



# ESTUARY AND GULF OF ST. LAWRENCE NORTHERN SHRIMP (*PANDALUS BOREALIS*) STOCK STATUS UPDATE IN 2024

## CONTEXT

The Fishery management sector of Fisheries and Oceans Canada (DFO) has requested an update on the stock status of northern shrimp in the Estuary and Gulf of St. Lawrence (EGSL), as well as a harvest projections for the next fishing season based on the decision rules proposed as part of the review of the precautionary approach (PA).

This Science Response is from the regional peer review of November 28, 2024 on the Estuary and Gulf of St. Lawrence Northern Shrimp (*Pandalus borealis*) Stock Status Update in 2024.

## SCIENCE ADVICE

### Status

- In 2024, the stock status indicators for Sept-Iles, Anticosti and Esquiman are below their limit reference point (LRP) with very high or high probabilities, which places these stocks in the critical zone of the precautionary approach (PA).
- The Estuary stock status indicator is above the proposed upper stock reference (USR) in 2024 with a very high probability, placing this stock in the healthy zone of the PA.
- Relative exploitation rates for stocks are low in 2024 compared to their history.

### Trends

- The estimated relative biomasses for Sept-Iles, Anticosti and Esquiman have declined over the last two decades and have reached, for the past three years, the lowest values in the time series starting in 1990.
- The estimated relative biomass for Estuary has been high for the past four years, but the trend remains uncertain.
- The relative exploitation rates have decreased significantly over the last two years for Sept-Iles, Anticosti and Esquiman, while they remain low for Estuary.
- In general, the abundance of juveniles observed over the last five years was low in the four stocks.

### Ecosystem and Climate Change Considerations

- Although deep water temperatures have stabilized over the past two years, part of the northern shrimp population remains exposed to historically warm and depleted dissolved oxygen conditions.

Quebec Region

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- The impact of predation by redfish could decrease in the coming years, but remains at historically high levels.

**Stock Advice**

- According four decision rules proposed for these stocks, the projected harvests for 2025 are 1,425 t for Estuary, and vary between 0 and 807 t for Sept-Iles, between 0 and 885 t for Anticosti and between 0 and 1,171 t for Esquiman.

**BASIS FOR ASSESSMENT**

**Assessment Details**

**Year Assessment Approach was Approved**

This assessment follows the framework developed in 2023 during the review of the precautionary approach (DFO 2023, Bourdages et al. 2023, Smith and Bourdages 2024).

**Assessment Type**

Interim-Year Update

**Most Recent Assessment Date**

1. Last Full Assessment: January 2022 (DFO 2022, Bourdages et al. 2022)
2. Last Interim-Year Update: October 2023 (DFO 2023)

**Stock Assessment Approach**

1. Broad category: Data-poor
2. Specific category: Surplus Production model

**Stock Structure Assumption**

Results from a recent genomics study suggest that northern shrimp from the EGSL form a different population from adjacent populations on the Scotian Shelf and Newfoundland/Labrador/Arctic (Bourret et al. 2024). These results show reduced connectivity between these three populations.

Other results also suggest that there are distinct biological components within the EGSL. The results of the population genomics study show that connectivity seems limited between certain stocks in the EGSL, and more particularly between Esquiman and the other stocks further west (Bourdages et al. 2023).

**Reference Points**

- Limit Reference Point (LRP): 0.4 (40%) of  $B_{MSY}$  (biomass at maximum sustainable yield)
- Upper Stock Reference (USR): 0.8 (80%) of  $B_{MSY}$
- Target Reference Point (TRP):  $B_{MSY}$
- Removal Reference (RR): Not defined

