Survey of *Nucella lamellosa* Abundance and Size in Shady Cove, San Juan Island, WA

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Abstract: We resurveyed abundance and shell length of the *Nucella lamellosa* population of Shady Cove as previously measured by Spight from 1969 to 1972. Of the 1163 snails counted and measured, shell length ranged from 11-63 mm and averaged 34.4±9.3 mm over the entire population, and within breeding groups averaged 40.4±7.5 mm. From 1969-1972 shell length ranged from 8 - 48 mm, and averaged 30.4 mm over the entire population, and 34.4 mm within breeding groups. Since Spight's surveys from 1969-1972, the range of shell sizes has increased with larger individuals and increases in average shell length in both the full population and within breeding groups.

Methods

Historical studies

Nucella lamellosa has repeatedly proven itself worthy of long-term study; owing to several factors of the snail's life. The snail is large and slow moving, tags can easily be glued to the shell that will last several years, they don't go through a planktonic stage, and their food supply is located within the tidal zone. Tom M. Spight, University of Washington Department of Zoology, began his study of snail populations at Shady Cove in August, 1967. The snails found were all tagged. Through the fall of the same year, he found ≥80% of them each time a census of the area was taken. Encouraged by these findings, after April 1969, Spight extended the search area along 40 m of shoreline and tagged all of the *Nucella lamellosa* in the area. In total, he marked 4272 *N. lamellosa* by July, 1970.

