Fishery biology of the sea cucumber *Parastichopus californicus* (Stimpson, 1857) from the San Juan Islands, Washington

Lummi Natural Resources Department
2013–2015 Sea Cucumber Study

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ABSTRACT

The California (or giant red) sea cucumber *Parastichopus californicus* (Stimpson, 1857) (Echinodermata: Aspidochirotida: Stichopodidae) has been commercially harvested from the marine waters of Washington State for more than 40 years, but the dive fisheries (primary gear type) targeting *P. californicus* have only been actively managed for about 20 years following their peak production in the late 1980s and early 1990s. Today, all *P. californicus* dive fisheries are co-managed by the western Washington treaty tribes, including the Lummi Nation, and the state's natural resource authority, the Washington Department of Fish and Wildlife (hereafter, "co-managers"). While the co-managers continue to collaborate on stock assessment procedures for *P. californicus* and to refine harvest strategies for the species, gaps in the co-managers' understanding of the basic fishery biology of *P. californicus* remain an issue (as is the case for many sea cucumber fisheries across the Pacific Ocean and elsewhere). To rectify the problem, the Lummi Natural Resources Department (LNR) agreed to conduct field research that was designed to extend the published work of others and to verify management-relevant aspects of *P. californicus* life history. Fishery-dependent and fishery-independent data were gathered during various months from June 2013 through May 2015 at 12 sites in the San Juan Islands, Washington that were open to commercial harvest diving. Fifty *P. californicus* were hand-collected by diver(s) during each sampling trip (n = 18) and individually bagged to insure that any ejected coelomic contents, including gonads, were traced back to the individual sea cucumber (N = 900). In the laboratory, the whole, wet (round) weight of *P. californicus* was recorded then the sea cucumber was dissected to determine its sex, split-and-drained (market) weight, and gonad weight. In addition, notes on the incidence of ecto- and endofauna associated with *P. californicus* were recorded. Existing morphometric analyses were used to convert sea cucumber weights to estimated whole, contracted lengths and to estimate the age of *P. californicus* to 6+ years. Finally, a gonadosomatic index was used to evaluate reproductive maturity. This report contains useful information about the age and growth of *P. californicus*, and the size structure and reproductive biology of the species in the San Juan Islands, Washington. Several indicators of size-selective harvesting of *P. californicus* are described, including a decrease in the average market weight of individual sea cucumbers compared to market weights from past decades. The LNR study also revealed that local reproductive capacity of the sea cucumber may be impacted by size-selective harvesting and that peak spawning in *P. californicus* occurs several weeks earlier in Washington State compared to that which was previously published for the species. Lastly, some novel information is provided concerning the relationship between *P. californicus* and a commensal polychaete worm and parasitic snail. Several management considerations are discussed based on the LNR findings: 1) implementing a size restriction for *P. californicus*, 2) updating harvestable biomass estimates more frequently, 3) adjusting timing of the sea cucumber spawning closure, 4) expanding assessment of *P. californicus* inside of existing no-harvest zones, and 5) integrating the LNR findings with current sea cucumber hatchery practices.

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INTRODUCTION

In the Northeast Pacific Ocean, the fishery potential of the California (or giant red) sea cucumber *Parastichopus californicus* (Stimpson, 1857) (Echinodermata: Aspidochirotida: Stichopodidae) was first identified in late 19th century reports prepared by government officials tasked with commoditizing novel marine resources (e.g., Swan 1886); however, viable commercial fisheries for *P. californicus* along the U. S. West Coast and the Pacific Coast of Canada were not established until nearly a century later (Bradbury 1990; Muse 1998) following the serial exploitation of sea cucumber fisheries elsewhere in the Pacific (Anderson et al. 2011). Initially managed passively during the 1970s and 1980s, these fisheries (gear types: diving and trawling) peaked about 25 years ago when annual landings of *P. californicus* exceeded four million pounds in Washington State alone (Bradbury and Conand 1991; Bradbury 1994; Carson et al. 2016). Recognizing that a turnabout from ineffectual management was needed, jurisdictions in the region began actively managing their sea cucumber fisheries in the mid-1990s. By the close of the 20th century, natural resource authorities coast-wide had implemented practices such as quota allocation systems based on catch histories and routine stock assessments, gear and harvest area restrictions and, in some jurisdictions, limiting entry to better manage *P. californicus* fisheries in the region (Woodby et al. 1993; Bradbury et al. 1998; Bruckner 2005; Hajas et al. 2011; Carson et al. 2016).

Today, the *P. californicus* dive fisheries of Washington State are co-managed by the treaty tribes of western Washington and the state's natural resource authority, the Washington Department of Fish and Wildlife, WDFW (hereafter, "co-managers"). Annual harvest management agreements are negotiated by the co-managers that allocate, as per U. S. federal court decisions (NWIFC *undated*), equal sharing of total allowable catches (TAC; 50% for the treaty tribes and 50% for the state) from within five management regions (hereafter, "districts") spanning the U. S. portion of the Salish Sea (Figure 1). The TAC for each district is calculated by applying an annual harvest rate (5–9%) to an estimate of the total harvestable biomass of *P. californicus* as determined by periodic stock assessment surveys (e.g., diver and/or ROV; Bradbury et al. 1998; Carson et al. 2016). For example, in sea cucumber District 1, an area from the U. S.–Canada boundary through the San Juan Islands (Figure 1), the total harvestable biomass of *P. californicus* shallower than –120 ft MLLW was estimated to be ~ 5.9 million pounds in 2014 (Carson et al. 2016). Applying a 9% annual harvest rate to this biomass estimate results in a TAC of 534,000 pounds for management year 2015–2016; or put another way, an annual harvest share of 267,000 pounds for the state and the same amount to be harvested by the collective tribes sharing treaty fishing rights in District 1. It should be noted that, as of this writing, the co-managers intend to incrementally reduce the annual harvest rate of 9% to 5%, 1% per management year, to achieve sustainability in the District 1 fishery by 2020 (*sensu* Hajas et al. 2011). Other management measures include gear type and time of day restrictions (diving during daylight hours only), area closures (for conservation purposes) and, in management year

2014–2015, a seasonal closure to protect the reported peak spawning period of *P. californicus* (June–July; Cameron and Fankboner 1986; Carson et al. 2016). Finally, there is no size limit for

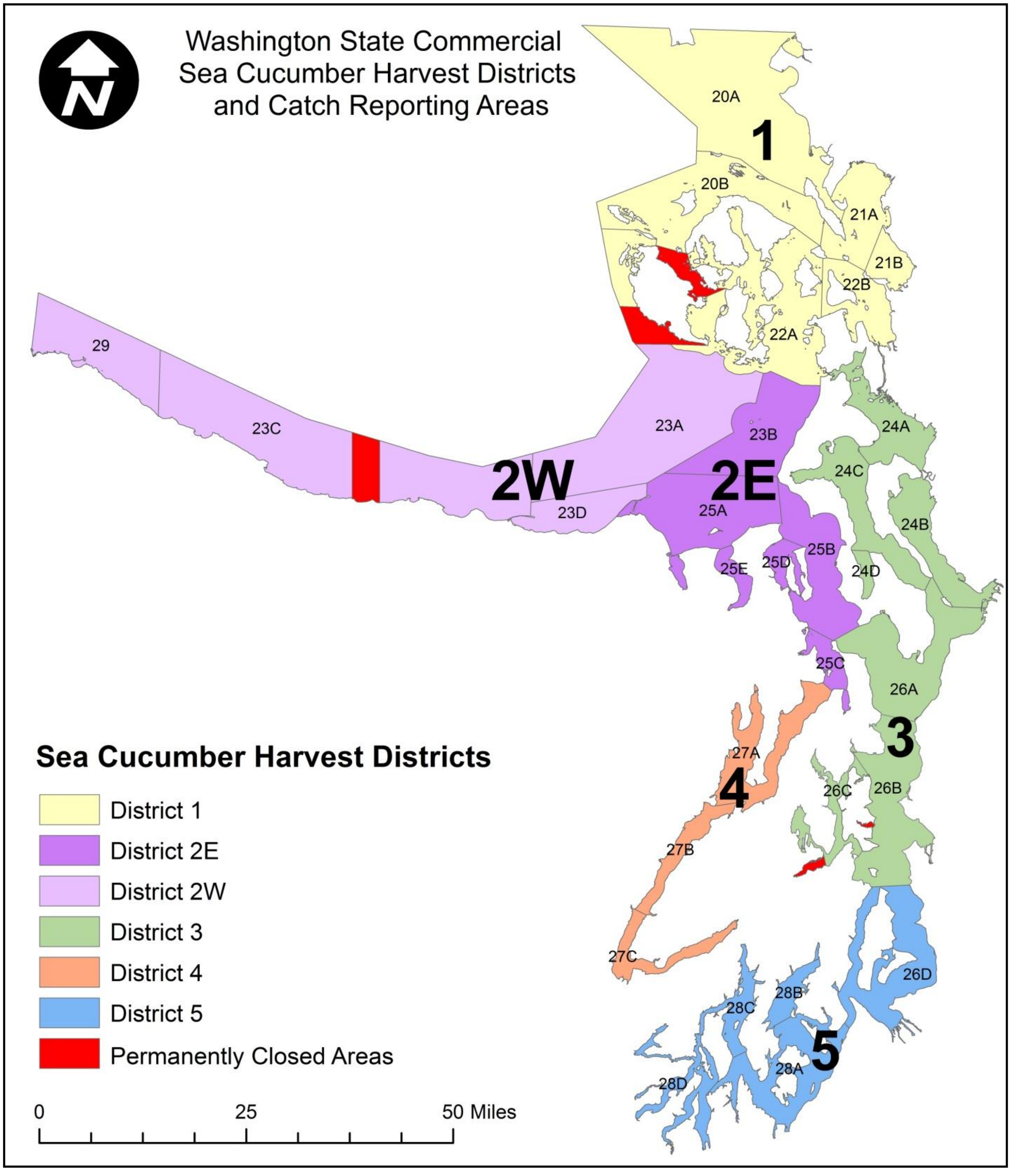

Figure 1. Map showing locations of the sea cucumber *Parastichopus californicus* harvest management areas (Districts 1–5) and closed conservation zones in Washington State (source: Washington Department of Fish and Wildlife; 2015–2016 Sea Cucumber Harvest Management Plan).

Figure 2. Voluntary minimum size (whole, contracted length ~ 20 cm) of the sea cucumber *Parasthichopus californicus* retained by many commercial harvest divers in the Washington State fisheries. Note that albinism is evident in this sea cucumber shown from May 7, 2014. Completely lacking the natural pigmentation of *P. californicus*, this individual was released unharmed at its point of capture, Eagle Cliff, Cypress Island.

P. californicus harvested in Washington State; however, many commercial divers voluntarily restrict themselves to harvesting *P. californicus* of whole, contracted lengths (WL) no shorter than approximately 5 cm (or 2”) on either side of a gloved hand [WL ≈ 20 cm (or 8”); Figure 2].

In recent years, following implementation of the tribal-state quota allocation system, the TAC of *P. californicus* in District 1, the San Juan Islands, Washington, has been relatively static, varying little from a yearly average of about 650,000 pounds. Shortly after 2002, WDFW intentionally reduced the size of the state fleet by nearly half (Bruckner 2005; Carson et al. 2016). Concurrently, the tribes began exercising their treaty rights to harvest *P. californicus*, only reaching capacity to consistently harvest their share of the TAC around six years ago (Figure 3). Since then, some co-managers have expressed concerns about the sustainability of *P. californicus* fisheries in Washington State because exploitation rates have been high relative to other sea cucumber populations along the West Coast and because there are some possible indications of over-exploitation including reduced catches per unit effort (CPUEs) in the state fishery, lower abundance of *P. californicus* in some of WDFW’s survey index stations (Carson et al. 2016), increased average or maximum harvest depths across fleets, dive operations targeting the boundaries of conservation zones, and increased warnings or citations for divers harvesting in closed areas. Thus, while the aforementioned management measures helped place the Northeast

Pacific sea cucumber fisheries among the better-managed ones globally (Purcell et al. 2013), clearly, in Washington State, there is room for improved understanding of some basic aspects of the fishery biology of *P. californicus* and how these might inform harvest management (Friedman et al. 2011; Purcell et al. 2013).

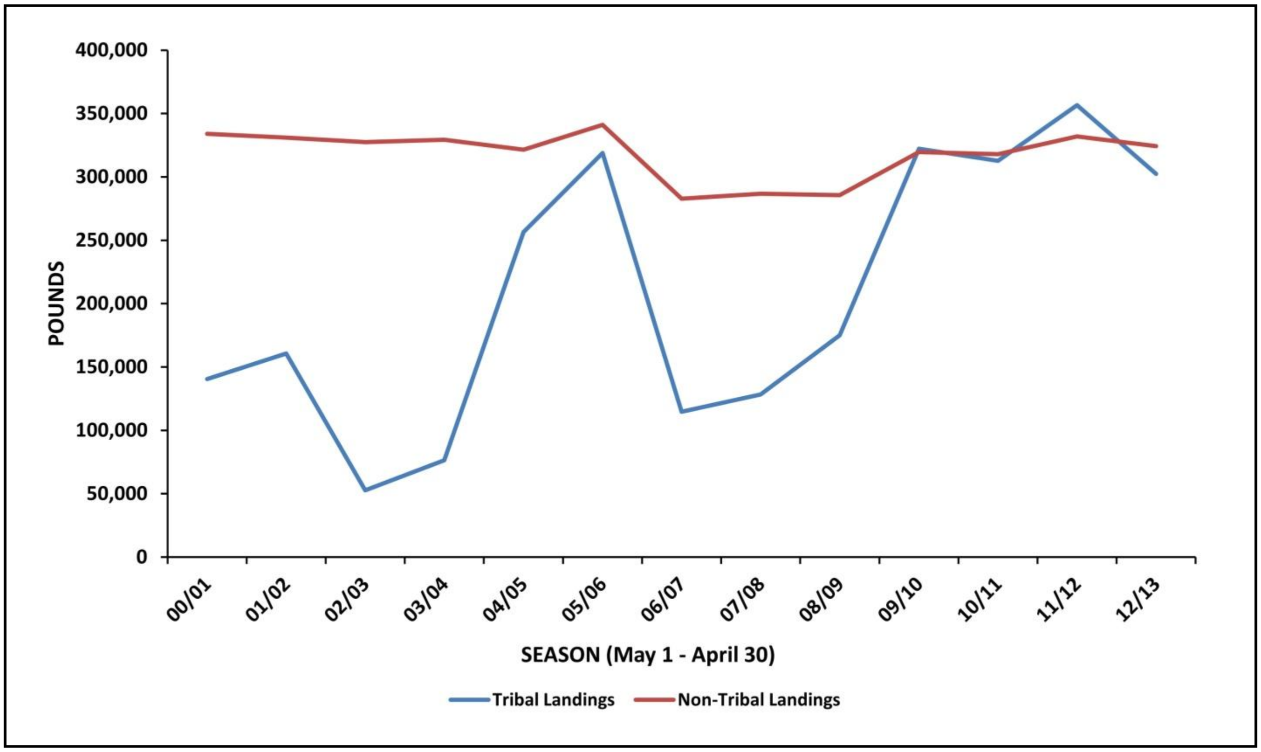

Figure 3. Trend in landings (pounds, lb) of the sea cucumber *Parastichopus californicus* harvested in District 1, the San Juan Islands, Washington, by tribal and non-tribal divers from the 2000–2001 season to the 2012–2013 season. This graph shows that the treaty tribes reached capacity to consistently harvest their share (~325,000 lb) of the total allowable catch (~650,000 lb) starting in the 2009-2010 season (source: Tribal Online Catch Accounting System, Northwest Indian Fisheries Commission, Olympia).

To address these concerns, the co-managers gathered in Port Townsend in early November 2013 to hold a two-day workshop on sea cucumber harvest management in Washington State. Among the agenda topics were summaries of past management strategies, data gathering, and discussions of future management proposals. At the workshop, staff from the Lummi Natural Resources Department (LNR), the natural resource authority for just one of the 20 treaty tribes in western Washington, the Lummi Nation, identified gaps in the scientific literature concerning *P. californicus*, made a call to action for the co-managers to fill those gaps, and outlined what field research LNR would conduct in the ensuing years to move the co-managers' understanding of the fishery biology of *P. californicus* forward. At the time, LNR committed to re-evaluating the reproductive period of *P. californicus* and the relationship between round and market weights (i.e., whole, wet weight vs. split-and-drained weight). This would be accomplished by extending the work of Cameron and Fankboner (1986, 1989) and others (e.g., Heizer 1991; Hannah et al. 2012). Furthermore, LNR committed to using existing literature (e.g., Yingst 1982; Cameron and Fankboner 1989; Hannah et al. 2012) to reconstruct or estimate the size and age structures of

P. californicus available to commercial harvest divers. In the end, the intent of the LNR study was to develop additional management measures for consideration by the co-managers to achieve sustainability in Washington State's *P. californicus* dive fisheries.

MATERIALS AND METHODS

The Lummi Nation's commercial harvest diving fleet lands approximately 80% of the treaty tribal share of sea cucumbers in Washington State [Tribal Online Catch Accounting System (TOCAS), Northwest Indian Fisheries Commission (NWIFC), Olympia, Washington]. Most of its harvest activity takes place in District 1, the San Juan Islands, where the highest biomass of *P. californicus* occurs (Bradbury et al. 1998; Carson et al. 2016); hence, LNR staff concentrated their fieldwork at several locations in District 1 that were open to commercial harvest (Figures 1 and 4). This report presents fishery-dependent and fishery-independent data (Appendix C) collected over a two-year period from June 2013 through May 2015.

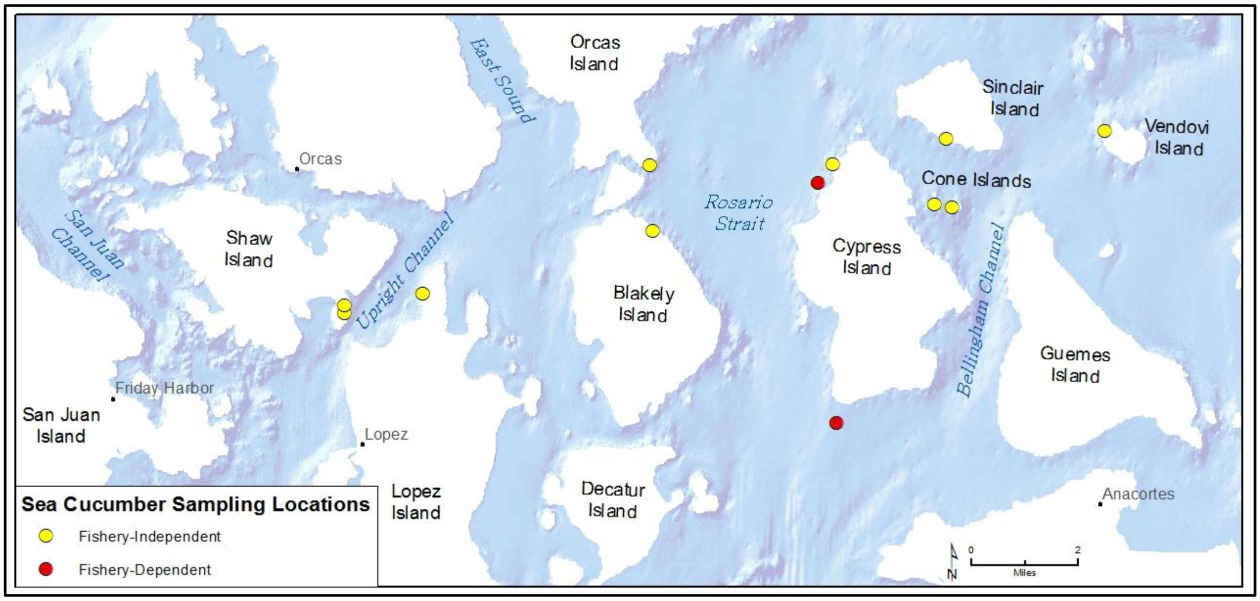

Figure 4. Map showing locations where the sea cucumber *Parastichopus californicus* was sampled from June 2013 through May 2015 in the San Juan Islands, Washington, inside sea cucumber management District 1. The red circles indicate ride-along trips aboard Lummi Nation commercial harvest diving vessels.

Fishery-dependent data were gathered on two separate ride-along trips aboard Lummi Nation commercial harvest diving vessels working in the vicinity of Cypress Island (Figure 4). The first ride-along trip occurred on June 12, 2013; the second, May 7, 2014. During the first trip, 50 *P. californicus* were haphazardly selected from a commercial harvester's catch bag brought aboard the vessel after one dive to an average depth of –75 ft MLLW. Once onboard, the whole, wet weight (round weight) and the split-and-drained weight (eviscerated, market weight) of individual sea cucumbers were measured to the nearest 5 g using a handheld spring scale. These data were collected opportunistically while the harvest diver processed his catch. During the second trip, 50 *P. californicus* were haphazardly selected from a commercial harvester's catch bag after one dive to an average depth of –110 ft MLLW. Since additional information concerning the sex and reproductive status of animals was to be collected starting with the second trip, the sea cucumbers were purchased from the harvest diver and placed inside single zip-locked plastic bags (one sea cucumber per bag) for processing later and to insure that any ejected viscera or coelomic contents, including gonads, were contained and traced back to the individual (*sensu* Courtney 1927). These samples were then stored inside a large, iced cooler until being processed (the following day) at a wet laboratory located on the Northwest Indian College (NWIC) campus in Bellingham.

At the onset of the study, LNR staff planned to sample catches of *P. californicus* solely while riding along with willing commercial harvest diving crews. After conducting the first two ride-along trips, however, it was apparent that certain onboard factors might jeopardize successfully completing the scheduled work. These included: 1) a lack of input on where or when sampling occurred, 2) commercial handling/loading of catch leading to stress-induced visceral ejection in *P. californicus*, 3) LNR staff disrupting a crew's topside workflow via their sampling activities, 4) possible mixing of samples from different locations or dives, and 5) variable end to work day affecting the post-sampling storage or processing of *P. californicus* (i.e., logistical issues). Consequently, for the remainder of the study, LNR staff opted to gather their data independently.

Figure 5. Lummi Natural Resources Department staff diver preparing to sample the sea cucumber *Parastichopus californicus* offshore of Vendovi Island, San Juan Islands, Washington in July 2014 (Photo credit: Roland Coberly).

Fishery-independent data were gathered from May 27, 2014 to May 28, 2015 (Figure 5) using the same voluntary minimum size limit [no shorter than ~ 5 cm (2") on either side of a gloved hand or WL ~ 20 cm; Figure 2] adopted by many commercial harvest divers as a guideline to retain *P. californicus*. A minimum of 50 sea cucumbers were collected semimonthly (and individually bagged) from several points within four general locations [west to east: Upright

Channel, Rosario Strait, Bellingham Channel, and the junction of Bellingham, Samish, and Padilla bays (hereafter, Bays/Vendovi Island); Figure 4] during *P. californicus*' reported spawning period (February through October; Cameron and Fankboner 1986); but, none were collected past October 15, 2014 nor anytime during winter 2014–2015 since the likelihood of detecting sea cucumber gonads was low or nil due to the seasonal aestivation (visceral atrophy) process in *P. californicus* (Fankboner and Cameron 1985). Sampling resumed on March 17, 2015 and continued through May 2015, overlapping the previous year's starting point. By the end of the study, LNR staff divers had collected over 800 sea cucumbers or 100 *P. californicus* monthly, a 10-fold increase over Cameron and Fankboner's (1986) sampling rate, throughout the central-east San Juan Islands (Figure 4) at depths ranging from –17 ft to –49 ft MLLW (Figure 17).

Figures 6 through 12 provide a visual summary of the procedures used to process *P. californicus* following each sampling trip. At the NWIC wet laboratory, every bagged sea cucumber was weighed (minus the zip-lock bag weight) to the nearest 0.1 g to determine its round weight or whole, wet weight in air (WWA). The animal was then dissected to determine its sex (male, female, unknown), and the gonads were removed and weighed to the nearest 0.0001 g. Counts of the commensal scale worm *Arctonoe pulchra* and the shell-less, parasitic snail *Enteroxenos parastichopoli* were opportunistically recorded, and the market weight or split-and-drained weight in air (SWA) of each sea cucumber was determined to the nearest 0.1 g. Lastly, muscle tissue samples from 200 individuals were collected and stored in alcohol for future genetic analysis.

Figure 6. Round weight or whole, wet weight in air (WWA) of the sea cucumber *Parastichopus californicus* was recorded to the nearest 0.1 g. Zip-lock bags were used in the field to insure that any ejected viscera or coelomic contents, including gonads, were contained and traced back to the individual. The electronic balance was adjusted to account for the weight of the zip-lock bag.

Figure 7. After the round weight was recorded, the sea cucumber *Parastichopus californicus* was removed from its zip-lock bag and inspected for the scale worm *Arctonoe pulchra* (Polychaeta) which was then enumerated. The scale worm *A. pulchra* (center of photograph) forms a commensal relationship with *P. californicus*.

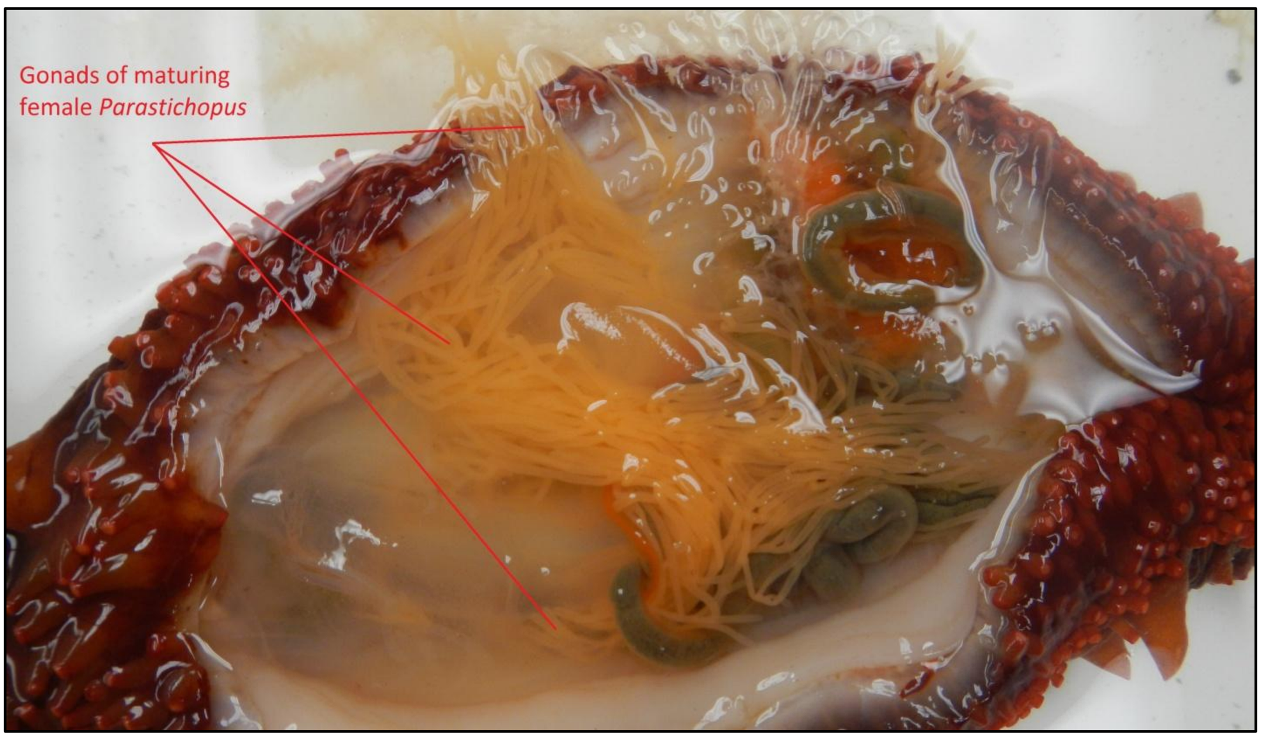

Figure 8. The sex (male, female, unknown) of the sea cucumber *Parastichopus californicus* was determined after making an incision along the tube-foot side of the body, from the cloaca to the calcareous ring below the feeding tentacles. Pictured are the orange genital tubules of a female sea cucumber. Male *P. californicus* have cream-colored genital tubules.

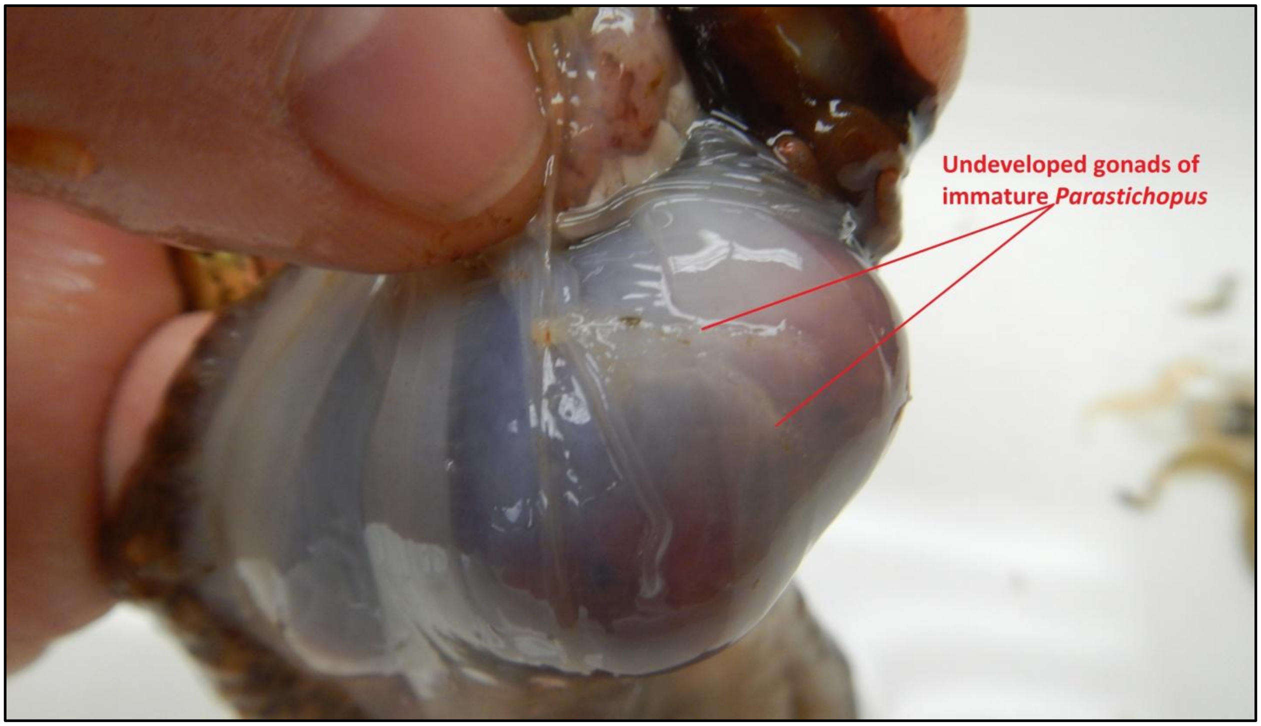

Figure 9. Visual sex determination of the sea cucumber *Parastichopus californicus* was not possible for immature or spawned-out individuals; hence, the sex of this type of sea cucumbers was recorded as “unknown”.

Figure 10. In addition to counting the commensal scale worm *Arctonoe pulchra*, the shell-less, parasitic snail *Enteroxenos parastichopoli* (Mollusca) was enumerated. Here, numerous yellowish, egg-laden *E. parastichopoli* are attached to the upper intestine of the sea cucumber *Parastichopus californicus*.

Figure 11. The gonads of every sea cucumber *Parastichopus californicus* sampled (male, female, and unknown) were excised at the gonad basis near the calcareous ring, placed in small plastic trays, and weighed to the nearest 0.0001 g.

Figure 12. Split-and-drained weight (SWA) of the sea cucumber *Parastichopus californicus* was recorded to the nearest 0.1 g.

Depth-specific information about various marine water quality parameters (e.g., temperature, salinity, light transmission, and chlorophyll fluorescence) observed during the fishery-independent phase of this study was downloaded from Washington Department of Ecology's (DOE) Marine Water Quality Monitoring Program website:

http://www.ecy.wa.gov/programs/eap/mar_wat/watercolumn.html.

Here, DOE summarizes and posts data from replicated casts of a CTD (Conductivity-Temperature-Depth), an oceanographic instrument (Figure 16) designed to provide detailed profiles of the marine water column conditions throughout the U. S. portion of the Salish Sea. The monthly averages from four core monitoring stations in the vicinity of the San Juan Islands [Strait of Georgia (GRG002), Bellingham Bay (BLL009), Rosario Strait (RSR837), and Admiralty Inlet (ADM001)] were graphically presented in this report to create a visual reference of water quality conditions at a depth of 5 m at the time of sampling *P. californicus*.

Data Analyses

Unlike most fish and shellfish, which have rigid body forms supported by internal or external calcified structures that readily facilitate evaluating their size and age (DeVries and Frie 1996), *P. californicus* is a soft-bodied organism lacking analogous, "readable" hard structures that exhibits considerable variation in shape, whole weight, and length (Figure 13) due to its body design (Smiley 1986), locomotory behavior (Margolin 1976), feeding strategies (Cameron and Fankboner 1984; Jaeckle and Strathmann 2013), reproductive cycle (Cameron and Fankboner 1986), and the autumnal resorption and late-winter regeneration of its gut and other coelomic structures (Fankboner and Cameron 1985). Thirty-five years ago, Yingst (1982) came up with a novel way to address this problem, albeit in the congeneric sea cucumber *Parastichopus parvimensis*, by developing a body size index, SI, for the genus that is still in use today (e.g., Hannah et al. 2012):

$$SI = (WL, cm) \times (WW, cm) \times 0.01;$$

where WL is the whole, contracted length of *Parastichopus* measured (cm) from end-to-end, WW is the whole, contracted width measured (cm) at its widest point, and 0.01 is a scaling factor (Figure 14).

