

C. NORTHERN SHRIMP ASSESSMENT SUMMARY FOR 2014

State of the Stock

Overfishing and overfished status could not be determined for the northern shrimp (*Pandalus borealis*) stock in the Gulf of Maine. The ASMFC Summer Shrimp Survey biomass index is at record low levels based on data since 1984. The 2013 northern shrimp landings were 49% of the established quota, and were also the lowest since 1984. Catch-per-unit-effort (pounds per trap and trawl pounds per trip) also reflects the same trend (lowest on record since 1991).

Several key indices are at or near record lows for their respective time series (e.g., survey biomass index, survey recruitment index, commercial landings, and CPUE); this suggests that the northern shrimp stock is very low presently, and there is considerable uncertainty about when it might increase.

Projections

Projections would not be conducted for northern shrimp, as recruitment is highly variable and environmentally driven, making projections unreliable even over a short time frame. The assessment has been updated annually for management purposes.

Catches

Annual landings of Gulf of Maine northern shrimp (Figure C1) declined from an average of 11,400 mt (25.1 million pounds) during 1969-1972 to about 400 mt (0.89 million pounds) in 1977, culminating in a closure of the fishery in 1978. The fishery reopened in 1979 and landings increased steadily to over 5,000 mt (11 million pounds) by 1987. Landings ranged from 2,300 to 6,400 mt (5.1-14.1 million pounds) during 1988-1995, and then rose dramatically to 9,500 mt (21 million pounds) in 1996, the highest since 1973. Landings declined to an average of 2,000 mt (4.4 million pounds) for 1999 to 2001, and dropped further in the 25-day 2002 season to 450 mt (1 million pounds), the lowest northern shrimp landings since the fishery was closed in 1978. After 2002, landings generally increased, reaching another peak of around 6,000 mt (13.2 million pounds) in 2010 and 2011. Preliminary landings (not accounting for late reporting) in 2013 declined to 306 mt (0.67 million pounds), which was 49% of the TAC set by ASMFC for 2013. The fishery was closed before the TAC was reached to prevent an extended season that would harvest undersize males.

Limited observer coverage indicates discarding is negligible in both the directed shrimp fishery and non-directed finfish fisheries in the Gulf of Maine. Therefore, reported landings reflect total fishery removals.

Commercial CPUE of northern shrimp has declined in the last few years to near records lows for the time series (Figure C2).

Stock Distribution and Identification

Northern shrimp inhabit boreal waters of the North Atlantic and Arctic Oceans. In the Gulf of

Maine, they are at the southern extent of their range. The population in the Gulf of Maine is thought to be a single stock that does not mix with other populations further north. Northern shrimp undergo seasonal, sex-specific migration inshore and offshore. Juveniles remain in coastal waters for a year or more before migrating to deeper offshore waters, where they mature as males. The males pass through a series of transitional stages before maturing as females. Egg-bearing females move inshore in late autumn and winter, where the eggs hatch. Females are targeted in the Gulf of Maine fishery.

Data and Assessment

The northern shrimp assessment explored three different models that used total landings, catch at length, proportion female at length, and two fishery independent indices, the ASMFC summer shrimp survey and the NEFSC fall bottom trawl survey.

The proposed model for northern shrimp was a forward-projecting size-structured model (UME model) developed by the University of Maine in conjunction with the northern Shrimp Technical Committee. As a complement, a Collie-Sissenwine Analysis (CSA) and a surplus production model (ASPIC) were also run to estimate biomass and fishing mortality.

None of the proposed stock assessment models were accepted to serve as a basis for management. The UME size structured model did not fit catch and survey length composition and survey indices sufficiently well. The CSA was sensitive to the data weighting schemes resulting in inconsistent determination of overfishing status. The ASPIC model was unable to respond to the highly variable recruitment of northern shrimp, resulting in an extreme retrospective pattern and making estimates of F and B in the terminal year unreliable. Given that these models were not accepted, this report provides survey indices in lieu of model estimates for recruitment and biomass.