### Harvest Control Rules

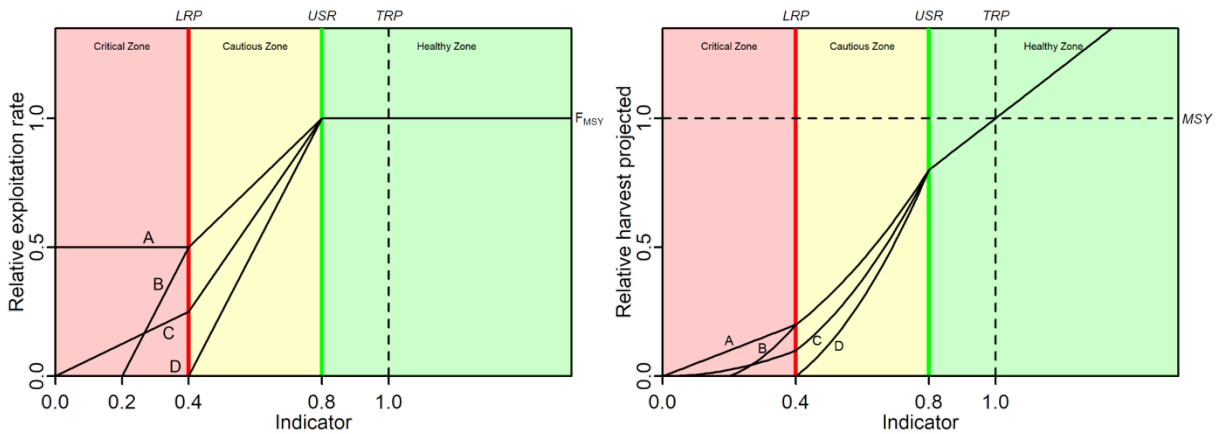


Figure 1. Four proposed harvest control rules (HCR) presenting relative exploitation rate ( $F/F_{MSY}$ , left) and relative projected harvest (right) as a function of the stock status indicator ( $B/B_{MSY}$ ). The reference points are presented on the panels by the vertical lines which define the three zones of the PA.

### Data

- Commercial landings: 1982–2024
- Annual ecosystem survey of the northern Gulf of St. Lawrence: 1990–2024 for assessment units Sept-Iles, Anticosti and Esquiman, and 2008–2024 for Estuary.

