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Fisheries

The relationship between American lobster landings and sea surface temperatures in Prince Edward Island, Canada

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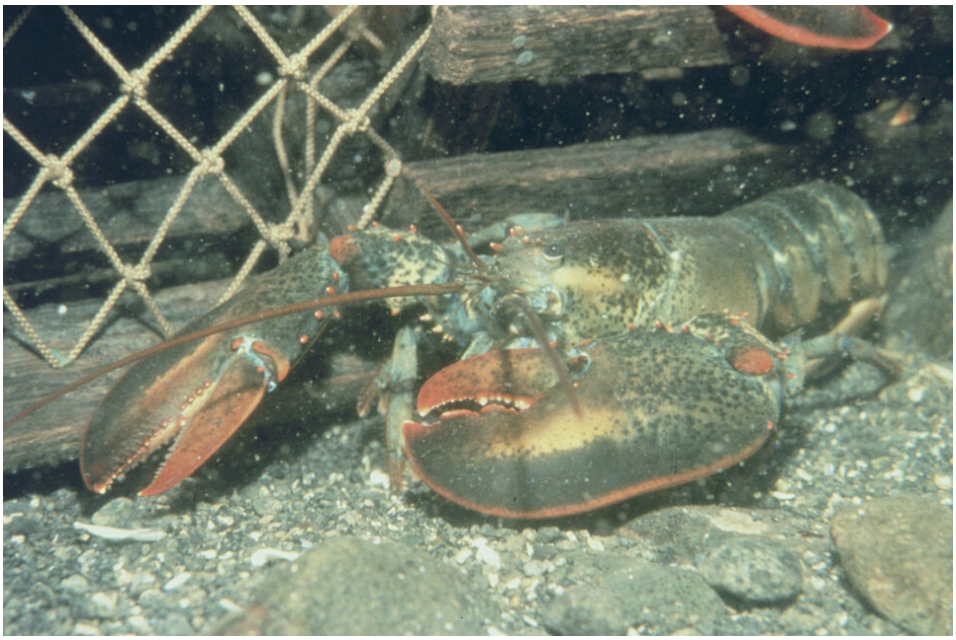
Results provide empirical evidence of a statistically significant relationship between SST and the lobster catch



Study assesses the relationship between American lobster landings and sea surface temperatures in Prince Edward Island, Canada. Results provide empirical evidence of a statistically significant relationship between sea surface temperature and lobster landings in Prince Edward Island. Past ocean temperatures have a quantifiable influence on current lobster landings, providing insights to understand how future ocean warming might impact the PEI lobster fishery. Photo by Rick Wahle (Public domain, via Wikimedia Commons).

The American lobster (*Homarus americanus*) is an important fisheries resource in Prince Edward Island (PEI). The lobster industry, valued at CAD $438 million and employing over 8500 people, is the third largest in PEI, with more than 1200 licensed fishers actively engaged across its three main Lobster Fishing Areas (LFAs). Over the past few decades, the lobster fishery has grown to represent a considerable portion of marine harvests in Canada. Lobster fisheries accounted for 69.7 and 58.5 percent of all **fishery landings** (https://www.princeedwardisland.ca/sites/default/files/publications/asr_2020_0.pdf) (i.e., yield) in PEI in 2017 and 2020, respectively. PEI fishers represent approximately 13 percent of the over 9000 Canadian fishers and 9 percent of over 13,000 North American fishers, emphasizing the magnitude of this sector for the economy of PEI.

Since lobsters are cold-blooded animals, ambient temperature has a significant impact on their physiological functions, including growth, reproduction, metabolism, and survival. Adult lobsters exhibit a wide temperature tolerance, surviving in waters ranging from −1 to 30 degrees-C, but their larval stages are considerably **more sensitive** (https://doi.org/10.1163/1937240X-00002150) to temperature fluctuations. While some studies suggest faster larval growth in warmer waters within a suitable range, exceeding this range can have detrimental effects on lobster larvae. Research suggests that high temperatures can **disrupt** (https://doi.org/10.1093/icesjms/fsv093) larval development, survival, and recruitment.

Previous research has explored the relationship between ocean temperature and lobster populations in regions such as the Gulf of Maine and the northeastern United States, limited attention has been given to Prince Edward Island (PEI), which presents unique ecological, economic, and regulatory conditions. Anecdotal accounts from lobster fishermen in the U.S. State of Maine purport a reduced catch in recent years, while those on PEI are seeing an abundance of young lobster **moving northward** (https://doi.org/10.1111/gcb.14778)in search of cooler water due to climate change, the latter of which is supported by recent findings.

