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# MEMORANDUM — NOTE DE SERVICE

CAFSAC ADVISORY DOCUMENT 79/3

TO / À: Dr. A.W. May
Assistant Deputy Minister
Atlantic Fisheries

FROM / DE: B.S. Muir
Chairman
CAFSAC



SECURITY - CLASSIFICATION - *DE SÉCURITÉ*

OUR FILE - *N/RÉFÉRENCE*

YOUR FILE - *V/RÉFÉRENCE*

DATE March 5, 1979

SUBJECT / OBJET: Canso Marine Environment Workshop

Attached is the Executive Summary for this workshop which is Part 1 of four parts (Fisheries and Marine Service Technical Report No. 834). The remaining parts are in various stages of translation, editing and duplication and will follow as soon as ready.

CAFSAC was asked to undertake an examination of the impact of the Canso Causeway on the fisheries resources of the area. Heretofore, debate and discussion were based on present experience and individual memory of local conditions. When the Causeway was constructed environmental impact statements and the associated study and documentation were not required. The lack of good "before" information has made it very difficult to determine what effects the Causeway may have had. In attempting to understand the changes over two and a half decades, one is impressed with the dramatic events that have occurred in the natural fluctuation of fish stocks, in fisheries harvesting methods and in climatic swings. Significant accumulation of events such as dredging, agricultural and forestry practices in the Gulf area have also taken place. It is a difficult task to separate the confounding events. The extent of industrialization below the Causeway and its effects are also impressive. To a large extent the industrialization results from the existence of the Causeway.

The workshop endeavored to document all the evidence it could concerning comparisons of before and after. It attempted to evaluate this objectively. In a few cases, no "hard conclusions" can be made because of lack of pre-causeway measurements. Wherever possible, an attempt was made to state clearly the alternate hypotheses so that future research might shed further light.

As the attached Technical Report is a summary, it is difficult to further summarize, but some specific conclusions are given on page 4. The workshop was asked to consider the biological benefits of various categories of modification to the Causeway and statements regarding this directly precede the "Conclusions and Recommendations" on page 4.

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Inspection of the "calendar of events" shown on page 3 will give you a quick impression of the complexity of the problem. So many man-made and natural events have taken place, that analysis of the effects of one is seriously confounded.

The results of the workshop have not answered all the questions and there should have been no expectation that they could have. The debate will certainly continue and new insights will emerge in coming years. However, the workshop did achieve the principal objectives of collecting and evaluating all the scientific measurements available and organizing these into a useful information base from which further discussion can proceed.

B.S. Muir

Attachment

# Canso Marine Environment Workshop Part 1 of 4 Parts Executive Summary

F. D. McCracken
Editor

Biological Station,
St. Andrews, N.B., EOG 2XO

January 1979

**Fisheries & Marine Service Technical Report No. 834**

Fisheries and Environment Canada
Pêches et Environnement Canada

Fisheries and Marine Service
Service des pêches et de la mer

## Fisheries and Marine Service
## Technical Reports

These reports contain scientific and technical information that represents an important contribution to existing knowledge but which for some reason may not be appropriate for primary scientific (i.e. *Journal*) publication. Technical Reports are directed primarily towards a world wide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Fisheries and Marine Service, namely, fisheries management, technology and development, ocean sciences, and aquatic environments relevant to Canada.

Technical Reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report will be abstracted in *Aquatic Sciences and Fisheries Abstracts* and will be indexed annually in the Service's index to scientific and technical publications.

Numbers 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. The series name was changed with report number 715.

Details on the availability of Technical Reports in hard copy may be obtained from the issuing establishment indicated on the front cover.

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Ces rapports contiennent des renseignements scientifiques et techniques qui constituent une contribution importante aux connaissances actuelles mais qui, pour une raison ou pour une autre, ne semblent pas appropriés pour la publication dans un journal scientifique. Il n'y a aucune restriction quant au sujet, de fait, la série reflète la vaste gamme des intérêts et des politiques du Service des pêches et de la mer, notamment gestion des pêches, techniques et développement, sciences océaniques et environnements aquatiques, au Canada.

Les Rapports techniques peuvent être considérés comme des publications complètes. Le titre exact paraîtra au haut du résumé de chaque rapport, qui sera publié dans la revue *Aquatic Sciences and Fisheries Abstracts* et qui figurera dans l'index annuel des publications scientifiques et techniques du Service.

Les numéros 1-456 de cette série ont été publiés à titre de Rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457-700, à titre de Rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Le nom de la série a été modifié à partir du numéro 701.

La page couverture porte le nom de l'établissement auteur où l'on peut se procurer les rapports sous couverture cartonnée.

• Cover design by Christine Rusk

Fisheries and Marine Service
Technical Report 834

January 1979

# CANSO MARINE ENVIRONMENT WORKSHOP
## PART 1 OF 4 PARTS
## Executive Summary

F. D. McCracken
Editor

St. Andrews Biological Station
Resource Branch
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St. Andrews, New Brunswick EOG 2X0

This is the one hundred and fifteenth Technical Report from
the Biological Station, St. Andrews, N.B.

## PREFACE

This report is a record of the papers presented and the discussion and findings of a workshop organized by the Canadian Atlantic Fisheries Scientific Advisory Committee to assess effects of construction of the Canso Causeway on marine ecology of the area.


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## ABSTRACT

McCracken, F. D. 1979 [Editor]. Canso marine environment workshop; Part 1 of 4 parts, Executive summary. Fish. Mar. Serv. Tech. Rep. 834, vii + 17 p.

Canso Strait linking St. Georges Bay (north) and Chedabucto Bay (south) was closed by a Causeway in 1954 without preparation of an impact statement. The resulting ice-free, deep-water port and concurrent industrialization there provided great benefits to the region. Recently, concern about fisheries in the region prompted documentation and a review of oceanography and biology of fish species there by a Working Group of scientists. From a fairly extensive data base, including a comprehensive bibliography, it was concluded that closing the Strait had resulted in changes in water stratification, temperatures, salinities and flow patterns within the Strait. Changes in adjacent bays and more distant regions were negligible.

Industrial pollution occurring post-Causeway is mainly confined to the southern Strait near the source and apparently there are no long-term, far-reaching closure effects. Most biological effects possibly attributable to closure have been confounded by subsequent significant unrelated ecological events.

No adverse changes identifiable with the Causeway, except for occasional localized fisheries, could be determined for groundfish, mackerel, salmon and invertebrates excluding lobsters. For herring there was insufficient evidence to determine whether stocks or fisheries in the region were affected.

Recruitment failure was accepted as the cause of the dramatic decline of lobster fisheries in Chedabucto Bay, but the group was unable to attribute this failure to blocking a supply of larvae from St. Georges Bay, recruitment overfishing, non-Causeway environmental and marine climate effects or an admixture of these three.

Disbenefits of significantly modifying the Causeway to allow increased transport could not be equated with any doubtful increase in lobster recruitment. Larval enhancement by artificial means and improved management are within man's control and were considered, but, lacking cost details on various options, the Executive Committee could only recommend that lobster specialists examine possible rehabilitation measures, develop options including potential cost/benefits and the likelihood of detecting and measuring results, these to be considered later by the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC)


Key words: Recruitment (lobster), physical oceanography, fish migrations, larval drift, industrial wastes, straits, Canso Causeway, overfishing, marine geology, fisheries management


## RESUME

McCracken, F. D. 1979 [Editor]. Canso marine environment workshop; Part 1 of 4 parts, Executive summary. Fish. Mar. Serv. Tech. Rep. 834, vii + 17 p.