## ASSESSMENT

## Stock Status and Trends for Estuary

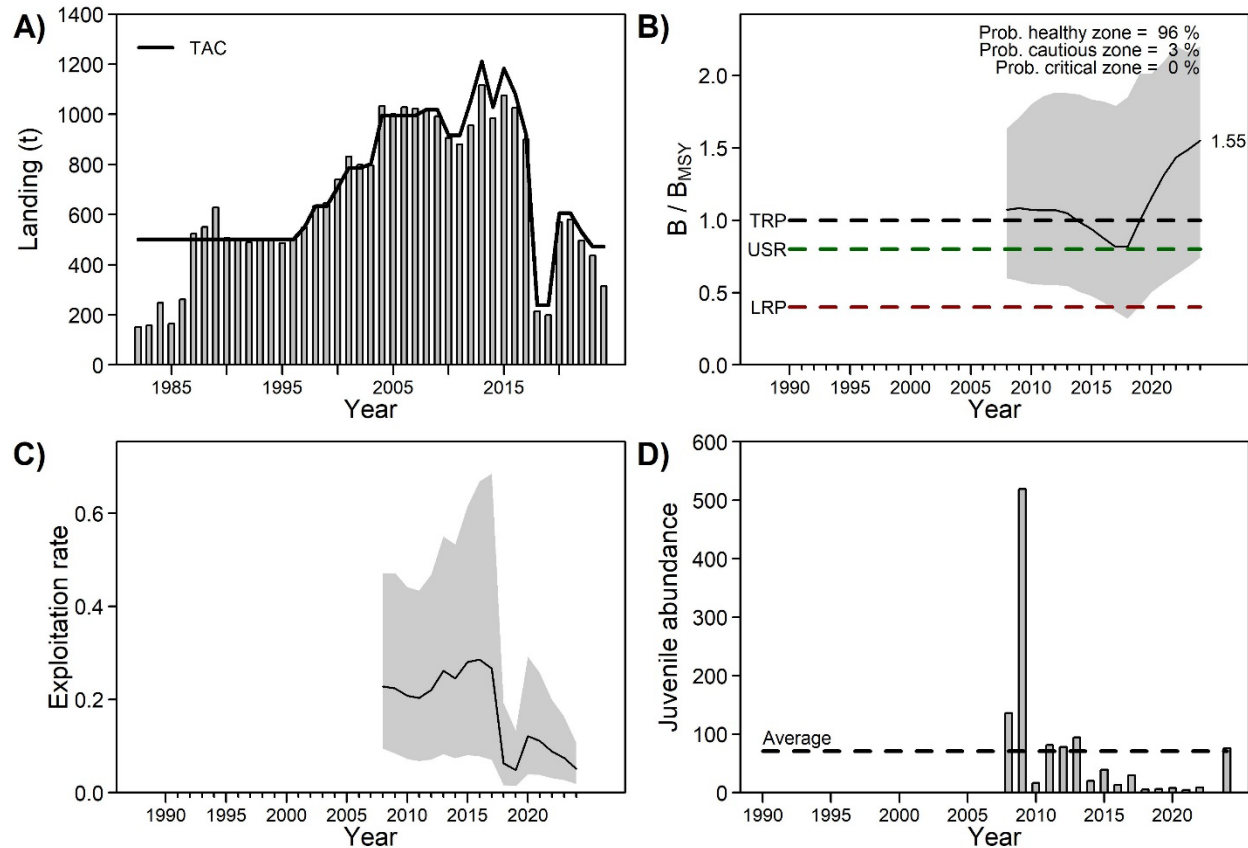


Figure 2. Estuary assessment unit. (A) Landings and total allowable catches, (B) stock status indicator ( $B/B_{MSY}$ ), (C) relative exploitation rate, (D) juvenile abundance (in millions, data not available in 2023).

### Biomass

The estimated relative biomass has been increasing since 2019, reaching since 2022 the highest values in the entire time series starting in 2008 (Figure 2B). In 2024, biomass is above the URS and is estimated at 1.55 times the  $B_{MSY}$ .

### Exploitation rate

The relative exploitation rate decreased significantly in 2018 and has remained low since (Figure 2C).

### Recruitment

The abundance of juvenile shrimp has been low over the past ten years with the exception of 2024 when it is average (Figure 2D). The relationship between recruitment and subsequent biomass is uncertain.

### Outlook

The Estuary stock is currently above the USR and is therefore in the healthy zone of the PA, with a probability of 96%, but the trend remains uncertain.