Body size indices in sea cucumbers, whether derived from single measurements of multiple individuals of known age (Cameron and Fankboner 1989) or from multiple measures of individuals over time (Yamana and Hamano 2006; Hannah et al. 2012), can provide a reasonably accurate assessment of growth without sacrificing the animal. When this is not possible for research purposes, or if *P. californicus* is sampled dockside or at the marketplace, natural resource authorities may use Yingst (1982) in conjunction with other morphometric analyses (e.g., Cameron and Fankboner 1989; Hannah et al. 2012) to reconstruct or estimate the size and age structures of *P. californicus* from a single metric, the split-and-drained weight in air (SWA).

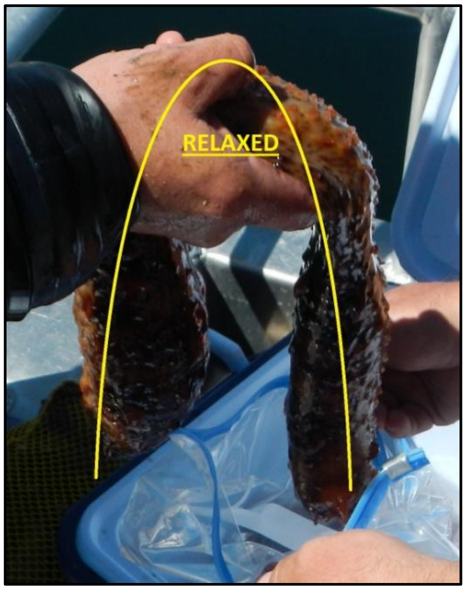

Figure 13. Natural variation in shape and length of an individual sea cucumber *Parastichopus californicus* sampled at Vendovi Island, San Juan Islands in July 2014. At left, the longitudinal muscles running the length of the body wall are relaxed; at right, contracted. In addition, the cloaca and anus close to retain coelomic fluid and contents adding further rigidity (Photo credit: Aaron Hillaire).

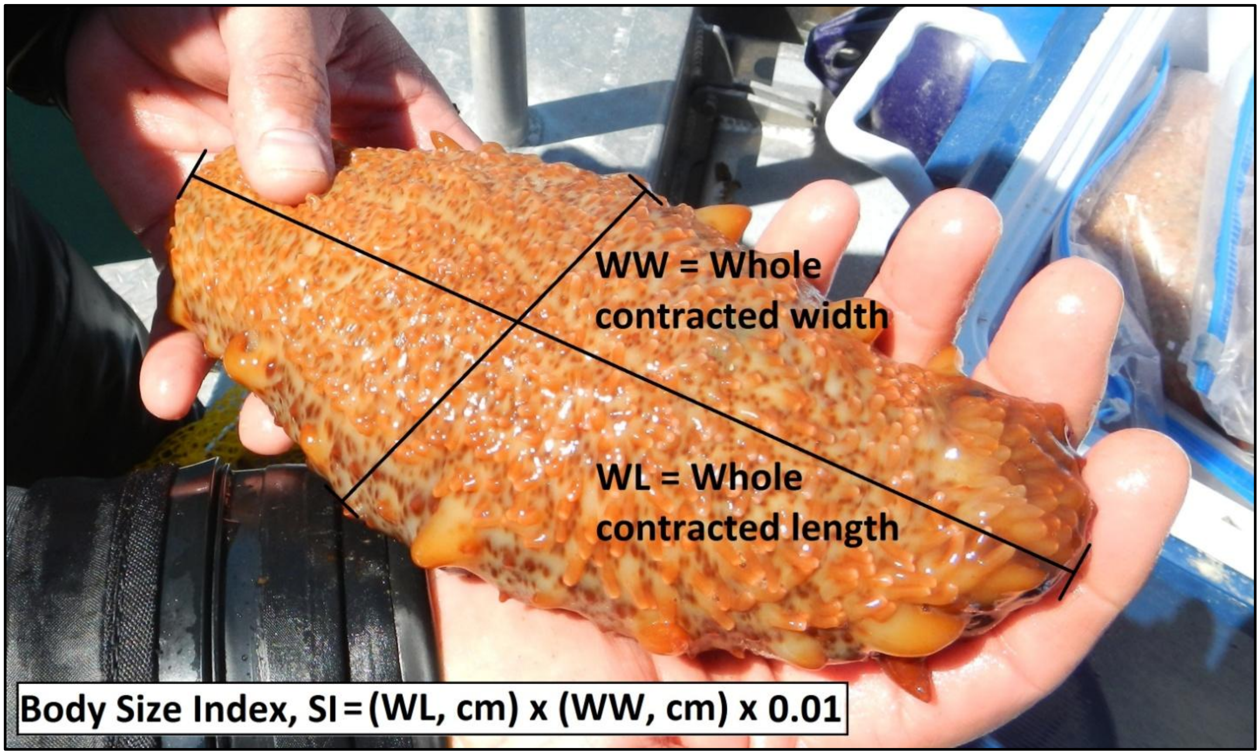

Figure 14. Measurements used by Yingst (1982) and others in calculating the body size index, SI, of sea cucumbers of the genus *Parastichopus* as a way to standardize size metrics in live specimens (Photo credit: Aaron Hillaire).

For example, the SI of *P. californicus* sampled during the LNR study was calculated by rearranging the following significant regression equation (R^2 = 0.932; F = 263.19; P < 0.001) reported by Hannah et al. (2012):

$$\log_e(\mathrm{SWA}) = 4.71 + [1.260 \times \log_e(\mathrm{SI})];$$

where $\log_e$ is the natural log, SWA is the split-and-drained weight in air (g), and SI = body size index. *Parastichopus californicus* was then aged according to its SI value (Table 1), the relationship of which was reported by Cameron and Fankboner (1989) for the sea cucumber's first four years of life. For older *P. californicus* (≥ 5 years), ages were assigned following a size frequency analysis of SWA to reveal plausible age groups (DeVries and Frie 1996). A sea cucumber was assigned a year class (e.g., 2009) based on its age and the year it was sampled. For example, a 4 year old sea cucumber sampled in 2013 was assigned to the 2009 year class; a 2 year old sea cucumber sampled in 2014 was assigned to the 2012 year class, and so on.

Table 1. Body size index (SI) values for the sea cucumber *Parastichopus californicus* as reported by Cameron and Fankboner (1989) for individuals of known age through 4 years. In 2014 and 2015, Lummi Natural Resources Department staff assigned one of four age classes (1, 2, 3, or 4 years) to *P. californicus* based on where its SI fell in the ranges indicated below.

Age (year)	Mean SI[a]	Range[a]	*n*
1	0.101	0.000 – 0.250	34
2	0.445	0.251 – 0.750	52
3	0.897	0.751 – 1.150	11
4	1.340	1.151 – 1.450	4

[a] These values were adjusted by a factor of 10 from those reported by Cameron and Fankboner (1989) since the authors used a scaling factor of 0.10 instead of 0.01 as originally developed by Yingst (1982).

Most commercial harvest divers consider the length of *P. californicus* when deciding to retain a questionable-sized sea cucumber; therefore, this metric warranted special examination for management purposes. Like SI, the whole, contracted length (cm), or WL, of *P. californicus* sampled during the LNR study was calculated by rearranging the significant regression equation (R^2 = 0.836; F = 91.64; P < 0.001) reported by Hannah et al. (2012):

$$\log_e(\mathrm{SWA}) = -2.03 + [2.310 \times \log_e(\mathrm{WL})];$$

where $\log_e$ is the natural log, SWA is the split-and-drained weight in air (g), and WL = whole, contracted length (cm).

Age and growth tables were prepared (DeVries and Frie 1996) showing both mean SWA (± standard deviation, SD) and mean WL (± SD) for each year class (2008–2013) of *P. californicus* sampled during the LNR study. Furthermore, instantaneous growth rates, G, were calculated as:

$$G = [(\log_e Y_2 - \log_e Y_1)/(t_2 - t_1)];$$

where t_1 is the time at the beginning of an interval and t_2 the time at the end, and $\log_e Y_1$ and $\log_e Y_2$ are the natural logs of successive sizes (Y_1 and Y_2) over a unit of time (Busacker et al. 1990). Specific growth rates, i.e., G multiplied by 100 and expressed as a percentage, for SWA were then reported for selected time periods from the age and growth table.

Cumulative distribution plots of SWA and WL were constructed (Neumann and Allen 2007) indicating the proportion of sampled *P. californicus* less than or equal to a given size for different age classes (2, 3, 4, 5 and 6+ years). A line at the 50^{th} percentile was plotted for reference purposes only. Finally, for both fishery-dependent and fishery-independent samples, percent frequencies of SWA were grouped into size bins of 30 g and plotted by sample date. Likewise, percent frequencies of WL were grouped into size bins of 2 cm and plotted by sample date. Two reference lines were overlaid on each histogram: one at the voluntary minimum size of *P. californicus* retained by commercial harvest divers (SWA ≈ 130 g; WL ≈ 20 cm), and one at the mean size at maturity for *P. californicus* (i.e., spawning-capable; age ≥ 5 years; SWA ≈ 200 g; WL ≈ 24 cm).

A number of methods were used to explore how the size of *P. californicus* might have changed over time and space due to commercial fishing. Market weight or SWA data for all sampling trips were graphically presented (by sampling date) using box-and-whisker plots. According to Analytical Software (2013), the box encloses the middle half of the data, bounded by the lower and upper quartiles. The box is bisected by a line at the value for the median. The vertical lines at the top and bottom of the box are called the whiskers, and they indicate the range of "typical" data values. Whiskers always end at the value of an actual data point and cannot be longer than 1½ times the size of the box. Extreme values above or below the whiskers are displayed as stars for possible outliers and as circles for probable outliers. Statistical comparisons were then made among data sources (fishery-dependent vs. fishery independent), general locations (Bays, Bellingham Channel, Rosario Strait, and Upright Channel), and sampling depths (10–19, 20–29, 30–39, 40–49, and 50+ ft relative to mean lower low water, MLLW), whereas visual comparisons were made between the LNR data and selected results from historical works concerning *P. californicus*. For example, the mean SWA (± SD) of *P. californicus* from 2014 and 2015 (fishery-independent data) were plotted for sex by sampling date and overlaid by the monthly SWA averages (sexes combined) for an analogous two-year period from 1982 and 1983 (Fankboner and Cameron 1985). In addition, a reference line indicating the average SWA (313 g) of market-sampled sea cucumbers (sexes combined) from British Columbia, Canada during 1997–2001 (Campagna and Hand 2004) was plotted atop the LNR data. Lastly, an historical photograph analysis was conducted similar to McClenachan's (2009) work with exploited finfish from the Florida Keys. Here, a 1980s-era photograph of Canadian commercial harvest divers and their catch of *P. californicus* (Sloan 1989) was positioned alongside and scaled to a contemporary photograph of the catch from a Lummi Nation commercial harvest diving operation to allow for easy visual comparisons of WL between the two time periods.

Since commercially-harvested *P. californicus* is landed "split-and-drained" (i.e., cut, dewatered, and eviscerated), understanding the relationship between market weight (split-and-drained weight or SWA) and round weight (whole, wet weight or WWA) is important for management purposes, especially when live-sampling sea cucumbers and converting between the two metrics. Following Hannah et al. (2012), regression techniques were used to examine the relationship between SWA and WWA; data were natural log ($\log_e$)-transformed to normalize them and grouped into two-month sampling periods to coincide with the sampling periods reported by those authors. The relationships between $\log_e$ (SWA) and $\log_e$ (WWA) were then plotted for the two-month sampling periods, and the results of the linear regression analysis were tabulated with those of Hannah et al. (2012) for comparison-sake and to assess seasonal and interannual variability in the relationship between round and market weights. In the end, ratios of the two metrics among sampling periods were explored in two ways based on earlier studies: 1) the ratio of SWA to WWA *sensu* Hannah et al. (2012) and 2) the ratio of WWA to SWA *sensu* Heizer (1991).

The reproductive biology of *P. californicus* was revisited following the work of Cameron and Fankboner (1986). The proportional sex ratios of sea cucumbers collected by LNR staff were plotted for all sampling dates during the fishery-independent phase of the study. Reproductive maturity was evaluated simply using a gonadosomatic index or GSI (Crim and Glebe 1990). In *P. californicus*, GSI studies measure vitellogenesis (yolk deposition) in females (and ostensibly, spermatogenesis in males) (Smiley 1988). After the GSI peaks, spawning may occur at any time (Cameron and Fankboner 1986); hence, the peak spawning period of *P. californicus* follows shortly after the peak in GSI, an important distinction to make when reviewing GSI data for the species. During the present study, the GSI for each sea cucumber was calculated after Cameron and Fankboner (1986) as the gonad weight divided by the split-and-drained weight multiplied by 100. Mean GSI (± SD) values by sex (male, female, unknown) were plotted for each sampling date in 2014 and 2015. Monthly averages in *P. californicus* GSI for an analogous but historical two-year period (1982 and 1983; Cameron and Fankboner 1986) overlaid these values for easy visual comparison between the studies. In addition, individual gonad weight (g) was plotted against the estimated contracted length (cm) of female and male *P. californicus* for the months with the highest average GSI in each of the two study years; the exponential relationship between the two metrics was also examined. The mean GSI (± 95% CI) values for the sexes were plotted by sampling period, and the mean GSI (± 95% CI) values (sexes combined) were plotted for age class (2, 3, 4, and 5+ yr) by sampling period to inform a discussion of how these data might be used for in-season management purposes.

Several researchers have pursued experimental aquaculture of *P. californicus*, mostly in conjunction with other marine species (e.g., Ahlgren 1998; Paltzat et al. 2008; Hannah et al. 2013); however, as the practice develops beyond experimentation, it will become increasingly important for culturists to be aware of the natural incidence of *P. californicus* commensals and parasites (Blaylock and Bullard 2014). To this end, frequency distributions of the commensal scale worm *Arctonoe pulchra* (Polychaeta) and the shell-less, parasitic snail *Enteroxenos parastichopoli* (Mollusca) were calculated for sampling date and location, and for sex and age of *P. californicus*. Proportional presence of *A. pulchra* and *E. parastichopoli* were then plotted at three levels (0, 1, and ≥ 2 organisms per sea cucumber) for each of three factors (date, location, and age of *P. californicus*).

Except for the regression analysis above, or unless otherwise indicated, the LNR samples were analyzed using non-parametric statistical methods. Differences in mean ranks of samples were tested using a non-parametric, one-way ANOVA, the Kruskal-Wallis test (Elliott 1993), followed by multiple pair-wise comparisons with Dunn's test. Furthermore, the Mann-Whitney *U*-test, the non-parametric equivalent of a *t*-test, was used to examine differences between two samples (Elliott 1993). For these analyses, the α–value was set at 0.001 instead of 0.05, and only P values < 0.001 were considered as significantly different. The more stringent standard was used to protect against type I errors. All statistical analyses were performed using Statistix 10 software (Analytical Software 2013).

RESULTS

Environmental Conditions

Seasonal variation in six of the eight water quality parameters measured at 5-m depth was evident during the LNR sea cucumber study (Figures 15–18). Some water quality parameters followed normal patterns for most sampling dates [e.g., fluorescence and photosynthetically active radiation (PAR)], while others were anomalous for most sampling dates (e.g., seawater temperature, salinity, and density). The remaining water quality parameters (i.e., dissolved oxygen, pH, and light transmission) exhibited normal patterns only half of the time (DOE 2015).

During the LNR study, the photoperiod peaked at slightly more than 16 hr in June of both years. Seawater temperature increased from springtime lows of less than 9° C to highs of nearly 11.5° C in July 2014 and May 2015. Seawater pH levels remained just below 8 for most of the study, but seawater pH dropped briefly to a low of 6.5 in July 2014. Dissolved oxygen levels decreased from 8 mg L^{-1} to 5 mg L^{-1} with warming seawater temperature during the first year of the study, yet increased with two of three rises in fluorescence, the latter indicating increased algae growth and photosynthesis. Fluorescence peaked in June and September 2014 (5.8 mg Chl m^{-3} and 3.3 mg Chl m^{-3}, respectively), but reached a study-high of 8.0 mg Chl m^{-3} in May 2015 (Figure 15).

Percent light transmission decreased from the low 90s to the mid-80s during the course of the study including two distinct drops coinciding with spring algae blooms in June 2014 (86.5%) and May 2015 (80.4%; Figures 15 and 17). Lastly, whereas salinity and density remained nearly static throughout the study (Figure 17), PAR exhibited much variation, decreasing from spring to fall, with peaks in May and September 2014 (320 uE m^{-2} s^{-1} and 200 uE m^{-2} s^{-1}, respectively), and peaks in March and June 2015 (190 uE m^{-2} s^{-1} and 320 uE m^{-2} s^{-1}, respectively; Figure 18).

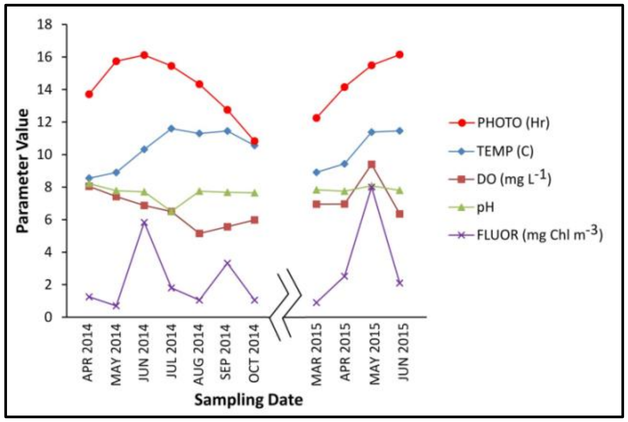

Figure 15. Environmental conditions at 5-m depth (DOE 2015) encountered while sampling the sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington during various months in 2014 and 2015. Data are monthly averages from 5 to 15 casts of a CTD oceanographic instrument. PHOTO = photoperiod, TEMP = seawater temperature, DO = dissolved oxygen, and FLUOR = chlorophyll fluorescence.

Figure 16. CTD (Conductivity-Temperature-Depth) array being deployed in the marine waters of Puget Sound (Photo credit: Washington State Department of Ecology).

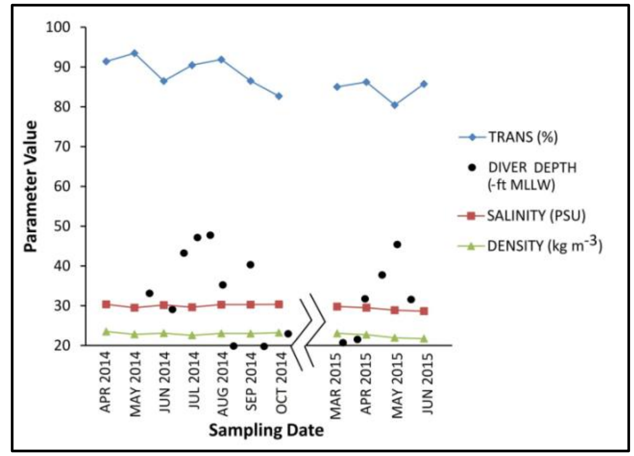

Figure 17. Environmental conditions at 5-m depth (DOE 2015) encountered while sampling the sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington during various months in 2014 and 2015. Diver depth indicates the average depth (–ft MLLW) at which *P. californicus* was sampled on the dates indicated. Except for diver depth, data are monthly averages from 5 to 15 casts of a CTD oceanographic instrument. TRANS = light transmission, MLLW = mean lower low water, and PSU = practical salinity unit.

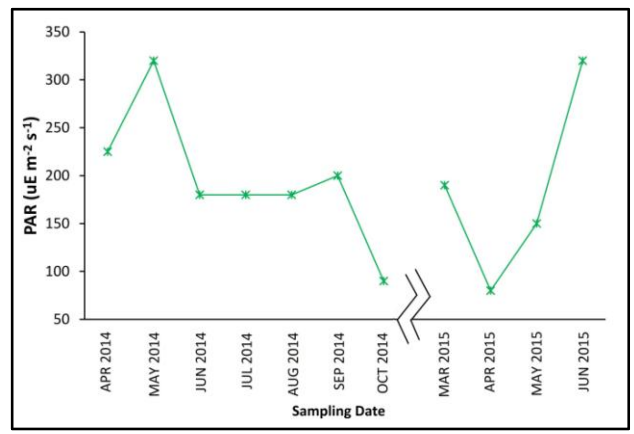

Figure 18. Photosynthetically active radiation (PAR) readings at 5-m depth (DOE 2015) encountered while sampling the sea cucumber *Parastichopus californicus* in the San Juan Islands during various months in 2014 and 2015. uE = Einstein units.

Age and Growth

Table 2 summarizes the age and growth of 484 of the 900 *P. californicus* sampled from June 2013 through May 2015 in the San Juan Islands, Washington. Only the first five years were tabulated since differentiating the mean sizes at age of older *P. californicus* (i.e., sea cucumbers aged ≥ 6 years) was not possible given the limitations of the aging methods of Cameron and Fankboner (1989) (ref. Table 1, this study) and DeVries and Frie (1996). Indeed, the size frequency analysis recommended by the latter authors for animals lacking readable hard structures revealed just one plausible age group (5 years) for *P. californicus* older than 4 years (Figure 19).

Immature sea cucumbers (age ≤ 4 years old) comprised one-third of all *P. californicus* sampled (314 of 900) whereas almost half of all *P. californicus* sampled (416 of 900) were estimated to be 6 years old or older. This was especially evident in the age distribution of sea cucumbers sampled independent of the fishery (Figure 20). In contrast, the catches of *P. californicus* sampled during commercial ride-along trips were comprised mostly of immature individuals aged ≤ 4 years (Figure 20). The youngest sea cucumbers sampled were 2 years old; less than 3% of all *P. californicus* sampled were of this age. In recent years, mean sizes at age for some younger *P. californicus* were larger than those of older sea cucumbers in the sample; this was apparent in the SWA data, but not the WL data (Table 2). For example, for 4 year old *P. californicus*, the 2011 mean SWA was greater than the 2010 mean SWA which was greater than the 2009 mean SWA. The overall mean sizes, SWA and WL, of 2, 3, 4, and 5 year old sea cucumbers were 61g, 109 g, 157 g, and 197 g, and 14 cm, 18 cm, 21 cm, and 24 cm, respectively (Table 2).

Daily specific growth rates (SGR, %) were reasonably consistent among the year classes sampled in 2014 and 2015, decreasing (or slowing) with age, with only slight differences observed between the two sample years (Table 3). For example, for the 2011 year class sampled in 2013 and 2014, the daily SGR between ages 2 and 3 (365 d) was 0.179%, whereas for the 2012 year class sampled in 2014 and 2015, the daily SGR between the same ages was 0.173%. The largest difference in SGR among year classes occurred between 2010 and 2011. For the 2010 year class sampled in 2013 and 2014, the daily SGR between ages 3 and 4 (365 d) was 0.099%, whereas for the 2011 year class sampled in 2014 and 2015, the daily SGR between the same ages was 0.113% (Table 3).

Figures 21–24 show cumulative distribution plots of *P. californicus* sizes (SWA and WL) at age. These are useful for determining, at a glance, the proportion (or % if multiplied by 100) of sampled *P. californicus* less than or equal to a given size for 2, 3, 4, 5, and 6+ year old sea cucumbers. For example, 50% of the 4 year old *P. californicus* sampled during commercial ride-along trips were less than approximately 145 g SWA (Figure 21), whereas 50% of the 4 year old *P. californicus* sampled independent of the fishery were less than approximately 160 g SWA (Figure 22).

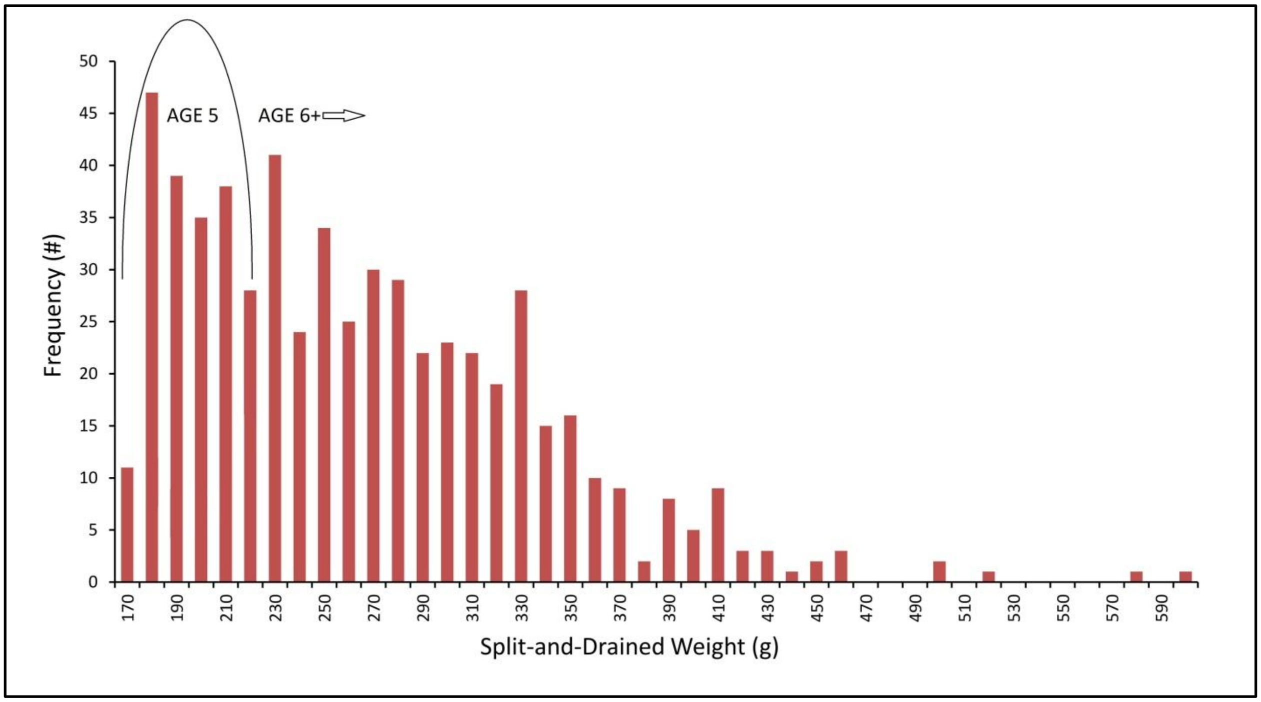

Figure 19. Results of a size frequency analysis of split-and-drained weights (g) in the sea cucumber *Parastichopus californicus* to assess plausible age groups of mature (≥ 5 years) individuals (n = 586) sampled in the San Juan Islands, Washington from June 2013 through May 2015.

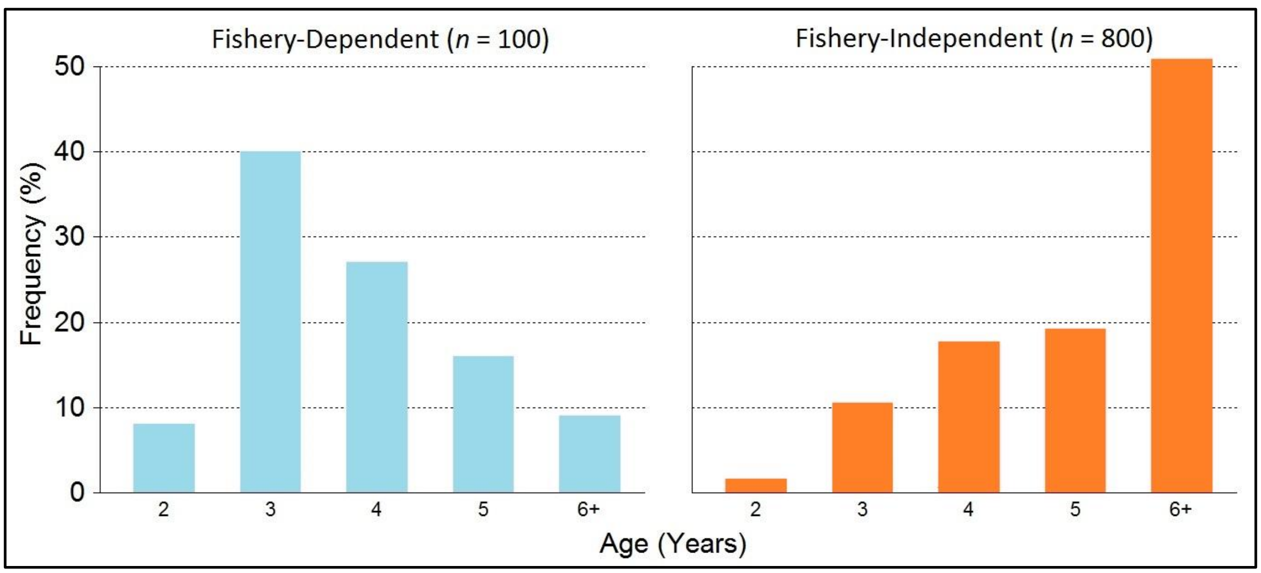

Figure 20. Percent frequency distributions of estimated ages (2–6+) of the sea cucumber *Parastichopus californicus* sampled during commercial ride-along trips (light blue bars) and independent of the fishery (orange bars) in the San Juan Islands, Washington from June 2013 through May 2015. The number of sea cucumbers sampled (n) for each data source is indicated parenthetically.

Table 2. Age and growth of the sea cucumber *Parastichopus californicus* sampled in the San Juan Islands, Washington (n = 484) during various months from June 2013 through May 2015. The number of *P. californicus* sampled for a given age is shown parenthetically following the mean size (g or cm) ± standard deviation, SD. Only the first five years through the onset of sexual maturity (= age 5) were tabulated since differentiating the mean sizes at age of older *P. californicus* (i.e., age 6+ for year classes ≤ 2009) was not possible given the limitations of the aging methods of Cameron and Fankboner (1989) (ref. Table 1, this study) and DeVries and Frie (1996). NA = none available.

		Mean Split-and-Drained Weight (g) (± SD) at Age (year)			
Year Class	No. of Sea Cucumbers	2	3	4	5
2013	1	**77 (1)**			
2012	55	61 ± 12 (15)	**115 ± 15 (40)**		
2011	152	55 ± 13 (5)	106 ± 14 (68)	**160 ± 11 (79)**	
2010	152	NA	108 ± 15 (17)	155 ± 13 (78)	**198 ± 12 (57)**
2009	115	NA	NA	151 ± 13 (11)	197 ± 13 (104)
2008	9	NA	NA	NA	197 ± 12 (9)
Overall Mean ± SD (#)		61 ± 13 (21)	109 ± 15 (125)	157 ± 13 (168)	197 ± 12 (170)

		Mean Estimated Whole, Contracted Length (cm) (± SD) at Age (year)			
Year Class	No. of Sea Cucumbers	2	3	4	5
2013	1	**16 (1)**			
2012	55	14 ± 1 (15)	**19 ± 1 (40)**		
2011	152	14 ± 1 (5)	18 ± 1 (68)	**22 ± 1 (79)**	
2010	152	NA	18 ± 1 (17)	21 ± 1 (78)	**24 ± 1 (57)**
2009	115	NA	NA	21 ± 1 (11)	24 ± 1 (104)
2008	9	NA	NA	NA	24 ± 1 (9)
Overall Mean ± SD (#)		14 ± 1 (21)	18 ± 1 (125)	21 ± 1 (168)	24 ± 1 (170)

Table 3. Daily specific growth rates (SGR, %) of the sea cucumber *Parastichopus californicus* sampled in the San Juan Islands, Washington over three years (2013–2015). SGR was calculated using changes in the split-and-drained weights (g) in air (SWA) and methods described by Busacker et al. (1990).

	Age (years) and Interval (days)						
Year Class	2	(365 d)	3	(365 d)	4	(365 d)	5
2012		0.173%					
2011		0.179%		0.113%			
2010				0.099%		0.067%	
2009						0.072%	

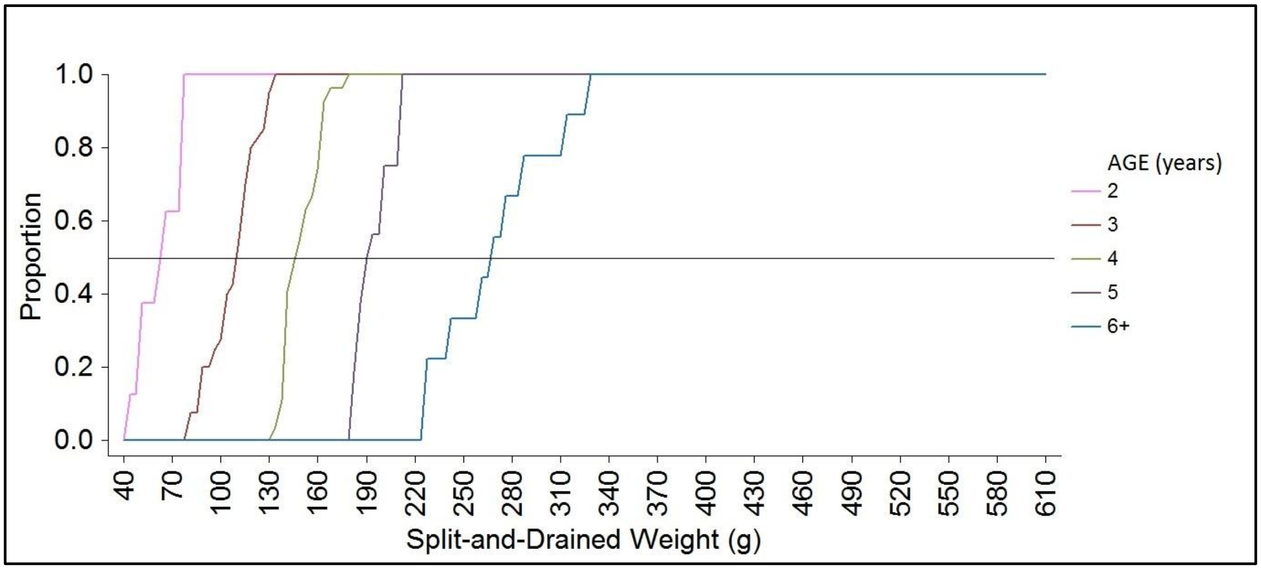

Figure 21. Cumulative distribution plot of split-and-drained weights (g) in air (SWA) of the sea cucumber *Parastichopus californicus* for ages 2–6+ years sampled in the San Juan Islands, Washington (n = 100) during ride-along trips aboard Lummi Nation commercial harvest diving vessels on June 12, 2013 and May 7, 2014. The line at the 50th percentile was plotted for reference purposes only.