Biological Reference Points

Biological reference points for northern shrimp calculated in the last assessment and currently used as thresholds in management are historical proxies for F and exploitable biomass based on estimates of average F and average exploitable biomass from the CSA model during a time when both landings and biomass were considered stable (1985-1994).

For SARC 58 in 2014, new biological reference points were proposed but were not accepted.

Fishing Mortality

The estimates of fishing mortality were too sensitive to model configuration and were not accepted for use in fishery management.

Recruitment

Northern shrimp recruitment is affected by both spawning stock size and environmental conditions. Warmer waters lead to poorer recruitment. The recruitment index in 2013 was the lowest in the time series at 1 shrimp per tow, and the 2012 index was only slightly higher at 7 shrimp per tow, compared to the time series (1984-2013) mean recruitment index of 367 shrimp

per tow (Figure C3). The 2011 index was also relatively low, at 44 shrimp per tow, representing three successive poor year classes.

Stock Biomass and Abundance

The biomass index from the summer shrimp survey has declined since 2008 and reached a time series (1984-2013) low (1.0 kg per tow) in 2013 relative to a time series average of 12.9 kg per tow (Figure C4). The 2012 biomass index was the second lowest in the time series (2.5 kg/tow).

Trends in the index of total abundance from the summer shrimp survey showed the same patterns, with the 2013 index being the lowest in the time-series at 27 shrimp per tow, and the 2012 index being the second lowest at 138 shrimp per tow (Figure C4). The time-series average is 1,458 shrimp per tow.

Trends in the NEFSC fall survey since 2009 have also indicated a major decline in biomass.

Special Comments

1) Gulf of Maine northern shrimp is a short-lived species with highly variable recruitment which is influenced by environmental conditions. As a result, this is a difficult species to assess. Changing environmental conditions in the Gulf of Maine may exacerbate this problem and make sustainable management more difficult.

2) CSA model: The analytical extensions to the CSA model represent a step forward, but the application to northern shrimp was not accepted because of sensitivity to weighting of data inputs and lack of robustness regarding determination of stock status. Incorporation of other data types, including effort, catch rate and environmental drivers, represent logical and promising steps for future development.

3) UME model: A size-based model like the UME model is most appropriate for difficult-to-age species. However, the application to northern shrimp needs to be further developed as it is not ready for management use.

4) ASPIC model: The high variability of recent recruitment in this stock cannot be accommodated by this model type. Given this recent variability, the ASPIC model should not be used at this time for assessment of the Gulf of Maine northern shrimp stock.

5) The SARC 58 (in 2014) review panel did not peer review previous northern shrimp assessments. The SARC 58 recommendations and comments apply solely to the models and updated data presented in this most recent northern shrimp assessment. Between SARC 45 (in 2007) and SARC 58 the northern shrimp population experienced the highest and lowest recruitment on record, which contributed to difficulties in the SARC 58 assessment.

References

45th Northeast Regional Stock Assessment Workshop (45th SAW). 2007. 45th SAW assessment summary report. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 07-11; 37 p.

Total Catch of Northern Shrimp (thousands of metric tons; 1 mt = 2,205 lbs)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Min ¹	Mean ¹	Max ¹
Commercial Harvest	2.1	2.6	2.3	4.9	5.0	2.5	6.1	6.4	2.5	0.3	0.3	3.7	9.5
Commercial Discards	Assumed to be zero for this assessment.												

¹: Minimum, mean, and maximum catch are based on 1984-2013 data.

