Estimating Seasonal Harbor Seal Abundance for Virginia from Haul-out Survey and Tagging Data

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INTRODUCTION

- Harbor seal distribution along the United States (U.S.) east coast has expanded to the mid-Atlantic in recent decades, possibly due to rapid growth of gray seal populations in Canada and northeastern U.S. [1]; [2]; [3].
- From 2014-2025, the U.S. Navy conducted haul-out counts, photo-ID, and satellite tagging in the lower Chesapeake Bay and coastal waters of Virginia (VA) (Figure 1) to assess harbor seal occurrence, habitat use, haul-out behavior and abundance.
  - Harbor seals were observed returning seasonally (fall to spring) to VA haul-out locations [4], which are near important areas for Navy training and testing activities.
- With this suite of data, the first seasonal abundances for harbor seals in VA were estimated using various methods.
- **Improved understanding of this regional population and harbor seal distribution along the U.S. east coast will contribute to analyzing potential impacts of military readiness activities on pinnipeds.**

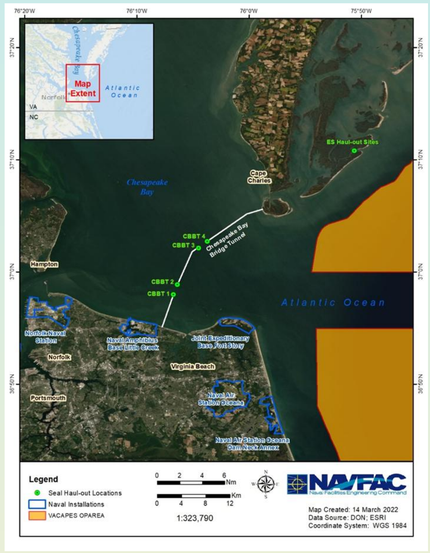


Figure 1. CBBT and ES haul-out locations and nearby U.S. Naval installations. VACAPES OPAREA= Virginia Capes Range Complex Operating Area

METHODS: DATA SOURCES

- Haul-out surveys were conducted annually, from fall to spring, at two survey areas in southeastern VA (Figure 1):
  1) Lower Chesapeake Bay along the Chesapeake Bay Bridge Tunnel (CBBT), on the four rock armor " islands", from 2014-2025 (Figure 2)
  2) Southern region of the Eastern Shore (ES); several haul-out sites within a tidal salt marsh habitat, from 2016-2025 (Figure 3)
- Systematic counts of seals (hauled out and in water) were conducted during each survey at the CBBT and ES.
  - Images of seals were collected between counts for photo-ID and mark-recapture analyses.
- Used 2016-2025 count and photo-ID data for abundance analyses to capture full geographic extent of local population.
- Satellite tags (with wet/dry switches) were deployed on 14 harbor seals (Figure 3) that were captured at the ES survey area from 2018-2022 [5].
  - Analyzed % time a seal spent dry per hour (during daytime) while in VA waters to account for seals submerged during haul-out counts and possibly missed by observers.



Figure 2. A group of harbor seals hauled out near the tip of one of the CBBT islands. Photo taken under NMFS General Permit # 19826



Figure 3. Tagged harbor seal captured/released at an ES haul-out site. Photo taken under NMFS-NEFSC Permit # 21719

METHODS: ABUNDANCE ESTIMATION

- Estimated seasonal population abundance **(N)** of harbor seals for the study area (including CBBT and ES) using two approaches.

1) Mark-recapture Approach

- Used photo-ID data to fit a Chapman modified Lincoln-Petersen mark-recapture model.
- For each season, sighting histories for identified individuals were divided into 2 sampling periods: mark (n_1) and recapture (n_2).

$$N = \left((n_1+1) * (n_2+1)/(m_2+1)\right) - 1$$

n_1= # of seals identified during mark sampling period
n_2= # of seals identified during recapture sampling period
m_2= total # of seals sighted during both periods

2) Telemetry Correction Factor Approach

- Calculated total mean seal count (n) for the study area for each season and for all 9 seasons to get an average abundance.
- Applied a telemetry correction factor based on the mean proportion of time seals spent ashore (h) at VA haul-out sites [6].
- The reciprocal of (h) accounts for seals in the water.
- Assumed haul-out activity did not vary among years, so applied (h) to each season's mean count.

$$N = n/h$$

n = mean seal count during field season
h = mean proportion of time seals were hauled out during sampling period

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RESULTS

Mark-recapture Approach:

- Total of 221 harbor seals were uniquely identified via photo-ID for the study area (Figure 4).
- 2019-2020 season: lowest number of marks (n_1) and recaptures (n_2), resulting in the lowest abundance estimate (Table 1). Probably due to less survey effort for this season.
- Highest number of marks and recaptures recorded for the 2016-2017 and 2022-2023 seasons. The 2016-2017 season had the highest amount of survey effort.
- Abundance estimate range: 35 (95% CI: 4.56-65.44) to 131 (95% CI: 78.9-182.85) individuals (Table 1; Figure 5)

Table 1. Number of harbor seals identified during mark (n1) and recapture (n2) sampling periods and total number of harbor seals sighted during both periods (m2) from 2016-2025. CI= confidence interval