Le détroit de Canso, qui reliait la baie St. Georges (au nord) à la baie Chedabouctou (au sud), a été fermé en 1954 par une route sans qu'on en ait évalué les répercussions sur l'environnement. La région a profité beaucoup du nouveau port en eau profonde, libre de glace, et de l'industrialisation qui l'accompagna. A la suite de récentes inquiétudes à propos des pêches, un groupe de travail, formé de scientifiques, a réuni de la documentation pour étudier les caractéristiques de la mer et les espèces de poisson de la région. L'examen d'une masse suffisamment complète de données, appuyée par une bibliographie exhaustive, a révélé que la fermeture du détroit avait entraîné des modifications de la stratification des eaux, de leur température, de leur salinité et de leur écoulement. Dans les baies adjacentes et les régions plus éloignées, ces modifications ont été négligeables.

La pollution industrielle produite en aval de la route est surtout limitée à la partie sud du détroit, près d'où elle tire son origine. Apparemment, la fermeture du détroit n'a aucun effet à long terme ni sur de grandes distances. La plupart des effets biologiques qu'on pourrait imputer à cette pollution se confondent avec d'importants phénomènes écologiques qui se sont produits par la suite sans y être reliés.

Sauf pour ce qui concerne parfois la pêche pratiquée dans des zones précises et mis à part le homard, ni les poissons de fond, les maquereaux, les saumons, les invertébrés n'ont eu à souffrir de la fermeture du détroit. Dans le cas du hareng, les données étaient insuffisantes pour qu'on pût déterminer si leurs stocks avaient diminué dans la région.

La baisse vertigineuse de la pêche du homard dans la baie de Chédabouctou fut attribuée à un recrutement insuffisant de l'espèce. Le groupe fut cependant incapable de prouver que cela était dû à l'absence de larves en provenance de la baie St Georges ou à la surexploitation des recrues ou à des effets du climat marin ou de l'environnement ou encore à une combinaison des trois.

Les désavantages qu'entraînerait une modification sensible de la route, construite pour favoriser le transport, ne pourraient être compensés par l'éventuelle augmentation de la reproduction du homard. Le comité exécutif a envisagé des interventions comme l'introduction de larves par des moyens artificiels, l'amélioration de l'aménagement, mais à cause du manque de détails sur le coût de ces entreprises, il s'est contenté de recommander l'examen par des spécialistes du homard des mesures éventuelles de repeuplement et l'élaboration des possibilités d'intervention dont ils auront évalué la rentabilité et dont les résultats pourront être prévus et mesurés, ces questions devant être examinées ensuite par le Comité scientifique consultatif des pêches canadiennes de l'Atlantique.

# EXECUTIVE SUMMARY

## INTRODUCTION

Since closure of the Canso Causeway in the fall of 1954, great benefits have accrued to residents of Cape Breton Island and those parts of Nova Scotia adjacent to the Strait of Canso. Not least of these benefits was creation of one of the finest ice-free, deepwater ports in Eastern Canada, and this has stimulated growth of industry and population there (Fig. 1).

Recently, however, voices have increasingly been raised against the Causeway, blaming it for pollution effects and for failures in lobster and herring fisheries.

Initial consideration of the impact that the Causeway may have had on fisheries of the region suggested that this was extremely difficult to assess. Not only was pertinent fisheries and oceanographic information prior to construction lacking, but during the two decades since construction various events of major ecological significance have confounded the situation and prevented causal relationships being understood. If the Causeway had been conceived during the 1970's, actual construction undoubtedly would have been preceded by a sound impact statement and the collection of good baseline data. The final decision concerning the construction of the Causeway would have then depended upon the outcome of these and other studies. In the 1950's no such formalized analysis was undertaken. Many of the difficulties experienced in providing a definitive statement now were therefore due to the lack of such an impact study.

Viewing current concerns it soon appeared there was a need for a well documented review of the biology and oceanography of Strait of Canso area and an assessment of effects that the Causeway may have had on the ecology there. So the Atlantic Fisheries and Marine Service Research Directors' Committee asked CAFSAC (Canadian Atlantic Fisheries Scientific Advisory Committee) to organize a workshop on this topic. Subsequently a Steering Committee was formed to spearhead the activities.

Papers presented at the Workshop, together with pertinent excerpts from the proceedings and summaries of the findings, are published herein as a four-part Fisheries and Marine Technical Report. These papers are listed *in toto* in Appendix 3; however, only those not published elsewhere are reproduced in this report.