Current Status of Northern Shrimp Based on the ASMFC Summer Shrimp Survey Indices

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Min ²	Mean ²	Max ²
Biomass (kg per tow)	10.3	23.4	66.0	11.5	16.8	15.4	13.9	8.6	2.5	1.0	1.0	12.9	12.9
Total Abundance (numbers per tow)	887	3,661	9,998	887	1,737	1,627	1,373	830	138	27	27	1,458	9,998
Recruitment (numbers per tow)	286	1,752	374	28	506	555	475	44	7	1	1	367	1,752

²: Minimum, mean, and maximum are derived from the entire 1984-2013 time-series

Reference Point	SARC 45 (2007)	
	Definition	Value
F_{Threshold}	Maximum F during stable period (1985-94)	0.48 ³
F_{Target}	Average F during stable period (1985-94)	0.38 ³
B_{Threshold}	0.5*Average B during stable period (1985-1994)	9,000 mt
B_{Limit}	2,000 mt less than lowest value estimated by ASPIC model	6,000 mt

³: F reference points estimates are updated at each annual assessment update; these values are from the 2013 update. Assessment models presented at SARC 58 (in 2014) were not accepted. For this reason, SARC 58 does not provide new reference points.

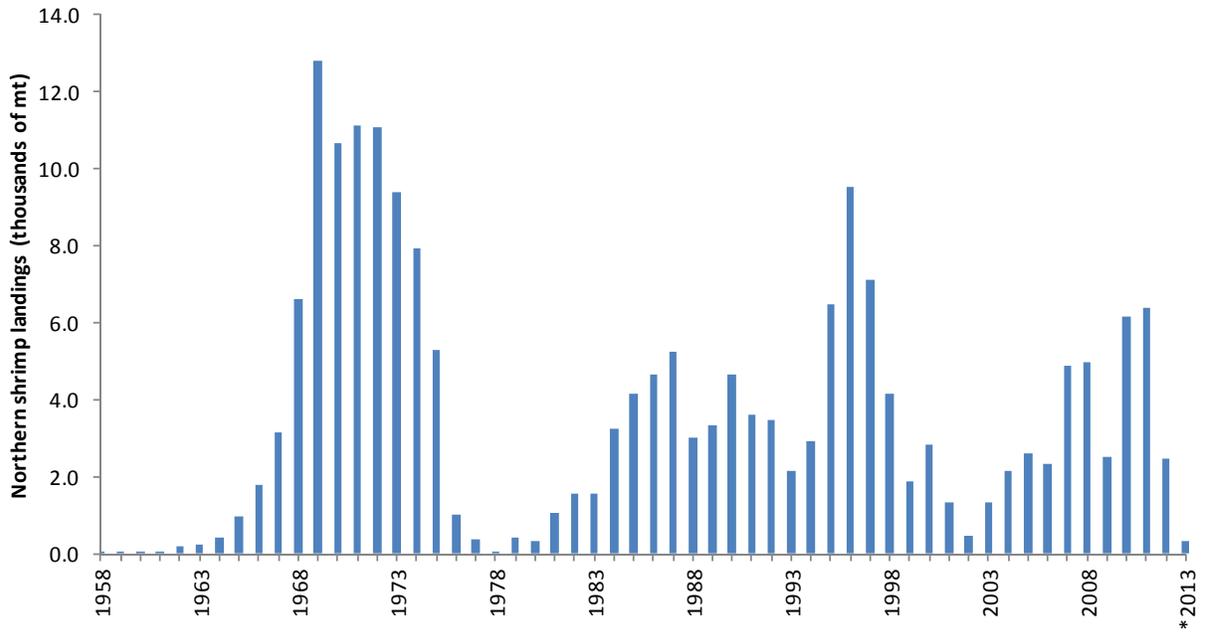


Figure C1. Commercial landings of northern shrimp in the Gulf of Maine. *: 2012 and 2013 data are preliminary and may change.