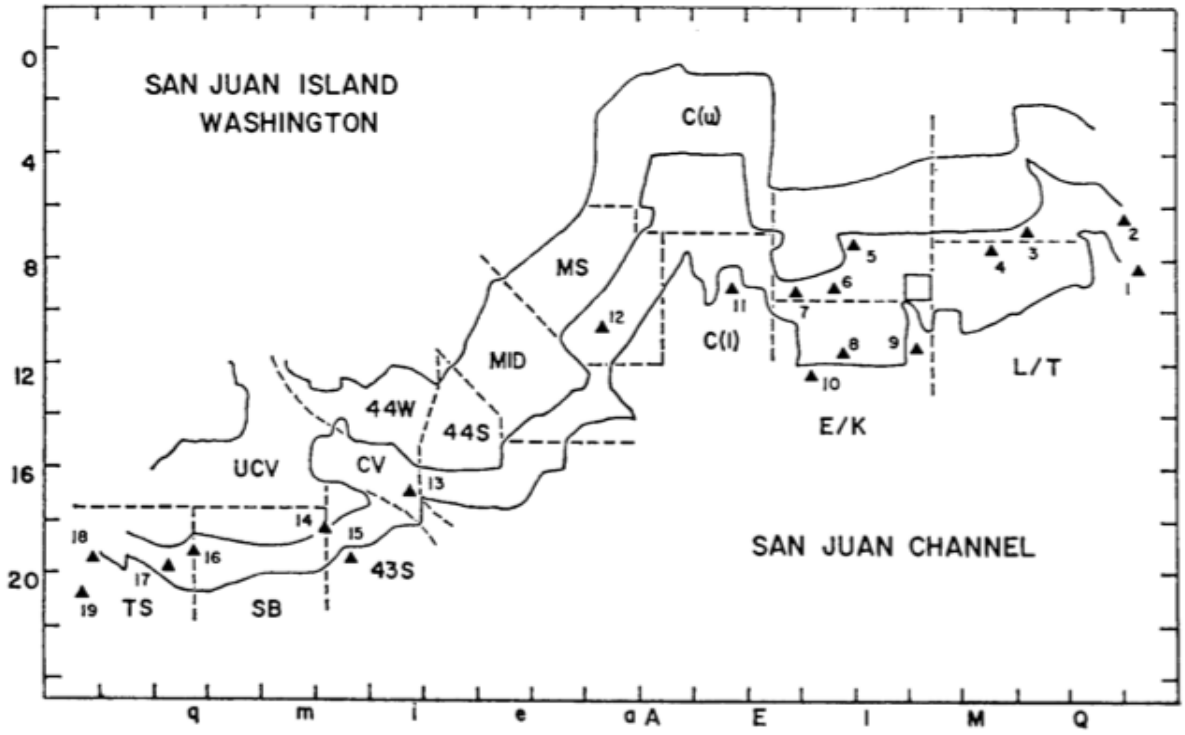

***Fig. 1 The primary study area (Shady Cove) outlined by +1.8 m (uppermost), +60 cm, and -30 cm contours, relative to MLLW*. Breeding sites used during the study period are indicated by numbered triangles. The shoreline was divided into 15 provinces that are outlined with dashed lines (UCV, MS, L/T, etc.). The grid marks on the margins are 2 m apart and the numbers and letters on the margins are the names of the 1m-wide rows and columns used to identify locations. The 2018 study re-censused populations V and VI in provinces CV, UCV, 43S, SB, and TS (from Sizes of Populations of a Marine Snail, by Tom Spight, 1974, Ecology Vol. 55, No. 4, p. 714).**

Nucella lamellosa is distributed continuously along the rocky beaches around San Juan Island through the feeding season; however, during the breeding season, adults aggregate in groups of 50 to 1000 snails (Spight 1974). These breeding units were defined as populations, and the areas of the shore that the breeders of a population separated into were defined as the population areas. The majority of the adults on each of the small collecting units came from one of the four populations I, IV, V, and VI (Spight 1974). The four populations on the 40 m of shoreline used 17 breeding sites from 1968 to 1971, with single populations using as many as four sites in one year. The 2018 re-census was performed on populations V and VI (Fig. 1). Monthly censuses were performed from April to October, 1968 to 1971. Two types of censuses were made: (1) during a survey, each province was visited once, and all tagged animals seen were listed. (2) during a collection, each province was inspected on two consecutive days; all snails seen on either day were collected and measured, and any unmarked snail found was given a tag. These methods were established early in Spight's study, specifically in his 1972 dissertation: Chapter 1 - Patterns of Numerical Change in the Populations at Shady Cove.

Site description

Shady Cove is approximately 0.8 km north of the main laboratories on the Friday Harbor Labs Biological Preserve. This eastern San Juan Island location consists of a steep rocky shore with few small tide pools in the intertidal. The porphyritic igneous rock is strewn with numerous shallow crevasses. The southern boundary of the site is a deep cleft in the intertidal and the region of study extends 40 m north from here, covering an area of about 100 m^2.