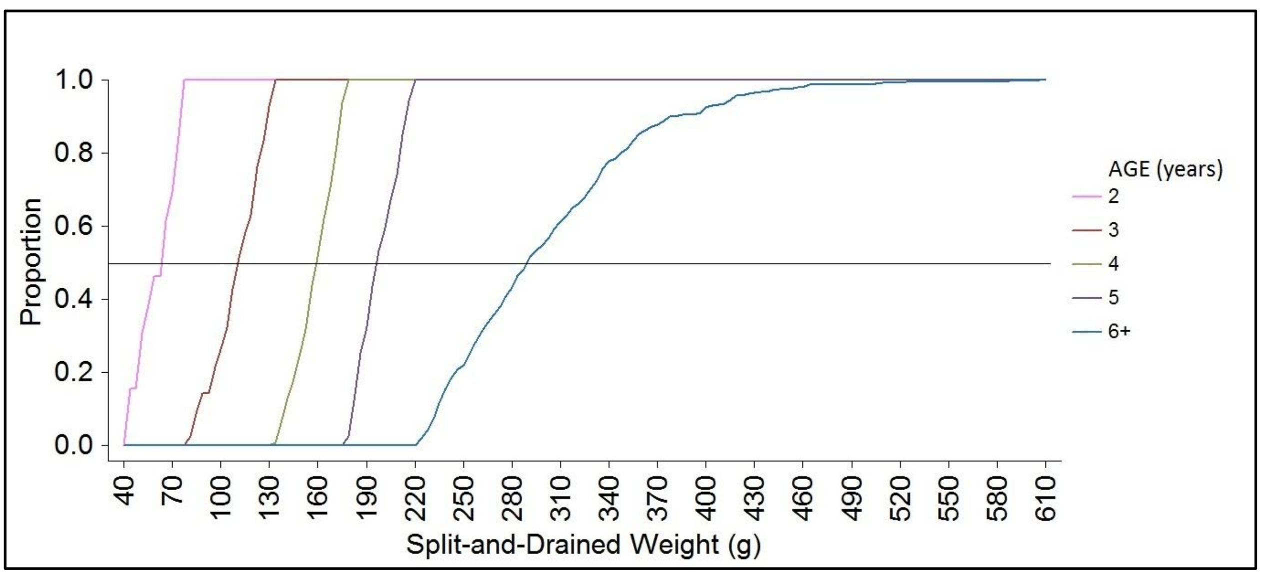

Figure 22. Cumulative distribution plot of split-and-drained weights (g) in air (SWA) of the sea cucumber *Parastichopus californicus* for ages 2–6+ years sampled in the San Juan Islands, Washington (n = 800) during various months from May 27, 2014 through May 28, 2015. Sea cucumbers were sampled independent of the commercial fishery. The line at the 50th percentile was plotted for reference purposes only.

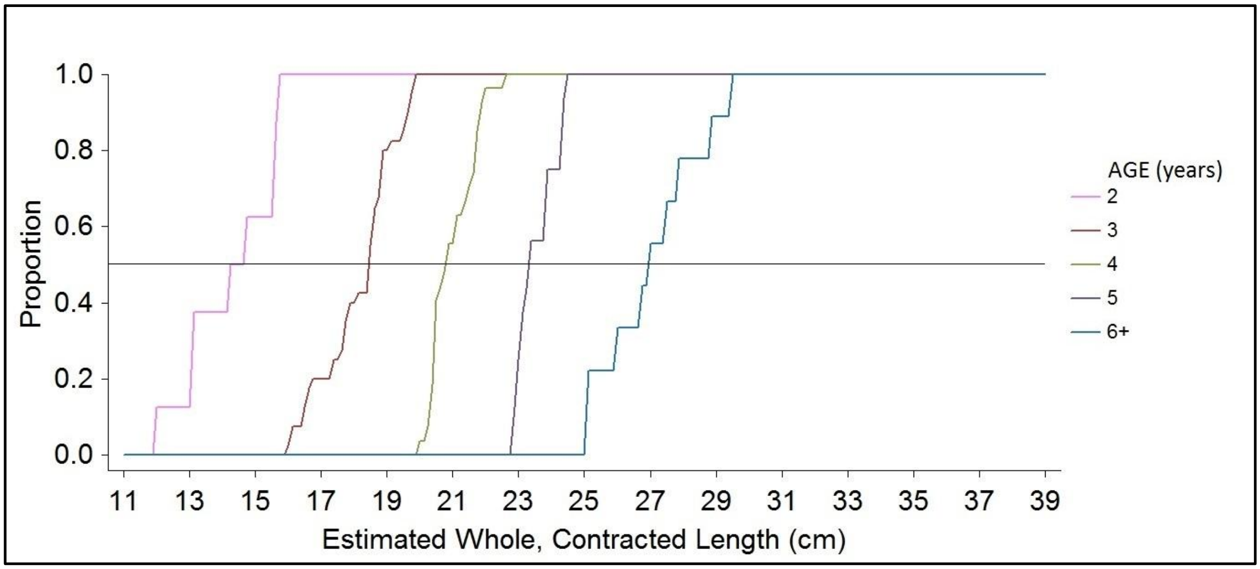

Figure 23. Cumulative distribution plot of estimated whole, contracted lengths (cm) (WL) of the sea cucumber *Parastichopus californicus* for ages 2–6+ years sampled in the San Juan Islands, Washington (*n* = 100) during ride-along trips aboard Lummi Nation commercial harvest diving vessels on June 12, 2013 and May 7, 2014. The line at the 50th percentile was plotted for reference purposes only.

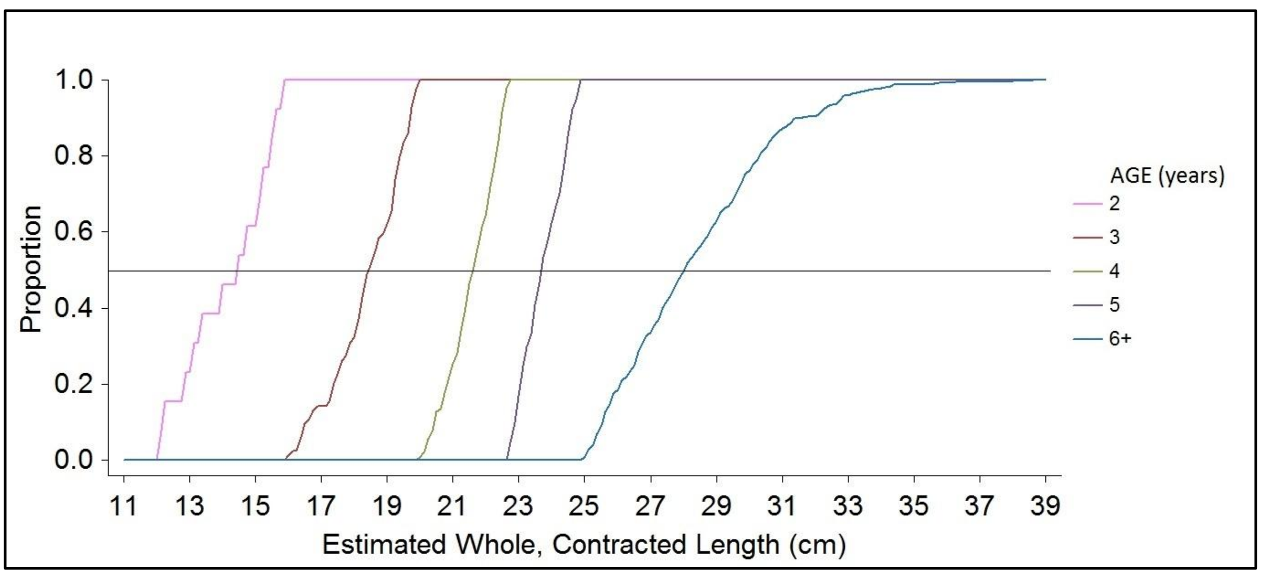

Figure 24. Cumulative distribution plot of estimated whole, contracted lengths (cm) (WL) of the sea cucumber *Parastichopus californicus* for ages 2–6+ years sampled in the San Juan Islands, Washington (*n* = 800) during various months from May 27, 2014 through May 28, 2015. Sea cucumbers were sampled independent of the commercial fishery. The line at the 50th percentile was plotted for reference purposes only.

Size Structure

The round weights or whole, wet weights in air (WWA) of *P. californicus* sampled during the commercial ride-along trips ranged from 135 g to 1,000 g. The combined average WWA for these trips was 410 g (n = 100). The WWA of *P. californicus* sampled independent of the fishery, but using the same voluntary minimum size limit as the commercial harvest diving fleet, ranged from 91g to 2,043 g. The combined average WWA for all fishery-independent sampling trips was 603 g (n = 800). When all data (fishery-dependent and fishery-independent) were pooled, the overall average WWA was 581 g (N = 900).

Appendices A and B show the size frequency (%) distributions for both fishery- and fishery-independent data. The split-and-drained weights in air (SWA) of *P. californicus* sampled during the commercial ride-along trips ranged from 40 g to 325 g (mean ± SD = 143 ± 56 g), whereas the SWA of sea cucumbers sampled independent of the fishery ranged from 42 g to 606 g (mean ± SD = 232 ± 80 g) (Figure 25; Appendices A and B). The overall average SWA from the LNR study (fishery-dependent and fishery-independent data combined) was 222 g (N = 900). Nearly half of the sea cucumbers sampled during commercial ride-along trips (48 of 100) were smaller than the commercial harvest diving fleet's voluntary minimum size limit (SWA ≈ 130 g; Appendix A), whereas most *P. californicus* sampled independent of the fishery (88% or 703 of 800) were larger than the voluntary size threshold (Appendix B). In fact, during the commercial ride-along trips, the mean SWA never exceeded 160 g (Appendices A). Furthermore, the difference between the SWA from the fishery-dependent data (n = 100) vs. the SWA from the fishery-independent data (n = 800) was significant (Mann-Whitney test, $U_{\text{Dependent}}$ = 15,386, $U_{\text{Independent}}$ = 64,614, normal deviate, d = 10.04, P < 0.001), i.e., commercially-caught sea cucumbers were smaller (and younger) than those sampled independent of the fishery (Figures 20 and 26).

Temporospatial variation in the size frequency distributions of *P. californicus* was also evident during the study, mostly in the fishery-independent data (Appendix B; but, see also Figure 25). For example, the mean SWA (± SD) of sea cucumbers sampled independent of the fishery in 2014 was 243 ± 92 g (n = 500), whereas the same statistic in 2015 was 214 ± 79 g (n = 300). When SWA was compared between years, the difference was significant (Mann-Whitney test, U_{2014} = 91,185, U_{2015} = 58,815, normal deviate, d = 5.11, P < 0.001). Moreover, a non-parametric ANOVA revealed significant differences in SWA among general locations (Kruskal-Wallis test, H = 140.56, P < 0.0001). Pair-wise comparisons demonstrated that the SWA of *P. californicus* sampled at the junction of Bellingham, Samish, and Padilla bays (i.e., Vendovi Island) was significantly higher than the SWAs from the other general locations; the Rosario Strait SWA was the lowest (Dunn's test, Z = 3.765, P < 0.001; Figure 27). With respect to sampling depths, a non-parametric ANOVA for SWA revealed a significant difference at this scale as well (Kruskal-Wallis test, H = 116.39, P < 0.0001). Pair-wise comparisons of the SWAs by sampling depth showed that *P. californicus* from diver depths > 50 ft MLLW were significantly smaller than sea cucumbers from shallower depths (Dunn's test, Z = 3.891, P < 0.001; Figure 28). It should be noted that sea cucumbers from diver depths > 50 ft MLLW were sampled only during the commercial ride-along trips.

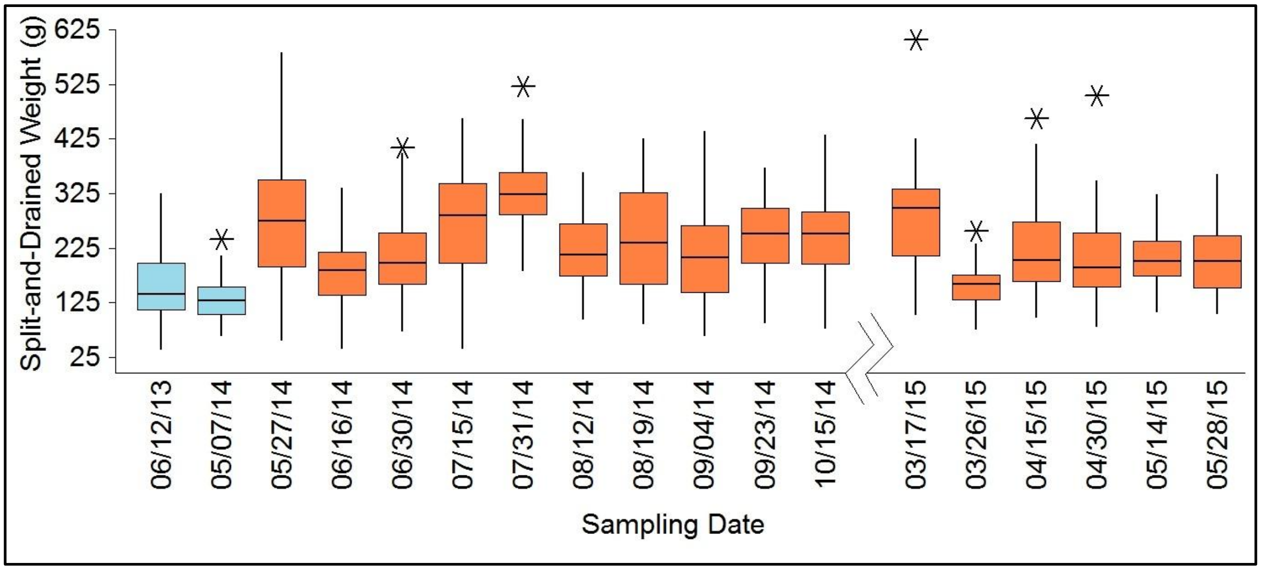

Figure 25. Box-and-whisker plots of split-and-drained weight in air (g), or market weight, of the sea cucumber *Parastichopus californicus* collected in the San Juan Islands, Washington on various dates (50 sea cucumbers per trip) over a two-year period. The light blue boxes represent fishery-dependent data (n = 100), whereas the orange boxes represent fishery-independent data (n = 800).

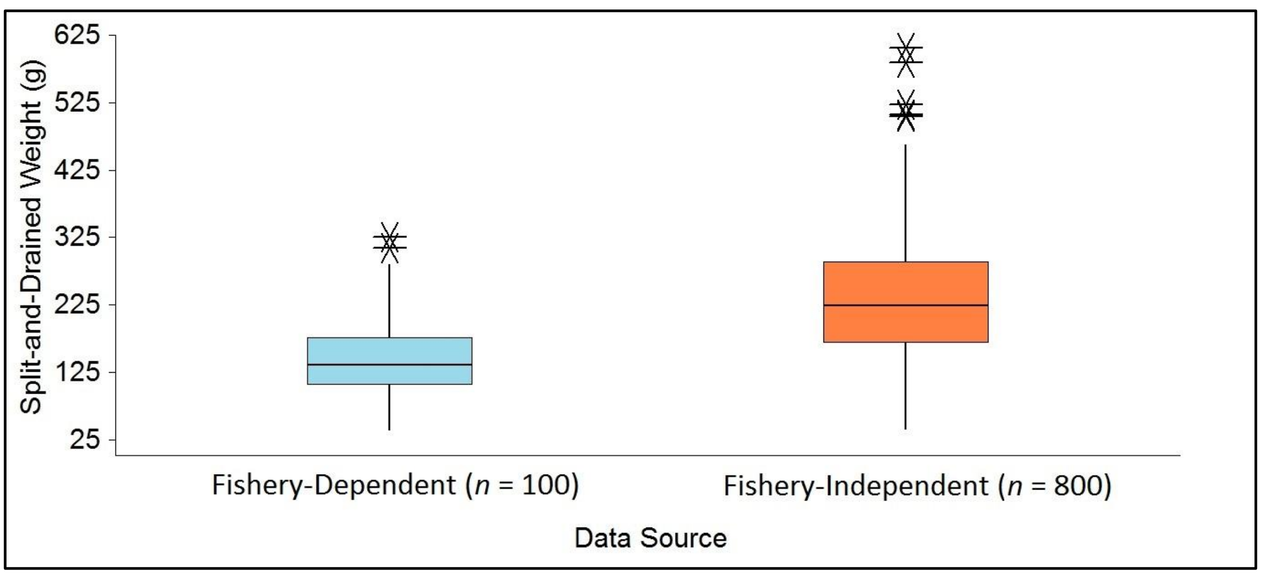

Figure 26. Box-and-whisker plots of split-and-drained weight (g) in air (SWA), or market weight, of the sea cucumber *Parastichopus californicus* sampled during commercial ride-along trips (light blue box) and independent of the fishery (orange box) in the San Juan Islands, Washington from June 2013 through May 2015. The number of sea cucumbers sampled (n) for each data source is indicated parenthetically. The SWA of the fishery-dependent data was significantly lower than that of the fishery-independent data (Mann-Whitney test, $U_{\mathrm{Dependent}}$ = 15,386, $U_{\mathrm{Independent}}$ = 64,614, and normal deviate, d = 10.04, P < 0.001).

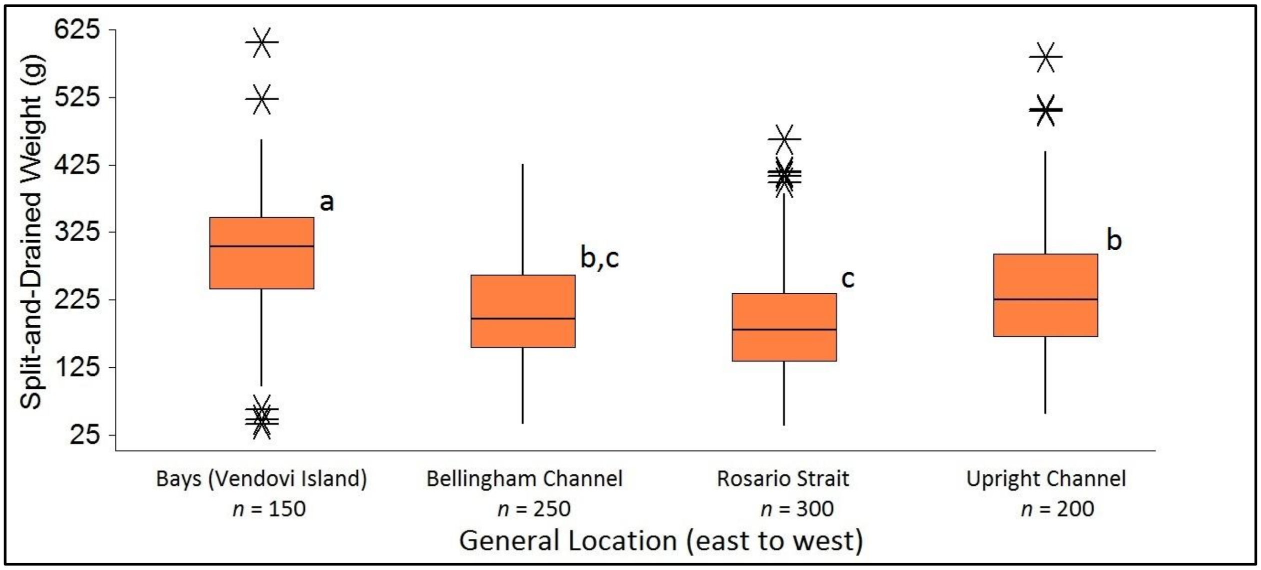

Figure 27. Box-and-whisker plots of split-and-drained weight in air (g), or market weight, of the sea cucumber *Parastichopus californicus* from four general locations in the San Juan Islands, Washington sampled on various dates from June 2013 through May 2015 (50 sea cucumbers per sampling trip; fishery-dependent and fishery-independent data combined). The number of sea cucumbers sampled (n) at each general location is indicated below each box. General locations sharing letters indicate SWAs that were not significantly different from one another (Dunn's pair-wise comparisons test, $Z = 3.765$, $P < 0.001$).

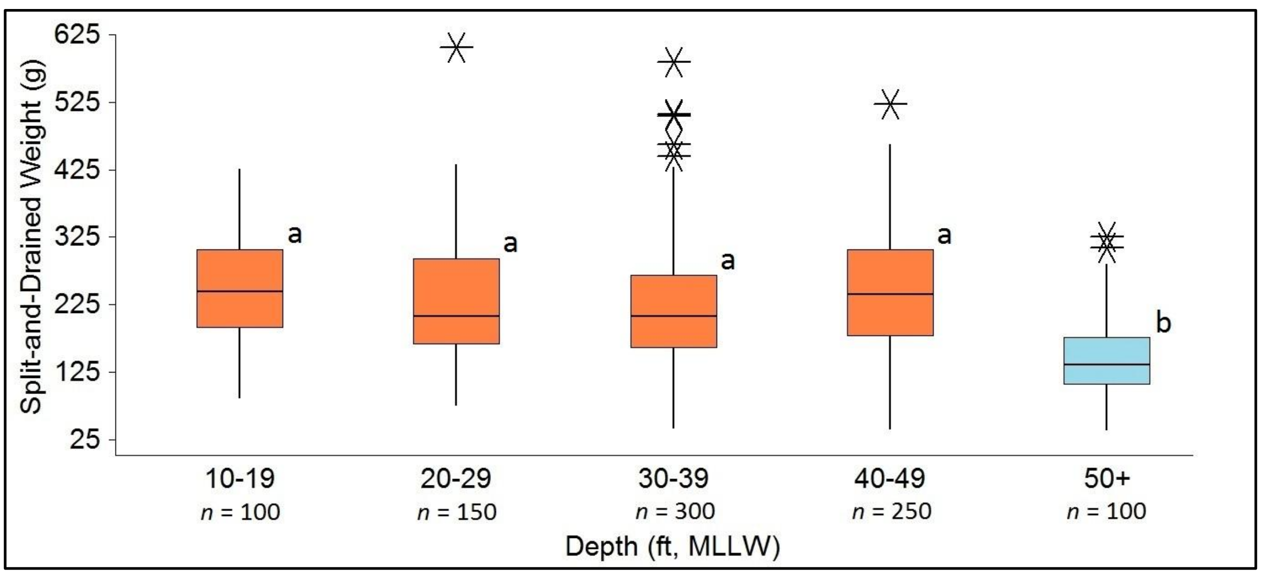

Figure 28. Box-and-whisker plots of split-and-drained weight in air (g), or market weight, of the sea cucumber *Parastichopus californicus* collected at five sampling depths in the San Juan Islands, Washington on various dates from June 2013 through May 2015 (50 sea cucumbers per sampling trip). The number of sea cucumbers sampled (n) at each depth is indicated below each box. The light blue box indicates *P. californicus* sampled during two commercial ride-along trips. Sampling depths sharing letters indicate SWAs that were not significantly different from one another (Dunn's pair-wise comparisons test, $Z = 3.891$, $P < 0.001$).

Further assessment of SWA revealed differences in the size structure of *P. californicus* at the decadal scale as well. With few exceptions, average SWAs from the LNR study were lower than a five-year average (313 g) of SWAs of *P. californicus* (*N* = 1,133) landed in British Columbia, Canada from 1997 to 2001 (Campagna and Hand 2004; Figure 29). In yet another comparison with earlier research on *P. californicus* (Fankboner and Cameron 1985), while negligible, if any, differences existed in SWAs of female and male *P. californicus* sampled during the LNR study (Figure 29), and while temporal changes in SWA between the two studies appeared similar, especially when comparing the 2014 data with that of 1982, the mean SWA values from the LNR study were mostly 20–30% lower than the monthly averages reported for British Columbia, Canada by Fankboner and Cameron (1985) more than 30 years ago (Figure 29). Ultimately, sea cucumbers of unknown sex exhibited smaller SWAs than sexed individuals for two reasons: 1) age or maturity (i.e., gonads very small or undifferentiated indicating young age), and 2) seasonal aestivation or visceral atrophy (Fankboner and Cameron 1985; Cameron and Fankboner 1986).

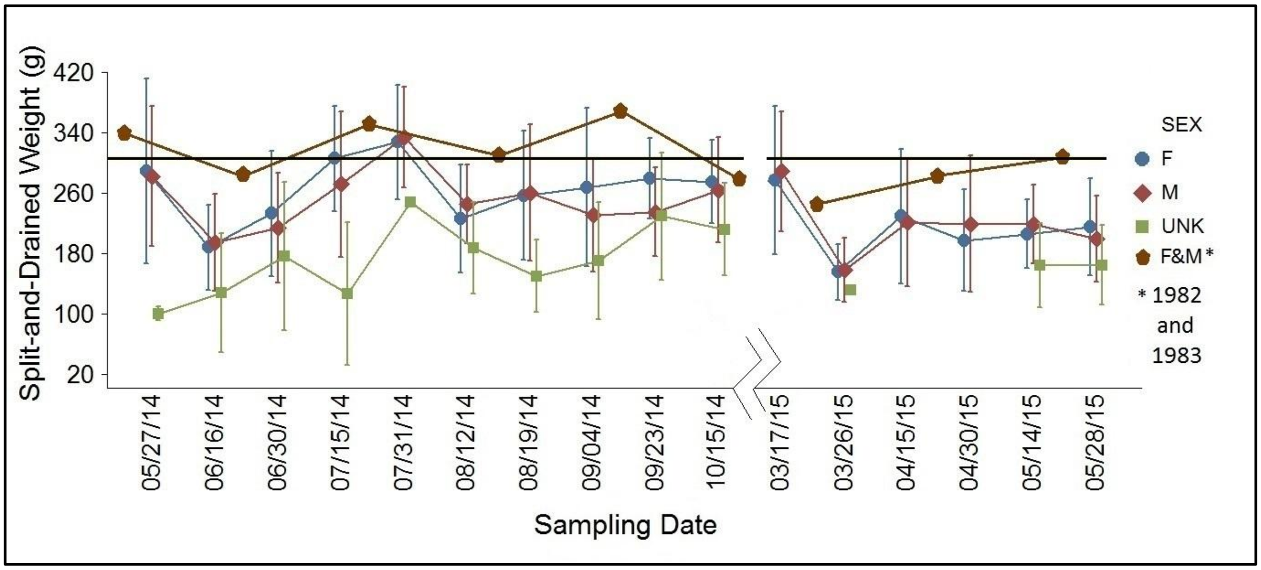

Figure 29. Mean (± SD) split-and-drained weights (SWA) of female (F), male (M), and unknown sex (UNK) sea cucumber *Parastichopus californicus* sampled independent of the fishery from locations open to commercial harvest in the San Juan Islands, Washington from May 2014 through May 2015. Monthly averages of the SWAs of *P. californicus* (sexes combined, F&M) sampled independent of the fishery in British Columbia, Canada over an analogous two-year period, but decades earlier (1982 and 1983; Fankboner and Cameron 1985), were plotted for reference purposes only. Similarly, the black reference line at 313 g represents the average SWA of *P. californicus* (sexes combined) landed in British Columbia, Canada (*N* = 1,133; range: 225–489 g) from 1997–2001 (Campagna and Hand 2004).

The estimated whole, contracted lengths (WL) of *P. californicus* sampled during the commercial ride-along trips ranged from 12 cm to 29 cm (mean ± SD = 20 ± 3 cm), whereas the WL of sea cucumbers sampled independent of the fishery ranged from 12 cm to 39 cm (mean ± SD = 25 ± 4 cm). During the commercial ride-along trips, the mean WL never exceeded 21 cm (Appendices A and B). As with SWA, nearly half of the sea cucumbers sampled during commercial ride-along trips (48 of 100) displayed WL values shorter than the commercial harvest diving fleet's voluntary minimum size limit of ~ 20 cm (Appendix A), whereas most sea cucumbers sampled independent of the fishery (88% or 703 of 800) were longer than the voluntary size threshold (Appendix B). Indeed, the historical photograph analysis (*sensu* McClenachan 2009) indicated that the WLs of *P. californicus* retained by commercial harvest divers today may be 50% of the WLs from 30+ years ago (Figure 30).

Figure 30. Historical photograph analysis (*sensu* McClenachan 2009) of sea cucumber *Parastichopus californicus* catches from two time periods: one decades-old, the other, more contemporary. At left, Canadian commercial harvest divers process their catch of *P. californicus* off the British Columbia coastline in the 1980s (Sloan 1989). At right, a Lummi Nation crew member does the same, but more recently (May 7, 2014) in the San Juan Islands, Washington. The red lines overlaying the crew members' upper arms are the same length to provide scale. The drop-down lines at the top of the photographs match the red and white lines overlaying selected sea cucumbers in the bins.

Relationship between Round Weight and Market Weight

This relationship was explored for the sake of comparing the results to those of Hannah et al. (2012) who used a similar ratio to examine temporal differences in the relationship. For example, those authors found no significant difference in the ratio between seasons. On the other hand, in the LNR study, linear regression revealed a significant difference in the relationship between the natural log ($\log_e$) market weight (split-and-drained weight or SWA) and $\log_e$ round weight (whole, wet weight or WWA) among two-month sampling periods (F = 3,631.2; $P < 0.00001$); a non-significant F test for lack of fit indicated use of an appropriate regression model (F = 0.84; P = 0.7986). The high significance of the linear regression result suggests that round weight explains a significant portion of the variation in market weight – not too surprising given the natural fluctuation in coelomic fluids/contents of individual *P.*

californicus (Fankboner and Cameron 1985; Hannah et al. 2012). Further comparison of the regression lines by two-month sampling period (Figure 31) indicated significant differences in their slopes and elevations (F = 3.83 and 7.52, respectively; P < 0.01). Table 4 lists the regression equations for each two-month sampling period and compares them with the results of Hannah et al. (2012). The average round weight (581 g) of all *P. californicus* sampled during the LNR study (N = 900) was inserted into these equations to solve for SWA, which ranged from 228 g to 237 g using Hannah et al.'s (2012) regression equations, and from 217 g to 239 g using those of the LNR study. In the end, the minimum and maximum SWA values differed by less than 5% using the equations of Hannah et al. (2012), whereas the minimum and maximum SWA values from the LNR equations differed by less than 10% (Table 4).

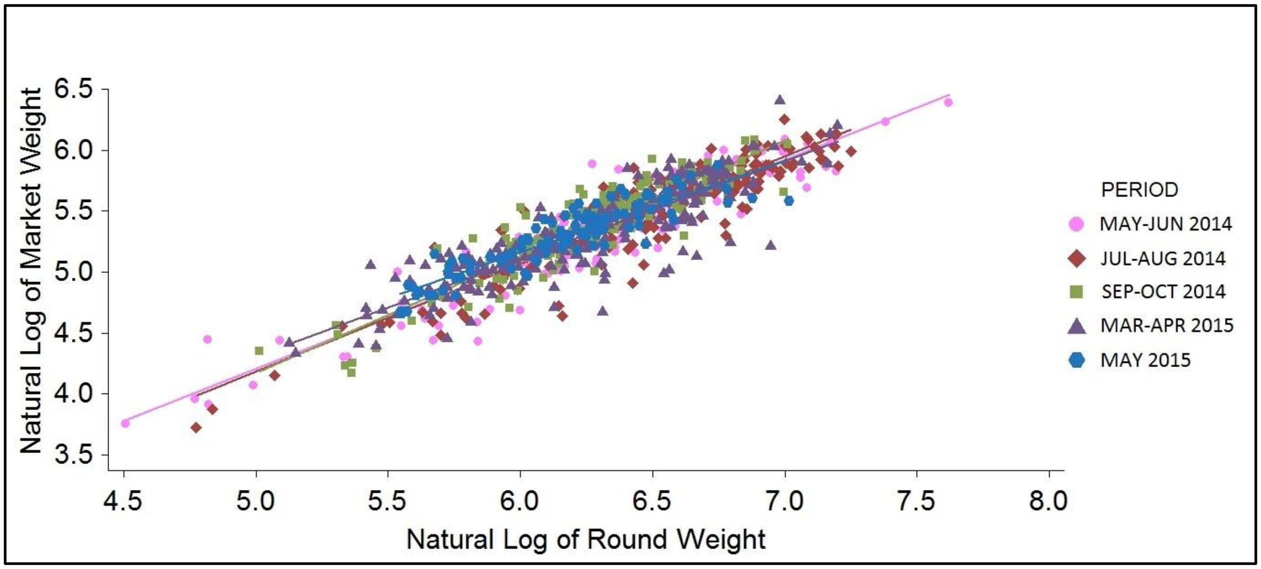

Figure 31. Relationships between the natural logs ($\log_e$) of round weight (whole, wet weight in air, WWA) and market weight (split-and-drained weight in air, SWA) of the sea cucumber *Parastichopus californicus* sampled independent of the fishery during several two-month periods analogous to those of Hannah et al. (2012). Round weights ranged from 91 g to 2,043 g, whereas SWA ranged from 42 g to 606 g. The regression equations and R^2 values are summarized in Table 4.