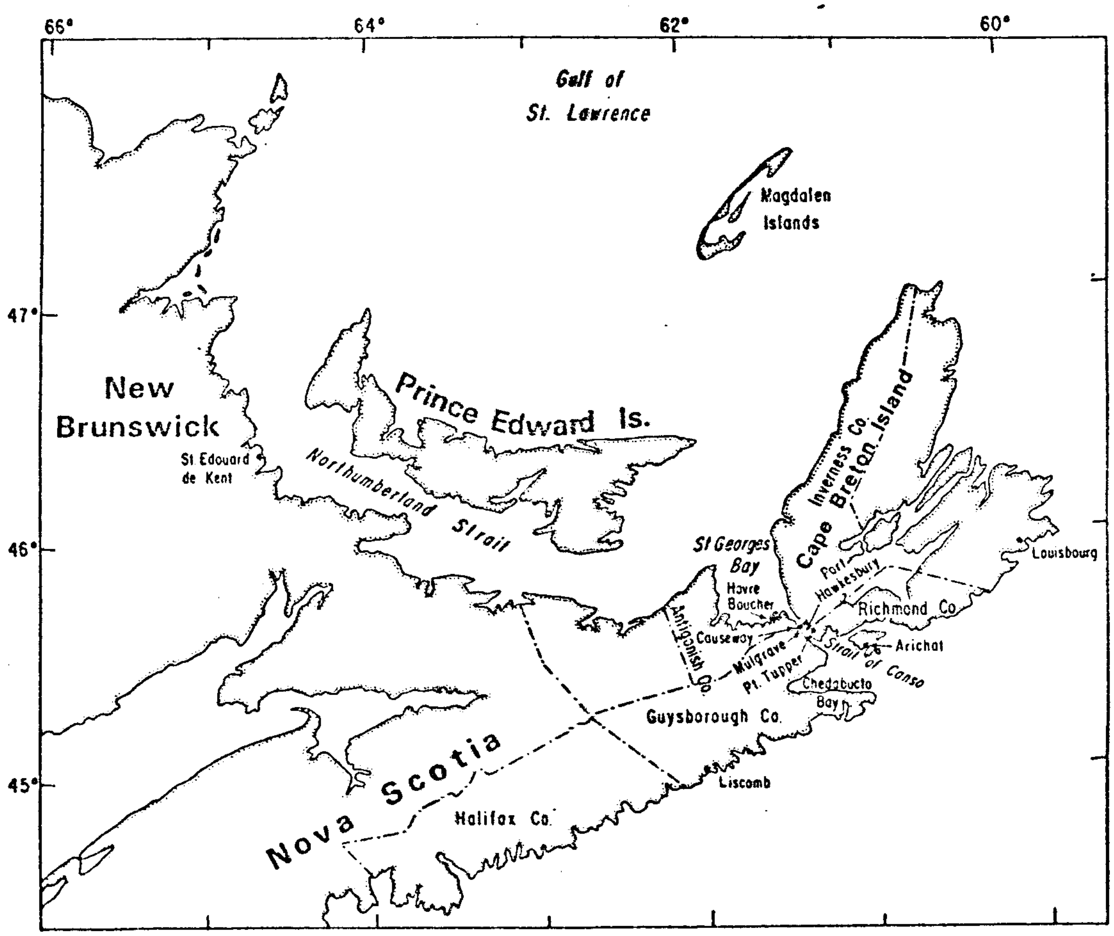


Fig. 1. Map showing location of Canso Strait, the Causeway and pertinent area and place names in the region.

## WORKSHOP OBJECTIVES

*Primary objectives*

To assess the effects that the Canso Causeway may have had on marine ecology and fisheries of the area.

*Definition of area*

While the primary focus will be on Canso Strait itself together with St. Georges Bay and Chedabucto Bay, it is recognized that the sphere of influence could extend to Northumberland Strait, N.W. shore of Cape Breton Island, and the shores of Cape Breton Island and mainland Nova Scotia adjacent to Chedabucto Bay.

*Sub-objectives*

(a) To assemble as complete a data base as possible, including an annotated bibliography.

(b) To examine this data base from the primary objective and to document a group assessment of the impact of the Causeway on each major plant or animal species which occurred there.

(c) To undertake a preliminary evaluation of the environmental benefits and disbenefits which might be caused by opening part of the Causeway to allow a flow between the two sides. (This will require an examination of the biological effects of recent industrial developments in the Strait of Canso area.)

(d) To identify research projects necessary (and feasible) to refine and improve the impact assessments or conclusions reached.

(e) To provide complete documentation of the data base as well as assessments and conclusions reached during the workshop.

## THE CANSO MARINE ENVIRONMENT WORKSHOP

*First meeting*

The first meeting of the Workshop was held at the Bedford Institute of Oceanography in Dartmouth on November 22-24, 1977, bringing together many interested persons mainly from Federal and Provincial Government agencies and Universities (Appendix 1).

Response to the request for documentation was excellent and, besides the comprehensive bibliography (Dadswell 1979) and overview papers which had been solicited beforehand (Dadswell 1979 and Trites 1979), many excellent and useful papers were presented.

After reviewing the quite extensive data base, the Workshop concluded that any possible changes which might be attributed to construction of the Causeway were confounded by the variety of significant ecological events (Fig. 2) which had occurred in the area during the two decades since construction.

An examination of the environmental data base was followed by a review of available information on plant and animal species which occur in the Canso Strait area. An attempt was made to assess whether any changes had occurred and whether or not these could be attributed to the Causeway. The results of the assessments for individual species or groups of species are summarized in this volume. Excepting lobsters and herring (for which a further review was suggested) and the occasional small fishery for particular species in a localized area, no adverse changes attributable to building of the Causeway could be identified.

A need for some clarification of points raised in papers submitted on herring was identified and for an in depth review of the collapse of an important local fishery (fished from St. Edouard de Kent) at the northern end of the Northumberland Strait.

The dramatic decline in lobster fisheries of Chedabucto Bay area generated considerable discussion from which a consensus emerged that a recruitment failure had occurred, likely occasioned by a decrease in the supply of larval lobsters settling there. Four major hypotheses (not mutually exclusive) possibly having a significant causal influence were raised.

(i) St. Georges Bay was a significant source of larval lobsters for the Chedabucto Bay area. With closure of Canso Strait by the Causeway, residual flow of primarily surface water (presumably containing significant numbers of larval lobsters) from St. Georges Bay to Chedabucto Bay was cut off.

(ii) Decline of the lobster fishery in Chedabucto Bay was primarily caused by recruitment overfishing. The decline in abundance of lobsters is evident from several lobster districts throughout the Maritimes and is not exclusive to the Chedabucto Bay area. This hypothesis suggests that effects of increased real fishing effort and existence of an intensive fishery which removes a large proportion of lobsters before they reach maturity outweigh any contribution larval lobsters from St. Georges Bay might have made to Chedabucto Bay production.

(iii) Decreased recruitment to the stock of lobsters in Chedabucto Bay was likely due to either a series of short-term climatic events or a long-term trend towards less favourable environmental conditions for successful recruitment of lobster larvae than those which prevailed in earlier years.

(iv) The increased industrialization following construction of the Causeway resulted in pollution effects which affected successful production of lobster larvae during the post-Causeway period.