This article – **summarized** (https://doi.org/10.3390/foods14122072)from the **original publication** (https://creativecommons.org/licenses/by/4.0/) [Khan, M. et al. 2025. Lobster Yield Dynamics in a Warming Ocean: A Generalized Linear Modeling Case Study in Prince Edward Island, Canada. *Foods* 2025, 14(12), 2072] – presents the results of a study that examined the relationship between lobster landings and sea surface temperatures (SST) around PEI using a Generalized Linear Model (GLM; a flexible generalization of ordinary linear regression), and interpreted these historical relationships in light of projected ocean warming under different emissions scenarios.

Study setup

This study addressed how do historical SST patterns influence lobster landings in Prince Edward Island. Monthly average SST around PEI was obtained from 1982 to 2021 from the **Surface Temperature Group** (https://doi.org/10.1038/s41597-019-0236-x)at the University of Reading, UK. Data were collected from five location points within the LFAs in PEI (Fig. 1). Thirty-two-year summaries of PEI lobster landing data from the period 1990 to 2021 were collected from the official website of Fisheries and Oceans Canada. Additionally, landing information from 2003 to 2022 for each LFA in PEI was collected from Fisheries and Oceans Canada's office

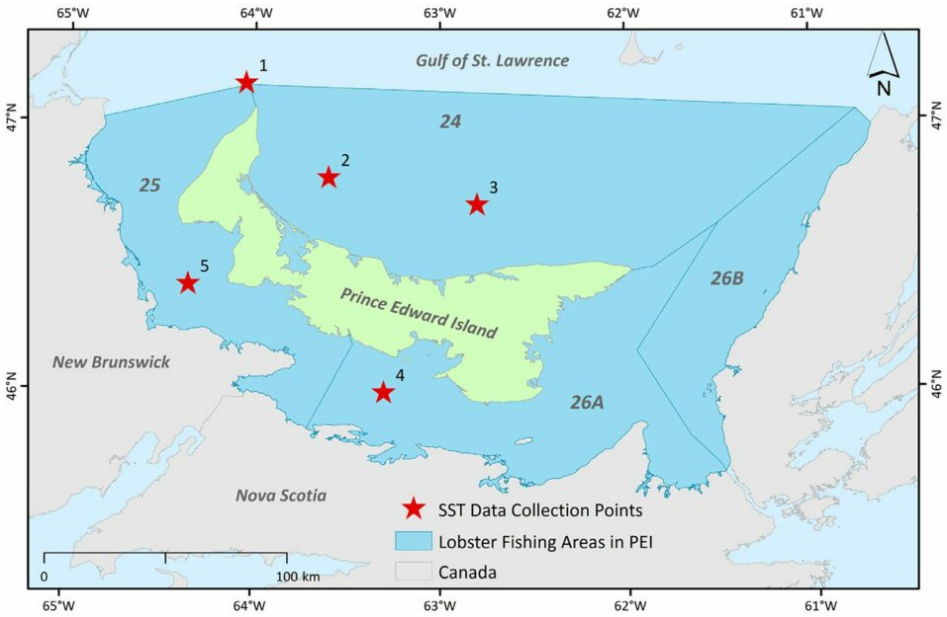


Fig. 1. SST data collection points (red) in the water around PEI.

For detailed information on the experimental design, data collection and analyses, including the Generalized Linear Model used, refer to the original publication.

Results and discussion

Results of this study provide the first detailed analysis of American lobster landings in PEI using a statistical modeling framework that incorporates both current and historical sea surface temperatures (SST) over an eight-year period, aligned with the species' maturation timeline. By integrating long-term SST dynamics with fisheries management variables such as carapace length (CL), our approach contributes a regionally focused model that can inform adaptive strategies for climate-resilient fisheries management in Atlantic Canada. Therefore, any substantial change in water temperature may disrupt the lobster population's distribution pattern and, thus, the stock in PEI.