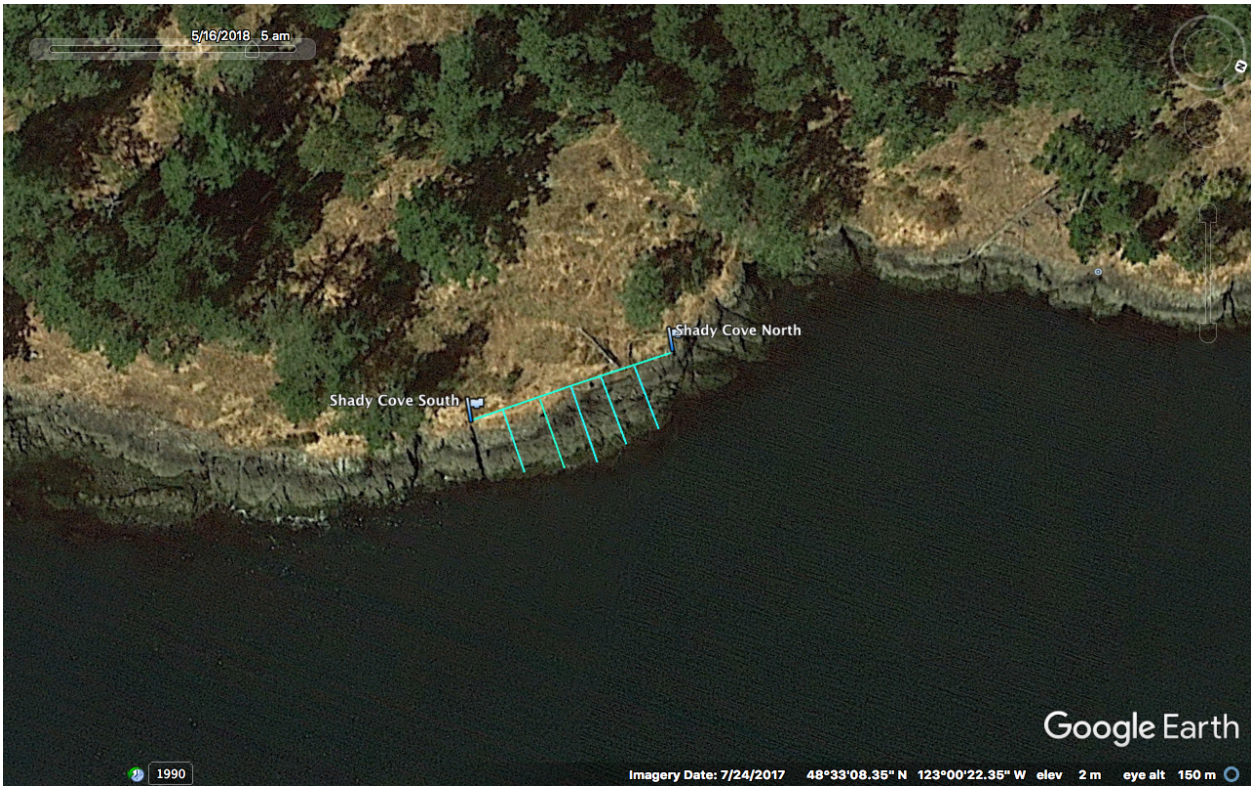

Fig. 2 ***Shady Cove Google Earth image of area surveyed by FHL student research teams 19 April 2018.*** **The portion of the historical study site containing populations V and VI was divided into six approximately equal subsections shown in blue lines. All *N. lamellosa* were collected and their shell lengths measured to the nearest mm. A breeding aggregation of 241 snails was found in the furthest north subsection corresponding with breeding site #13 in province CV from Spight 1974.**

Resurvey Methods

The study site was surveyed on 19 April 2018 from 12:45 to 15:35. Tidal height at the start of survey was -0.15m MLLW. Waves were between 0 and 0.6 m. There was sun with some clouds, some breeze, and dew on the grass but no precipitation. Air temperature was 13° C as measured using a hand-held, infrared thermometer.

The focus of the re-census was populations V and VI (Fig. 1, Spight 1974). This accounted for half of the populations where Spight found the majority of breeding adults in the original study (Spight 1972). The area was divided into six, more or less even, subsections (Fig. 2) and teams of 2 student researchers collected snails from each of them for the first hour of surveying. Subsequently, 5 students re-examined the areas while the other five measured the shell length of snails (to the nearest mm) that had already been collected. A breeding aggregation was found on the furthest north subsection and all of these individuals were collected and shell lengths were measured and recorded separately, to determine the size distribution of the breeding population. In total, 20.4 person-hours were spent searching for and collecting *N. lamellosa*, while 7.9 person-hours were spend verifying and measuring snails.

Data handling

Raw shell length frequency data was extracted from Spight 1974 using WebPlotDigitizer version 4.1 on 19 May 2018. The data extracted using WebPlotDigitizer was then rounded to the nearest integer. The number of measurements (N) extracted by WebPlotDigitizer closely matched the expected number of individuals collected and measured as listed in Spight's figure. For 1969, WebPlotDigitizer produced N=917 compared to N=915 reported by Spight. For 1970, WebPlotDigitizer produced N=496, the same as reported by Spight. For 1971, WebPlotDigitizer produced N=501, compared to N=500 reported by Spight. For 1972, WebPlotDigitizer produced N=793 compared to N=781 produced by Spight.