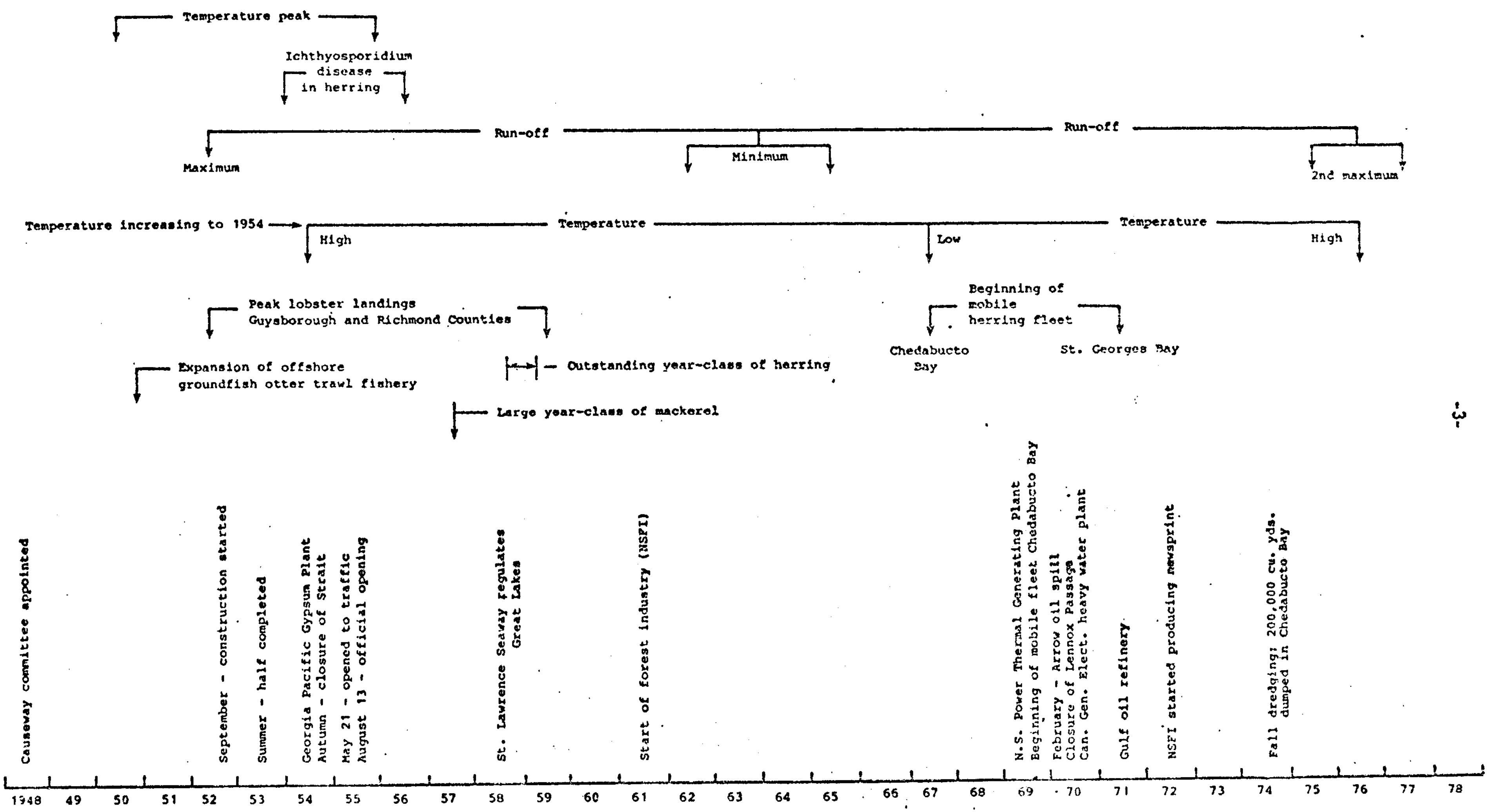


Fig. 2. Chart showing claendar of events associated with construction of the Canso Strait Causeway.

The consensus rejected the pollution hypothesis. Discussion also revealed that not all available data had been assembled and further documentation and examination of the new data from St. Georges Bay were desirable before conclusions could be derived about the other three possible hypotheses. Consequently, it was agreed that a further workshop session was desirable and in this the main focus should be on identified problems pertaining to herring and lobsters as well as such remedial measures as might be feasible. R. W. Trites was asked to provide current information for the Cape Breton area based on seabed drifters and remote sensing of oil spill drift, D. G. Robinson to provide a more careful analysis of lobster landing data and effort, A. B. Stasko to report on larval data obtained from tows in St. Georges Bay by MEL, and K. F. Drinkwater to report on transport times through the Strait of Canso.

*Second meeting*

The second meeting was convened at the Biological Station, St. Andrews, N.B., on February 23, 1978, with participants listed in Appendix 2. Additional papers were presented and, after reviewing the new data, the following conclusions emerged:

*Finfish*: There is adequate evidence that some portion of the mackerel population used Canso Strait for migration into the Gulf. The Causeway evidently has had no impact on the population, but may have affected local fisheries based on these migrants.

There is insufficient evidence to determine whether or not closure of the Strait of Canso did affect herring stocks in the area. Any changes in the Gulf of St. Lawrence, such as the collapse of the St. Edouard de Kent fishery and the reported change in direction of herring movements around Prince Edward Island subsequent to closure of the Strait of Canso are confounded by contemporaneous changes in the temperature regime, an epizootic in the mid-1950's and by other environmental changes.

*Lobsters*: While evidence can be assembled in support of the remaining three hypotheses put forward in the previous workshop, insufficient data were available to provide a definite conclusion as to which (if any) of the three hypotheses was most probable or indeed whether or not construction of the Causeway had affected the lobster fishery of the Chedabucto Bay area. Clearly, the center of the lobster problem was recruitment failure, but differences in opinion occurred in interpretation of the recruitment mechanism and importance of the Strait in supplying lobster larvae.

Assuming that a significant proportion of the recruitment which occurred in Chedabucto Bay prior to the Causeway originated as larvae in St. Georges Bay, an analysis was presented which could explain the mechanism of recruitment failure (Dadswell 1979).

However, another analysis indicates that about 10% of larvae produced in St. Georges Bay would have passed south through the Strait of Canso to Chedabucto Bay in the absence of the Causeway (Harding et al. 1979). From this, it was calculated that survival of these larvae would contribute about 3% to the weight of Chedabucto Bay landings in 1954. This level of impact agreed with an analysis suggesting that this number of larvae was about 1% of that produced by Chedabucto Bay stock in 1954 (Robinson 1979). These analyses suggest that interruption of a recruitment mechanism by the construction of a Causeway would have had a relatively small impact upon the fishery of the study area.

*Causeway modifications*: Although no definite conclusions were reached as to whether or not construction of the Causeway had affected the lobster fishery of Chedabucto Bay, benefits and disbenefits that might accrue from modification of the Causeway were considered. Such measures as tubes, syphons, cuts, etc., have been suggested. The workshop consensus was that lobster was the only species requiring consideration. Any feasible modification to the Causeway would pass relatively few larvae. Also, unless the Causeway was almost totally removed, net drift would probably not move them to Chedabucto Bay, but rather drop them in the areas of industrial pollution.

A major opening appears incompatible with industrialization. It would probably interfere with the ice-free port and approaches off Chedabucto Bay. There would also be the risk of spreading the industrial pollution now largely in the sediments both into Chedabucto Bay and St. Georges Bay.

CONCLUSIONS AND RECOMMENDATIONS

The workshop objectives have now been fulfilled. A data base and bibliography have been compiled which are available to everyone. After examining the data in detail and assessing it, the Steering Committee was directed to summarize it, to consider preparation of reports and to document the conclusions and recommendations which emerged. These conclusions and recommendations are summarized below:

(a) Possibly excepting lobsters and the occurrence of species or small fisheries in extremely local areas, no adverse changes in biota could be identified which could be attributed to the building of the Causeway.

(b) For lobsters, the consensus accepted the fact of recruitment failure on the Chedabucto Bay side of the Strait. It was unable to attribute this failure to construction of the Causeway and prevention of lobster larvae from St. Georges Bay entering Chedabucto Bay, recruitment overfishing, non-Causeway related environmental effects or changes in marine climate, or an admixture of these three.

Pollution effects were rejected as a likely cause of the recruitment failure in lobsters of Chedabucto Bay.

(c) While it was recognized that modification of the Causeway to allow the transport of significant amounts of surface waters might allow an increased supply of lobster larvae to enter Chedabucto Bay, any modification would pass relatively few larvae without running the risk of interfering with the ice-free port and approaches off Chedabucto Bay. The costs of making such a modification as well as the social costs incurred by the elimination of the ice-free port would be enormous. In no way could they be equated with any doubtful increase in lobster recruitment which might possibly be generated by the modification.

Accepting these premises, clearly any recommendations which might be made should be aimed at attempting to increase recruitment of lobsters in Chedabucto Bay area.

Of the three hypotheses which may be relevant in interpreting decline of the lobster fishery in Chedabucto Bay, one (non-Causeway related environmental effects) is mainly beyond man's control.

Factors which man can control are raised in response to the hypotheses involving loss of larvae due to the physical barrier imposed by construction of the Causeway and suggestion that recruitment overfishing had occurred. In the first instance, remedial measures might include attempts at enhancing natural recruitment rates by artificial means to compensate for the postulated larval loss. In the second instance, improved management of the lobster resource would result both in an increased biomass of lobsters in the area and increased annual recruitment from the natural population.