The ratio of market weight (SWA) to round weight (WWA) of *P. californicus* sampled independent of the fishery ranged from 0.179 to 0.691 with a median value of 0.396. In 2014, the mean SWA: WWA ratio (± SD) was 0.392 ± 0.072 (n = 500), whereas in 2015, the mean SWA: WWA ratio (± SD) was 0.406 ± 0.074 (n = 300). This difference was significant (one-way ANOVA, $F_{1, 798}$ = 7.01, P = 0.0083). Furthermore, a significant difference was detected in the ratio of the market weight to round weight for the different sampling periods of the LNR study (Kruskal-Wallis one-way non-parametric ANOVA, H = 52.86, P < 0.0001). Pair-wise comparisons of the ratios of SWA to WWA for the two-month sampling periods revealed a significant difference both among and between sampling years (Dunn's test, Z = 3.891, P < 0.001; Figure 32).

Table 4. Results of regression analyses between the natural log ($\log_e$) market weight (i.e., split-and-drained weight in air or SWA) and the $\log_e$ round weight (i.e., whole, wet weight in air or WWA) of the sea cucumber *Parastichopus californicus* from two studies: one in British Columbia (BC), Canada (2007/2008; Hannah et al. 2012), the other, in the San Juan Islands, Washington (2014/2015; this study). For both studies, the regressions were based on samples collected independent of commercial fisheries (for the BC study, WWA ranged from 1g to 1,536 g, whereas WWA ranged from 91 g to 2,043 g in the current study); however, the overall average WWA (581 g) from the LNR study (fishery-dependent and fishery-independent data combined; $N = 900$) was used in the equations below to solve for SWA for descriptive purposes only. Finally, the 2007/2008 regressions were significant at $P < 0.001$, whereas the 2014/2015 regressions were significant at $P < 0.00001$.

Period	*n*	Regression Equation	R^2	*F*	SWA, if WWA = 581 g
Sep-Oct 2007[a]	174	$\log_e(\text{SWA}) = -0.504 + [0.933 \times \log_e(\text{WWA})]$	0.987	13,623.9	229 g
Jan-Feb 2008[a]	216	$\log_e(\text{SWA}) = -0.490 + [0.936 \times \log_e(\text{WWA})]$	0.993	31,021.1	237 g
Jul-Aug 2008[a]	166	$\log_e(\text{SWA}) = -0.246 + [0.892 \times \log_e(\text{WWA})]$	0.987	12,293.9	228 g
May-Jun 2014	150	$\log_e(\text{SWA}) = -0.071 + [0.856 \times \log_e(\text{WWA})]$	0.863	930.5	217 g
Jul-Aug 2014	200	$\log_e(\text{SWA}) = -0.232 + [0.883 \times \log_e(\text{WWA})]$	0.839	1,033.7	219 g
Sep-Oct 2014	150	$\log_e(\text{SWA}) = -0.610 + [0.956 \times \log_e(\text{WWA})]$	0.830	721.5	239 g
Mar-Apr 2015	200	$\log_e(\text{SWA}) = 0.293 + [0.803 \times \log_e(\text{WWA})]$	0.758	618.5	222 g
May 2015	100	$\log_e(\text{SWA}) = 0.655 + [0.751 \times \log_e(\text{WWA})]$	0.811	420.9	230 g

[a] Source: Hannah et al. (2012).

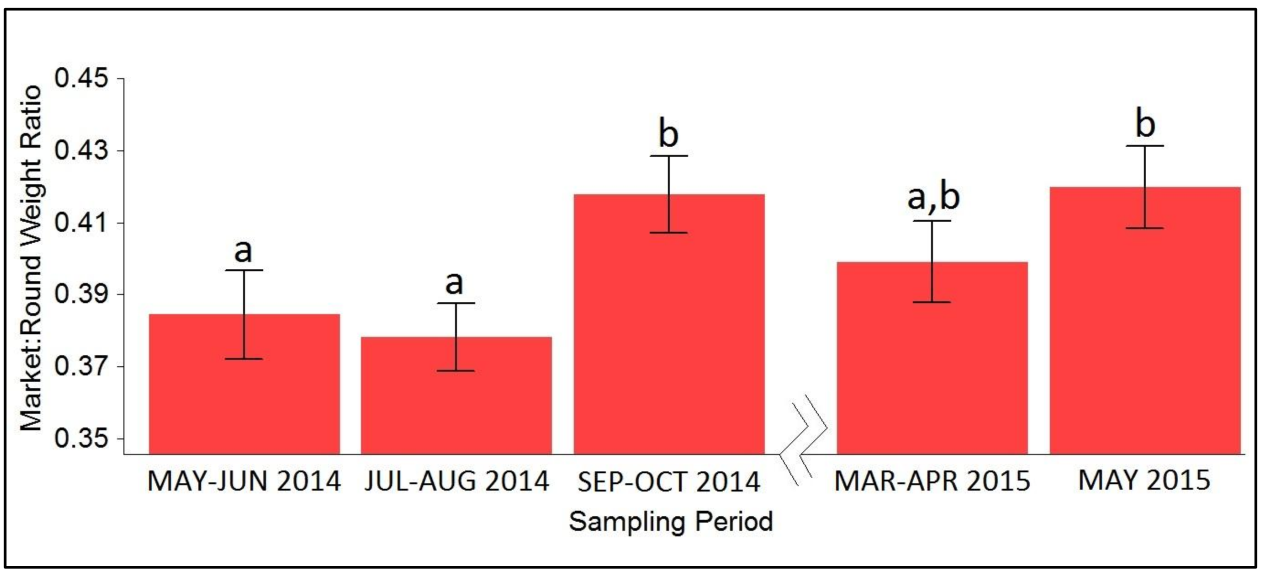

Figure 32. Mean ratio (± 95% CI) of the market weight (split-and-drained weight in air or SWA) to round weight (whole, wet weight in air or WWA) of the sea cucumber *Parastichopus californicus* sampled independent of the fishery in the San Juan Islands, Washington from May 2014 to May 2015. The data were grouped into two-month sampling periods analogous to those of Hannah et al. (2012). Bars sharing letters indicate ratios that were not significantly different from one another (Dunn's pair-wise comparisons test, $Z = 3.891$, $P < 0.001$).

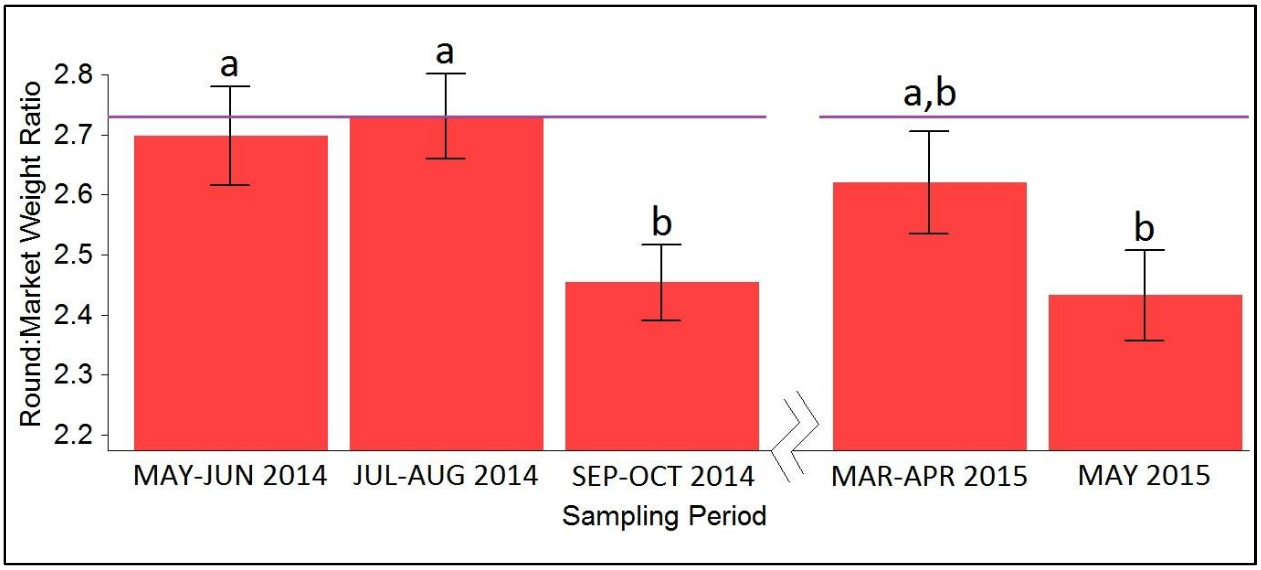

Figure 33. Mean ratio (± 95% CI) of the round weight (whole, wet weight in air or WWA) to the market weight (split-and-drained weight in air or SWA) of the sea cucumber *Parastichopus californicus* sampled independent of the fishery in the San Juan Islands, Washington from May 27, 2014 through May 28, 2015. Bars sharing letters indicate ratios that were not significantly different from one another (Dunn's pair-wise comparisons test, $Z = 3.891$, $P < 0.001$). The purple reference line at 2.73 represents the average WWA: SWA ratio of market-sampled *P. californicus* (sexes combined) from British Columbia, Canada reported by Heizer (1991) for January 1991.

By reversing the ratio of the two metrics, the resulting WWA: SWA ratios can be compared to the overall average (2.73) reported by Heizer (1991) from 25 years ago (Figure 33). The overall average WWA: SWA ratio from the fishery-independent phase of the LNR study (2.61) was only slightly lower (< 5%) than that reported by Heizer (1991). A non-parametric one-way ANOVA for the WWA: SWA ratios by sampling period revealed significant differences in these values (Kruskal-Wallis test, $H = 52.86$, $P < 0.0001$). Pair-wise comparisons of the ratios revealed a significant difference both among and between sampling periods (Dunn's test, $Z = 3.891$, $P < 0.001$; Figure 33).

Reproductive Biology, Gonadosomatic Index, and Spawning Periodicity

Aspects of the reproductive biology of *P. californicus* sampled aboard commercial harvest diving vessels were only available from the second of two ride-along trips. On May 7, 2014, the sexes of *P. californicus* sampled ($n = 50$) were about even (44% female, 50% male, and 6% unknown). In addition, the gonadosomatic index (GSI) ranged from 0.087 to 9.739, averaging (± standard error) 2.065 ± 0.309, with a relatively low median value of 1.162. Lastly, at the time of harvest, most of the sea cucumbers sampled during this trip had not reached sizes or ages that were capable of spawning (Appendix A).

The sexes of *P. californicus* sampled independent of the fishery were also about even (Figure 34), with some variation in them as the spawning season came to a close by the end of summer 2014 followed by the aestivation (visceral atrophy) phase beginning in fall 2014. Sex determination in *P. californicus* became increasingly difficult during these normal life history

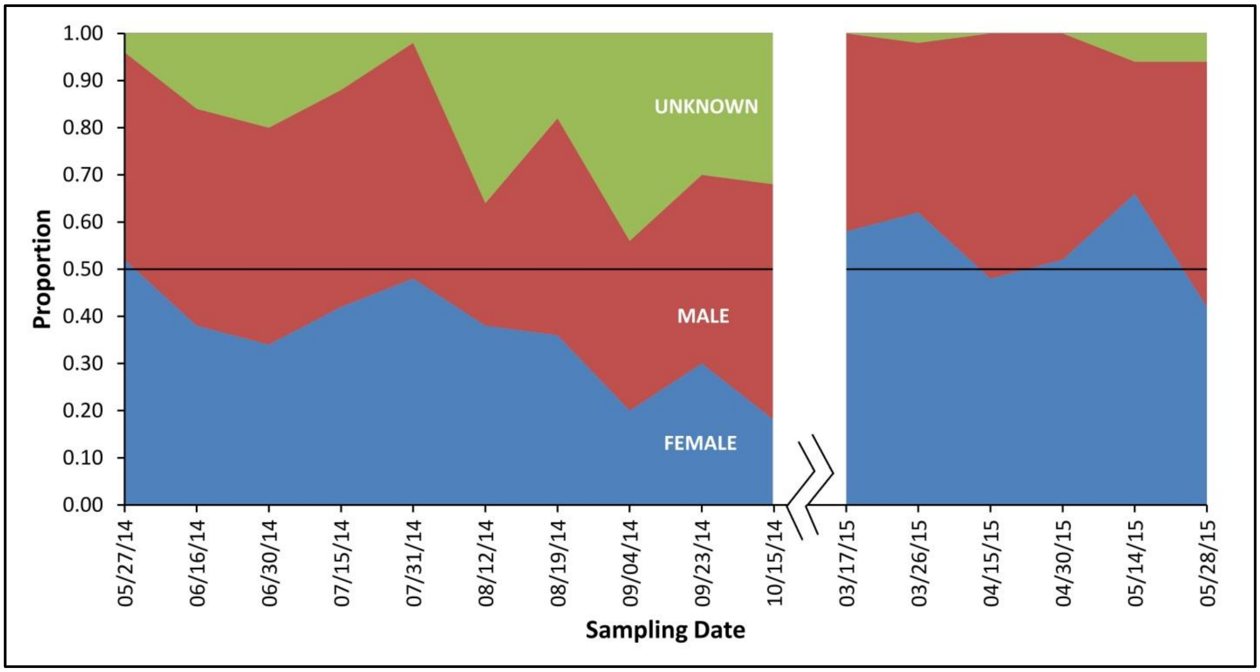

Figure 34. Proportional sexes (female, male, and unknown) of the sea cucumber *Parastichopus californicus* from the San Juan Islands, Washington, by sampling date (n = 50 per trip) during the fishery-independent phase of the LNR study. The line at the 50th percentile was plotted for reference purposes only.

events (Figure 34) as gonadal material was expelled, sloughed away, or was resorbed by the sea cucumber (Fankboner and Cameron 1985; Cameron and Fankboner 1986; Smiley 1988).

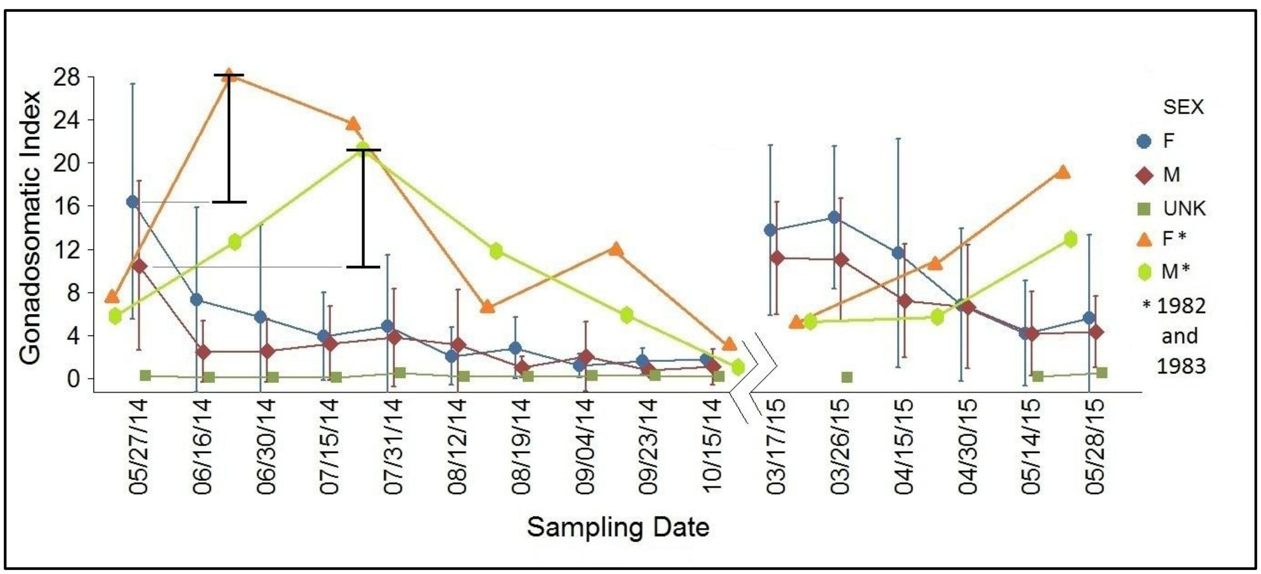

Figure 35. Mean gonadosomatic index (± SD) for the sea cucumber *Parastichopus californicus* from Washington State and British Columbia, Canada (BC) over analogous two-year periods but separated by more than 30 years (this study and Cameron and Fankboner 1986). The black vertical lines (**I**) indicate the differences in peak GSI among the sexes between the two studies. Note also that peak spawning of *P. californicus* occurs weeks earlier in the San Juan Islands compared to Indian Arm, BC. F = female, M = male, and UNK = unknown.

The plotted mean GSIs for *P. californicus* (by sampling date) suggests that peak spawning of the sea cucumber in the San Juan Islands, Washington occurred during April and May of 2014 and during March and April of 2015 (Figure 35), several days or weeks earlier than the peak (June and July) reported by Cameron and Fankboner (1986) for *P. californicus* sampled in British Columbia (BC), Canada over 30 years ago. In 2014 and 2015, mean GSI for male *P. californicus* peaked at approximately 10, whereas mean GSI for female *P. californicus* peaked at approximately 16. In contrast, the mean GSIs for male and female *P. californicus* from BC (Cameron and Fankboner 1986) were essentially double those of the San Juan Islands, peaking at approximately 22 and 28, respectively (Figure 35).

During the peak spawning period of *P. californicus* in the San Juan Islands, Washington, the relationships between gonad weight and estimated contracted length of female and male *P. californicus* were exponential in May 2014, the high R^2 values (> 0.6) indicating reasonably strong associations between the metrics (Figures 36 and 37). In March 2015, the exponential relationships between gonad weight and estimated contracted length of female and male *P. californicus* were not nearly as strong as those of the previous year, likely owing to fewer samples at the extreme ends of both metrics and the possibility that some animals were spawned out, either partially or entirely (Figures 38 and 39).

A nonparametric ANOVA revealed a significant difference in the distributions and median GSIs among the sexes (Kruskal-Wallis test, H = 258.36, P < 0.0001). In general, female sea cucumbers exhibited higher GSIs than male sea cucumbers, and of course, those individual *P. californicus* of undetermined sex (Dunn's pair-wise comparisons test; Z = 2.394, P < 0.05). Figure 40 shows the changes in mean GSI (± 95% CI) by sex and two-month sampling period for *P. californicus* collected independent of the fishery during 2014 and 2015.

Additional nonparametric ANOVAs (Kruskal-Wallis test) revealed significant differences in the GSIs among sampling periods (H = 262.30, P < 0.0001) and among ages (H = 44.49, P < 0.0001). Figure 41 shows the changes in mean GSI (± 95% CI) by age and two-month sampling period for *P. californicus* collected independent of the fishery during 2014 and 2015. Follow-up pair-wise comparisons showed that the GSIs (sexes combined) for summer and fall 2014 were significantly lower than the other sampling periods, whereas the GSI (sexes combined) for spring 2015 was significantly higher than the other sampling periods (Dunn's test, Z = 2.807, P < 0.05). Finally, GSI increased with age of *P. californicus* (sexes combined) through 4 years, reflecting the natural progression of gonad development for the species (Smiley 1988; Sewell et al. 1997). Indeed, pair-wise comparisons of the GSIs by age revealed that 2 and 3 year olds were significantly different from each other and from 4 and 5+ year olds; however, the latter were not significantly different from each other (Dunn's test, Z = 2.638, P < 0.05).

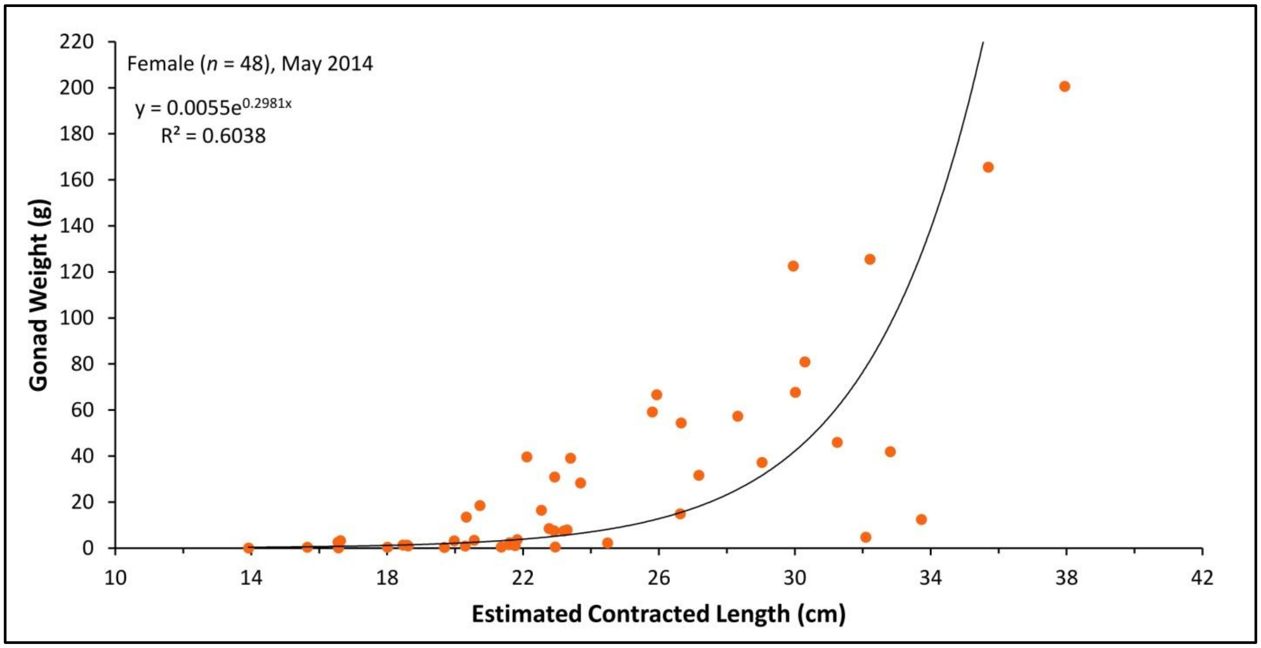

Figure 36. Exponential relationship between gonad weight (g) and estimated contracted length (cm) of the female sea cucumber *Parastichopus californicus* sampled in May 2014 during peak spawning of the species in the San Juan Islands, Washington.

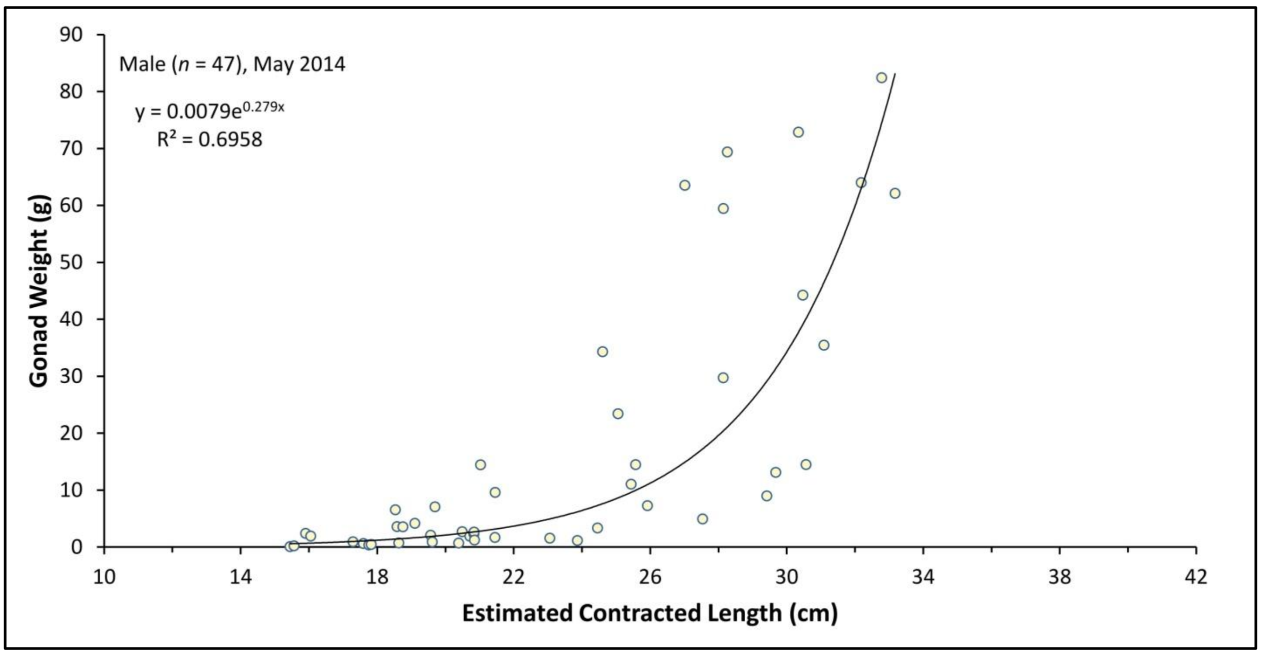

Figure 37. Exponential relationship between gonad weight (g) and estimated contracted length (cm) of the male sea cucumber *Parastichopus californicus* sampled in May 2014 during peak spawning of the species in the San Juan Islands, Washington.

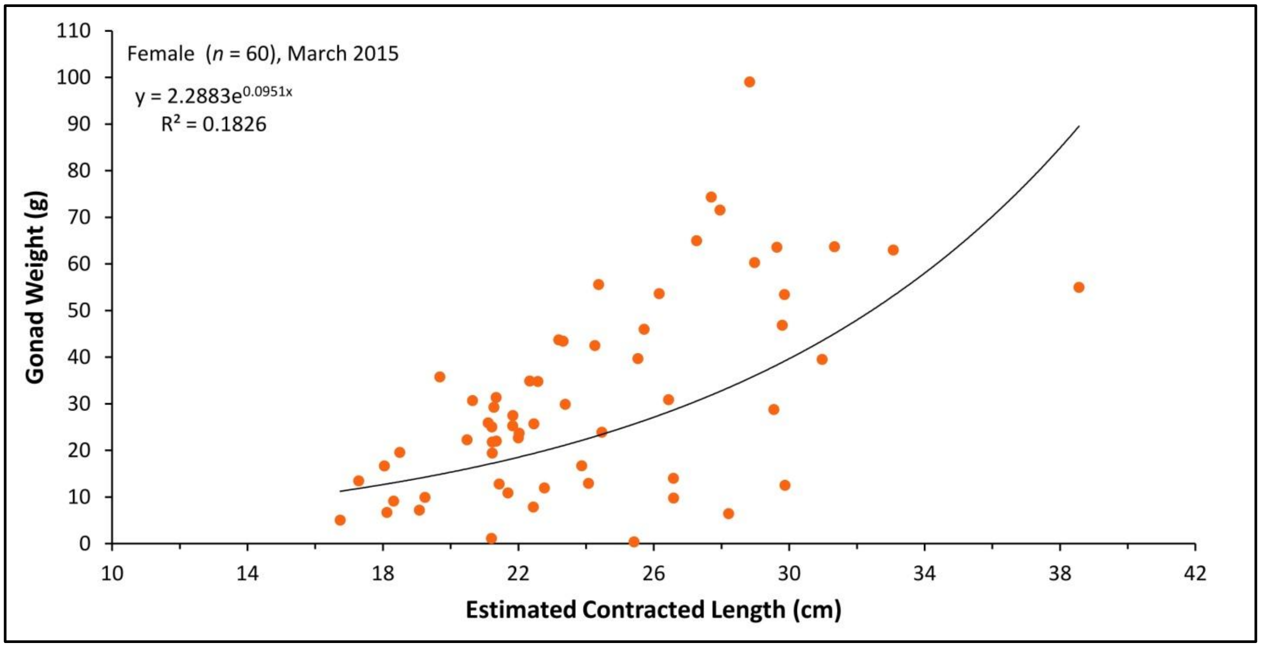

Figure 38. Exponential relationship between gonad weight (g) and estimated contracted length (cm) of the female sea cucumber *Parastichopus californicus* sampled in March 2015 during peak spawning of the species in the San Juan Islands, Washington.

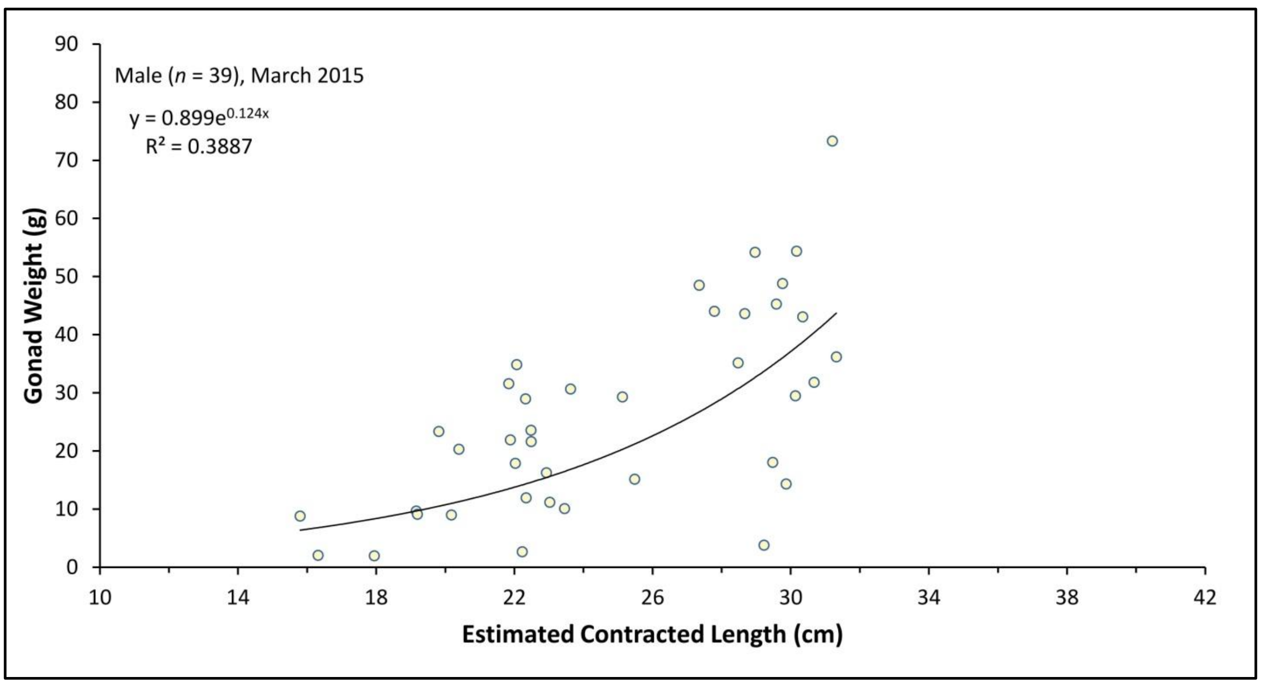

Figure 39. Exponential relationship between gonad weight (g) and estimated contracted length (cm) of the male sea cucumber *Parastichopus californicus* sampled in March 2015 during peak spawning of the species in the San Juan Islands, Washington.

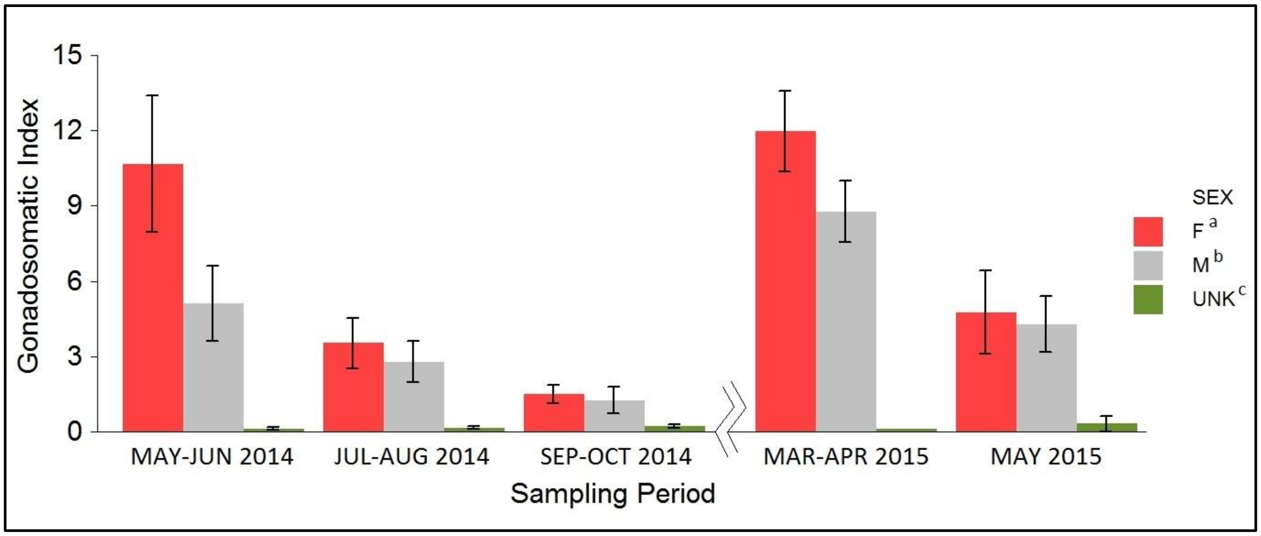

Figure 40. Mean GSI (± 95% CI) by sex and two-month sampling period for the sea cucumber *Parastichopus californicus* collected independent of the fishery in the San Juan Islands, Washington during 2014 and 2015. Separate letters associated with sex (F = female, M = male, and UNK = unknown) indicate that the GSIs for those groups were significantly different from one another (Dunn's pair-wise comparisons test, $Z = 2.394$, $P < 0.05$).