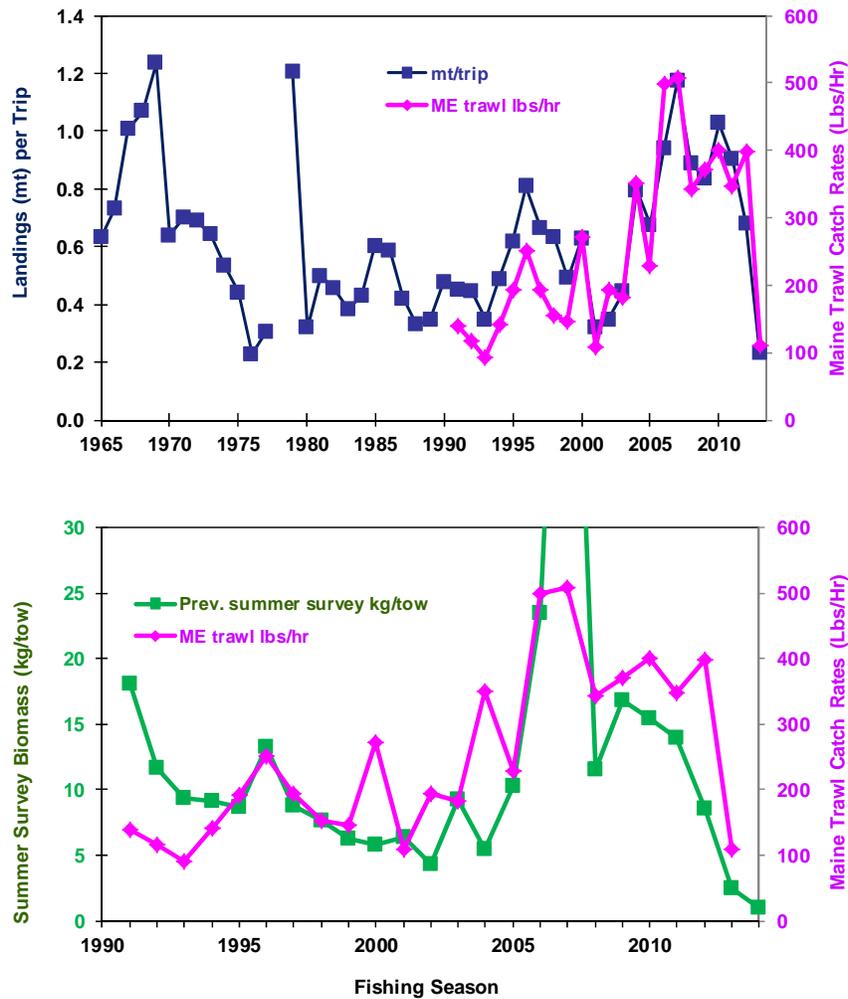


Figure C2. Commercial CPUE of northern shrimp in metric tons per trip (all states and gears combined) plotted with Maine trawl pounds per hour (top), and Maine trawl lbs/hr plotted with the summer survey index (kg/tow) for the summer prior to the fishing season (bottom). 2012 and 2013 CPUE data are preliminary.

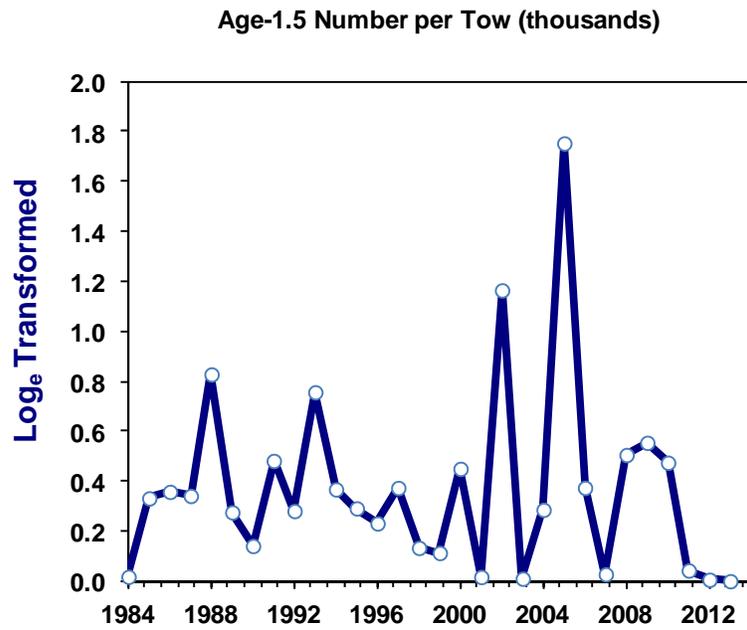


Figure C3. Recruitment index for northern shrimp from the ASMFC summer shrimp survey.