A matrix of various degrees of artificial larval enhancement and improved management actions was examined; however, lack of information on costs of possible management options precluded a cost-benefit analysis. The Steering Committee was unable to develop detailed recommendations. Therefore, it was recommended that lobster specialists should examine possible rehabilitative measures; develop a series of options and include their potential cost/benefits and the likelihood of being able to detect and measure their results. These options and their implications are to be considered by CAFSAC at a later meeting.

## SUMMARIES OF PAPERS PRESENTED

### VERTEBRATE FISH IMPACTS
J. S. Scott, September 1978

*Groundfish*

In the period reviewed (1945-65) landing statistics were not divided into offshore and inshore contributions and effort data are not available (Scott 1979). Fish landing figures for Fisheries Districts may include catches from offshore and distant grounds besides local catches which would be most affected by closure of the Strait of Canso. This source of error applies more to south of the Strait than to the north where fisheries remained largely inshore and landings were less affected by development of offshore fisheries in the early 1950's.

Landings of most major groundfishes in the local areas of Chedabucto and St. Georges Bays followed general trends of landings in wider areas south and north of the Strait of Canso area.

*Cod:* Annual landings showed a period of general decline for about 6-8 years preceding construction of the Causeway, in both local and more general areas north and south of the Strait of Canso. Immediately following closure of the Strait, landings increased in both Chedabucto Bay and St. Georges Bay areas. Years of peak landings corresponded to periods of peak landings from the Scotian Shelf and southern Gulf of St. Lawrence respectively, suggesting that cod landings reflect conditions more widespread than the local influence of closure of the Strait.

Tagging experiments prior to construction of the Causeway indicate movements of cod round Cape Breton to and from the Gulf of St. Lawrence and from Chedabucto Bay to offshore banks. There is no evidence of movement through the Strait of Canso.

The Canso Causeway has not adversely affected cod distribution or landings in the general area of the Strait of Canso.

*Haddock:* Annual landings in Chedabucto Bay area from 1945 to 1965 followed a pattern similar to landings from the offshore Scotian Shelf: a sharp increase from about 1950, high fluctuating catches in the early 1960's and a collapse in the mid-1960's. Landings in St. Georges Bay were small and erratic but followed the decline which characterized the southern Gulf of St. Lawrence fishery from about 1953, to virtual disappearance of the fishery by the mid-1960's. The Gulf haddock fishery was dependent on immigration from Scotian Shelf stock(s) and heavy exploitation of the latter from about 1955 probably caused the collapse.

Tagging experiments prior to closure of the Strait of Canso showed that haddock migrated from the inshore Scotian Shelf round Cape Breton Island to the Gulf of St. Lawrence in spring, with no evidence of movement through the Strait. Later experiments showed a reverse migration in autumn as far as offshore banks.

Canso Causeway has had no determinable effect on stocks of haddock in the Gulf of St. Lawrence or Scotian Shelf. Decline in the fisheries north and south of the Strait was probably due to pressure exerted on stocks by the fisheries on the Scotian Shelf.

*Pollock*: Landings were always negligible on the northern side of the Strait of Canso. In Chedabucto Bay they increased steadily from the late 1940's and after a decrease in the late 1950's recovered and then declined from 1960 to 1965, following the general trend off the Atlantic coast. Landings by Fisheries District prior to construction of the Canso Causeway indicate an easterly migration of pollock from the southwest as far as the northwest coast of Cape Breton but not farther into the Gulf of St. Lawrence, with no evidence of movement through the Strait of Canso.

Closure of the Strait of Canso had no determinable effect on pollock fisheries in the area.

*American plaice*: Landings were negligible in St. Georges Bay area from 1945-1965. In Chedabucto Bay area the only significant landings were from 1953-1956 and 1963-1965 which appear to reflect market conditions rather than fluctuations in stocks.

*Common hake*: Prior to 1955, landings in Chedabucto and St. Georges Bays were low. After 1955 they increased, peaking in 1958 in the south, then collapsing. In the north they rose erratically until 1964, then fell to an intermediate level in 1965. Landings in St. Georges Bay were much higher than to the south. These effects may be attributable to closure of the Strait of Canso or to other environmental changes and in either case appear to have benefitted the St. Georges Bay area and ultimately reduced the fishery in the Chedabucto Bay area.

*Pelagic fishes*

*Herring*: Landings in St. Georges Bay and Chedabucto Bay areas were essentially stable from 1933 to 1967 with no discernible effect on them from closure of the Strait of Canso (Messieh 1979).

A delay in arrival of herring on the spawning grounds in the western Gulf of St. Lawrence since about 1956 is attributed by Messieh to a general decrease in sea temperature. Ware (1979) argues that other herring populations in the Gulf do not show this delay, and diversion of migration from the Strait of Canso to round Cape Breton Island would explain the delay for herring migrating from the Atlantic coast to the Gulf.

Tagging studies show movement of herring between southwest Newfoundland, Magdalen Islands and western Gulf of St. Lawrence and between southwest Nova Scotia and Chedabucto Bay area, but no movement between Chedabucto Bay area and Gulf of St. Lawrence (Messieh 1979). Studies of meristics and age-length compositions indicate separate populations in the Gulf and on the Atlantic coast of Nova Scotia prior to and since construction of the Canso Causeway.

Any changes in herring fisheries in the Gulf of St. Lawrence, such as collapse of the fishery in the northern part of the Northumberland Strait from St. Edouard de Kent and the reported change in direction of herring movements round Prince Edward Island subsequent to closure of the Strait of Canso are confounded by contemporaneous changes in temperature regime, epizootic disease in the mid-1950's and other environmental effects.

There is no evidence that the local herring fisheries in the Canso Strait area have been directly affected by construction of the Causeway. There is insufficient evidence to determine whether closure of the Strait affected herring stocks in more distant areas, including the decline in those in northern Northumberland Strait.

*Mackerel*: Fishermen state that prior to construction of the Causeway there was migration of mackerel through the Strait of Canso, northwards in spring and southwards in autumn, as well as migration round Cape Breton Island (Ware 1979). The temporary decline in the abundance of mackerel in the late 1950's in the Gulf may be attributed to the Causeway or to some other factor such as temperature or epizootic disease which also reduced the herring stocks.

The mackerel population in general has flourished subsequent to closure of the Strait so that any disruption of the migratory path has not affected total stock although there may have been effects in local areas.

*Other species*

*Salmon*: Tagging data from 1914-1940 indicate that salmon homing to rivers in the Gulf of St. Lawrence did not use the Strait of Canso for entry into the Gulf. However, a small proportion of salmon destined for rivers on the Atlantic coast of Nova Scotia, which had already entered the Gulf, probably exited via the Strait of Canso. No smolts tagged in south coast Nova Scotian rivers have been recovered in the Gulf of St. Lawrence.

For salmon, the effect of closure of the Strait is not measurable.

*Alewives (Gaspereau)*: There is basically no information available on this species. Landings appear to reflect market demand rather than availability.

