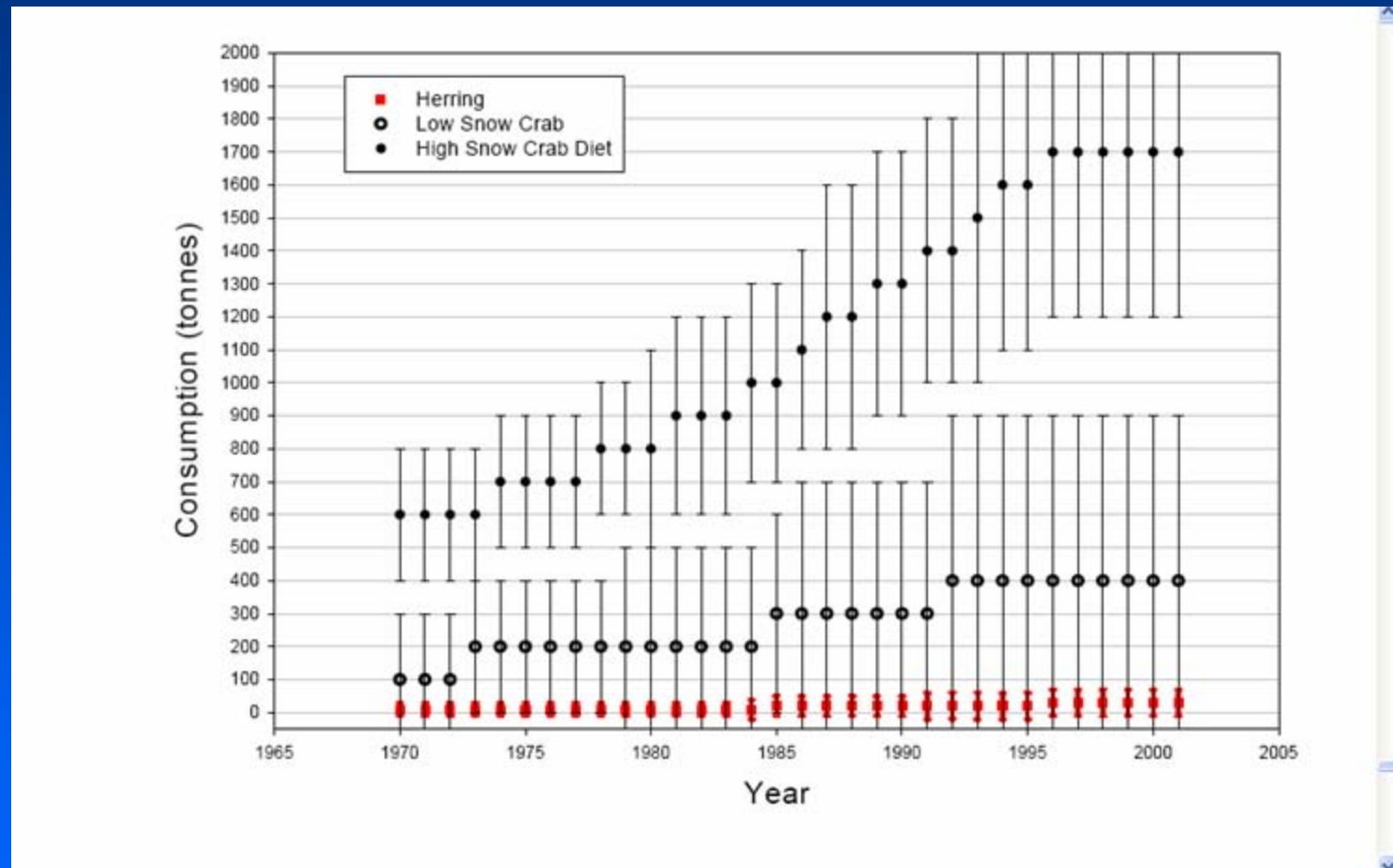
Predators - Prédateurs



Consumption of 4T herring in 4T and during winter in 4Vn by grey seals. Vertical bars $\pm 1SE$ (Hammill and Stenson, 2002).

Natural mortality - Mortalité naturelle

Predators - Prédateurs



Consumption of 4T snow crab and herring by harp seals using a 4T estuary and 4T Gulf diet combined. Vertical bars ± 1 SE (Hammill and Stenson, 2002).