Results

Historical data

Year	Total N. lamellosa	Average shell length whole population [mm]	Average shell length in breeding aggregation [mm]	Range in shell length [mm]
1969	915	28.2	31.7	10 - 45
1970	496	29.7	32.5	9 - 47
1971	500	31.7	34.8	8 - 48
1972	781	31.8	38.4	9 - 48

April 2018 Resurvey

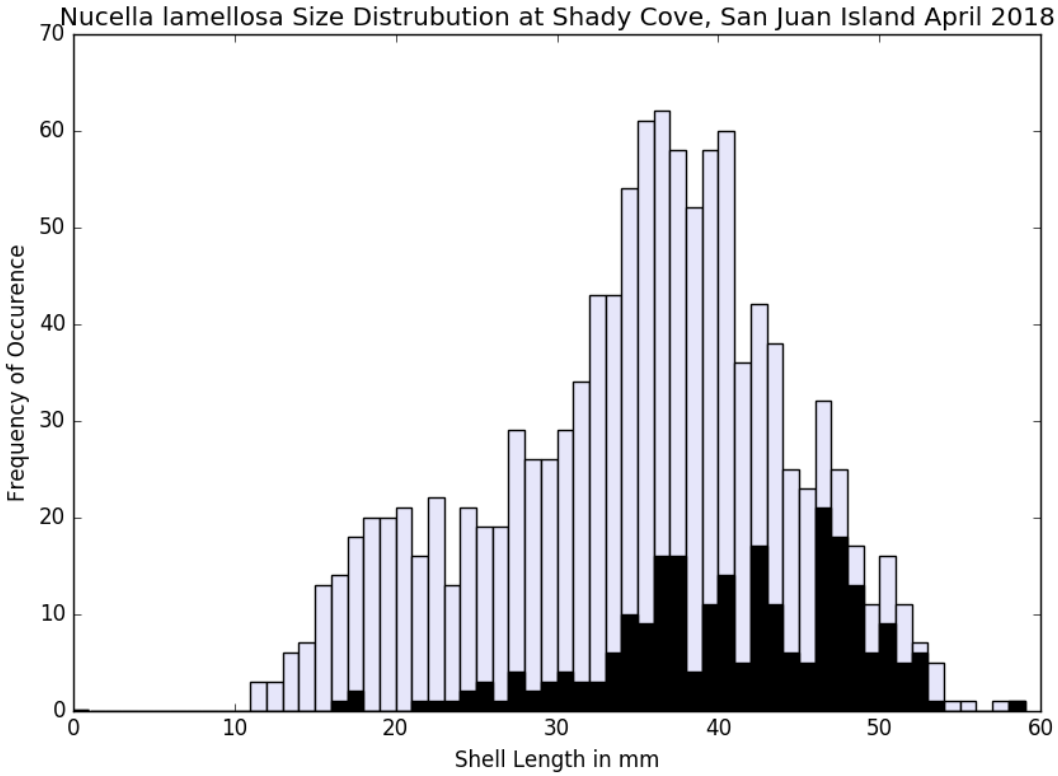

Fig. 3 ***N. lamellosa size distribution in populations V and VI at Shady Cove 19 April 2018.*** **Individuals from breeding groups are represented by black boxes.**

In total, 1163 *N. lamellosa* were found in the study area, 241 of which were in breeding aggregations. There was a single breeding aggregation in the study area. Shell length ranged from 11 - 59 mm within the entire population and 16 - 59 mm within the breeding aggregation. For the whole population, shell length averaged 34.4±9.3 mm. Within the breeding aggregation, shell length averaged 40.4±7.5 mm.