*Grey seal*: Since closure of the Strait of Canso there is evidence of greater stability of ice in St. Georges Bay. This may have enhanced the reproductive success of the grey seal. If so, this is a disbenefit since more seals cause greater problems to the fisheries.

INVERTEBRATE FISHERIES IMPACTS
D. G. Robinson, August 1978

*Plants*

*Chondrus crispus* is the only marine plant of economic significance in the area (Pringle 1979). Over the 50-yr period that Irish moss has been harvested in St. Georges Bay there are no data indicating a change in its availability. However, there has been a significant increase in harvest during the 1970's. Information from surveys in Chedabucto Bay indicates that it is present but not in quantities suitable for harvest.

In the northern part of the Strait of Canso near the Causeway there is evidence that siltation has adversely affected algae. Reduced flushing and increased industrialization in the southern part of the Strait have led to elimination of some seaweed species.

There is no evidence of a change in availability of Irish moss on the south shore of Nova Scotia.

*Invertebrates*

*Scallops*: Small beds exist in several areas, notably in the outer part of St. Georges Bay where they have been fished commercially since the mid-1950's (Stasko 1979). In Chedabucto Bay, commercial scallop fishing has been non-existent; landings recorded there come from other areas.

There appears to be no Causeway-related change within this fishery.

*Rock crabs, snow crab, shrimp*: There are no commercial fisheries in the area for these species and no effects can be associated with building of the Causeway.

*Oysters*: The fishery existing in the Gulf of St. Lawrence prior to construction of the Causeway still exists (Stasko 1979). A general decrease during the late 1950's and early 1960's was due to an epidemic of Malpeque disease which started at the north end of Northumberland Strait and destroyed most native stocks in the Gulf of St. Lawrence. In Chedabucto Bay and along the Atlantic coast small sporadic fisheries exist. Effects of the disease, discovery or development of new beds, closures of others due to local pollution, siltation or damming, and crediting of landings in other than harvesting areas mask any possible small-scale effects resulting from the Causeway.

*Clams, mussels*: Landings before and after Causeway construction tend to reflect market conditions rather than availability (Stasko 1979). In the general area south of the Causeway, local production has never been sufficient to support a sustained industry. Throughout the Strait clam beds are closed due to bacterial pollution.

*Lobsters*: Historically, lobsters have been the mainstay of inshore fishing in the Maritimes, and the area around the Strait of Canso is no exception. The decline in the lobster fishery along the southeast coast of Nova Scotia has had a serious socio-economic impact. Indeed, an objective of this Workshop was to investigate any possible relationship between the Canso Causeway and this decline.

Combined landings for the counties of Halifax, Guysborough and Richmond exceeded 10.5 million pounds live weight in 1900 (Robinson 1979). In 1977, combined landings were 500 thousand pounds. This decline did not proceed evenly; combined landings fell to 1.5 million pounds in 1924, rose to 6.2 million pounds in 1932, declined again to 2.4 million pounds in 1947, and rose again to 5.0 million pounds in 1954. The Strait of Canso was closed by construction of the Causeway in 1954. The question before us was "Did the Causeway have a significant effect on this third decline along this coast, and if so, what was the mechanism of that effect?"

Analysis of data available indicated that all Maritime lobster stocks have been subjected to increased effective fishing effort during this century which has been expressed in decreased survival to maturity for female lobsters (Robinson 1979). Superimposed on this general pattern are cycles of fishing effort linked to cycles of fishery productivity. Thus, a peak in effort was evident during the mid-1930's and during the latter 1950's in the study area. It was hypothesized that this trend in lobster fisheries along this coast was the cause of the decline.

If the Causeway had a significant impact on the lobster fishery along this coast, it may have operated through one of several mechanisms:

1) Pollution from increased industrialization.

2) Environmental change, such as decreased summer temperatures.

3) Interruption of a larval recruitment mechanism, with the Causeway acting as a barrier.

Industrial pollution only commenced in the early 1960's, by which time the decline was well along. Analyses presented in this Workshop, indicate that existing pollution does not extend beyond the southern mouth of the Strait of Canso. A lobster fishery still exists even within this polluted southern part of the Strait. Therefore, the decline cannot be attributed to pollution.

Warm surface water from St. Georges Bay is thought to have intruded into Chedabucto Bay before the Causeway was constructed. Cessation of this supply probably led to some localized reduction in summer temperatures within

Chedabucto Bay. However, the overall system is dominated by the near-shore coastal current and wind-driven surface currents, with inputs from the Strait of Canso having a relatively minor impact (Trites 1979).

Clearly, the centre of the lobster problem was recruitment failure, but differences in opinion occurred in interpretation of the recruitment mechanism and importance of the Strait as a means of transporting a supply of lobster larvae.

Assuming that a significant proportion of the recruitment occurring in Chedabucto Bay prior to the Causeway originated as larvae in St. Georges Bay, an analysis was presented which could explain the mechanism of recruitment failure (Dadswell 1979).

However, another post-Causeway analysis indicates that about 10% of the larvae produced in St. Georges Bay would have passed south through the Strait of Canso to Chedabucto Bay in the absence of the Causeway (Harding et al. 1979). From this, it was calculated that survival of these larvae would contribute about 3% to the weight of Chedabucto Bay landings in 1954. This impact level agreed with an analysis which suggested that this number of larvae was about 1% of that produced by Chedabucto Bay stock in 1954 (Robinson 1979). These analyses suggest that interruption of a recruitment mechanism by construction of the Causeway would have had a relatively small impact upon the fishery of the study area.

The many discussions centered on the above submissions have been of great assistance in developing the following generalized picture of lobster ecology along the southeast Nova Scotia coast. Growth rates, and probably larval survival rates, are lower than in the southern Gulf of St. Lawrence, whereas size at maturity is higher. Besides, the extensive offshore areas suitable for harboring brood stock refugees along the southwest coast of Nova Scotia do not exist along the eastern coast. The latter area cannot be compared directly with either of the adjacent highly productive areas in terms of stock recruitment potential. Currently the Northumberland Strait lobster fishery is showing signs of recovery 10 yr after its collapse, but a slower recovery would be expected along the southeast coast of Nova Scotia because of lower growth rates, lower larval survival and greater generation length. Effort has been removed in large part from the latter lobster stocks and even without improved management measures this is a source for optimism about the future of this fishery. Nevertheless, improved management measures could accelerate and sustain a recovery of this system.

## ENVIRONMENTAL IMPACTS AND POLLUTION EFFECTS

R. H. Cook, August 1978

The papers submitted to the Workshop about environmental impacts and pollution did not present any pre-Causeway information. As most industrialization of the Point Tupper area, namely the pulp mill (N.S. Forest Industries), the oil refinery (Gulf Oil), the heavy water plant (Atomic Energy of Canada) and the N.S. Power generating station, was developed following construction of the Causeway, the impact of the Causeway in terms of the effect on distribution of pollutants within the Strait is not known. Clearly, however, the construction of the Causeway substantially protected St. Georges Bay from the pollution loadings at Mulgrave and Point Tupper and there was a significant change in circulation patterns within the Strait area. The reduction in circulation near Point Tupper would tend to localize the impact of pollution on Chedabucto Bay. The change in ice patterns within the Strait post-Causeway is also dramatic, the southern part of the Strait now being essentially ice-free with the inherent advantages to marine transportation.