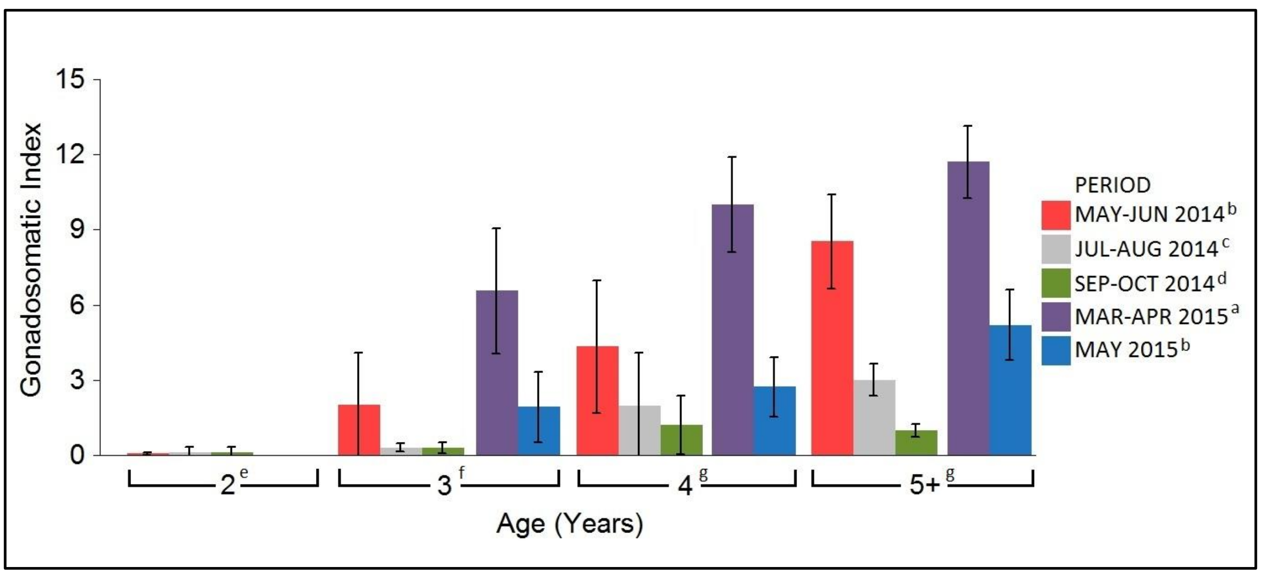

Figure 41. Mean GSI (± 95% CI) by age and two-month sampling period for the sea cucumber *Parastichopus californicus* collected independent of the fishery in the San Juan Islands, Washington during 2014 and 2015. Sampling periods sharing letters indicate GSIs that were not significantly different from one another (Dunn's pair-wise comparisons test, $Z = 2.807$, $P < 0.05$). Similarly, ages sharing letters indicate GSIs that were not significantly different from one another (Dunn's pair-wise comparisons test, $Z = 2.638$, $P < 0.05$).

Incidence of a Commensal Scale Worm and a Parasitic Snail

The commensal scale worm *Arctonoe pulchra* occurred in 10% to 70% of *P. californicus* sampled in 2014 and 2015. The incidence rate of the polychaete was no more than 3 scale worms per sea cucumber. Ostensibly, proportional presence of *A. pulchra* was influenced by the sampling date and location, and by the age of the sea cucumber sampled (Figures 42–47). The sex of *P. californicus* did not appear to influence proportional presence of the scale worm. Indeed, 49% of female *P. californicus* (n = 178) had at least one *A. pulchra* attached, whereas 41% of male *P. californicus* (n = 151) had at least one scale worm attached. Lastly, at least one *A. pulchra* was found on 51% of the sea cucumbers of unknown sex (n = 60).

Proportional presence of *A. pulchra* increased during the spring of both study years, peaking in mid-summer 2014 and again in mid-fall 2014 (Figure 42). This is not unusual for the species (Pernet 1998). While no clear longitudinal trend was observed in sea cucumbers with one scale worm attached, there was a slight increase in proportional presence of *A. pulchra* at higher densities (i.e., $\geq$ 2 polychaetes per sea cucumber) moving from west to east (Figure 44). In addition, the proportional presence of *A. pulchra* increased with the age *P. californicus* sampled (Figure 46).

The shell-less, parasitic snail *Enteroxenos parastichopoli*, on the other hand, occurred in less than 30% of *P. californicus* sampled in 2014 and 2015. The incidence rate of *E. parastichopoli* was variable; usually no more than one or two snails per sea cucumber, but infestations as high as 42 *E. parastichopoli* per sea cucumber were observed. Approximately 14% of female *P. californicus* (n = 51) were infested with at least one parasitic snail, whereas 15% of male *P. californicus* (n = 55) were infested with at least one *E. parastichopoli*. Regarding sea cucumbers of unknown sex, 29% (n = 34) were infested with at least one parasitic snail.

Like *A. pulchra*, proportional presence of *E. parastichopoli* increased slightly during spring, but decreased mid-summer 2014, and decreased further by the last sampling date in fall 2014 (Figure 43). In terms of location (Figure 4), the highest proportional presence of parasitic snails occurred at Lopez Island (Upright Channel) and in the vicinity of Cone and Sinclair islands (Bellingham Channel; Figure 45). And while proportional presence of *E. parastichopoli* in 2, 3 and 4 year old *P. californicus* was somewhat static at about 0.20, proportional presence of parasitic snails in 5+ year old sea cucumbers fell below 0.15 (Figure 47). Ultimately, irrespective of sampling date, location, or age of the sea cucumbers sampled, there appeared to be an inverse relationship between proportional presence of the parasitic snail and proportional presence of the commensal scale worm of *P. californicus*: whenever or wherever there was an increase in proportional presence of *A. pulchra*, there was a subsequent decrease in proportional presence of *E. parastichopoli* and vice-versa (Figures 42–47).

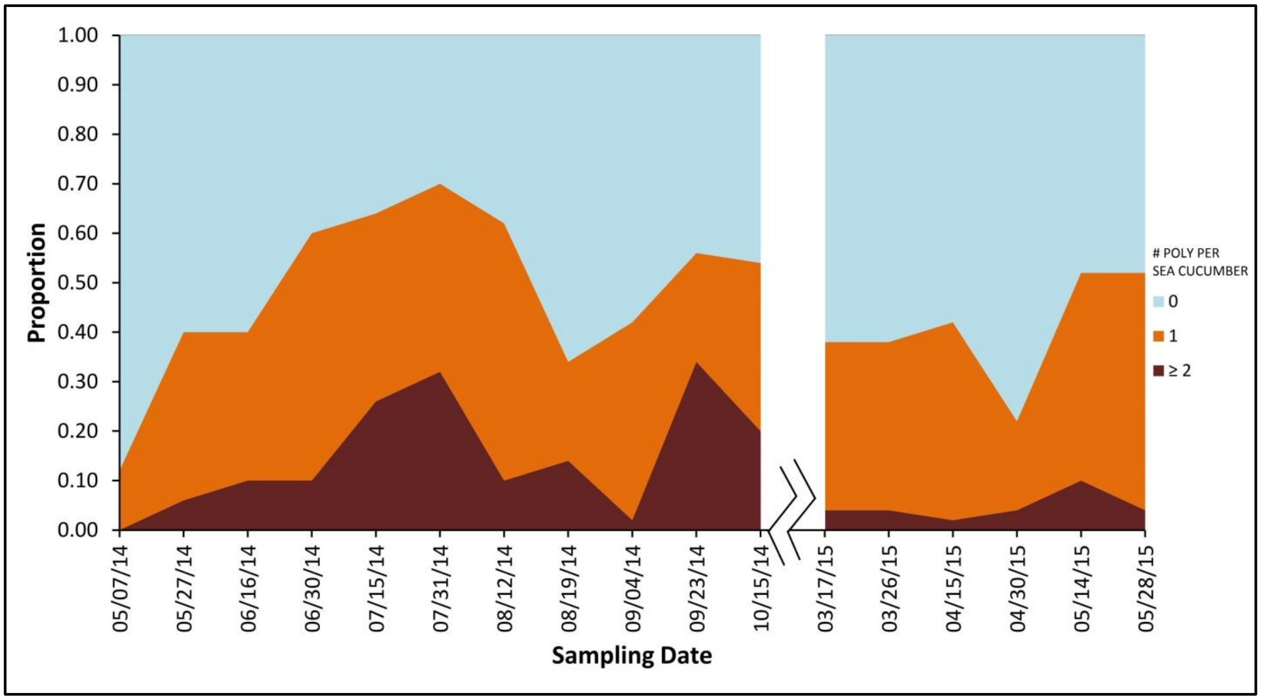

Figure 42. Proportional presence of the scale worm *Arctonoe pulchra* (Polychaeta) associated commensally with the sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington at three levels (0, 1, and ≥ 2 organisms per sea cucumber) by sampling date (n = 50 sea cucumbers per trip). POLY = polychaete worm.

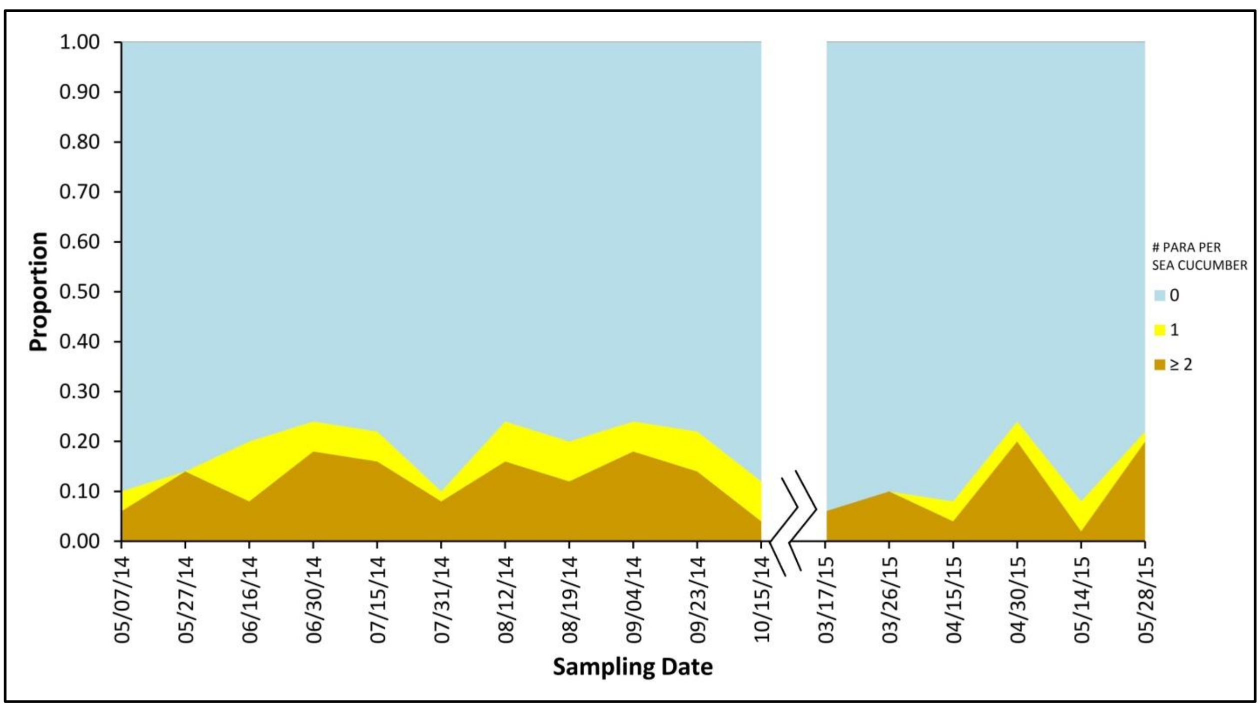

Figure 43. Proportional presence of the shell-less snail *Enteroxenos parastichopoli* (Mollusca) parasitizing the sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington at three levels (0, 1, and ≥ 2 organisms per sea cucumber) by sampling date (n = 50 sea cucumbers per trip). PARA = parasitic snail.

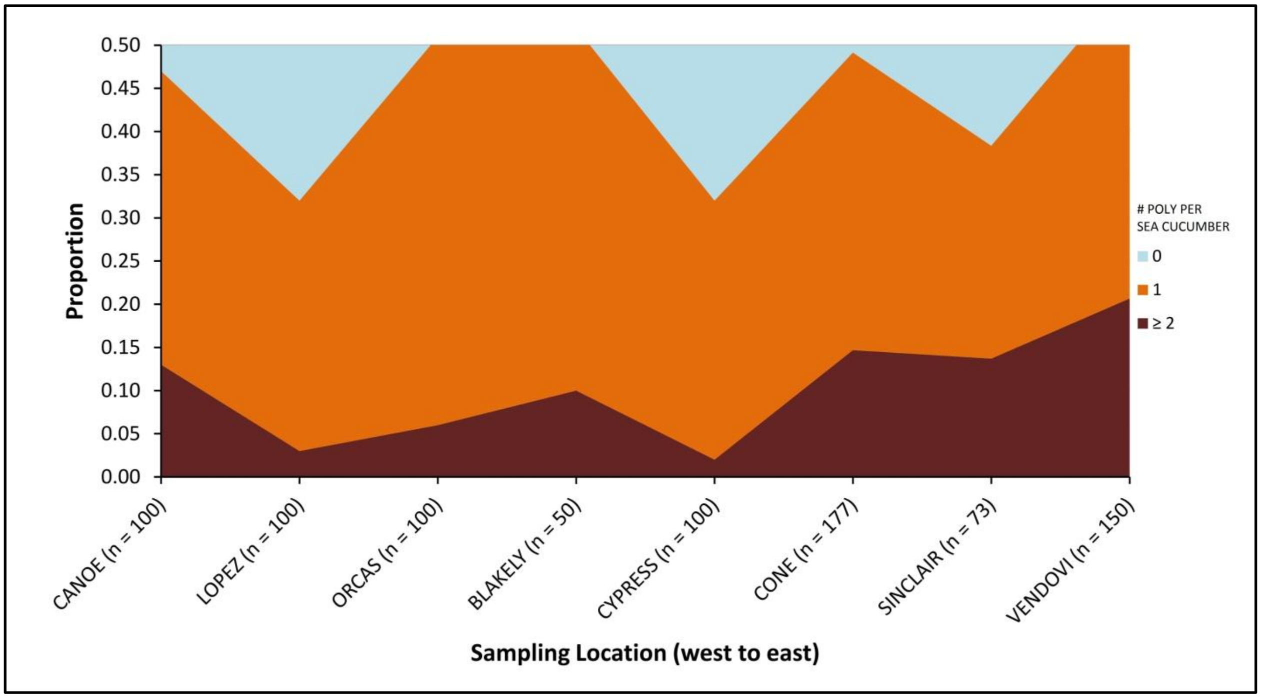

Figure 44. Proportional presence of the scale worm *Arctonoe pulchra* (Polychaeta) associated commensally with the sea cucumber *Parastichopus californicus* at three levels (0, 1, and ≥ 2 organisms per sea cucumber) by sampling location in the San Juan Islands, Washington. The number of sea cucumbers sampled by location is indicated parenthetically. POLY = polychaete worm

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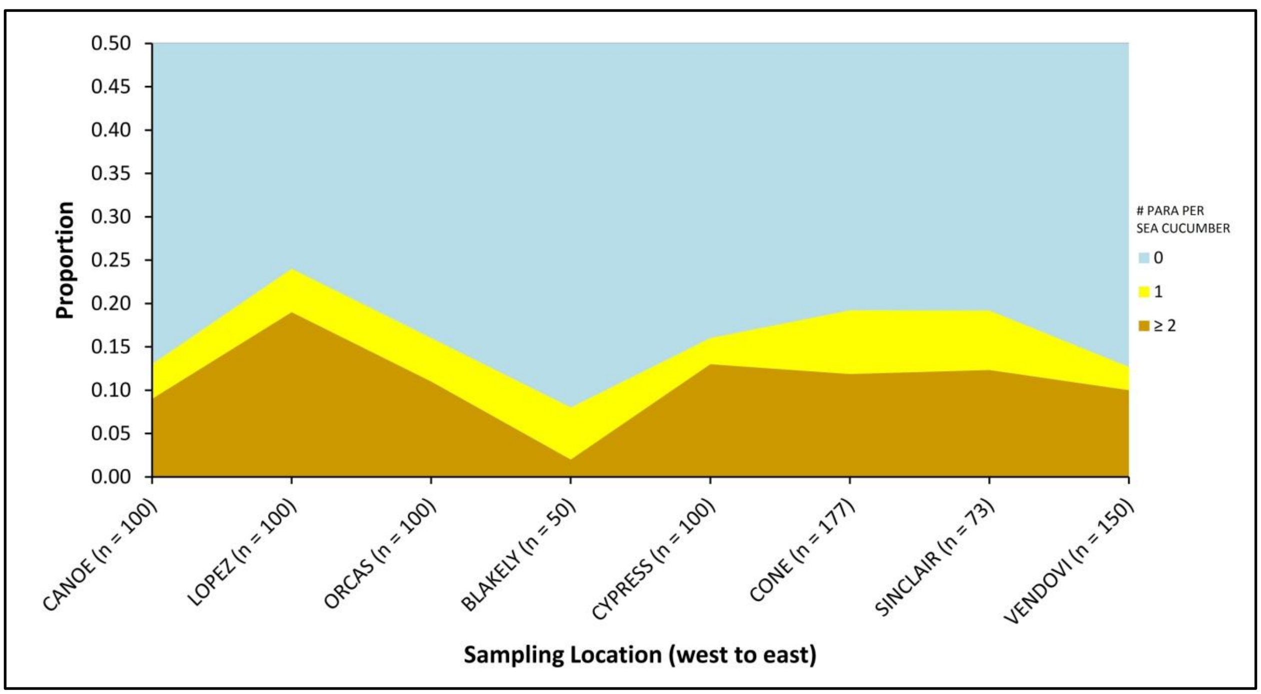

Figure 45. Proportional presence of the shell-less snail *Enteroxenos parastichopoli* (Mollusca) parasitizing the sea cucumber *Parastichopus californicus* at three levels (0, 1, and ≥ 2 organisms per sea cucumber) by sampling location in the San Juan Islands, Washington. The number of sea cucumbers sampled by location is indicated parenthetically. PARA = parasitic snail.

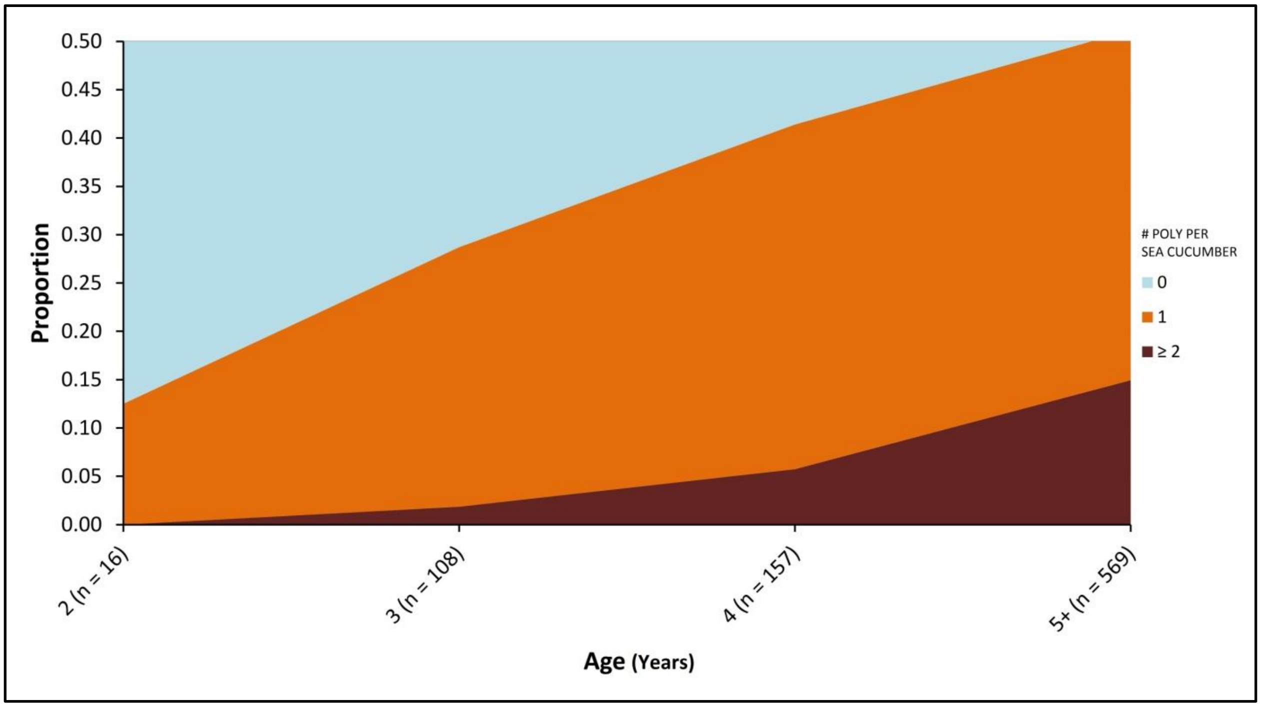

Figure 46. Proportional presence of the scale worm *Arctonoe pulchra* (Polychaeta) associated commensally with the sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington at three levels (0, 1, and ≥ 2 organisms per sea cucumber) by age (years) of sea cucumber. The number of sea cucumbers sampled at each age is indicated parenthetically. POLY = polychaete worm.

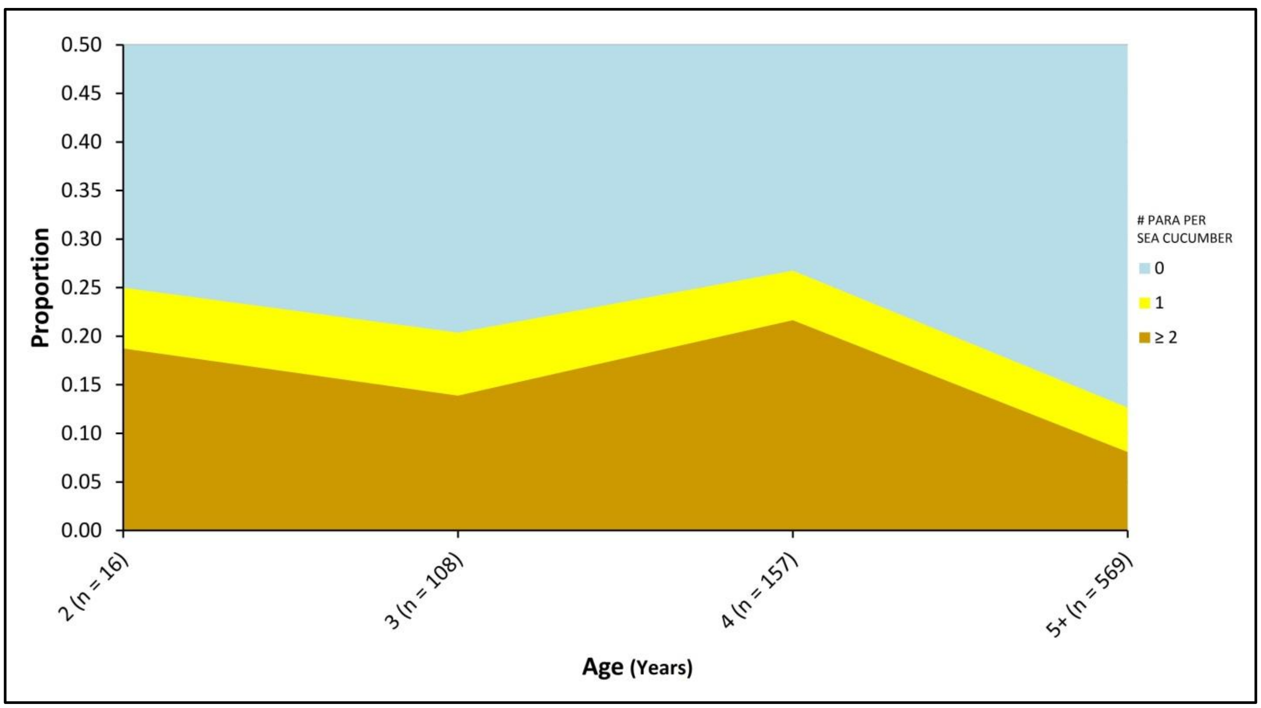

Figure 47. Proportional presence of the shell-less snail *Enteroxenos parastichopoli* (Mollusca) parasitizing the sea cucumber *Parastichopus californicus* in the San Juan Islands, Washington at three levels (0, 1, and ≥ 2 organisms per sea cucumber) by age (years) of sea cucumber. The number of sea cucumbers sampled at each age is indicated parenthetically. PARA = parasitic snail.

DISCUSSION

Impact of Global Climate Change

This study took place, coincidentally, during the warmest two-year period ever recorded on man-made instruments (Hansen et al. 2015, 2016). Around the planet, land and ocean temperatures were higher than average, exceeding records nearly everywhere (Figure 48). In the Northeast Pacific Ocean, elevated seawater temperatures contributed to record-breaking algae blooms in the region during the same period (Figure 49). These large-scale weather patterns and events should be kept in mind when considering the results of the LNR study; *P. californicus* was undoubtedly affected by them. Indeed, high primary productivity in the region certainly led to abundant food for planktotrophic larvae and deposit-feeding juvenile and adult stages of *P. californicus* (Strathmann 1971; Cameron and Fankboner1984; Edwards 2001; Figure 50), especially in 2015. Furthermore, sea cucumber gametogenesis (Cameron and Fankboner 1986),

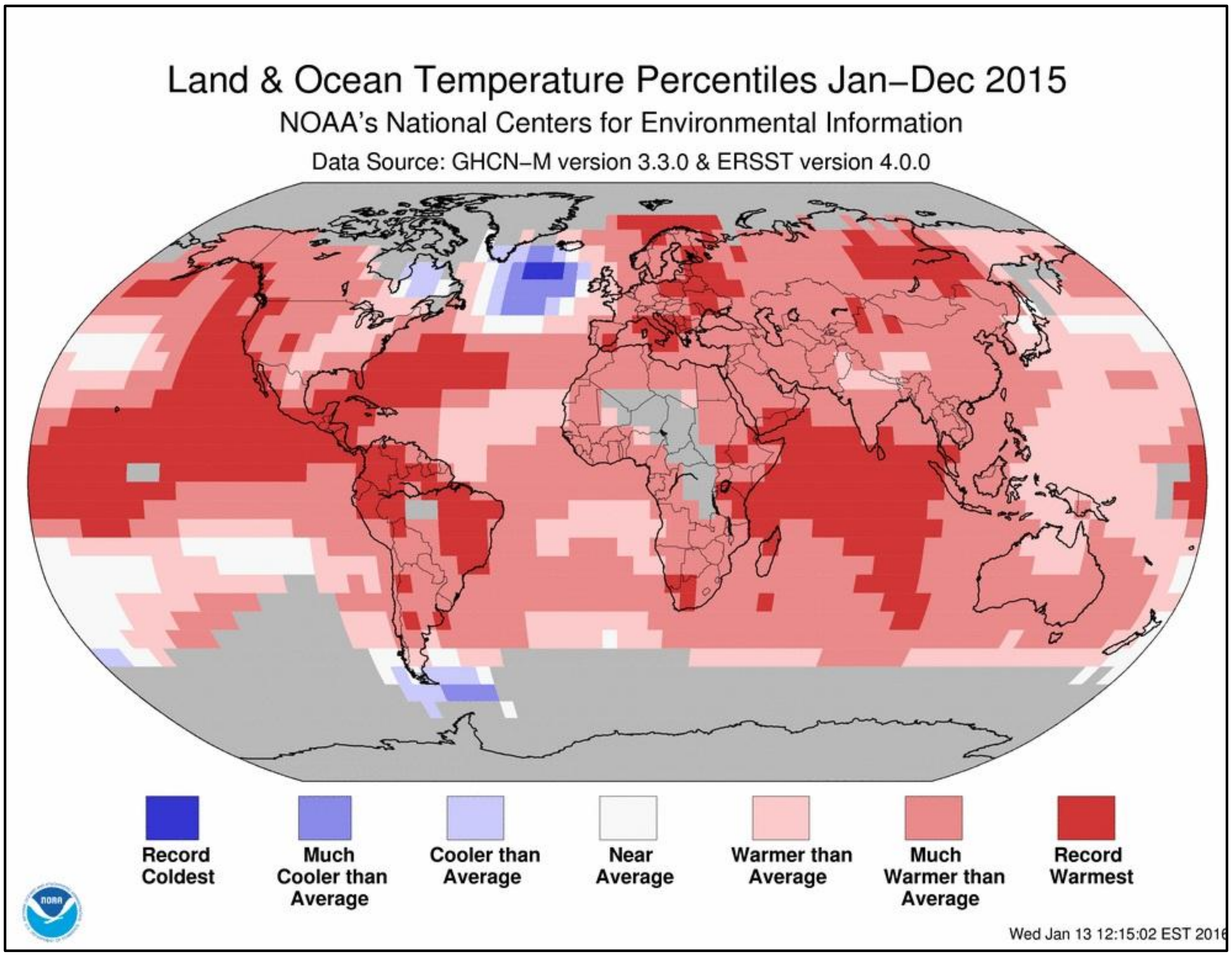

Figure 48. Schematic showing distribution and rank of record-breaking land and ocean temperatures around Planet Earth in 2015 (source: National Oceanic and Atmospheric Administration, NOAA).

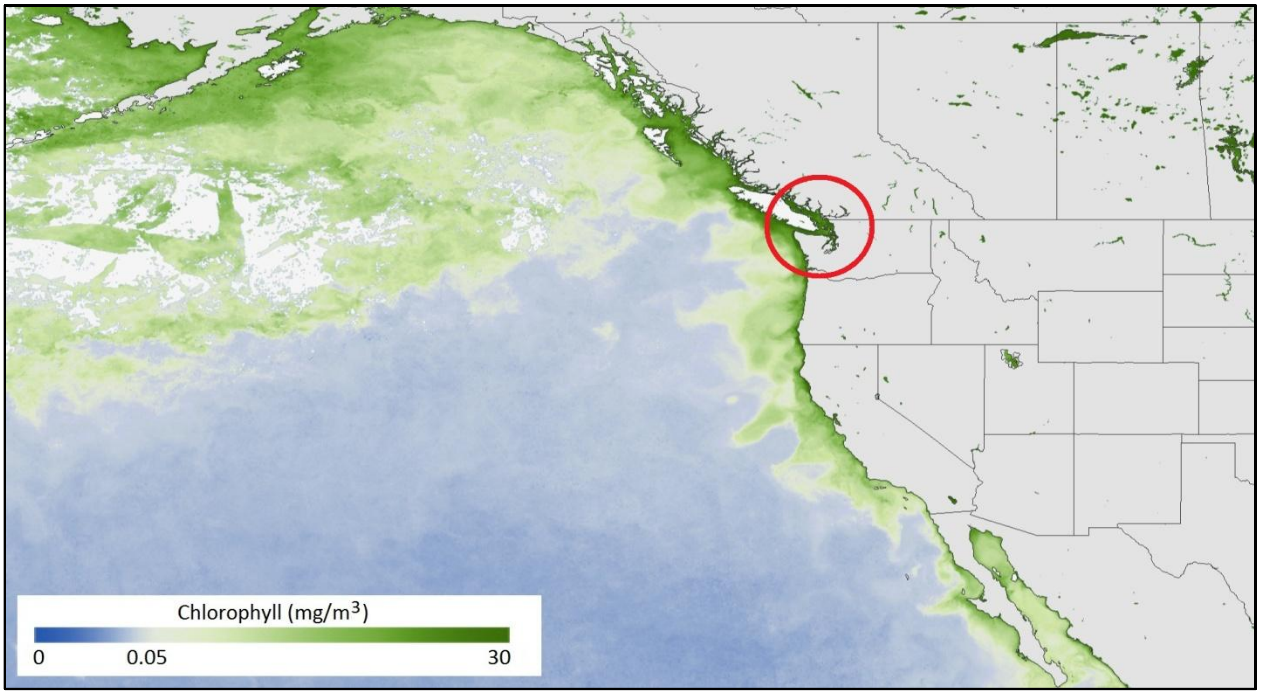

Figure 49. Distribution and density of record-breaking algae blooms, as indicated by chlorophyll readings (mg/m^3), throughout the Northeast Pacific Ocean in July 2015 (source: National Oceanic and Atmospheric Administration, NOAA). Note the high density of chlorophyll detected in the Salish Sea (circled in red) where the Lummi Natural Resources Department's 2013–2015 sea cucumber study took place.