Field Season	n1	n2	m2	Estimated Abundance	95% CI for Abundance
2016-2017	28	49	10	131	78.79 - 182.85
2017-2018	6	30	1	108	6.88 - 208.12
2018-2019	12	11	1	77	2.69 - 151.31
2019-2020	5	11	1	35	4.56 - 65.44
2020-2021	31	34	11	92	59.73 - 124.93
2021-2022	23	28	6	98	47.79 - 149.06
2022-2023	26	56	19	76	62.41 - 89.49
2023-2024	16	35	9	60	40.43 - 79.97
2024-2025	26	44	12	92	62.66 - 122.27

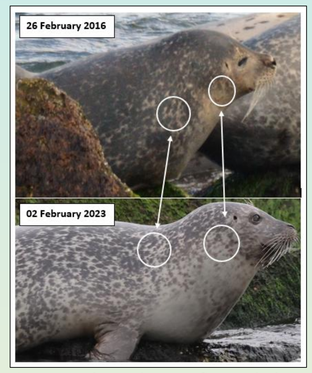


Figure 4. Harbor seal, CB047, first marked on 26 February 2016 and re-sighted across 8 field seasons

Telemetry Correction Factor Approach:

- Harbor seals spent a mean proportion of time (h) of 0.18 daylight hours hauled out while in VA waters.
- Mean counts for 2016-2025 ranged from 11.4 (SE=3.1) to 23.3 (SE=3.4) (Table 2).
  - Fluctuation in counts possibly due to variability in seal presence and/or survey effort across seasons.
  - 2017-2018 season: highest mean counts for CBBT and ES, resulting in an overall, higher mean count for study area.
- Abundance estimate range: 62 (95% CI: 34.54-89.23) to 126 (95% CI: 94-158.4) individuals (Table 2; Figure 5)
- Mean estimate of 82 individuals for all 9 seasons

Table 2. Mean counts of harbor seals for the study area from 2016-2025 and resulting abundance estimates calculated for each season using a telemetry correction factor. SE= standard error. CI= confidence interval

Field Season	Mean Count (SE)	Estimated Abundance	95% CI for Abundance
2016-2017	14.2 (2.1)	77	51.08 - 103.16
2017-2018	23.3 (3.4)	126	94 - 158.4
2018-2019	11.4 (3.1)	62	34.54 - 89.23
2019-2020	12.3 (3.2)	67	40.72 - 92.86
2020-2021	15.3 (2.8)	83	54.98 - 110.3
2021-2022	12.7 (2.8)	69	42.69 - 94.68
2022-2023	15.4 (3.9)	84	53.44 - 113.57
2023-2024	17.3 (3.6)	93	64.52 - 122.31
2024-2025	12.2 (2.5)	66	41.71 - 90.81

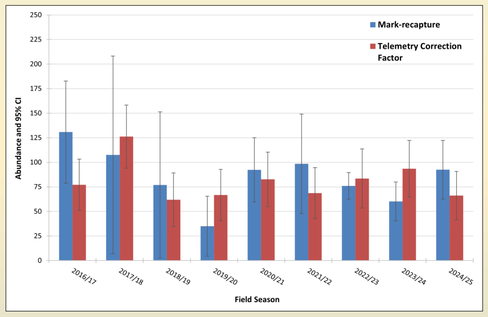


Figure 5. Total abundance estimates and 95% CIs for the study area calculated from the mark-recapture and telemetry correction factor approaches for the 2016-2025 seasons.

Comparison of Abundance Estimation Approaches:

- Fluctuation in abundance occurred across seasons for both approaches (Figure 5).
  - General trends: initial decrease in abundance from 2016-2019, followed by an increase, and then a fluctuation in estimates between 2021-2025.
- Abundance estimates using mark-recapture approach were slightly higher in comparison for several seasons. Overall, there was a wider range of values and a larger margin of error (Table 1; Figure 5).
- The seasons with the lowest and highest abundance estimates differed amongst approaches (Figure 5).
- Conducted a regression analysis for the seasonal abundance estimates.
  - Slope was not statistically significant for both approaches, indicating no trend in population abundance.

DISCUSSION

- A small, established harbor seal population occurs seasonally within southeastern VA. This supports claims that harbor seals are now re-occupying substantial portions of their previous range [1]; [2].
- This local population may be relatively stable based on fluctuations in the seasonal abundance estimates and regression analysis results indicating no significant trend.
  - Observed fluctuations could be due to several factors: sampling bias in survey effort, two unusual mortality events from 2018-2022, seasonal differences in haul-out behavior.
- Analyses based on counts from timelapse camera traps could improve abundance estimates due to more consistent sampling effort across the seasonal occupancy period. Camera traps were deployed on ES and CBBT survey areas from 2019-2026.
  - Using this count data and a haul-out correction from the telemetry data, abundances for the 2019-2024 seasons were estimated for peak occurrence months (e.g., February). Estimates ranged from 33-91 individuals [7].
- The results from this study provide valuable information towards harbor seal distribution along the U.S. east coast and developing more effective protective measures, which will help the Navy with maintaining environmental compliance.

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