Stock Status and Trends for Sept-Iles

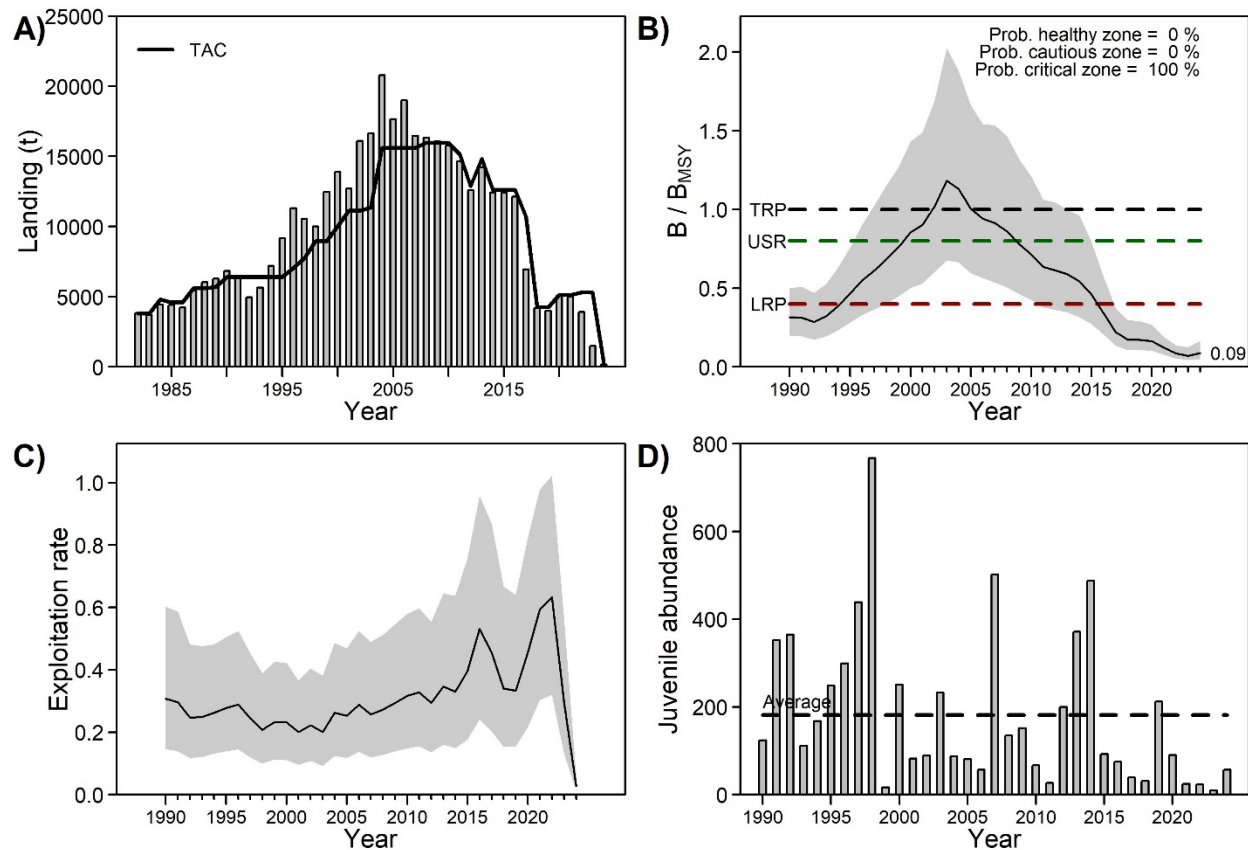


Figure 3. Sept-Iles assessment unit. (A) Landings and total allowable catches, (B) stock status indicator ( $B/B_{MSY}$ ), (C) relative exploitation rate, (D) juvenile abundance (in millions).

**Biomass**

Since 2004, the estimated relative biomass has declined, reaching since 2022 the lowest values of the entire time series starting in 1990 (Figure 3B). The biomass is in the critical zone since 2016 and in 2024, it is estimated at 0.09 of the  $B_{MSY}$ , or 23% of the LRP.

**Exploitation rate**

The trend of increasing relative exploitation rates since 2005 reversed in 2023. Since then, the exploitation rate has declined to reach a low value in 2024 (Figure 3C).

**Recruitment**

The abundance of juvenile shrimp has been low for the past five years (Figure 3D).

**Outlook**

The Sept-Iles stock is currently below the LRP and therefore in the critical zone of the PA, with a probability of 100%.