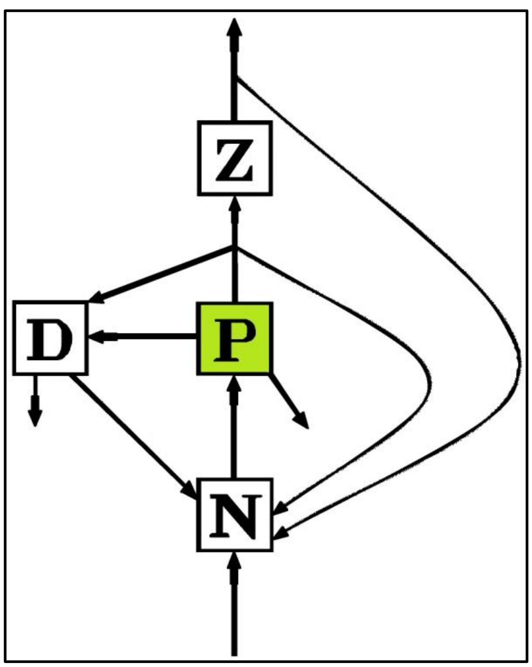

Figure 50. Simplified model showing the flow of inorganic and organic matter through a typical plankton system; N = nutrients, P = phytoplankton, D = detritus, and Z = zooplankton (redrawn from Edwards 2001). At right, the deposit-feeding sea cucumber *Parastichopus californicus* actively consumes detritus along the bottom (Photo credit: Chris Grossman/diver.net).

spawn timing (Reitzel et al. 2004; Morgan 2009), larval development (Asha and Muthia 2005), juvenile growth (An et al. 2007; Lavitra et al. 2010), and sometimes survival (Günay et al. 2015) are all highly influenced by seawater temperature among other factors.

In recent years, global climate change has contributed to the earlier arrival of springtime events in both terrestrial and aquatic ecosystems (Asch 2015; Ault et al. 2015; Chandler et al. 2015; Crozier 2015; EPA 2015; Hatfield and Prueger 2015), and clearly, it influenced environmental conditions at the local level as indicated by the many anomalous water quality readings captured by DOE's (2015) CTD casts in 2014 and 2015. For example, the disparate timing of the spring phytoplankton blooms (as indicated by peak chlorophyll fluorescence), while associated with peak photoperiod and PAR and preceding peak seawater temperatures in both study years as expected (Strickland 1983; Moore et al. 2015), reflected the different timing of the weather in 2014 and 2015.

Growth of *P. californicus* and Lee's Phenomenon

The LNR age and growth analysis of *P. californicus* revealed differences between younger and older sea cucumbers from the San Juan Islands, Washington. Given the aforementioned challenges associated with aging a soft-bodied organism such as *P. californicus*, it is possible that some of the observed differences in growth were related to the imperfect aging technique used by LNR staff (*sensu* Ricker 1975; DeVries and Frie 1996). Still, the body size index values used by Cameron and Fankboner (1989) were derived from sea cucumbers of known age, and the assignment of age 5 to *P. californicus* between 178 g and 229 g SWA (SI = 1.454 – 1.718) seemed plausible following the size frequency analysis (DeVries and Frie 1996). Finally, when compared to the results of age and growth analyses for sea cucumbers harvested commercially elsewhere (Ebert 1978; Herrero-Pérezrul et al. 1999; Sulardiono et al. 2012; Poot-Salazar et al. 2014), the growth pattern of *P. californicus* is quite similar and its size intermediate among the other species (Figure 51), lending further assurance that the LNR analysis provided a reasonably accurate assessment of age and growth for the species at least through age 5.

Several abiotic and biotic factors influence growth in sea cucumbers which can result in differences in size at age. For example, worldwide warming trends and abundant food undoubtedly explain some of the differences in sizes at age of *P. californicus* observed during the LNR study. Indeed, besides changes in seawater temperature, An et al. (2007) discussed the importance of considering the food supply (quality and quantity) available to sea cucumbers when assessing growth. Furthermore, Günay et al. (2015) reported on the role of seasonal aestivation (i.e., the visceral atrophy process) when describing changes in growth of sea cucumbers. These influences were also examined for *P. californicus* by Hannah et al. (2013), who recently demonstrated that the species grew significantly faster than seabed controls when presented with abundant, highly-nutritious food in an aquaculture setting.

Ultimately, the commercial dive fisheries for *P. californicus* most likely explain other discrepancies in growth between year classes. In Washington State, commercial harvest divers retain a range of *P. californicus* sizes, from large individuals (preferred) to a voluntary minimum length of sea cucumber (~20 cm WL). Regarding the minimum size retained, faster growing *P. californicus* will be subject to fishing mortality sooner and for a longer time period (assuming their harvest rate is < 100%) than slower growing individuals. Put another way, slow growing survivors of a year class will be smaller than their cohorts and will therefore take longer to enter the *P. californicus* dive fishery. This may result in some older sea cucumbers exhibiting smaller sizes at age when compared to younger sea cucumbers (ref. Table 2, this study), an effect of size-selective harvesting or mortality commonly referred to as "Lee's phenomenon" (Ricker 1975; DeVries and Frie 1996). When developing growth equations and growth curves for species subject to Lee's phenomenon, Vaughan and Burton (1994) recommend using the most recent mean size at age. Figure 51 shows growth curves for *P. californicus* through age 5 plotted with and without adjustments for Lee's phenomenon.

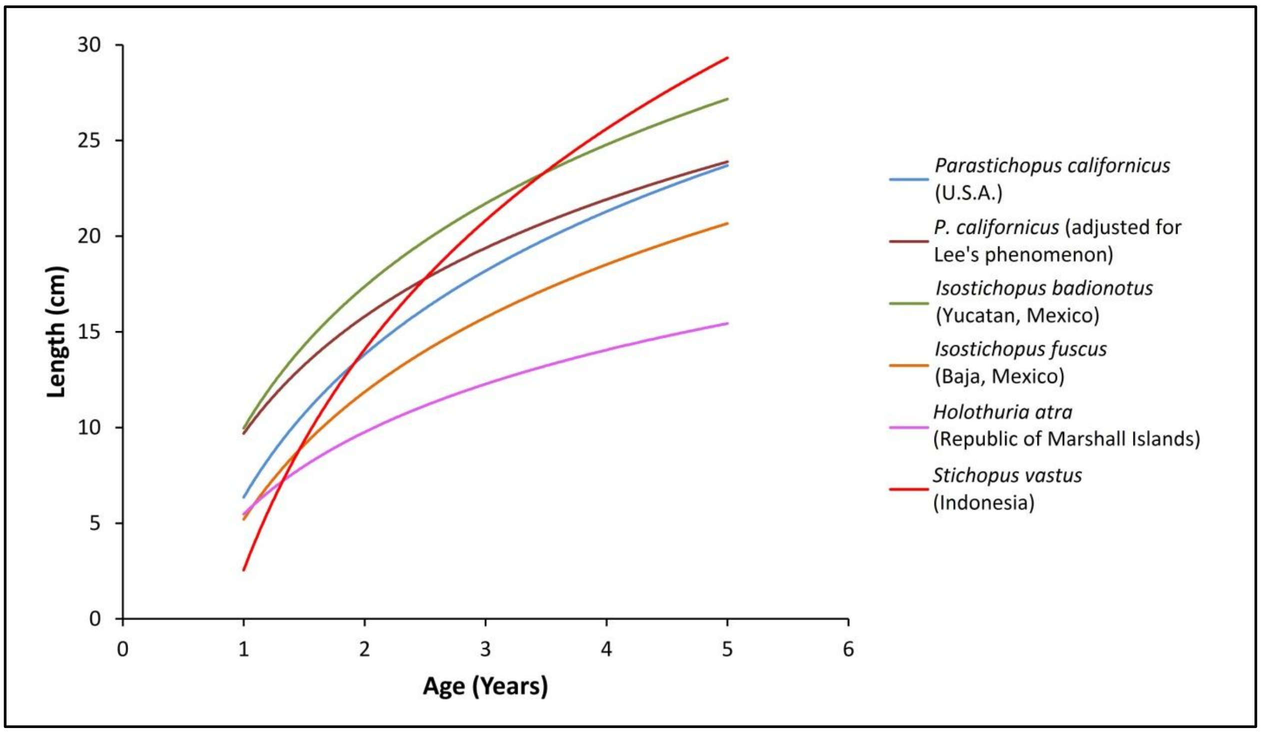

Figure 51. Growth curves (through age 5) of various commercial sea cucumbers from the Gulf of Mexico and from across the Pacific Ocean: *Parastichopus californicus* (San Juan Islands, Washington; this study), *Isostichopus badionotus* (Yucatan, Mexico; Poot-Salazar et al. 2014), *Isostichopus fuscus* (Baja, Mexico; Herrero-Pérezrul et al. 1999), *Holothuria atra* (Republic of Marshall Islands; Ebert 1978), and *Stichopus vastus* (Indonesia; Sulardiono et al. 2012). The growth curves for *P. californicus* are based on data found in Table 2 of this study. One growth curve is derived from the overall mean WLs at age for all year-classes sampled (blue), while the other is derived only from the most recent mean WL at age (maroon) to adjust for Lee's phenomenon as recommended by Vaughan and Burton (1994). The growth curves for species other than *P. californicus* are based on plots of their von Bertalanffy growth equations reported by the various authors.

Size-Selective Harvesting

Several lines of evidence from this study indicate that size-selective harvesting (*sensu* Fenberg and Roy 2008) has occurred in the *P. californicus* dive fisheries of Washington State, a rather obvious conclusion to make when comparing the size structures of *P. californicus* derived from fishery-dependent vs. fishery-independent data. Whether comparing historical market weights (i.e., SWA) to contemporary ones or comparing the lengths (i.e., WL) of *P. californicus* in an historical photograph to those of a modern image, whether comparing sizes at age of younger *P. californicus* to the same of older sea cucumbers (e.g., Lee's phenomenon) or comparing gonadosomatic indices of today to those of past decades, the data from the LNR study suggests that size-selective harvesting in the *P. californicus* dive fisheries has led to a reduction in body size of sea cucumbers in Washington State's management District 1, the San Juan Islands. The possibility of this outcome in a commercial sea cucumber fishery is not without precedent (e.g., Muthiga et al. 2010). Indeed, Anderson et al. (2011) reported a reduction in size of sea cucumbers harvested in 13 of 37 fisheries examined around the world. And most recently, González-Wangüemert et al. (2014) documented a reduction in sizes of sea cucumbers (*Holothuria* spp.) harvested from the fishable waters of the Aegean Sea off the coast of Turkey.

On the other hand, the SWAs of *P. californicus* landed by the commercial harvest diving fleet might just reflect the size, distribution, and abundance of animals within easy grasp, i.e., the proverbial "low hanging fruit". Smaller, younger sea cucumbers may be more abundant at greater depths (Figure 28), occupying habitats (e.g., mixed substrate with low-lying relief and gentle slopes) that are more amenable to being traversed by surface supplied air divers on foot trailing long umbilical hoses, safety lines, and large catch bags. Indeed, the possibility of the vertical distribution of *P. californicus* changing with ontogeny has been raised by others (Courtney 1927; Woodby et al. 1993; Zhou and Shirley 1996) and continues to be a relevant topic for future research (Cieciel et al. 2009). Still, the bulk of the LNR SWA data (fishery-independent) supports the premise of a reduction in size of sea cucumbers in District 1 over the years (Figure 29).

Size-selective harvesting of edible marine species has been observed over centuries, even millennia, but sometimes it is apparent over considerably shorter time periods (Jackson et al. 2001; Allendorf and Hard 2009). For example, Roy et al. (2003) demonstrated that the size structures of several species of intertidal marine snail in southern California, including two species known to be harvested by humans, shifted significantly toward smaller individuals over a period of about 150 years. Furthermore, in the past 30 years or so, the average size of the sea urchin *Paracentrotus lividus* decreased significantly in the nearshore areas of Italy where it is intensively harvested (Guidetti et al. 2004). Finally, the aforementioned changes in sizes of harvestable *Holothuria* spp. reported by González-Wangüemert et al. (2014) occurred only since 1996, the year Turkey first allowed commercial fisheries for its sea cucumbers.

Genetic Change(s) in *P. californicus*?

This is a relevant question given the body size changes reported here for *P. californicus*. Do the results of the LNR study merely indicate natural differences in phenotypic variability or plasticity between stocks of sea cucumbers in Washington State and British Columbia, or has commercial harvest diving actually generated enough selection to cause evolution in *P. californicus*, to alter morphological traits, and fishery outcomes with respect to yields and landings (Law 2000; Heino and Godø 2002; Ernande et al. 2003)? While the former is supported by research involving a highly-exploited marine snail (Fenberg et al. 2010), the decadal time scale of Washington State's commercial fisheries for *P. californicus* (1970s to present) suggests the latter is also entirely possible (Law 2007; Allendorf and Hard 2009). Besides, such a rapid "microevolutionary" response (Roy 2008) has already been documented for commercially-harvested sea cucumbers (Koskella 2015; Maggi and González-Wangüemert 2015). For example, González-Wangüemert et al. (2015) reported higher genetic diversity in an unfished population of the sea cucumber *Holothuria polii* vs. a fished population of the same species. Moreover, the authors reported less-pronounced genetic changes in an unfished vs. fished congeneric sea cucumber, *H. tubulosa*, attributing the genetic differences between the two species to the reality that *H. polii* comprises 80% of sea cucumbers landed off the coast of Turkey (i.e., higher landings of *H. polii* over time translated to a greater impact on its genetics compared to *H. tubulosa*).

Spawning Periodicity

By all published scientific accounts, *P. californicus* broadcast spawns primarily during spring and summer (Courtney 1927; Johnson and Johnson 1950; Cameron and Fankboner 1986; McEuen 1988) with some studies indicating that the sea cucumber migrates into shallower water for that purpose (Courtney 1927; Woodby et al. 1993; Zhou and Shirley 1996). The June–July spawning closure implemented by Washington State's natural resource authorities in management year 2014–2015 was based on this literature, mainly Cameron and Fankboner's (1986) work, which identified those two months as the peak spawning period for *P. californicus* using GSI data (Figure 52). Confounding this logical management action, however, were anecdotal reports from Washington State's treaty tribal and state commercial harvest divers that placed spawning of *P. californicus* earlier (i.e., springtime) rather than later. In addition, Cameron and Fankboner's (1986) samples were from Indian Arm, British Columbia, which is located about 80 km (~ 50 miles) due north of Washington State's prime fishing grounds, the San Juan Islands (Bradbury et al. 1998; Carson et al. 2016), suggesting the possibility of latitudinal variation in the reproductive biology of the species. Lastly, the number of *P. californicus* sampled by Cameron and Fankboner (1986) was low (10 animals per month) resulting in wide variation in the GSI data, especially around the purported peak of spawning (Figure 52). Hence, these issues – the difference in peak spawning reported in the scientific literature vs. reports from the "boots on the ground", the widespread latitudinal differences in spawn timing documented for other marine invertebrates (e.g., Sastry 1963; Lewis 1986; Pauley et al. 1986; Lardies and Castilla 2001; Vadas et al. 2015), and the fact that the co-managers' reference material for the reproductive biology of *P. californicus* was now more than 30 years old and possibly lacking in sampling rigor – prompted LNR staff to revisit Cameron and Fankboner (1986) and to verify spawn timing in *P. californicus*.

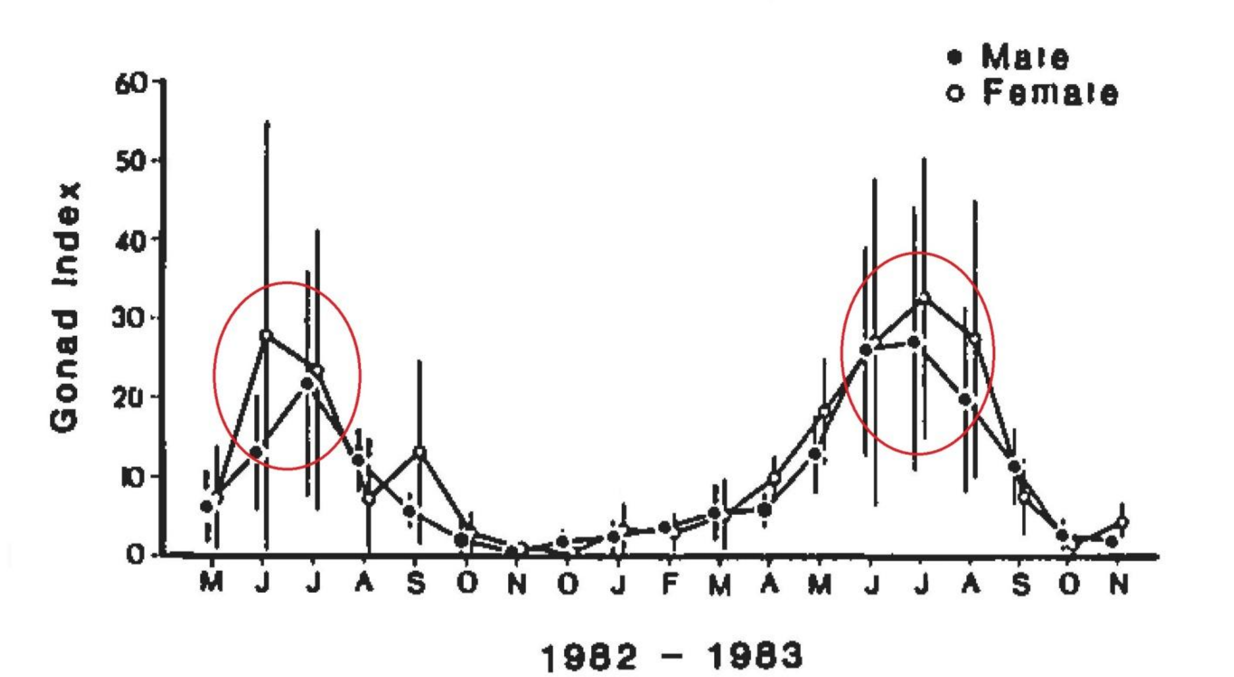

Figure 52. Original figure from Cameron and Fankboner (1986) showing mean gonadosomatic index (± SD) for male and female sea cucumbers *Parastichopus californicus* collected over two seasons (1982 and 1983) from Indian Arm, British Columbia, Canada. The authors purposefully offset the data for easy visual reference between the sexes. In Washington State, tribal and state natural resource authorities used these data to justify closing their *P. californicus* dive fisheries briefly to protect the peak spawning period (June–July) of the sea cucumber during management year 2014–2015. Indian Arm is about 80 km (~ 50 miles) due north of the San Juan Islands where most of Washington State's sea cucumbers are harvested.

Throughout its lifetime, *P. californicus* responds to triggers in the environment (Fankboner and Cameron 1985; Fankboner 2002); ostensibly, spawning is correlated with changes in photoperiod and seawater temperature (Cameron and Fankboner 1986). Like Cameron and Fankboner (1986), the LNR study indicated a distinct pattern in spawning of *P. californicus* using GSI data. Differences in mean GSI values between the studies notwithstanding, the LNR data differed from that of Cameron and Fankboner (1986) only in timing: GSI peaked in the spring and was followed by a steep decline in early summer. In 2014, peak GSI of *P. californicus* occurred in April–May. The spring phytoplankton bloom, as indicated by peak chlorophyll fluorescence, followed shortly thereafter in June, all of which preceded the peak seawater temperature in July – fairly typical plankton dynamics for temperate marine waters (Strickland 1983; Starr et al. 1990; Moore et al. 2015). In 2015, a similar progression of events occurred, but was phase-shifted four weeks earlier: peak GSI occurred in March–April, the spring bloom occurred in May, and the peak seawater temperature for the study was recorded in June. That peak spawning in *P. californicus*, as indicated by GSI, occurred before peak seawater temperatures in both LNR study years is consistent with a model developed by Reitzel et al. (2004) who predicted larval development time for Northeast Pacific marine invertebrates as a function of spawning date and seawater temperature. Reitzel et al. (2004) also reported that March to June was the peak reproductive period for most Northeast Pacific marine invertebrates, including echinoderms.

Change in Reproductive Capacity of *P. californicus*?

Previous research on selectively harvested marine invertebrates (e.g., Kido and Murray 2003), including sea cucumbers (e.g., Muthiga et al. 2010), and the apparent shift toward smaller *P. californicus* in the San Juan Islands, Washington beg this question. Has fecundity of *P. californicus* decreased with a decrease in body size? After all, the mean SWA of sexually mature *P. californicus* (age 5) sampled by LNR staff was 197 g, which was 25% lower than Humble et al.'s (2007) estimate of 260 g SWA for 5 year old *P. californicus* from British Columbia, Canada. And given the exponential relationship between gonad weight and estimated contracted length of *P. californicus* during peak spawning (this study), it must. Similarly, given the consistently lower GSI values of *P. californicus* in the present-day San Juan Islands, Washington compared to those values reported for British Columbia, Canada from more than 30 years ago (Cameron and Fankboner 1986), size-selective harvesting may have already affected the reproductive output of the species in local waters just as it has for sea cucumbers elsewhere (Muthiga et al. 2010). In fact, even though experimental evidence for the impacts of size-selective changes on marine invertebrates is limited, one study did show that reductions in maternal size can negatively affect the fitness of offspring and later reduce fecundity in the adult stage (Marshall and Keough 2004).

Ecto- and Endofauna of *P. californicus*

The scale worm *Arctonoe pulchra* has been recognized as a commensal of *P. californicus* since the late 19th century (Berkeley 1924; Salazar-Silva 2006), whereas the shell-less, parasitic snail *Enteroxenos parastichopoli* was first described only 55 years ago (Tikasingh 1961). Most studies of *A. pulchra* concern its anatomy and taxonomy (Pettibone 1953; Pernet 1998) or its behavior in the presence of potential hosts (Davenport 1950; Davenport and Hickok 1951; Dimock and Davenport 1971). Similarly, studies of *E. parastichopoli* have focused on histological aspects of the gastropod (Tikasingh 1962) and its systematics (Kincaid 1964).

Prior to the LNR study, information on the natural occurrence of both *A. pulchra* and *E. parastichopoli* was somewhat limited. For example, Cameron and Fankboner (1989) described the proportional presence (3 of 42 sea cucumbers inspected or 0.071) of *A. pulchra* in age 1 *P. californicus* from just one of 14 sampling locations. The authors also reported an incidence rate of 9.5% (6 of 63 sea cucumbers inspected) for *E. parastichopoli* in immature (ages 2–4 years) *P. californicus* during August 1983. Furthermore, Pernet (1998) remarked (anecdotally) that 20% of *P. californicus* he inspected in the field had *A. pulchra* commensal with the sea cucumber, whereas Lützen (1979; cited in Jangoux 1987) reported infestations of ~ 3 *E. parastichopoli* per sea cucumber in 37 of 244 *P. californicus* (15%) examined. While there are certainly consistencies among these works and the LNR study, besides reporting even higher incidence rates of commensals and parasites, the latter delves into the ecology of the species on multiple levels (time, space, and host) providing some possible directions for future research. For example, does the higher rate of incidence of *E. parastichopoli* in *P. californicus* of unknown sex (29%) vs. male and female sea cucumbers (15% and 14%, respectively) indicate a negative impact on reproductive capacity in *P. californicus*? Current knowledge of the relationship between parasitic gastropods and their echinoderm hosts suggests this may be unlikely (Jangoux 1987); still, it is difficult to imagine that a heavy infestation of *E. parastichopoli* in *P. californicus* (Figure 10) has no ecological consequences for the sea cucumber. And what drives higher proportional presence of *A. pulchra* in mature (5+ years) *P. californicus* compared to younger sea cucumbers? Host body size? Host reproductive status?

MANAGEMENT CONSIDERATIONS

One of the common challenges faced by managers of sea cucumber fisheries around the world is the dearth of knowledge concerning the basic biology and ecology of the commercially targeted species (Friedman et al. 2011; Purcell et al. 2013). Recently, Carson et al. (2016) provided valuable information on the distribution and abundance of *P. californicus* on the primary fishing grounds of Washington State, the San Juan Islands. The authors also reviewed past management practices and assessed their outcome(s) in the non-tribal fishery. The intent of the LNR study was to fill gaps in the co-managers' understanding of other aspects of the fishery biology of the species, including age and growth, the current size structure of the fished population, and management-relevant aspects of the reproductive biology of *P. californicus*. The overarching goal of both studies is to promote the long-term sustainability of the *P. californicus* dive fisheries of Washington State. To help achieve this goal, the co-managers are highly encouraged to consider the following actions based on the LNR study:

1) Implementing a size restriction for *P. californicus*,
2) Updating harvestable biomass estimates more frequently,
3) Adjusting timing of the sea cucumber spawning closure,
4) Expanding assessment of *P. californicus* inside of existing no-harvest zones, and
5) Integrating the LNR findings with current sea cucumber hatchery practices.

Implementing a Size Restriction for *P. californicus*

Given the indicators of size-selective harvesting in the *P. californicus* dive fisheries of the San Juan Islands, it is important that the co-managers consider adopting a size restriction for the species (Fenberg and Roy 2008). Implementing a minimum size limit at sexual maturity of *P. californicus* (> 5 years) will reduce the possibility of an immature sea cucumber being harvested before it has had the opportunity to spawn at least once in its lifetime. According to Ernande et al. (2004), this measure will also minimize evolutionary changes in maturation or size at maturity. On the other hand, implementing a maximum size limit will restore the reproductive capacity of *P. californicus* by protecting those sizes with the highest gamete production and egg quality (Conover and Munch 2002). Furthermore, according to Law (2007), a maximum size limit should result in faster growth being selected for in the long term. Alternatively, a slot limit will allow for harvest of *P. californicus* above a minimum size yet below a maximum size, reducing impacts to small, young sea cucumbers (least experienced) and large, old ones (most experienced). Minimum size limits have been implemented for sea cucumber fisheries of the western Indian Ocean (Muthiga et al. 2010) and slot limits are currently in place for a number of marine invertebrate fisheries, including red sea urchin *Mesocentrotus franciscanus* (Washington State, USA; Carson et al. 2016) and American lobster *Homarus americanus* (Newfoundland, Canada; Xu and Schneider 2012). Irrespective of the size restriction(s) adopted, the co-managers should feel confident that, given sufficient time in place, the rule(s) will result in preserving that portion of the *P. californicus* population with the greatest reproductive potential and genetic predisposition to larger sizes (Fenberg et al. 2010).

Using a minimum size limit as an example, the challenge of implementing such a restriction on the soft-bodied *P. californicus*, of course, is its natural variation in shape, length, and weight depending on the season and the sea cucumber's age and activity. Still, the LNR study provides the proof of principle that it is entirely possible to (mostly) avoid retaining *P. californicus* of a size below a predetermined threshold; in this case, a voluntary minimum size (~20 cm whole, contracted length or WL) used by the commercial harvest diving fleet. Indeed, only 12% of *P. californicus* (97 of 800) collected by LNR staff independent of the fishery were less than 20 cm WL. Put another way, 88% of the sea cucumbers retained by LNR staff divers had whole, contracted lengths above the predetermined threshold (Appendix B). By establishing that an estimate of the whole, contracted length of *P. californicus* can be made using a simple visual reference (e.g., 2" or 5 cm to either side of a diver's gloved hand ≈ 20 cm), the results of the LNR study suggest that it is possible to develop a diver-carried gauge that commercial harvesters can use underwater to measure questionable-sized *P. californicus*. The results of the LNR study also suggest that, if sorting the catch topside after a dive, a weight threshold can be used to cull out live, immature sea cucumbers before processing them. Following are examples of how these measures might be put into practice.

A minimum size limit for *P. californicus* should consider the sea cucumber's size at sexual maturity. According to Cameron and Fankboner (1986), *P. californicus* becomes spawning-capable after 5 years which was later confirmed by others (Smiley 1988; Sewell et al. 1997). In order for a sea cucumber to spawn at least once in its lifetime before being harvested, the minimum size limit should protect all sizes of *P. californicus* through age 5; hence, commercial harvest divers might therefore be restricted to harvesting sea cucumbers aged ≥ 6 years. The minimum SWA and WL of age 6 *P. californicus* from District 1 are 220 g and 25 cm, respectively (Figures 21–24). In terms of WWA, a 6 year old sea cucumber will weigh, on average, approximately 580 g or 1-¼ lb (ref. Table 4, this study). Since commercial harvest divers use visual estimates of *P. californicus* lengths when deciding to retain a questionable-sized sea cucumber, diver-carried gauges should be 25 cm (or 10”) long and constructed of a durable material such as aluminum or heavy-duty plastic. When a questionable-sized *P. californicus* is encountered underwater, a commercial harvest diver can briefly (< 10 sec) manipulate it to induce contraction of the individual (Hannah et al. 2012) at which point *P. californicus* will be measured against the diver-carried gauge; if shorter than the diver-carried gauge, the sea cucumber should be released. Furthermore, prior to processing *P. californicus* topside after a dive, when a questionable-sized individual is encountered in the catch, the WWA of the sea cucumber can be determined using a certified scale (e.g., a handheld, spring-style balance); if WWA of the animal is less than 580 g or 1-¼ lb, the sea cucumber should be released.

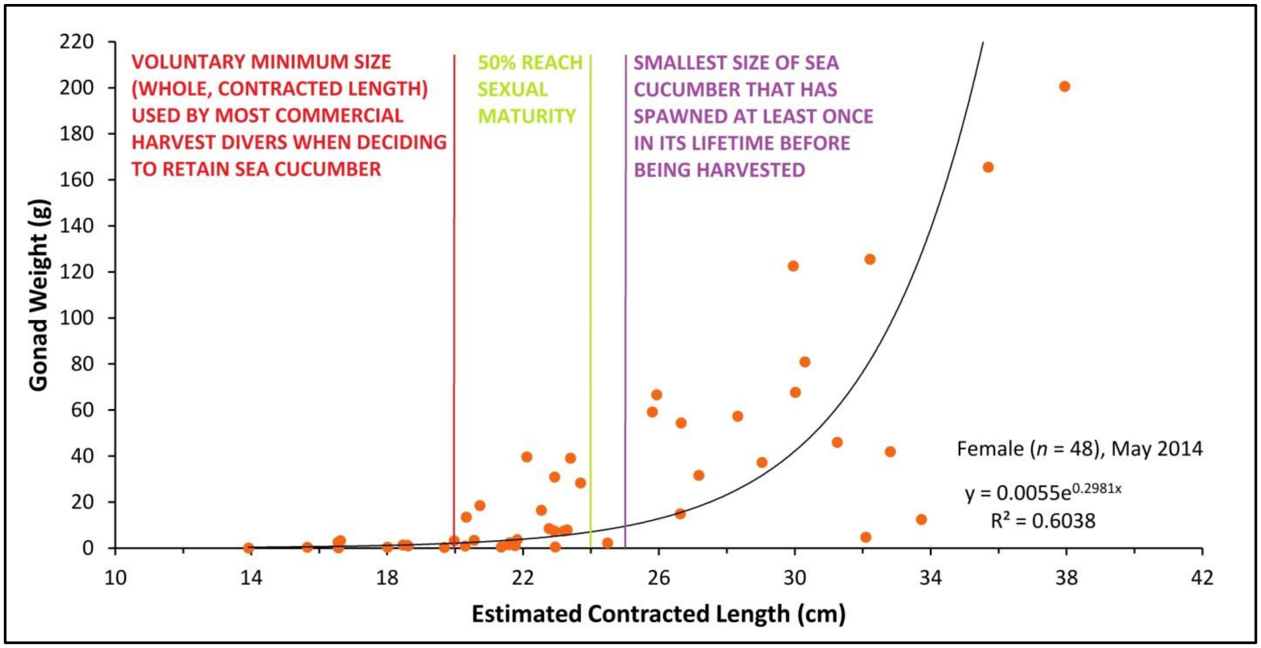

Figure 53. Some considerations for a minimum size limit vs. the reproductive capacity of the sea cucumber *Parastichopus californicus* from the San Juan Islands, Washington. Data show the exponential relationship between gonad weight (g) and the estimated contracted length (cm) of a female sea cucumber.

In terms of enforcing a minimum size limit, natural resource authorities can monitor *P. californicus* catches at the harvest site, dockside/boat launch, or the marketplace. Irrespective of sampling location, a sufficient number (e.g., *n* > 30; Elliott 1993) of randomly-selected, sea cucumbers from a commercial harvest diving operation can be weighed and compared to the WWA or SWA thresholds. For example, if sampling live *P. californicus* at the harvest site, natural resource authorities can use the WWA value of 580 g or 1-¼ lb as the minimum size limit, whereas if sampling at the terminal end of the fishery, natural resource authorities can use the SWA value of 220 g as the threshold. In the end, the commercial harvest diving operation will be in compliance with the restriction if, say, 85% of the *P. californicus* sampled have WWAs or SWAs exceeding the minimum size limit. The rationale for including a buffer from complete compliance with the minimum size limit is the inherent plasticity of the sea cucumber body wall which can vary slightly by life stage and season (ref. Table 4, this study).

Updating Harvestable Biomass Estimates More Frequently

Recently, WDFW conducted an extensive remotely operated vehicle (ROV) survey of the San Juan Islands across seasons, from fall 2010 to spring 2011, covering approximately half of sea cucumber District 1 during the process (Carson et al. 2016). Using the ROV recordings, Carson et al. (2016) estimated the density of *P. californicus* (m^{-2}) available to commercial harvest divers by substrate type/area and by two depth bins. To calculate a harvestable biomass estimate for District 1, the authors converted the estimated number of sea cucumbers from each substrate type/area and depth bin into the fishery unit, SWA, using a 20+ year old average SWA of 286 g (0.63 lb) per sea cucumber from Bradbury et al. (1998); Carson et al. (2016) assumed no seasonal nor interannual variation in the SWA conversion factor. The resulting harvestable biomass estimate for *P. californicus* was ~ 5.9 million pounds (± 95% CI), an amount which is currently used by the co-managers to allocate equal harvest shares (50% for the treaty tribes, 50% for the state) of the annual total allowable catch for the San Juan Islands management area. Prior to Carson et al. (2016), the last formal estimate of the harvestable biomass of *P. californicus* in District 1 was developed nearly 20 years ago (Bradbury et al. 1998).