The results of this study build upon and extend the existing literature on the impacts of ocean temperature on lobster populations by offering a region-specific, temporally integrated analysis focused on PEI. Our model incorporates a biologically informed 8-year SST exposure window to reflect the full maturation period of lobsters. Additionally, the inclusion of regulatory parameters such as carapace length (CL) introduces a management dimension that has not been widely considered in similar models. These elements offer novel insights into how both environmental and regulatory variables jointly influence landings, providing a valuable foundation for local adaptation strategies in climate-sensitive fisheries.

Developing image-based methods to incorporate fishery-collected data for American lobster stock assessment

Image-based method to estimate the length of American lobsters provides high-quality data and helps engage fishermen in fishery management.

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In this study, SST was utilized as a proxy for ocean floor temperature, which is crucial for understanding lobster life cycles. While we aimed to investigate the potential impacts on lobster populations across Lobster Fishing Areas in PEI, time series data for bottom temperatures are often unavailable. Consequently, we relied on SST, recognizing that while it generally correlates with water depth, variations across LFAs may lead to discrepancies in the specific temperature conditions experienced by lobsters. This limitation should be acknowledged when interpreting the results in relation to spatial variations within the fishery.

Additionally, it is important to note that lobster larvae inhabit the upper water column before settling on the ocean floor, indicating that their life cycle is not entirely independent of SST. Landings per license were used as a proxy for relative lobster abundance due to the lack of consistent, long-term fishery-independent data. While this metric offers a practical and standardized measure over time, it does not directly reflect true population size and **may be influenced** (https://doi.org/10.1002/9781118517444.ch5) by changes in effort, fisher behavior, market, quota, gear efficiency, or other factors.

In PEI, the number of fishing days fluctuates annually due to weather conditions, and restrictions related to the presence of endangered species, such as North Atlantic whales, can further limit fishing opportunities. This reduction in available fishing days may impact landings, especially if fishermen start later in the season. On the other hand, access to credits and government subsidies for lobster

fishermen also influences harvesting. The interplay of increased SST, changes in the total number of fishing licenses, and stringent management regulations (such as carapace length requirements) may also have influenced annual landings in PEI in recent years.

The results between SST and landings should be interpreted with caution, and they should be interpreted as correlations, not direct causation. Regional ocean warming presents a complex picture for PEI lobster populations. Recent studies approve the impact of warming waters on lobster behavior, physiology, and range, as well as the challenges of the fisheries sector, including the potential loss of habitat suitability.

In PEI, a decline in stock is a potential consequence, but other scenarios may also emerge. Additionally, the specific impact of warming on lobster populations will likely be influenced by a multitude of interacting climate change factors beyond temperature alone. These factors include changes in ocean acidification, lower oxygen levels, shell disease, and prey availability, all of which can have significant effects on lobster physiology, behavior, and overall population health. Understanding how these various stressors interact with rising temperatures will be crucial for predicting the future of the PEI lobster fishery under a changing climate.

The lobster industry must prioritize adaptive measures that align with projected changes in ocean temperatures and ecosystem dynamics. These may include revising fishing quotas, diversifying target species, and enhancing habitat restoration efforts to mitigate the impact of warming on lobster populations. Furthermore, the development of predictive models and monitoring tools to track changes in lobster distribution, growth, and breeding patterns can provide valuable insights for sustainable resource management in PEI. By integrating adaptive management with long-term greenhouse gas (GHG) reduction efforts, the lobster industry can potentially address both immediate and future challenges.

Accurately forecasting future lobster stock dynamics remains a challenge. However, our findings on temperature sensitivity offer valuable insights into potential vulnerabilities. While rising temperatures under different emissions scenarios might initially benefit lobster populations in areas with suitable habitats, the long-term consequences of combined climate stressors require further investigation through more comprehensive models that incorporate these additional environmental factors.

Perspectives

The future of American lobster fisheries in PEI in the context of climate change is a complex and evolving issue that involves both opportunities and challenges. This study provides empirical evidence of a statistically significant relationship between SST and lobster landings in PEI, using a model that demonstrated significant lagged effects of SST, particularly for the months of August one and three years prior to landing, and the average SST eight years prior, corresponding with key biological periods in the lobster life cycle.

These findings suggest that past ocean temperatures have a quantifiable influence on current lobster landings, providing important insights for understanding how future ocean warming scenarios might impact the PEI lobster fishery. While the results highlight significant trends, and the model captured climate-related signals, its explanatory power is limited by data constraints and the absence of important policies and biological and environmental variables, indicating the need for more comprehensive analyses that incorporate additional key factors to fully assess long-term sustainability.

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