Stock Status and Trends for Anticosti

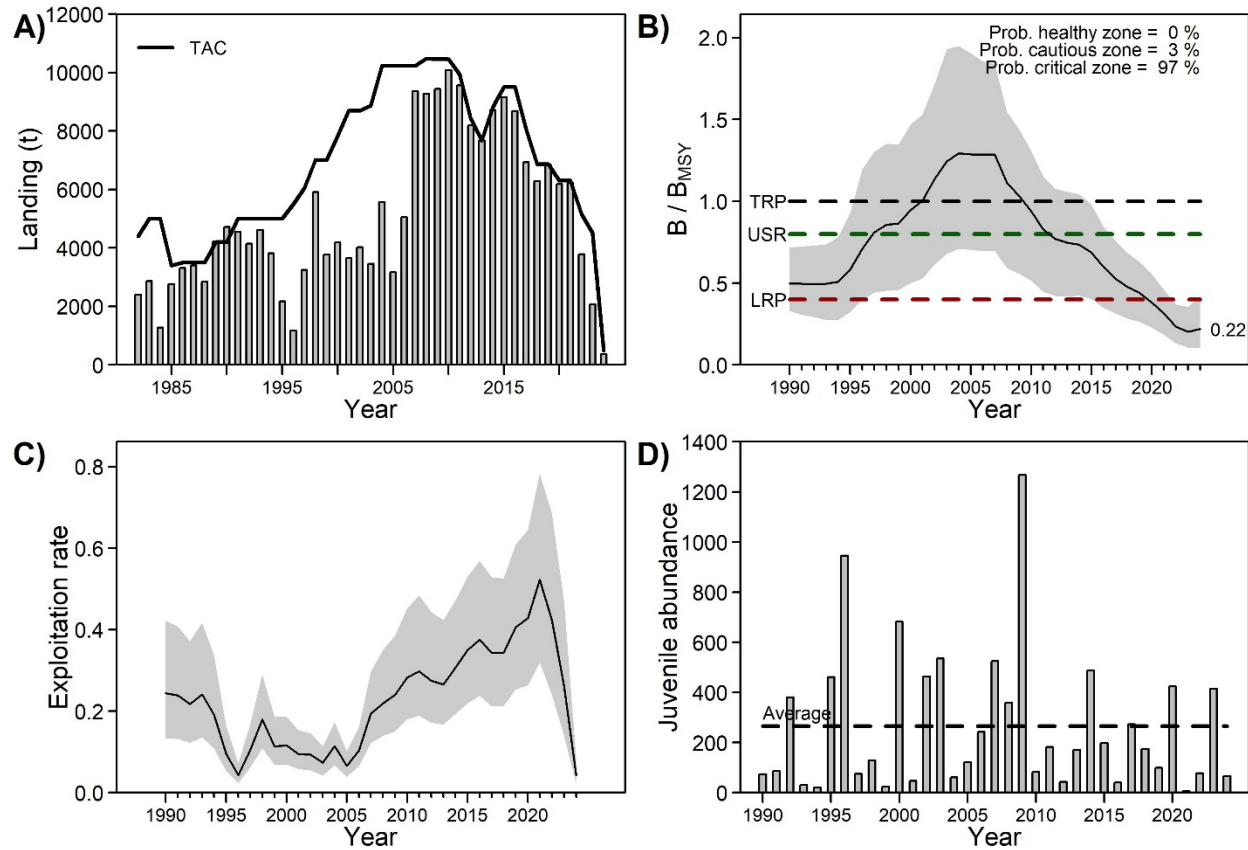


Figure 4. Anticosti assessment unit. (A) Landings and total allowable catches, (B) stock status indicator ( $B/B_{MSY}$ ), (C) relative exploitation rate, (D) juvenile abundance (in millions).

**Biomass**

Since 2008, the estimated relative biomass has declined, reaching since 2022 the lowest values of the entire time series starting in 1990 (Figure 4B). The biomass is in the critical zone since 2020 and in 2024, it is estimated at 0.22 of the  $B_{MSY}$ , or 55% of the LRP.

**Exploitation rate**

The trend of increasing relative exploitation rates since 2005 reversed in 2022. Since then, the exploitation rate has declined to reach a low value in 2024 (Figure 4C).

**Recruitment**

Juvenile shrimp abundance has been low in the last four years with the exception of 2023 (Figure 4D). The juvenile abundance observed in 2023 could explain the increase in total biomass of the stock in 2024.

**Outlook**

The Anticosti stock is currently below the LRP and therefore in the critical zone of the PA, with a probability of 97%.