The LNR study underscores the need for more frequent updates to harvestable biomass estimates for *P. californicus* in Washington State. For example, the overall average SWA from the LNR study (222 g; N = 900) corresponds to a 22% decline in the market weight of *P. californicus* reported by Bradbury et al. (1998) (286 g; n = 458) which was used by Carson et al. (2016) for their harvestable biomass calculations. Assuming the LNR data is representative of the current state of *P. californicus* in the San Juan Islands (and given the sampling locations and methods used, there is no reason to suspect otherwise), the co-managers might consider a conversion factor (CF) of 0.49 (= 222 g ÷ 454 g), not 0.63 (= 286 g ÷ 454 g), to calculate a harvestable biomass estimate for the species in the management area. When 0.49 is substituted for 0.63 and used to calculate the "Pounds split-drained" column from Carson et al.'s (2016) Table 1, the revised District 1 biomass becomes ~ 4.6 million pounds (all substrates and depth bins combined, and after an additional correction factor of 1.21 is applied to "Pounds split-drained" to extrapolate to the rest of the district or the portion not covered by the ROV survey). A harvestable biomass estimate approaching the one currently used by the co-managers (i.e., ~ 5.9 million pounds; Carson et al. 2016) would then lie at the upper end of the 95% CI for the revised harvestable biomass estimate.

The LNR study revealed also that *P. californicus* SWAs were variable in both time and space; hence, contrary to the findings of Hannah et al. (2012), the LNR results suggest that the co-managers *should* consider seasonal or annual regressions when converting between WWA and SWA during stock assessments of the species. The temporal and spatial differences in *P. californicus* SWA were large enough that should they be extrapolated to the spatial extent of

Carson et al. (2016) for calculating harvestable biomass estimates for the species, the differences would affect harvest share allocation among the co-managers. For example, using the same calculations as above, but with CFs based on the SWA results in Table 4 of this study, harvestable biomass estimates may differ by as much as 10%: the harvestable biomass estimate based on a CF from late spring (May-June) 2014 [CF = 217 g ÷ 454 g = 0.48] is ~ 4.5 million pounds, whereas the harvestable biomass estimate based on a CF from fall (September-October) 2014 [CF = 239 g ÷ 454 g = 0.53] is ~ 5 million pounds.

The exercises above highlight the need for more frequent stock assessment surveys, including size structure analyses, to develop timely and accurate harvestable biomass estimates for *P. californicus*. Methods and data have been presented that will allow the co-managers to sample sea cucumbers at harvest sites, dockside, or at the market to reconstruct the size and age structures of *P. californicus* in sea cucumber management districts of importance to their constituents. In this way, the co-managers can avoid the pitfall of "playing catch-up" with respect to taking corrective management action when faced with fishery-induced changes in the sea cucumber population(s).

Adjusting Timing of the Sea Cucumber Spawning Closure

The GSI results from the LNR study and those of Cameron and Fankboner (1986) represent the extreme ends of the peak reproductive period for *P. californicus* (or for that matter, most marine invertebrates from the Northeast Pacific) as modeled and reported by Reitzel et al. (2004). Still, it is recommended that the co-managers use the results of the LNR study to inform a revised peak spawning closure for *P. californicus* in the marine waters of Washington State, not only because of the latitudinal differences between the two studies and LNR's 10-fold increase in monthly sampling rate compared to Cameron and Fankboner (1986), but also because a springtime spawning closure agrees well with anecdotal reports from tribal and state commercial harvest divers whose input is important for the effective management of the *P. californicus* dive fisheries (*sensu* Slacum et al. 2008).

Many springtime biological processes occurred earlier than usual in 2014 and 2015 (especially the latter year), even by as much as four weeks (e.g., Ault et al. 2015; Chandler et al. 2015; Crozier 2015; this study). The March-April peak in *P. californicus* GSI suggested by the 2015 LNR data was therefore not likely the norm for the species, but rather, an anomaly influenced by recent record-breaking weather patterns across the planet. In contrast, the April-May peak in *P. californicus* GSI suggested by the 2014 LNR data was likely more representative of a typical year and should be adopted by the co-managers as the minimum closure period to protect peak sea cucumber spawning in local marine waters.

One alternative to a permanent April-May spawning closure would be to adopt an annual spawning closure window based on in-season GSI data (*sensu* Vadas et al. 2015). In this scenario, natural resource authorities collect fishery-dependent GSI data for *P. californicus* (thus, avoiding unnecessary sacrifice of animals) starting in February and continuing every 2 or 3 weeks until a mean GSI (sexes combined) of 3 or 4 is reached, at which point the dive fisheries close to protect peak spawning of *P. californicus*. Two months later (i.e., the duration of peak spawning), natural resource authorities then begin collecting fishery-*independent* data every 2 or 3 weeks, targeting a mean GSI (sexes combined) of 3 or 4 to reopen the dive fisheries. According to Vadas et al. (2015), such windows can be adjusted by setting GSI values to enhance sustainability or to meet conservation objectives in different management areas. Spawning closure windows can also be adjusted for climate-induced interannual variation in spawning of *P. californicus*, but will be costly to implement, requiring at least two people and vessel support to successfully collect the required data over several weeks each year. Perhaps a simpler alternative would be to consider expanding the April-May closure by up to one month on either side of the peak spawning period to account for changes in seawater temperature and to better reflect the theoretical range (March-June) for peak reproduction of most Northeast Pacific marine invertebrates (Reitzel et al. 2004).

Expanding Assessment of *P. californicus* inside of No-Harvest Zones

No-harvest zones have the potential to impact sea cucumber populations in many positive ways (Halpern and Warner 2002). For example, Muthiga et al. (2010) reported that marine protected areas (MPA) off the coast of Africa had larger sea cucumbers with larger gonads and higher fecundity than partially-protected or fished areas. Larger, heavier sea cucumbers were also found in non-fished areas of the Mediterranean Sea compared to fished areas (González-Wangüemert et al. 2015). Furthermore, no-take areas of the Great Barrier Reef, Australia maintained considerably higher densities of sea cucumbers compared to areas open to fishing (Uthicke et al. 2004); and Schroeter et al. (2001) reported similar results for a congener of *P. californicus*, the warty sea cucumber *Parastichopus parvimensis*, off the coast of California. Finally, no-harvest zones can have a positive impact on genetic variation in a species, allowing a segment of its population to express its full growth potential (Conover and Munch 2002; Allendorf and Hard 2009). Such effects have only just begun to be documented for commercial sea cucumbers (González-Wangüemert et al. 2015; Maggi and González-Wangüemert 2015).

Sea cucumber studies in the no-harvest zones or MPAs of Washington State have focused mainly on the relative abundance or density of *P. californicus* both inside and outside of the regulated areas (Bradbury et al. 1998; Tuya et al. 2000; Carson et al. 2016). For example, like researchers elsewhere (Schroeter et al. 2001; Uthicke et al. 2004), Carson et al. (2016) reported higher abundance of sea cucumbers in no-harvest zones compared to fished areas of the San Juan Islands, but cautioned that recent estimates of *P. californicus* density inside of no-harvest zones were still lower than historical (≥ 25 years ago) estimates from fished areas. While the benefit of these studies to the co-managers is not in dispute, improving natural resource authorities' understanding of the biological characteristics of an unfished segment of the population beyond simple counts or abundance estimates will entail repeating most, if not all, of the LNR methods inside of the no-harvest zones of the San Juan Islands. For example, methods and data were presented that will allow the co-managers to sample *P. californicus* live, converting between round weight (WWA) and market weight (SWA) without sacrificing the animals (*sensu* Hannah et al. 2012). Conducting size and age assessments of *P. californicus* inside of the no-harvest zones might inform future management decisions about size restrictions (Fenberg and Roy 2008). Furthermore, decreases in reproductive capacity will be better evaluated by collecting GSI data or other measures of *P. californicus* fecundity inside of the no-harvest zones (Muthiga et al. 2010). Comparing the genetic diversity of sea cucumbers inside of the no-harvest zones to that of *P. californicus* collected during the LNR study will provide the co-managers with important information concerning the effect(s) of fishing selection on the population (González-Wangüemert et al. 2015; Maggi and González-Wangüemert 2015). Lastly, results of a DNA analysis from inside the no-harvest zones of the San Juan Islands and from the archived LNR samples can also be compared to genetic records for *P. californicus* held at the U.S. National Institutes of Health's GenBank® to assess population-level differences on a wider scale (Nelson et al. 2002; Uthicke et al. 2010).

Integrating the LNR Findings with Current Sea Cucumber Hatchery Practices

Recently, the Suquamish Indian Tribe of the Port Madison Reservation (hereafter, Suquamish Tribe), another one of the western Washington treaty tribes that serves as a co-manager for the *P. californicus* dive fisheries, received a federal grant to help restore the depleted sea cucumber population of Central Puget Sound (District 3; Figure 1). To achieve its goal, the Suquamish Tribe partnered with the Kenneth K. Chew Center for Shellfish Research and Restoration (KKCC) to develop hatchery techniques for breeding and rearing *P. californicus* (Williams 2014). Earlier this year, hatchery staff from the KKCC collected several adult-sized sea cucumbers from the marine waters of District 3 and held them as broodstock for preliminary spawning trials in May 2016. At the time, only limited spawning was observed; hence, hatchery protocols will be adjusted to assure future reproductive success in *P. californicus* (Ryan Crim, Hatchery Manager, KKCC, Port Orchard, Washington; personal communication). According to Williams (2014), the collaborators will continue these efforts through 2017, and have long-term plans to produce *P. californicus* for stock enhancement purposes and to restore the ecosystem services provided by the species.

Moving forward, KKCC staff can use the results of the LNR study to inform sea cucumber hatchery practices in a number of ways. For example, hatchery staff can use the morphometric analyses presented here to confirm that their captive broodstock are of reproductive age and size. Growth of hatchery stock can be compared to results of the LNR study to assess whether growing conditions are adequate in the hatchery environment. The reproductive success of echinoderms is influenced by a combination of environmental variables including seawater temperature, phytoplankton abundance, and photoperiod (Cameron and Fankboner 1986; Starr et al. 1990; Morgan 2009; Bronstein and Loya 2013); therefore, KKCC staff can examine the relationship between GSI and environmental variables reported in the LNR study to replicate conditions that promote or increase spawning of *P. californicus* in the hatchery. Furthermore, the results of the LNR study suggest that the commensal scale worm *A. pulchra* reduces the incidence of the endoparasitic snail *E. parastichopoli*. Indeed, given the opportunity, *A. pulchra* readily feeds on larval mollusks in a laboratory setting (Pernet 1998); hence, KKCC staff can maintain *P. californicus* broodstock health by insuring that *A. pulchra* is commensal with sea cucumbers in the hatchery [Pernet (1998) provides detailed methods for developing and maintaining cultures of the scale worm]. Finally, the genetic considerations outlined in the LNR report should be considered as the Suquamish Tribe and KKCC move into the stock enhancement phase of the sea cucumber restoration project.

CONCLUSION

Sea cucumbers have been harvested from shallow marine waters across the Pacific Ocean for centuries, mostly to meet the demands of seafood markets in China or other Asian countries (Clarke 2004; Choo 2008; Figure 54). For the past 65 years, sea cucumber fisheries around the world, but especially across the Pacific, have followed "boom-and-bust" patterns characterized by rapid increases in production and short peaks followed by downward trajectories or collapses, often before natural resource authorities can affect positive change in management regimes (Friedman et al. 2011; Anderson et al. 2011). For the foreseeable future, and irrespective of the distance from the primary markets in Asia, the nexus of the trends in global sea cucumber fisheries will be the expanding Asian economy (Anderson et al. 2011). Because of this marketplace reality and the history and status of most sea cucumber fisheries, Purcell et al. (2013) encouraged natural resource authorities to work closely with their fishing constituents and to adopt multiple, yet easily-understood, and enforceable management measures to improve sustainability in their fisheries.

In the end, the results of the LNR sea cucumber study are generally consistent with other studies of exploited marine invertebrates (e.g., Kido and Murray 2003) and should be addressed by the co-managers sooner than later to avoid incurring any further "Darwinian debt", i.e., where the time to evolutionary recovery is greater than the amount of time it took to reach the undesirable evolutionary change (Allendorf and Hard 2009). Since the inception of the Washington State dive fisheries for *P. californicus*, treaty tribal and state natural resource authorities have made progress in managing the species, and will continue to refine their strategies to avoid a collapse in the fisheries (*sensu* Jackson et al. 2001). The recommendations outlined here are simple and intuitive; and with respect to implementing a size restriction, it can be readily monitored and should be enforceable. And while the *P. californicus* population in the San Juan Islands should be able to rebound (Fenberg et al. 2010), it may take several years or even decades for this to occur (Uthicke et al. 2004).

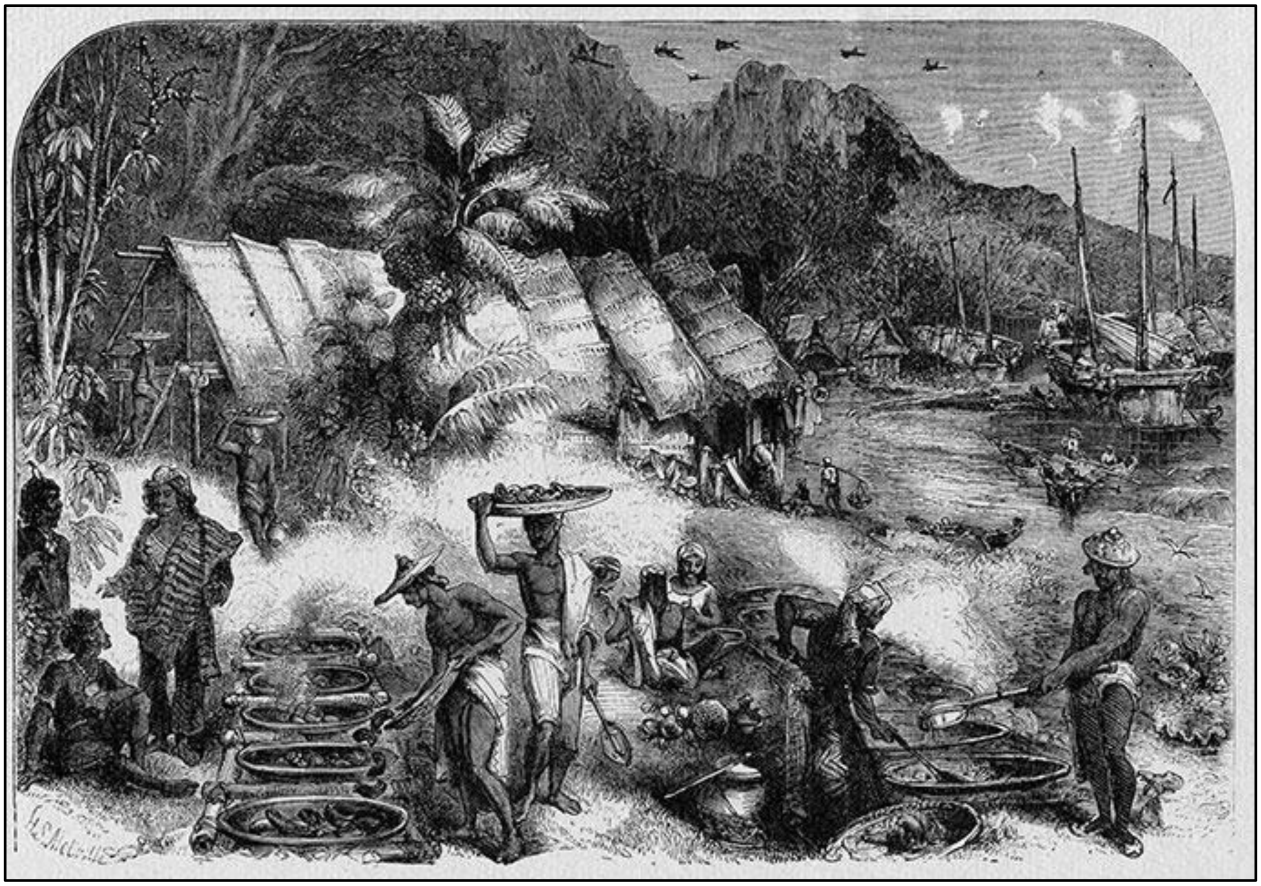

Figure 54. Antique print showing beachside processing of sea cucumbers harvested from the western Pacific Ocean near Australia (illustration by H. S. Melville, 1845).

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APPENDIX A

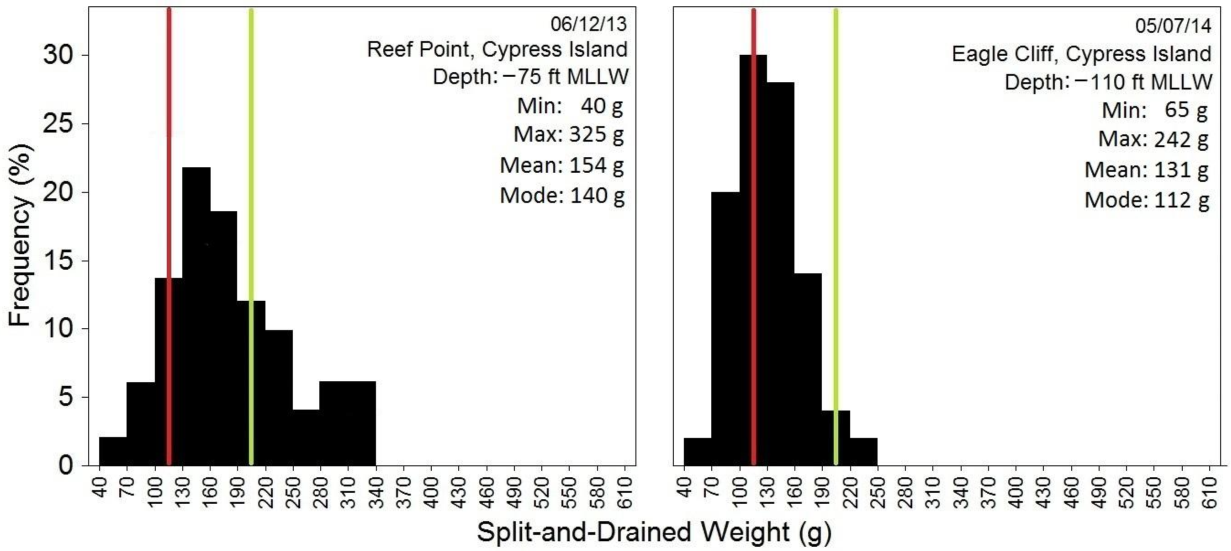

Figure A1. Percent frequency distributions of split-and-drained weights (g) in air (SWA) of the sea cucumber *Parastichopus californicus* sampled in the San Juan Islands, Washington during two ride-along trips (n = 50 per trip) aboard Lummi Nation commercial harvest diving vessels in June 2013 and May 2014. The red vertical line marks the voluntary minimum size of *P. californicus* retained by commercial harvest divers (SWA ≈ 130 g); the green vertical line marks the mean size at maturity for *P. californicus* (i.e., spawning-capable; SWA ≈ 200 g; age 5 years).

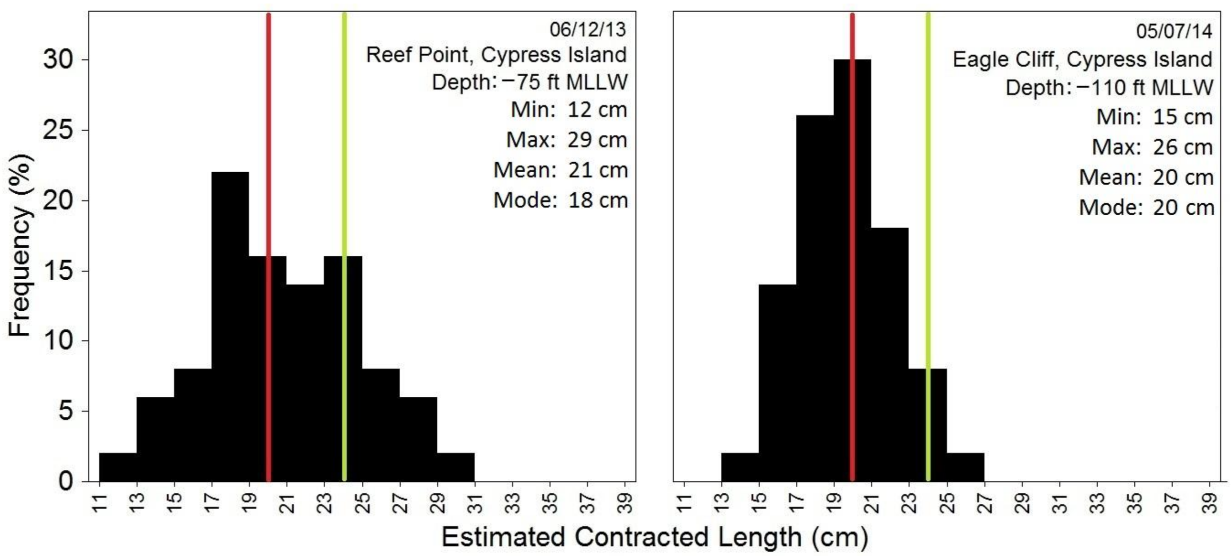

Figure A2. Percent frequency distributions of estimated whole, contracted lengths (cm) (WL) of the sea cucumber *Parastichopus californicus* sampled in the San Juan Islands, Washington during two ride-along trips (n = 50 per trip) aboard Lummi Nation commercial harvest diving vessels in June 2013 and May 2014. The red vertical line marks the voluntary minimum size of *P. californicus* retained by commercial harvest divers (WL ≈ 20 cm); the green vertical line marks the mean size at maturity for *P. californicus* (i.e., spawning-capable; WL = 24 cm; age 5 years).

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APPENDIX B

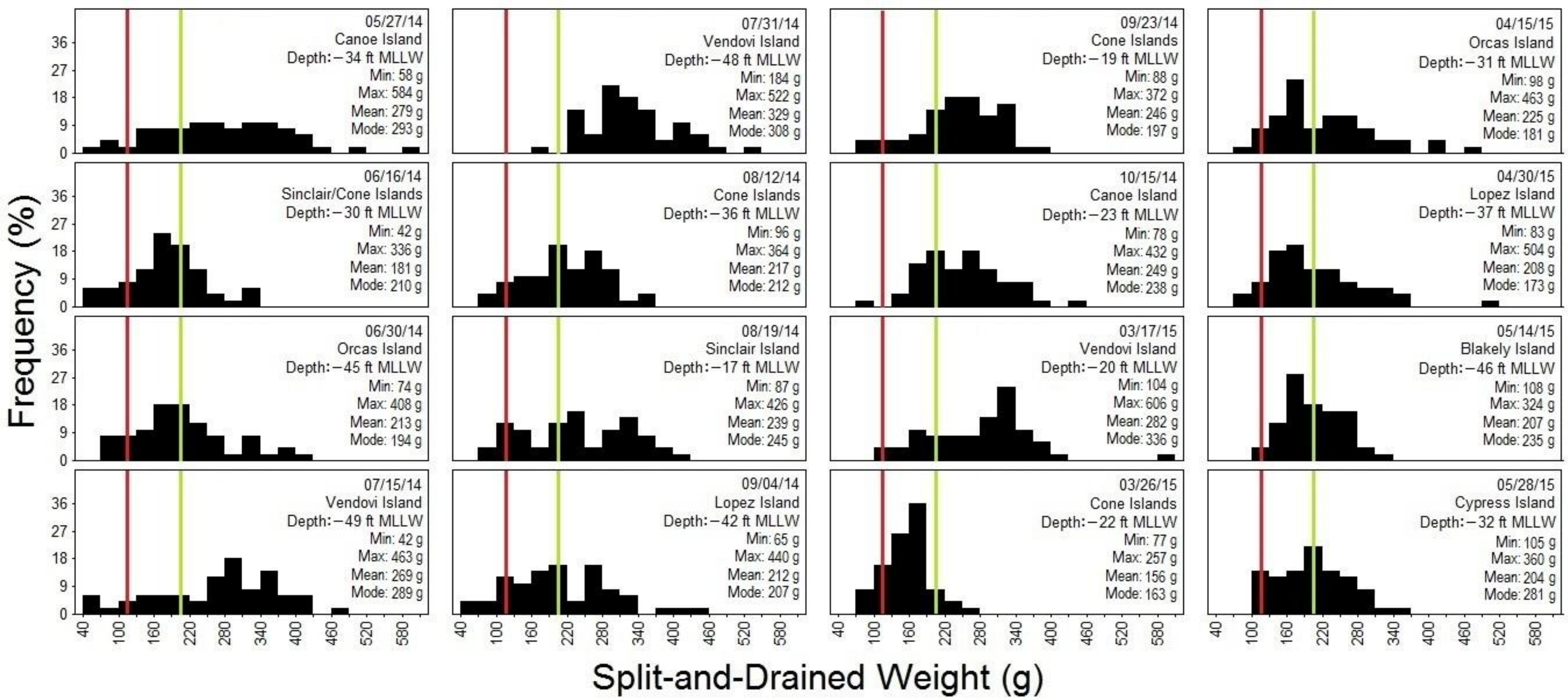

Figure B1. Percent frequency distributions of split-and-drained weights (g) in air (SWA) of the sea cucumber *Parastichopus californicus* sampled in the San Juan Islands, Washington in 2014 and 2015 by Lummi Natural Resources Department staff (n = 50 per sampling trip) independent of the fishery, but using the same voluntary minimum size limit as the commercial harvest diving fleet. The red vertical line marks the voluntary minimum size of *P. californicus* retained by commercial harvest divers (SWA ≈ 130 g); the green vertical line marks the mean size at maturity for *P. californicus* (i.e., spawning-capable; SWA ≈ 200 g; age 5 years).

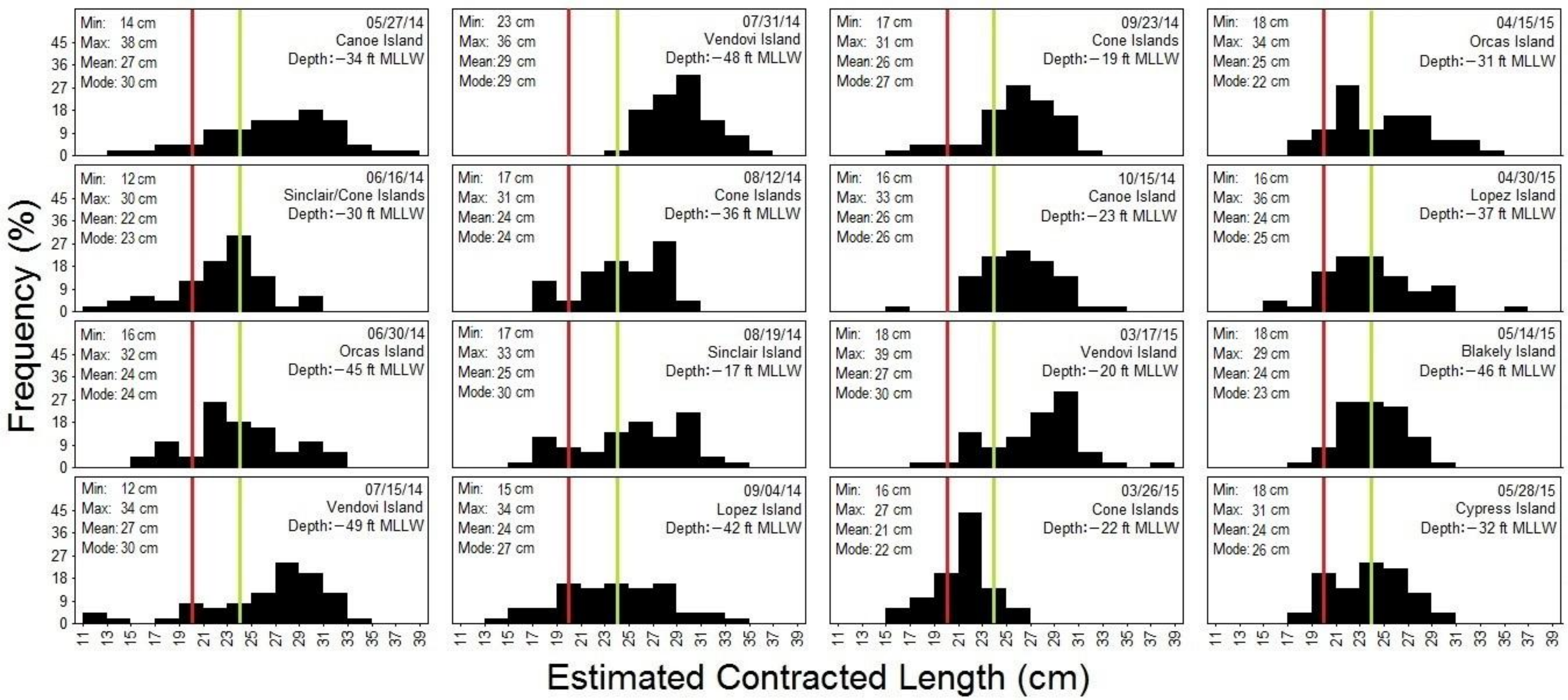

Figure B2. Percent frequency distributions of estimated whole, contracted lengths (cm) (WL) of the sea cucumber *Parastichopus californicus* sampled in the San Juan Islands, Washington in 2014 and 2015 by Lummi Natural Resources Department staff (n = 50 per sampling trip) independent of the fishery, but using the same voluntary minimum size limit as the commercial harvest diving fleet. The red vertical line marks the voluntary minimum size of *P. californicus* retained by commercial harvest divers (WL ≈ 20 cm); the green vertical line marks the mean size at maturity for *P. californicus* (i.e., spawning-capable; WL = 24 cm; age 5 years).