Comprehensive and multidisciplinary surveys conducted by the Atlantic Geoscience Centre in 1973 (Buckley 1973; Buckley et al. 1974); and the water quality model (Khumbare 1974); and field investigations by the Environmental Protection Service in 1972-73 (Wilson 1979; Machell et al. 1977) delineate the zone affected by the industrial water pollution sources. Biological indices based on presence and absence of foraminifera, ostracoda, and benthic species, generally along transects in the affected area, have demonstrated that the pulp mill has had a significant impact on environmental quality detectable at least up to 6 km downstream of Point Tupper. Wood fiber, elevated C:N ratios, heavy metals in sediments, besides the biological observations, all confirm the extent of the immediate zone of influence of these pollution sources. Apparently oxygen depletion caused by the oxidation of these organic wastes within the Strait is not severe (Khumbare 1974).

Information on the water pollution effects on fisheries of Canso Strait is severely limited. There is no pre-Causeway information available on the subject. There is some acute toxicity information available on effluents of industrial wastes discharged to the Strait (Wilson 1979) based on regulatory bioassay testing protocols. In this regard, the pulp mill does not meet the minimum toxicity requirements. Additionally, some information was made available on toxicity of pollutants to lobster (Wells 1975a, 1975b). From the information available, it appears that lobster larvae are relatively tolerant of pulp mill and oil refinery effluents (LC 10% and 0.1-0.3% respectively) and the impact of these sources of pollution on the lobster, beyond the localized zone of influence, would not be particularly detrimental.

From environmental pollution and toxicity information presented to the Canso Marine Environmental Workshop, the following statements can be made:

1. Industrial pollution sources occurred after construction of the Causeway which effectively confined the wastes to the southern end of the Strait and by reducing circulation confined their zone of influence closer to the sources

2. Chemical and biological investigations have delineated the area of the Strait immediately influenced by the pollution sources and, relative to the total study area (St. Georges Bay, Chedabucto Bay), the pollution effects are localized.

3. Toxicity of the major pollutants, especially to lobsters and lobster larvae, is not unduly severe.

Based on the foregoing there do not appear to be any long-term, far-reaching environmental effects associated with construction of the Causeway. All the effects seem to be of a localized or short-term nature and as such, do not constitute a major concern to fisheries of Chedabucto Bay.

PHYSICAL AND GEOLOGICAL OCEANOGRAPHY
D. J. Lawrence, September 1978

*Forminifera*

A temperature sensitive indicator species, *Ammonia beccarii*, at its northern limit in the Gulf of St. Lawrence and Bras D'Or Lakes, has been found useful to indicate environmental changes due to the Causeway. The species requires temperatures close to 20°C for reproduction.

*Pre-Causeway*: Despite much disturbance of the sediment layers due to bioturbation, the indicator species was largely absent from the northern portion of the Strait, and completely missing from the southern portion. This reflects the strong vertical mixing which kept surface temperatures below 15°C.

*Post-Causeway*: The warm water indicator species was present throughout the Strait north of the Causeway, reflecting surface temperatures of 20°C during summer stratification. Assemblages were different on either side of the Causeway.

*Ice*

*Pre-Causeway*: Loose ice from the Gulf usually filled the Strait above Mulgrave by 1 January and drifted south along the N.S. coast as far south as Cape Sable (O'Neill 1979). By mid-January, Gulf ice had packed solid, so drifting ceased and the southern part of the Strait stayed open in some years.

*Post-Causeway*: Ice from the Gulf is prevented from entering the southern Strait, which remains open. Significant quantities of drifting ice is now found only as far south as Halifax. Since long-term climatic data show a cooling trend over eastern Canada which should have resulted in production of more sea ice, the change in the southern limit of drifting ice along the Nova Scotia coast may be due to the Causeway.

*Climate*

This is classified as a mid-latitude variable type (O'Neill 1979). The Atlantic region has experienced a downward trend in mean annual temperature since the mid-1950's (0.5°C, 10-yr running means), a slow upward trend in precipitation (7% in 35 yr), and an increase in snowfall. Locally, at Port Hastings, however, there was no major temperature change comparing 1890-1907 and 1971-1976 periods. Precipitation increased but its variability decreased.

Although air and water temperatures on a year-to-year basis are correlated over wide geographic areas, nevertheless, air temperatures alone cannot account for sea temperature variability (Trites 1979). The links are complicated and indirect.

*Suspended solids*

Lacking data from the pre-Causeway era, any judgement of normality of conditions must be by comparison with contemporary data from other coastal embayments.

*St. Georges Bay*: Differences in sedimentation rates with depth imply vertical and horizontal transport (Hargrave 1979). Aperiodic changes in rates and composition imply resuspension occurring in events, more intense inshore, likely caused by wave action. Mean carbon depositional rates are normal for coastal marine bays.

*Canso Strait*: Particle distributions (1-100 µm) in the Strait during March 1970 were remarkably different from the remainder of the survey area (Chedabucto Bay) (Kranck and Sheldon 1979). No diatoms were present, and stations near the Causeway were dominated by effluent particles. Effluent was again found in June 1971. Water north of the Causeway had more normal particle distributions.

*Chedabucto Bay*: Size analysis (1-100 µm) showed a phytoplankton bloom in March 1970 nearly everywhere in surface waters, a minimum layer at 50 m, and increased concentrations below 50 m due to flocculated inorganic sedimentary material (Krank and Sheldon 1979). The bloom had declined and was mixed vertically by April-May. Average concentrations were of order 1 ppm, somewhat less than found for St. Margarets Bay (5-10 ppm). Oil concentrations from the *ARROW* were <10% of total.

*Bottom sediments*

*St. Georges Bay*: Mean daily deposition rates were normal for a marine coastal bay (Hargrave 1979) (June-Sept., 1976-77). Much resuspension occurred in events.

*Strait of Canso*: Underlying coarse sediments are the 'Sable Island sand and gravel' type (MacLean et al. 1977). The gravel fraction contained shell fragments at the southern end of the Strait and wood fibers at mid-Strait.

Overlying this is a discontinuous veneer of mud or 'Lahave clay', originating from local coast erosion and deposited since the Causeway was constructed. Thickness of this surface layer varied from 2 to >10 cm, and the boundary is much disturbed by bioturbation (Vilks et al. 1975). If a higher current regime were re-established, the depositional material would probably have a larger grain size than at present. However, the existing mud layer would not necessarily be eroded away before being sealed in (Kranck and Sheldon 1979).

*Chedabucto Bay*: The physiography is characterized by a smooth bottom with soft sediment (MacLean et al. 1977). Sediment types occurring are:

'Scotian Shelf drift': a poorly sorted glacial deposit, found S and SE of Isle Madame and in the approaches S of Cape Breton Island.

'Sable Island sand and gravel': a clean sand and gravel mixture with some silt nearshore, found S and W of Isle Madame.

'Lahave clay': A clayey silt with minor sand, found over most of the area. It is currently being deposited and is probably similar to 'Pugwash mud' (Kranck and Sheldon 1979).