**Stock Status and Trends for Esquiman**

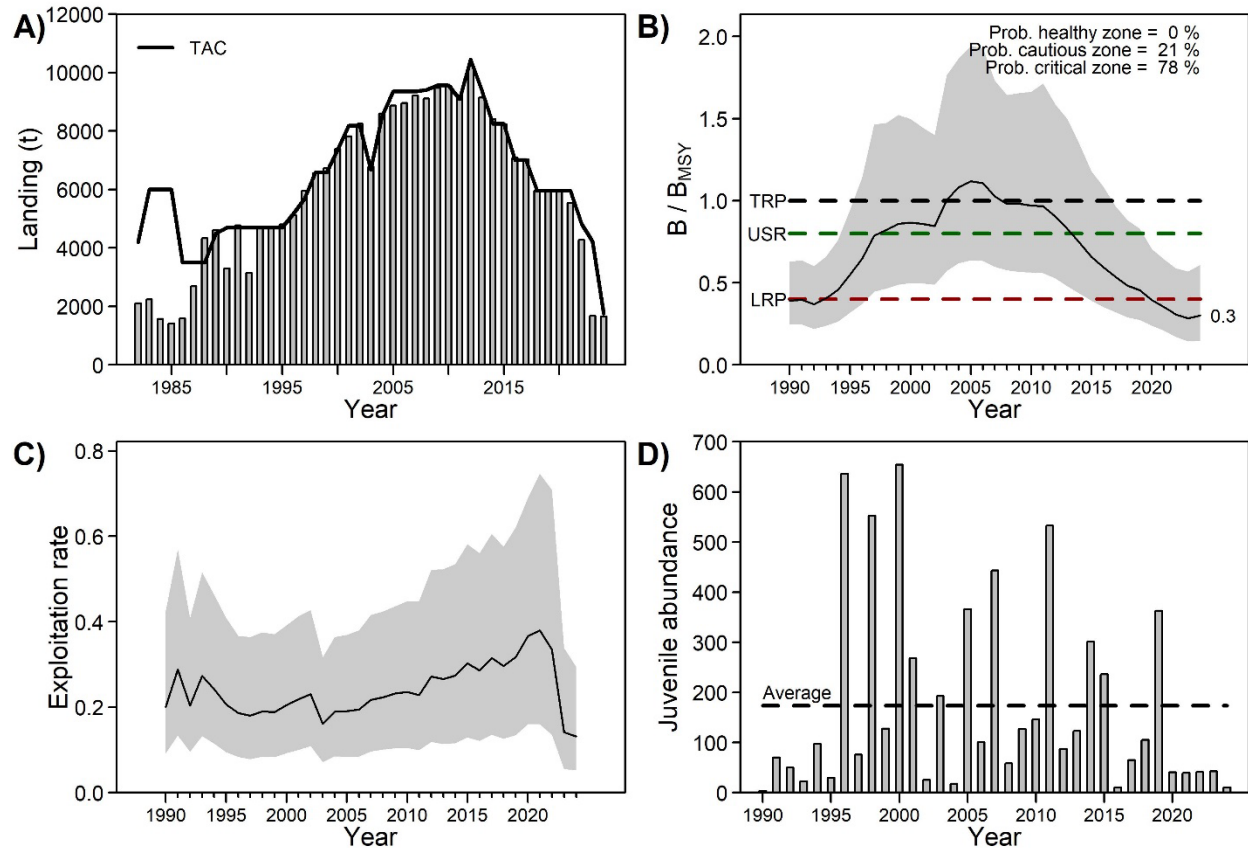


Figure 5. Esquiman assessment unit. (A) Landings and total allowable catches, (B) stock status indicator ( $B/B_{MSY}$ ), (C) relative exploitation rate, (D) juvenile abundance (in millions).

**Biomass**

Since 2007, the estimated relative biomass has declined, reaching the lowest values since 2022 of the entire time series starting in 1990 (Figure 5B). The biomass is in the critical zone since 2020 and in 2024, it is estimated at 0.30 of the  $B_{MSY}$ , or 75% of the LRP.

**Exploitation rate**

The trend of increasing relative exploitation rates since 2005 reversed in 2022. Since then, the exploitation rate has declined to reach a low value in 2024 (Figure 5C).

**Recruitment**

The abundance of juvenile shrimp has been low for the past five years (Figure 5D).

**Outlook**

The Esquiman stock is currently below the LRP and therefore in the critical zone of the PA, with a probability of 78%.

## History of Landings

Landings of northern shrimp in the EGSL gradually increased from nearly 1,000 metric tons (t) at the start of exploitation in the 1970s to more than 35,000 t in the late 2000s. Landings have subsequently declined to 5,673 t in 2023 and 2,509 t in 2024 (preliminary data as of October 31), out of overall total allowable catches (TAC) of 14,524 t and 3,060 t, respectively. Landings in 2024 are the lowest since 1974.

Preliminary statistics indicate landings in 2023 and 2024 of 437 t and 314 t in Estuary (TAC of 473 t), 1,481 t and 170 t in Sept-Iles (TAC of 5,304 t and 342 t), 2,078 t and 366 t in Anticosti (TAC of 4,525 t and 488 t), and 1,677 t and 1,660 t in Esquiman (TAC of 4,222 t and 1,757 t) (Table 1). As of October 31, 2024, the percentage of TAC achieved was 66% in Estuary, 50% in Sept-Iles, 75% in Anticosti and 94% in Esquiman. As the fishing season is not yet over, these landings could be revised upwards.

Table 1. Landings (t), fishing effort (hours) and catch per unit of effort (CPUE, kg/h) by assessment unit for Estuary (12), Sept-Iles (10), Anticosti (9) and Esquiman (8). The statistics presented are annual averages by decade or by year.

Year	Landings (t)				Effort (hours)				CPUE (kg/h)			
	12	10	9	8	12	10	9	8	12	10	9	8
<b>1982-1989</b>	336	4801	2887	2572	4634	51290	24670	16881	72	94	117	152
<b>1990-1999</b>	532	8463	3814	4976	3227	61359	23685	20986	165	138	161	237
<b>2000-2009</b>	926	16570	5721	8444	2587	56561	17025	18337	358	293	336	461
<b>2010-2019</b>	826	10939	8212	8080	3257	42817	26570	15379	254	255	309	525
<b>2020</b>	570	5101	6182	5992	1438	22388	22536	10440	396	228	274	574
<b>2021</b>	579	4982	6233	5535	1769	21561	25796	13115	327	231	242	422
<b>2022</b>	496	3909	3784	4276	749	21616	19457	13850	663	181	194	309
<b>2023</b>	437	1481	2078	1677	1400	17720	18288	8473	312	84	113	198
<b>2024</b>	314	170	366	1660	1442	2169	1861	7145	218	78	197	232