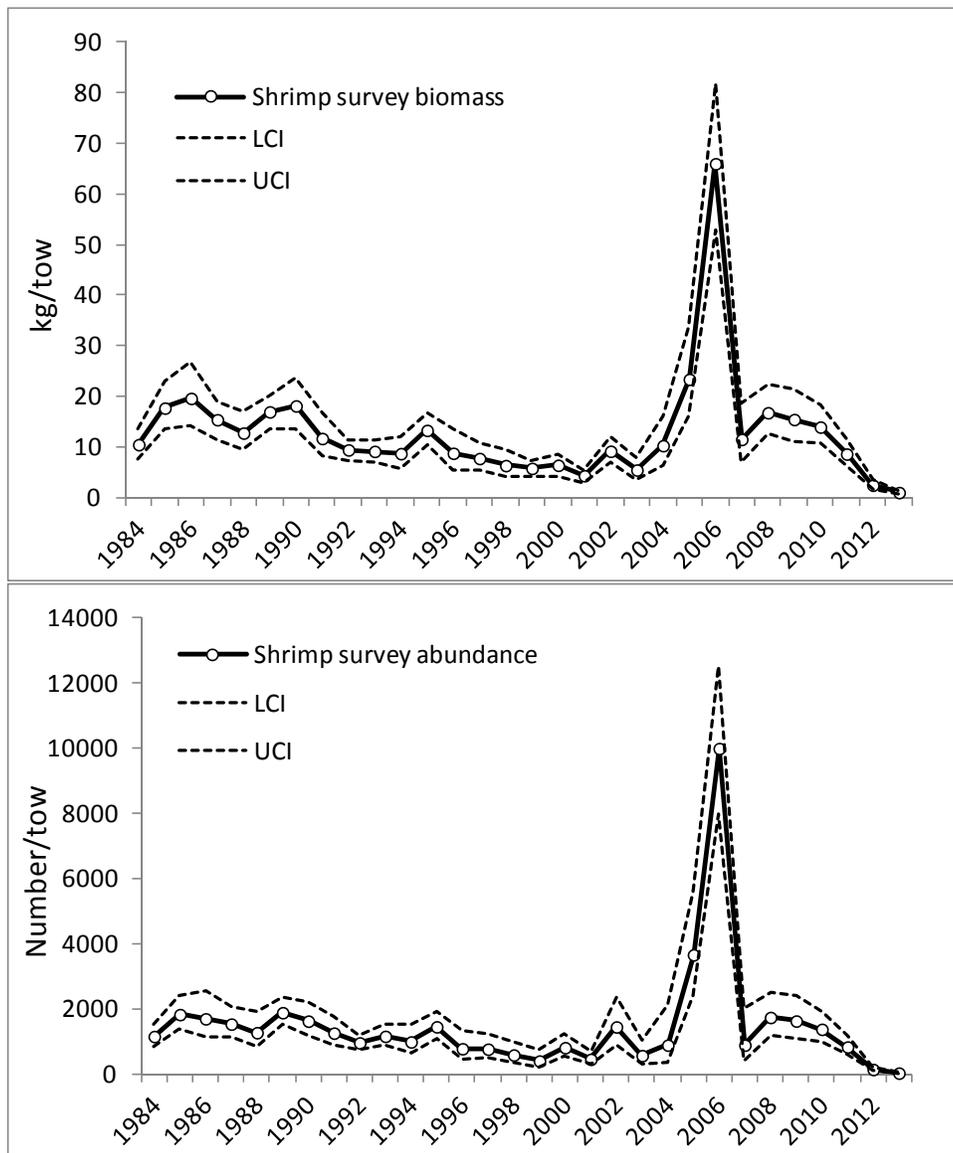


Figure C4. Northern shrimp survey indices of total biomass (top) and total abundance (bottom) with 95% confidence intervals from ASMFC summer shrimp survey.