*Sea level*

"After construction of the Causeway, water levels in St. Georges Bay and Chedabucto Bay, as measured at Havre Boucher and Arichat, apparently were similar to pre-Causeway conditions. Only in the Strait itself were changes readily measured. The prime effect was to eliminate the mixed tide within the Strait and to bring a slightly enlarged Chedabucto Bay type of tide right up to the south side of the Causeway. Similarly the St. Georges Bay type of tide reached southward in the Strait to the Causeway. Also the slope in mean level formerly spread throughout the Strait is now recorded as an abrupt change in level on either side of the Causeway" (Trites 1979).

The long-term difference in level is about 6 cm, the north side being higher (Lawrence and Greenberg 1979).

*Temperature and salinity*

*St. Georges Bay*: Although based on limited data, direct measurements suggest there was no change in water properties due to the Causeway (Drinkwater 1979). The major water exchange has always been through the entrance to the Bay, not through the Strait of Canso. Southward flow through the Strait might have altered the circulation pattern within the Bay, but would have had little effect on water properties or residence times.

*Strait of Canso*: The slope of the isotherms and isohalines indicates that entrainment of Chedabucto Bay bottom water was occurring in the central and southern part of the Strait in the pre-Causeway era (Drinkwater 1979).

The Causeway has caused a major reduction in current strength, from a strong tidal (100-200 cm/s) to a weak (10-20 cm/s) wind and external meteorologically forced regime. This has resulted in a change from well-mixed to stratified conditions, with summer surface temperatures becoming higher and bottom temperatures lower than previously (Trites 1979; Vilks et al. 1975).

*Chedabucto Bay*:

*Pre-Causeway*: In investigating a possible nutrient entrainment mechanism, it was assumed that Canso Strait water overrode and mixed with bottom water from Chedabucto Bay to form the upper layer of Chedabucto Bay (Drinkwater 1979). An entrainment ratio of 0.4 was determined using MacGregor's (1952) data. Trites (1979) suggests that much of the water in the surface layer may have come through the Strait. However, observations were limited to the axis of the Strait and Bay.

*Post-Causeway*: The Causeway has likely had little effect on the water properties. Observed density differences between upper and lower layers (0.2 to 1.0 $\sigma_T$) based on Neu's (1970) data are similar to those found by MacGregor (0.75 $\sigma_T$) (Lawrence 1979). The limited data base, particularly pre-Causeway, does not indicate any change in properties due to the construction of the Causeway. The expected changes are quite small and completely masked by the much larger natural changes going on at all scales (Trites 1979).

*Currents*

*St. Georges Bay*: The present flow pattern features a large weak clockwise gyre (5-6 cm/s) driven by steady eastward flow from Northumberland Strait. Pre-Causeway, there would also have been the effect of a residual flow southward into the Strait of Canso, and a small but possibly strong counter clockwise gyre driven by tidal flow at the junction of the Bay and Strait. Thus net pattern could have altered appreciably. However, rough estimates suggest the flushing times were not altered appreciably.

*Strait of Canso*:

*Pre-Causeway*: Strong tidal currents (200 cm/s) dominated the flow (Lawrence and Greenberg 1979; Drinkwater 1979). The superposition of a small (6 cm) long-term head difference resulted in a net southward flow of $7 \times 10^3 m^3 s^{-1}$ and a southward exchange of water between the two bays on most tide cycles. Residence times were only several days. Storm surges could produce temporary height differences 10 times larger than the long-term mean, while seasonal variations and St. Lawrence River runoff variations could double the mean value.

*Post-Causeway*: Flow south of the Causeway is weak and variable. At the mouth of the Strait, tidal constituents are of order 5 cm/s. A low frequency (3-5 day period) internal wave is often present with comparable amplitude, probably driven by meteorological events on the Scotian Shelf. Local winds affect currents in the top few metres.

*Chedabucto Bay*: Overall mean pattern from a 15-day current meter data base (April 1970) indicates a counter clockwise flow of about 3 cm/s perhaps driven by the Scotian Shelf drift current (Lawrence 1979). This would give a transit time around half the Bay of 12 days. In the pre-Causeway era, there would have been superposition of Strait of Canso outflow (6 cm/s in the upper layer (Drinkwater 1979) and a strong localized tidally driven counter clockwise gyre at the junction between Bay and Strait. The transit time around the southern half of the Bay might have been reduced to 4 d.

The Causeway was not expected to have had an effect on tides which are small (5 cm/s, east-west) or on meteorologically forced currents which now have amplitudes of order 10 cm/s in the 1-15 day band.

*Southern Cape Breton, inshore*: The study was based on an analysis of source regions for only those seabed and surface drifters recovered from the inshore region from Louisbourg to Liscomb (Trites 1979). The data are too sparse to indicate any Causeway related changes. However, they do indicate the variability in large-scale current patterns.

Bottom currents (1961-1973) were predominantly to the SW, but some NE flow did occur. Returns were scarce from Chedabucto Bay itself, indicating it was a low upwelling area.

Surface currents (1960-1970) were exclusively SW except for 1961 when some NE flow was indicated. During 1922-1924, extensive and systematic releases were made along several section lines perpendicular to the shore. Shore recoveries came mostly from releases made within 35 miles of shore. Sometimes the classical strong SW flow was observed, but significant NE flows occurred, the latter always coinciding with periods when St. Lawrence River outflow was expected to be weak.

There was some evidence for a clockwise gyre south of Cape Breton from ice drift (1964-65).

*Atlantic region*: Fluctuations in flow patterns outside St. Georges and Chedabucto Bays arising from large-scale processes appear to be much larger than anything that could reasonably be attributed to the Causeway.

APPENDIX 1

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APPENDIX 3

PAPERS PRESENTED OR TABLED


Buckley, D. E. Environmental marine geology of the Strait of Canso and Chedabucto Bay, Port Hawkesbury, Nova Scotia. Field Report No. 73-022.

Buckley, D. E., E. H. Owens, C. T. Shafer, G. Vilks, R. E. Cranston, M. A. Rashed, F. E. Wagner, and D. A. Walker. Canso Strait and Chedabucto Bay: a multidisciplinary study of the impact of man on the marine environment.

Dadswell, M. J. A bibliography of the environment and fisheries of the George Bay - Chedabucto Bay - Canso Strait region.

Dadswell, M. J. The Canso Causeway and its possible effects on the regional inshore fisheries - an overview.

Dadswell, M. J. A review of the decline in lobster (*Homarus americanus*) landings in Chedabucto Bay between 1956 and 1977 with an hypothesis for a possible effect by the Canso Causeway on the recruitment of eastern Nova Scotia lobster stocks.

Day, Joan K. A summary of industries located in communities bordering the Strait of Canso.

Drinkwater, K. F. Flow in the Strait of Canso and George Bay, Nova Scotia.

Drinkwater, K. F. Nutrient entrainment in Chedabucto Bay and its possible effects on production.

Harding, G. C. H., P. G. Wells, and K. F. Drinkwater. The distribution and abundance of lobster larvae in George Bay, Nova Scotia, in 1975 and the possible effect that the Canso Causeway has had on the Chedabucto Bay lobster fishery.

Hargrave, B. T. Suspended and sedimented particulate matter in George Bay.

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