## Ecosystem and Climate Change Considerations

Predation pressure from redfish on northern shrimp was high over the past eight years (Senay et al. 2023) and is considered to be a major factor contributing to the decline of northern shrimp. In 2023, the biomass of *S. mentella* was estimated at 2.3 million tons in the EGSL, compared to less than 100,000 tons prior to 2013 (DFO 2024). Although the biomass of redfish has been decreasing since 2020, predation pressure is expected to remain at historically high levels in the coming years.

For the past 15 years, northern shrimp in the EGSL have been exposed to warming and depletion of dissolved oxygen (DO) in their habitat. In 2022–2024, at least 50% of the biomass of female shrimp in the Sept-Iles, Anticosti and Esquiman stocks were exposed to DO levels below 31%, 26% and 24% respectively, while a quarter of the biomass was exposed to DO levels below 25%, 21% and 22% respectively, and to temperatures above 6.3°C, and even 7°C in some places (Figure 6). A significant proportion of the stocks is therefore exposed to DO levels corresponding to critical thresholds observed in the laboratory (Dupont-Prinet et al. 2013). A recent study, that evaluated the impact of warming, acidification and hypoxia in the laboratory, shows that the survival and aerobic performance of shrimp could decrease considerably when exposed to these combined factors (Guscelli et al. 2023).



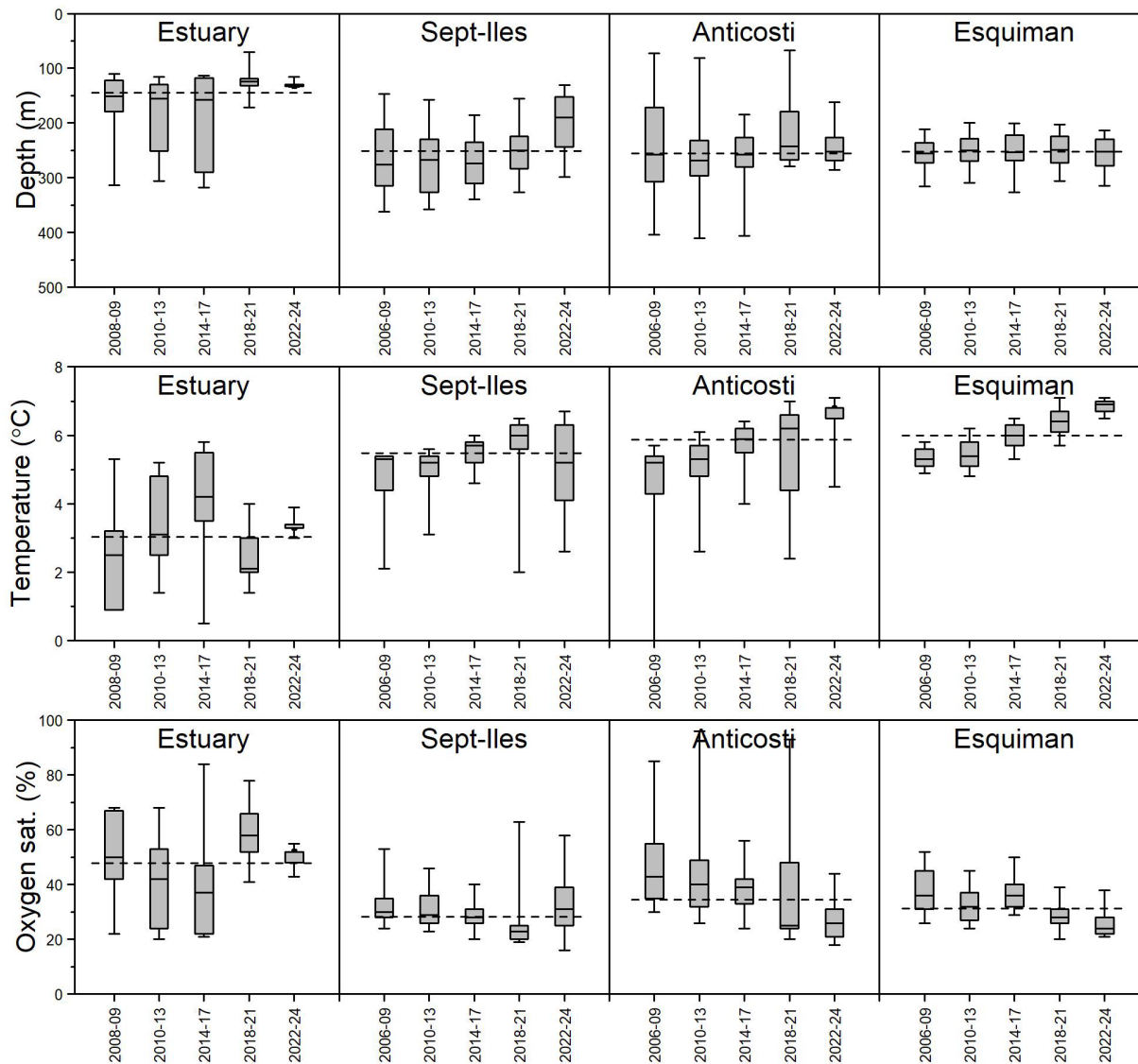


Figure 6. Female shrimp biomass distribution based on bottom-water depth, temperature and dissolved oxygen saturation per four-year period from the August DFO survey in the Estuary and the northern Gulf from 2006 to 2024 (2008 to 2024 in the Estuary).

**Stock Advice**

The perspectives for these stocks depend on the sensitivity and resilience of northern shrimp to environmental changes, predation pressure and fishing pressure. Current unfavourable conditions for northern shrimp, such as warming and oxygen depletion observed in deep waters, as well as high predation pressure by redfish, are not expected to improve significantly in the short to medium term.

The changes observed in the ecosystem indicate an increased risk of consequences for the sustainability of northern shrimp stocks and, consequently, for the ecosystem given its role as a forage species. The risk to the sustainability of shrimp stocks is currently greater than in the 1990s and early 2000s.

**Results of Harvest Control Rules**

According four proposed harvest control rules, the projected harvests for 2025, according to the 35th percentile rule, are 1,425 t for Estuary and vary between 0 and 807 t for Sept-Iles, between 0 and 885 t for Anticosti, and between 0 and 1,171 t for Esquiman (Table 2).

Table 2. Median and 35<sup>th</sup> percentile of the distribution of projected harvests for 2025 (t) per stock assessment unit under different harvest control rules (HCR).

HCR	$F_{2025}/F_{MSY}$	Projected harvest 2025 (t)	
		Median	35 <sup>e</sup> percentile
Estuary ( $B_{2025}/B_{MSY} = 1.51$ )			
A	1.00	1 652	1 425
B	1.00	1 652	1 425
C	1.00	1 652	1 425
D	1.00	1 652	1 425
Sept-Iles ( $B_{2025}/B_{MSY} = 0.13$ )			
A	0.50	948	807
B	0.00	0	0
C	0.08	158	135
D	0.00	0	0
Anticosti ( $B_{2025}/B_{MSY} = 0.29$ )			
A	0.50	993	885
B	0.22	434	386
C	0.18	357	318
D	0.00	0	0
Esquiman ( $B_{2025}/B_{MSY} = 0.34$ )			
A	0.50	1 384	1 171
B	0.35	958	810
C	0.21	586	495
D	0.00	0	0

**SOURCES OF UNCERTAINTY**

There are several uncertainties associated with estimating annual consumption of northern shrimp by redfish. Although this predation is known to be one of the important causes contributing to the decline of stocks, the magnitude and severity of this effect are unknown. However, the biomass of *S. mentella* in the EGSL has been declining in recent years, though it remains at historically high levels. The impact of predation could therefore decrease in the coming years but remains high.

The deep waters of the EGSL have warmed and depleted in DO in recent years (Blais et al. 2024, Galbraith et al. 2024). These changes expose part of the northern shrimp population to environmental conditions approaching the tolerance limits of the species and likely affect stock productivity. These conditions could continue to deteriorate in the long term according to different climate change models (Lavoie et al. 2020).

In Estuary, the adjustment of the surplus production model is more uncertain than the other stocks due to the shorter time series, the absence of a survey in 2023, and the uncertainty associated with the survey biomass estimates. The stock status trajectory is uncertain removal projections by the model exceed the values used for model fit. These factors contribute to an unquantified risk of overexploitation associated with projected harvests.

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