APPENDIX C

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
1	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	725.0	285.0	NA	6.58617	5.65249	NA	27.8	2.113	6+
2	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	260.0	100.0	NA	5.56068	4.60517	NA	17.7	0.920	3
3	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	825.0	325.0	NA	6.71538	5.78383	NA	29.4	2.345	6+
4	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	775.0	260.0	NA	6.65286	5.56068	NA	26.7	1.964	6+
5	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	475.0	185.0	NA	6.16331	5.22036	NA	23.1	1.499	5
6	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	560.0	160.0	NA	6.32794	5.07517	NA	21.7	1.336	4
7	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	600.0	160.0	NA	6.39693	5.07517	NA	21.7	1.336	4
8	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	460.0	200.0	NA	6.13123	5.29832	NA	23.9	1.595	5
9	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	660.0	210.0	NA	6.49224	5.34711	NA	24.4	1.658	5
10	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	320.0	225.0	NA	5.76832	5.41610	NA	25.1	1.751	6+
11	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	460.0	175.0	NA	6.13123	5.16479	NA	22.5	1.435	4
12	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	530.0	185.0	NA	6.27288	5.22036	NA	23.1	1.499	5
13	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	510.0	190.0	NA	6.23441	5.24702	NA	23.3	1.531	5
14	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	600.0	210.0	NA	6.39693	5.34711	NA	24.4	1.658	5
15	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	800.0	265.0	NA	6.68461	5.57973	NA	27.0	1.994	6+
16	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	680.0	140.0	NA	6.52209	4.94164	NA	20.5	1.202	4
17	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	325.0	135.0	NA	5.78383	4.90527	NA	20.1	1.168	4
18	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	600.0	200.0	NA	6.39693	5.29832	NA	23.9	1.595	5
19	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	450.0	140.0	NA	6.10925	4.94164	NA	20.5	1.202	4
20	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	525.0	210.0	NA	6.26340	5.34711	NA	24.4	1.658	5
21	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	1000.0	310.0	NA	6.90776	5.73657	NA	28.9	2.259	6+
22	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	575.0	140.0	NA	6.35437	4.94164	NA	20.5	1.202	4
23	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	450.0	140.0	NA	6.10925	4.94164	NA	20.5	1.202	4
24	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	400.0	160.0	NA	5.99146	5.07517	NA	21.7	1.336	4
25	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	530.0	180.0	NA	6.27288	5.19296	NA	22.8	1.467	5
26	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	530.0	165.0	NA	6.27288	5.10595	NA	22.0	1.369	4
27	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	235.0	75.0	NA	5.45959	4.31749	NA	15.6	0.732	2
28	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	735.0	275.0	NA	6.59987	5.61677	NA	27.4	2.054	6+
29	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	440.0	110.0	NA	6.08677	4.70048	NA	18.4	0.992	3
30	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	135.0	40.0	NA	4.90527	3.68888	NA	11.9	0.445	2
31	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	280.0	50.0	NA	5.63479	3.91202	NA	13.1	0.531	2
32	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	415.0	85.0	NA	6.02828	4.44265	NA	16.5	0.809	3
33	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	515.0	100.0	NA	6.24417	4.60517	NA	17.7	0.920	3
34	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	530.0	115.0	NA	6.27288	4.74493	NA	18.8	1.028	3
35	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	450.0	130.0	NA	6.10925	4.86753	NA	19.8	1.133	3

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
36	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	400.0	115.0	NA	5.99146	4.74493	NA	18.8	1.028	3
37	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	150.0	80.0	NA	5.01064	4.38203	NA	16.1	0.771	3
38	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	310.0	85.0	NA	5.73657	4.44265	NA	16.5	0.809	3
39	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	515.0	225.0	NA	6.24417	5.41610	NA	25.1	1.751	6+
40	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	400.0	115.0	NA	5.99146	4.74493	NA	18.8	1.028	3
41	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	475.0	150.0	NA	6.16331	5.01064	NA	21.1	1.269	4
42	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	475.0	110.0	NA	6.16331	4.70048	NA	18.4	0.992	3
43	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	530.0	115.0	NA	6.27288	4.74493	NA	18.8	1.028	3
44	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	260.0	50.0	NA	5.56068	3.91202	NA	13.1	0.531	2
45	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	300.0	100.0	NA	5.70378	4.60517	NA	17.7	0.920	3
46	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	375.0	110.0	NA	5.92693	4.70048	NA	18.4	0.992	3
47	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	400.0	125.0	NA	5.99146	4.82831	NA	19.5	1.098	3
48	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	275.0	60.0	NA	5.61677	4.09434	NA	14.2	0.613	2
49	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	300.0	130.0	NA	5.70378	4.86753	NA	19.8	1.133	3
50	06/12/13	CYPRESS	48.533000	122.721650	75	NA	NA	NA	460.0	110.0	NA	6.13123	4.70048	NA	18.4	0.992	3
51	05/07/14	CYPRESS	48.597783	122.731417	110	F	1	0	495.9	187.4	7.4285	6.20637	5.23325	3.96398	23.2	1.515	5
52	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	633.9	211.6	3.3530	6.45189	5.35470	1.58459	24.5	1.668	5
53	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	424.3	154.8	0.4447	6.05044	5.04213	0.28727	21.4	1.302	4
54	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	499.7	144.2	1.9116	6.21401	4.97120	1.32566	20.7	1.230	4
55	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	350.2	140.6	2.7064	5.85850	4.94592	1.92489	20.5	1.206	4
56	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	460.4	141.8	3.3900	6.13210	4.95442	2.39069	20.6	1.214	4
57	05/07/14	CYPRESS	48.597783	122.731417	110	F	1	0	475.2	137.6	0.8867	6.16374	4.92435	0.64440	20.3	1.185	4
58	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	198.9	85.9	2.5497	5.29280	4.45318	2.96822	16.6	0.816	3
59	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	309.4	112.2	3.5932	5.73463	4.72028	3.20250	18.6	1.008	3
60	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	371.4	128.3	7.0694	5.91728	4.85437	5.51005	19.7	1.121	3
61	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	2	383.7	112.9	0.7272	5.94986	4.72650	0.64411	18.6	1.013	3
62	05/07/14	CYPRESS	48.597783	122.731417	110	M	1	0	333.3	139.0	0.7085	5.80904	4.93447	0.50971	20.4	1.195	4
63	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	349.1	119.6	4.1732	5.85536	4.78415	3.48930	19.1	1.061	3
64	05/07/14	CYPRESS	48.597783	122.731417	110	UNK	0	0	298.6	95.8	0.1770	5.69910	4.56226	0.18476	17.4	0.889	3
65	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	258.3	132.6	3.1389	5.55412	4.88734	2.36719	20.0	1.151	4
66	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	371.1	182.7	0.4667	5.91647	5.20785	0.25545	22.9	1.485	5
67	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	319.6	128.2	0.2709	5.76707	4.85359	0.21131	19.7	1.121	3
68	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	328.1	138.1	13.4494	5.79332	4.92798	9.73888	20.3	1.189	4
69	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	304.5	146.2	2.6375	5.71867	4.98498	1.80404	20.8	1.244	4
70	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	1	516.7	200.0	1.1550	6.24746	5.29832	0.57750	23.9	1.595	5
71	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	421.9	162.8	3.6580	6.04477	5.09252	2.24693	21.8	1.355	4
72	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	281.4	101.0	0.3835	5.63978	4.61512	0.37970	17.8	0.927	3

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
73	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	1	134.7	75.5	0.3608	4.90305	4.32413	0.47788	15.7	0.736	2
74	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	280.1	111.5	6.5540	5.63515	4.71402	5.87803	18.5	1.003	3
75	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	328.5	112.3	1.2707	5.79454	4.72117	1.13152	18.6	1.009	3
76	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	220.8	86.1	0.0753	5.39726	4.45551	0.08746	16.6	0.817	3
77	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	264.6	101.9	0.4645	5.57822	4.62399	0.45584	17.8	0.934	3
78	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	476.7	242.0	7.2771	6.16689	5.48894	3.00707	25.9	1.856	6+
79	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	396.6	149.3	14.4530	5.98293	5.00596	9.68051	21.0	1.265	4
80	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	266.0	114.6	3.5630	5.58350	4.74145	3.10908	18.8	1.025	3
81	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	316.8	86.8	3.2261	5.75827	4.46361	3.71671	16.6	0.822	3
82	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	229.2	80.0	1.9348	5.43459	4.38203	2.41850	16.1	0.771	3
83	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	296.9	95.0	0.9293	5.69340	4.55388	0.97821	17.3	0.883	3
84	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	400.2	179.4	8.4883	5.99196	5.18962	4.73149	22.8	1.463	5
85	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	361.3	158.6	1.4738	5.88971	5.06639	0.92926	21.6	1.327	4
86	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	176.7	74.5	0.2235	5.17445	4.31080	0.30000	15.6	0.728	2
87	05/07/14	CYPRESS	48.597783	122.731417	110	UNK	0	0	144.8	64.7	0.1597	4.97535	4.16976	0.24683	14.6	0.651	2
88	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	410.8	127.1	0.9022	6.01811	4.84497	0.70983	19.6	1.113	3
89	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	11	414.0	156.3	1.6956	6.02587	5.05178	1.08484	21.4	1.312	4
90	05/07/14	CYPRESS	48.597783	122.731417	110	M	1	0	221.1	98.9	0.6273	5.39862	4.59411	0.63428	17.6	0.912	3
91	05/07/14	CYPRESS	48.597783	122.731417	110	F	1	0	390.6	189.2	7.8808	5.96768	5.24280	4.16533	23.3	1.526	5
92	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	322.8	104.4	0.3705	5.77703	4.64823	0.35489	18.0	0.952	3
93	05/07/14	CYPRESS	48.597783	122.731417	110	M	1	0	185.1	78.3	2.4114	5.22090	4.36055	3.07969	15.9	0.758	3
94	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	463.8	182.1	7.4808	6.13945	5.20456	4.10807	22.9	1.481	5
95	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	224.5	110.6	1.3198	5.41388	4.70592	1.19331	18.5	0.997	3
96	05/07/14	CYPRESS	48.597783	122.731417	110	UNK	0	0	364.5	136.9	0.7947	5.89853	4.91925	0.58050	20.3	1.181	4
97	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	384.0	126.4	2.0786	5.95064	4.83945	1.64446	19.6	1.108	3
98	05/07/14	CYPRESS	48.597783	122.731417	110	M	0	0	292.4	146.4	1.2353	5.67812	4.98634	0.84378	20.9	1.245	4
99	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	0	384.9	161.7	1.0779	5.95298	5.08574	0.66660	21.8	1.347	4
100	05/07/14	CYPRESS	48.597783	122.731417	110	F	0	3	256.4	112.7	0.9350	5.54674	4.72473	0.82964	18.6	1.012	3
101	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	477.8	167.7	39.6146	6.16919	5.12218	23.62230	22.1	1.387	4
102	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	731.7	214.6	34.3144	6.59537	5.36878	15.98993	24.6	1.687	5
103	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	839.6	292.6	29.7344	6.73293	5.67881	10.16213	28.1	2.157	6+
104	05/27/14	CANOE	48.559350	122.923966	34	UNK	1	0	280.3	106.7	0.0867	5.63586	4.67002	0.08126	18.2	0.969	3
105	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	450.7	146.1	2.3130	6.11080	4.98429	1.58316	20.8	1.243	4
106	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	585.6	339.7	67.6664	6.37264	5.82806	19.91946	30.0	2.429	6+
107	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	538.2	196.7	28.2883	6.28823	5.28168	14.38144	23.7	1.574	5
108	05/27/14	CANOE	48.559350	122.923966	34	M	1	0	1189.8	295.5	69.3935	7.08154	5.68867	23.48342	28.3	2.174	6+
109	05/27/14	CANOE	48.559350	122.923966	34	M	1	0	395.1	184.7	1.5668	5.97914	5.21873	0.84829	23.1	1.497	5

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
110	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	562.0	191.1	39.0431	6.33150	5.25280	20.43072	23.4	1.538	5
111	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	1102.6	399.9	125.4697	7.00543	5.99121	31.37527	32.2	2.764	6+
112	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	465.2	212.3	2.2348	6.14247	5.35800	1.05266	24.5	1.672	5
113	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	905.2	368.4	35.4598	6.80816	5.90917	9.62535	31.1	2.590	6+
114	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	870.8	396.4	4.7045	6.76941	5.98242	1.18681	32.1	2.745	6+
115	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	910.0	372.8	45.9377	6.81344	5.92104	12.32234	31.2	2.615	6+
116	05/27/14	CANOE	48.559350	122.923966	34	M	0	3	723.1	330.9	13.1229	6.58355	5.80182	3.96582	29.7	2.379	6+
117	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	645.8	257.6	14.8817	6.47049	5.55141	5.77706	26.6	1.950	6+
118	05/27/14	CANOE	48.559350	122.923966	34	M	0	11	866.3	348.3	72.8771	6.76423	5.85306	20.92366	30.3	2.477	6+
119	05/27/14	CANOE	48.559350	122.923966	34	F	2	0	485.2	175.3	16.4180	6.18456	5.16650	9.36566	22.5	1.437	4
120	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	1101.3	444.7	12.4101	7.00425	6.09740	2.79067	33.7	3.008	6+
121	05/27/14	CANOE	48.559350	122.923966	34	M	1	0	1082.0	416.4	82.4370	6.98657	6.03165	19.79755	32.8	2.855	6+
122	05/27/14	CANOE	48.559350	122.923966	34	F	2	11	578.2	182.4	30.8747	6.35992	5.20620	16.92692	22.9	1.483	5
123	05/27/14	CANOE	48.559350	122.923966	34	M	1	0	854.5	266.3	63.5382	6.75052	5.58462	23.85963	27.0	2.002	6+
124	05/27/14	CANOE	48.559350	122.923966	34	M	1	0	1316.3	428.0	62.1314	7.18258	6.05912	14.51668	33.2	2.918	6+
125	05/27/14	CANOE	48.559350	122.923966	34	M	1	0	476.5	223.8	23.4224	6.16647	5.41075	10.46577	25.1	1.744	6+
126	05/27/14	CANOE	48.559350	122.923966	34	F	2	0	831.9	314.6	37.1953	6.72371	5.75130	11.82305	29.0	2.285	6+
127	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	206.5	73.2	0.0849	5.33030	4.29320	0.11598	15.4	0.718	2
128	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	736.3	324.2	8.9902	6.60164	5.78136	2.77304	29.4	2.340	6+
129	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	810.5	292.7	59.4657	6.69765	5.67915	20.31626	28.1	2.158	6+
130	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	410.4	159.0	2.3192	6.01713	5.06890	1.45862	21.6	1.330	4
131	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	1013.6	399.0	64.0212	6.92126	5.98896	16.04541	32.2	2.759	6+
132	05/27/14	CANOE	48.559350	122.923966	34	M	0	6	551.8	278.3	4.9415	6.31319	5.62870	1.77560	27.5	2.073	6+
133	05/27/14	CANOE	48.559350	122.923966	34	UNK	0	0	258.1	94.1	0.4119	5.55335	4.54436	0.43773	17.2	0.877	3
134	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	1609.0	506.9	165.4842	7.38337	6.22831	32.64632	35.7	3.337	6+
135	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	575.2	231.8	11.0509	6.35472	5.44587	4.76743	25.4	1.793	6+
136	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	1279.4	354.2	14.4967	7.15415	5.86986	4.09280	30.6	2.511	6+
137	05/27/14	CANOE	48.559350	122.923966	34	F	0	2	1174.4	338.1	122.5430	7.06851	5.82334	36.24460	30.0	2.420	6+
138	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	540.1	156.4	9.6040	6.29175	5.05242	6.14066	21.5	1.312	4
139	05/27/14	CANOE	48.559350	122.923966	34	F	0	2	973.1	270.0	31.6122	6.88049	5.59842	11.70822	27.2	2.024	6+
140	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	912.5	297.0	57.2828	6.81619	5.69373	19.28714	28.3	2.183	6+
141	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	1198.0	417.3	41.8737	7.08841	6.03381	10.03444	32.8	2.859	6+
142	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	977.1	347.1	80.8902	6.88459	5.84961	23.30458	30.3	2.471	6+
143	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	703.4	258.2	54.3579	6.55593	5.55373	21.05263	26.7	1.954	6+
144	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	716.0	242.4	66.6104	6.57368	5.49059	27.47954	25.9	1.858	6+
145	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	444.6	144.5	18.4715	6.09718	4.97328	12.78304	20.7	1.232	4
146	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	935.6	239.6	59.1282	6.84119	5.47897	24.67788	25.8	1.841	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
147	05/27/14	CANOE	48.559350	122.923966	34	M	0	42	517.2	234.6	14.4836	6.24843	5.45788	6.17374	25.6	1.810	6+
148	05/27/14	CANOE	48.559350	122.923966	34	F	1	0	2043.4	583.8	200.5938	7.62237	6.36956	34.36002	37.9	3.733	6+
149	05/27/14	CANOE	48.559350	122.923966	34	F	0	0	147.5	57.6	0.0213	4.99383	4.05352	0.03698	13.9	0.594	2
150	05/27/14	CANOE	48.559350	122.923966	34	M	0	0	1014.7	351.7	44.2461	6.92235	5.86278	12.58064	30.5	2.497	6+
151	06/16/14	SINCLAIR	48.607638	122.666380	30	F	0	0	521.0	210.1	0.2835	6.25575	5.34758	0.13494	24.4	1.659	5
152	06/16/14	SINCLAIR	48.607638	122.666380	30	M	2	0	477.3	166.6	1.9878	6.16815	5.11560	1.19316	22.1	1.380	4
153	06/16/14	SINCLAIR	48.607638	122.666380	30	M	0	0	1329.5	335.5	24.7251	7.19256	5.81562	7.36963	29.9	2.405	6+
154	06/16/14	SINCLAIR	48.607638	122.666380	30	M	1	0	589.6	191.6	1.8427	6.37944	5.25541	0.96174	23.4	1.542	5
155	06/16/14	SINCLAIR	48.607638	122.666380	30	M	2	3	563.5	223.5	8.1897	6.33417	5.40941	3.66430	25.0	1.742	6+
156	06/16/14	SINCLAIR	48.607638	122.666380	30	UNK	1	9	591.9	209.0	0.0288	6.38334	5.34233	0.01378	24.3	1.652	5
157	06/16/14	SINCLAIR	48.607638	122.666380	30	F	1	0	603.8	224.9	2.2985	6.40324	5.41566	1.02201	25.1	1.751	6+
158	06/16/14	SINCLAIR	48.607638	122.666380	30	F	0	0	776.7	318.0	9.3762	6.65505	5.76205	2.94849	29.2	2.305	6+
159	06/16/14	SINCLAIR	48.607638	122.666380	30	M	0	0	471.9	234.9	7.3571	6.15677	5.45916	3.13201	25.6	1.812	6+
160	06/16/14	SINCLAIR	48.607638	122.666380	30	F	1	0	741.2	259.1	72.2513	6.60827	5.55721	27.88549	26.7	1.959	6+
161	06/16/14	SINCLAIR	48.607638	122.666380	30	M	0	0	659.1	316.2	1.7997	6.49088	5.75637	0.56917	29.1	2.294	6+
162	06/16/14	SINCLAIR	48.607638	122.666380	30	M	1	0	514.3	210.1	3.3188	6.24281	5.34758	1.57963	24.4	1.659	5
163	06/16/14	SINCLAIR	48.607638	122.666380	30	M	1	0	689.8	303.3	2.1289	6.53640	5.71472	0.70191	28.6	2.220	6+
164	06/16/14	SINCLAIR	48.607638	122.666380	30	M	1	0	712.3	220.3	0.3630	6.56850	5.39499	0.16478	24.9	1.722	6+
165	06/16/14	SINCLAIR	48.607638	122.666380	30	M	0	0	504.9	201.8	0.1738	6.22436	5.30728	0.08612	24.0	1.606	5
166	06/16/14	SINCLAIR	48.607638	122.666380	30	UNK	1	0	329.6	173.5	0.1266	5.79788	5.15618	0.07297	22.4	1.425	4
167	06/16/14	SINCLAIR	48.607638	122.666380	30	M	2	23	371.5	138.7	1.1263	5.91755	4.93231	0.81204	20.4	1.193	4
168	06/16/14	SINCLAIR	48.607638	122.666380	30	M	0	0	510.1	218.4	7.1231	6.23461	5.38633	3.26149	24.8	1.710	5
169	06/16/14	SINCLAIR	48.607638	122.666380	30	UNK	0	0	124.4	49.7	0.0544	4.82350	3.90600	0.10946	13.1	0.528	2
170	06/16/14	SINCLAIR	48.607638	122.666380	30	UNK	0	0	90.7	42.3	0.0066	4.50756	3.74479	0.01560	12.2	0.465	2
171	06/16/14	SINCLAIR	48.607638	122.666380	30	UNK	0	0	118.0	52.0	0.0680	4.77068	3.95124	0.13077	13.3	0.548	2
172	06/16/14	SINCLAIR	48.607638	122.666380	30	M	0	0	312.8	121.0	0.8195	5.74556	4.79579	0.67727	19.2	1.070	3
173	06/16/14	SINCLAIR	48.607638	122.666380	30	UNK	0	1	416.0	177.9	0.1190	6.03069	5.18122	0.06689	22.7	1.454	5
174	06/16/14	CONE	48.592732	122.683675	30	F	0	0	361.4	169.3	43.5972	5.88999	5.13167	25.75145	22.2	1.397	4
175	06/16/14	CONE	48.592732	122.683675	30	F	0	0	401.1	195.4	14.4232	5.99421	5.27505	7.38137	23.6	1.566	5
176	06/16/14	CONE	48.592732	122.683675	30	F	1	0	454.2	208.5	1.0693	6.11854	5.33994	0.51285	24.3	1.649	5
177	06/16/14	CONE	48.592732	122.683675	30	M	1	4	388.3	179.1	20.8679	5.96178	5.18794	11.65154	22.8	1.461	5
178	06/16/14	CONE	48.592732	122.683675	30	F	0	0	436.0	186.0	0.6730	6.07764	5.22575	0.36183	23.1	1.506	5
179	06/16/14	CONE	48.592732	122.683675	30	M	0	0	163.1	83.8	1.0638	5.09436	4.42843	1.26945	16.4	0.800	3
180	06/16/14	CONE	48.592732	122.683675	30	F	0	1	448.2	186.6	27.6049	6.10524	5.22897	14.79362	23.2	1.510	5
181	06/16/14	CONE	48.592732	122.683675	30	F	1	0	509.8	186.9	14.7125	6.23402	5.23057	7.87186	23.2	1.512	5
182	06/16/14	CONE	48.592732	122.683675	30	M	0	0	337.0	156.8	1.1113	5.82008	5.05497	0.70874	21.5	1.315	4
183	06/16/14	CONE	48.592732	122.683675	30	F	1	0	545.7	212.1	17.5761	6.30207	5.35706	8.28670	24.5	1.671	5

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
184	06/16/14	CONE	48.592732	122.683675	30	UNK	2	1	497.7	233.6	0.6150	6.21000	5.45361	0.26327	25.5	1.804	6+
185	06/16/14	CONE	48.592732	122.683675	30	M	1	1	424.2	176.6	4.3000	6.05021	5.17389	2.43488	22.6	1.445	4
186	06/16/14	CONE	48.592732	122.683675	30	F	2	0	529.7	192.4	27.0294	6.27231	5.25958	14.04854	23.5	1.547	5
187	06/16/14	CONE	48.592732	122.683675	30	M	0	0	314.4	135.4	0.6235	5.75067	4.90823	0.46049	20.2	1.170	4
188	06/16/14	CONE	48.592732	122.683675	30	M	0	0	400.6	184.0	10.6968	5.99296	5.21494	5.81348	23.0	1.493	5
189	06/16/14	CONE	48.592732	122.683675	30	M	0	0	330.4	160.4	8.9365	5.80030	5.07767	5.57138	21.7	1.339	4
190	06/16/14	CONE	48.592732	122.683675	30	M	0	0	509.0	239.9	3.9288	6.23245	5.48022	1.63768	25.8	1.843	6+
191	06/16/14	CONE	48.592732	122.683675	30	M	0	0	363.2	170.3	0.0445	5.89495	5.13756	0.02613	22.3	1.404	4
192	06/16/14	CONE	48.592732	122.683675	30	F	0	0	404.5	154.5	0.7928	6.00265	5.04019	0.51314	21.3	1.300	4
193	06/16/14	CONE	48.592732	122.683675	30	F	0	0	259.3	116.2	0.2094	5.55799	4.75531	0.18021	18.9	1.037	3
194	06/16/14	CONE	48.592732	122.683675	30	F	1	1	316.4	118.2	17.8279	5.75701	4.77238	15.08283	19.0	1.051	3
195	06/16/14	CONE	48.592732	122.683675	30	F	0	0	255.3	146.0	8.2689	5.54244	4.98361	5.66363	20.8	1.243	4
196	06/16/14	CONE	48.592732	122.683675	30	F	0	0	343.3	83.5	0.3958	5.83860	4.42485	0.47401	16.4	0.797	3
197	06/16/14	CONE	48.592732	122.683675	30	M	0	0	282.9	102.1	3.5906	5.64509	4.62595	3.51675	17.8	0.935	3
198	06/16/14	CONE	48.592732	122.683675	30	F	0	0	566.8	265.8	11.7407	6.34001	5.58274	4.41712	27.0	1.999	6+
199	06/16/14	CONE	48.592732	122.683675	30	UNK	1	0	123.8	84.6	0.0499	4.81867	4.43793	0.05898	16.4	0.806	3
200	06/16/14	CONE	48.592732	122.683675	30	F	0	1	266.2	136.4	1.5478	5.58425	4.91559	1.13475	20.2	1.177	4
201	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	750.6	240.6	64.3730	6.62087	5.48314	26.75520	25.9	1.847	6+
202	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	593.1	193.6	30.1456	6.38536	5.26579	15.57107	23.5	1.554	5
203	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	715.9	253.4	7.4118	6.57354	5.53497	2.92494	26.4	1.925	6+
204	06/30/14	ORCAS	48.601448	122.800528	45	UNK	0	10	528.9	194.2	0.0997	6.27080	5.26889	0.05134	23.6	1.558	5
205	06/30/14	ORCAS	48.601448	122.800528	45	F	0	0	540.8	162.1	0.2273	6.29305	5.08821	0.14022	21.8	1.350	4
206	06/30/14	ORCAS	48.601448	122.800528	45	F	0	2	470.9	147.4	9.6913	6.15465	4.99315	6.57483	20.9	1.252	4
207	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	681.7	244.9	0.7699	6.52459	5.50085	0.31437	26.1	1.873	6+
208	06/30/14	ORCAS	48.601448	122.800528	45	UNK	0	3	209.9	74.1	0.0070	5.34663	4.30542	0.00945	15.5	0.725	2
209	06/30/14	ORCAS	48.601448	122.800528	45	F	0	3	534.9	183.4	0.1402	6.28208	5.21167	0.07644	23.0	1.489	5
210	06/30/14	ORCAS	48.601448	122.800528	45	M	0	6	417.2	156.9	0.4760	6.03357	5.05561	0.30338	21.5	1.316	4
211	06/30/14	ORCAS	48.601448	122.800528	45	M	1	1	554.7	245.7	5.5235	6.31843	5.50411	2.24807	26.1	1.878	6+
212	06/30/14	ORCAS	48.601448	122.800528	45	F	0	0	1064.1	408.0	37.1927	6.96988	6.01127	9.11586	32.5	2.809	6+
213	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	622.9	174.1	0.7958	6.43439	5.15963	0.45709	22.5	1.429	4
214	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	509.1	182.6	7.4413	6.23264	5.20730	4.07519	22.9	1.484	5
215	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	666.5	273.8	1.6999	6.50204	5.61240	0.62085	27.3	2.047	6+
216	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	292.0	85.3	0.1820	5.67675	4.44617	0.21336	16.5	0.811	3
217	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	819.4	382.5	2.3533	6.70857	5.94673	0.61524	31.6	2.669	6+
218	06/30/14	ORCAS	48.601448	122.800528	45	UNK	1	0	380.3	121.6	0.0597	5.94096	4.80074	0.04910	19.2	1.075	3
219	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	421.3	178.0	3.3488	6.04335	5.18178	1.88135	22.7	1.454	5
220	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	314.2	113.7	5.8382	5.75003	4.73356	5.13474	18.7	1.019	3

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
221	06/30/14	ORCAS	48.601448	122.800528	45	F	0	1	469.2	157.0	0.5681	6.15103	5.05625	0.36185	21.5	1.316	4
222	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	676.4	178.9	4.3902	6.51678	5.18683	2.45400	22.7	1.460	5
223	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	635.4	209.8	2.1229	6.45425	5.34615	1.01187	24.4	1.657	5
224	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	573.5	258.8	1.0060	6.35176	5.55606	0.38872	26.7	1.957	6+
225	06/30/14	ORCAS	48.601448	122.800528	45	F	0	2	1167.9	322.1	1.8040	7.06296	5.77486	0.56007	29.3	2.328	6+
226	06/30/14	ORCAS	48.601448	122.800528	45	UNK	3	1	833.5	314.3	0.3928	6.72563	5.75035	0.12498	29.0	2.283	6+
227	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	568.0	238.6	8.9398	6.34212	5.47479	3.74677	25.8	1.835	6+
228	06/30/14	ORCAS	48.601448	122.800528	45	UNK	0	0	362.6	108.6	0.0068	5.89330	4.68767	0.00626	18.3	0.982	3
229	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	432.3	193.2	3.2984	6.06912	5.26373	1.70725	23.5	1.552	5
230	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	509.1	152.4	3.4326	6.23264	5.02651	2.25236	21.2	1.286	4
231	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	694.4	211.8	15.0615	6.54305	5.35564	7.11119	24.5	1.669	5
232	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	1046.0	330.6	1.8683	6.95273	5.80091	0.56512	29.7	2.377	6+
233	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	587.4	207.8	2.7856	6.37571	5.33658	1.34052	24.3	1.644	5
234	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	663.4	229.3	55.1079	6.49738	5.43503	24.03310	25.3	1.778	6+
235	06/30/14	ORCAS	48.601448	122.800528	45	M	3	0	740.5	297.8	39.6783	6.60733	5.69642	13.32381	28.4	2.188	6+
236	06/30/14	ORCAS	48.601448	122.800528	45	UNK	2	0	345.4	98.8	0.1270	5.84470	4.59310	0.12854	17.6	0.911	3
237	06/30/14	ORCAS	48.601448	122.800528	45	UNK	0	0	543.6	213.3	0.7920	6.29821	5.36270	0.37131	24.5	1.679	5
238	06/30/14	ORCAS	48.601448	122.800528	45	F	2	0	700.0	274.6	1.8120	6.55108	5.61532	0.65987	27.4	2.051	6+
239	06/30/14	ORCAS	48.601448	122.800528	45	M	2	0	983.8	336.0	1.2504	6.89142	5.81711	0.37214	29.9	2.408	6+
240	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	475.6	155.3	4.2956	6.16458	5.04536	2.76600	21.4	1.305	4
241	06/30/14	ORCAS	48.601448	122.800528	45	F	1	0	1099.7	399.0	6.9627	7.00279	5.98896	1.74504	32.2	2.759	6+
242	06/30/14	ORCAS	48.601448	122.800528	45	M	1	2	607.3	228.7	6.7654	6.40902	5.43241	2.95820	25.3	1.774	6+
243	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	600.3	202.0	4.3402	6.39743	5.30827	2.14861	24.0	1.608	5
244	06/30/14	ORCAS	48.601448	122.800528	45	F	1	16	467.1	214.5	0.9372	6.14654	5.36831	0.43692	24.6	1.686	5
245	06/30/14	ORCAS	48.601448	122.800528	45	UNK	1	2	295.0	95.7	0.0900	5.68698	4.56122	0.09404	17.3	0.889	3
246	06/30/14	ORCAS	48.601448	122.800528	45	M	1	0	576.8	172.3	1.2182	6.35750	5.14924	0.70702	22.4	1.417	4
247	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	488.3	170.3	6.9326	6.19093	5.13756	4.07082	22.3	1.404	4
248	06/30/14	ORCAS	48.601448	122.800528	45	UNK	0	0	454.2	179.0	0.0539	6.11854	5.18739	0.03011	22.7	1.461	5
249	06/30/14	ORCAS	48.601448	122.800528	45	UNK	1	0	532.4	362.9	0.5527	6.27740	5.89413	0.15230	30.9	2.559	6+
250	06/30/14	ORCAS	48.601448	122.800528	45	M	0	0	402.5	108.5	5.2999	5.99770	4.68675	4.88470	18.3	0.982	3
251	07/15/14	VENDOVI	48.613683	122.614767	49	M	2	17	620.3	187.8	9.2561	6.43020	5.23538	4.92870	23.2	1.517	5
252	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	845.7	283.3	16.4082	6.74016	5.64651	5.79181	27.7	2.103	6+
253	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	852.2	301.1	15.8474	6.74782	5.70744	5.26317	28.5	2.207	6+
254	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	819.8	289.2	8.7003	6.70906	5.66712	3.00840	28.0	2.137	6+
255	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	12	872.9	198.7	0.2816	6.77182	5.29180	0.14172	23.8	1.587	5
256	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	1261.8	462.6	4.3405	7.14029	6.13686	0.93828	34.3	3.103	6+
257	07/15/14	VENDOVI	48.613683	122.614767	49	M	2	0	676.1	273.0	1.4190	6.51634	5.60947	0.51978	27.3	2.042	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
258	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	752.8	255.7	17.3051	6.62380	5.54400	6.76774	26.5	1.938	6+
259	07/15/14	VENDOVI	48.613683	122.614767	49	F	2	0	850.4	342.5	3.7746	6.74571	5.83627	1.10207	30.1	2.445	6+
260	07/15/14	VENDOVI	48.613683	122.614767	49	F	2	0	797.4	235.2	19.3883	6.68136	5.46044	8.24332	25.6	1.814	6+
261	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	1253.3	370.5	10.7075	7.13354	5.91485	2.89001	31.2	2.602	6+
262	07/15/14	VENDOVI	48.613683	122.614767	49	UNK	0	0	605.6	179.6	0.2118	6.40622	5.19073	0.11793	22.8	1.465	5
263	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	1043.7	346.1	3.3813	6.95053	5.84673	0.97697	30.3	2.465	6+
264	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	288.4	98.6	0.3769	5.66435	4.59107	0.38225	17.6	0.910	3
265	07/15/14	VENDOVI	48.613683	122.614767	49	F	2	0	1018.3	352.1	18.6392	6.92589	5.86392	5.29372	30.5	2.499	6+
266	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	1409.3	402.2	14.3438	7.25085	5.99695	3.56634	32.3	2.777	6+
267	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	1	399.7	128.6	1.0638	5.99071	4.85671	0.82722	19.7	1.123	3
268	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	4	775.7	312.9	12.0409	6.65377	5.74588	3.84816	29.0	2.275	6+
269	07/15/14	VENDOVI	48.613683	122.614767	49	F	3	0	773.9	289.1	2.5338	6.65144	5.66677	0.87644	28.0	2.137	6+
270	07/15/14	VENDOVI	48.613683	122.614767	49	UNK	1	0	160.0	63.2	0.1216	5.07517	4.14630	0.19241	14.5	0.639	2
271	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	455.3	155.7	6.0899	6.12096	5.04793	3.91130	21.4	1.308	4
272	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	564.3	180.7	2.9978	6.33559	5.19684	1.65899	22.8	1.472	5
273	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	1043.6	355.5	6.6063	6.95043	5.87353	1.85831	30.6	2.518	6+
274	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	21	372.4	126.5	1.3695	5.91997	4.84024	1.08261	19.6	1.109	3
275	07/15/14	VENDOVI	48.613683	122.614767	49	F	2	0	1001.1	308.2	1.8257	6.90885	5.73075	0.59238	28.8	2.248	6+
276	07/15/14	VENDOVI	48.613683	122.614767	49	F	3	0	987.7	394.0	22.8849	6.89538	5.97635	5.80835	32.0	2.732	6+
277	07/15/14	VENDOVI	48.613683	122.614767	49	UNK	3	1	746.6	282.3	0.4592	6.61553	5.64297	0.16266	27.7	2.097	6+
278	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	8	617.3	134.2	0.4580	6.42536	4.89933	0.34128	20.1	1.162	4
279	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	709.9	262.2	50.4976	6.56512	5.56911	19.25919	26.8	1.977	6+
280	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	626.4	255.4	1.7859	6.43999	5.54283	0.69926	26.5	1.937	6+
281	07/15/14	VENDOVI	48.613683	122.614767	49	F	0	0	873.0	219.5	9.1032	6.77194	5.39135	4.14724	24.8	1.717	5
282	07/15/14	VENDOVI	48.613683	122.614767	49	F	2	0	839.2	304.7	7.6839	6.73245	5.71933	2.52179	28.6	2.228	6+
283	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	979.6	294.8	5.3612	6.88714	5.68630	1.81859	28.2	2.170	6+
284	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	647.6	272.2	12.2907	6.47327	5.60654	4.51532	27.3	2.037	6+
285	07/15/14	VENDOVI	48.613683	122.614767	49	F	0	0	1031.5	417.7	21.1161	6.93877	6.03476	5.05533	32.8	2.862	6+
286	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	1079.1	336.1	21.0735	6.98388	5.81741	6.27001	29.9	2.408	6+
287	07/15/14	VENDOVI	48.613683	122.614767	49	UNK	0	2	118.7	41.6	0.0313	4.77660	3.72810	0.07524	12.1	0.459	2
288	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	1132.7	352.4	1.9430	7.03236	5.86477	0.55136	30.5	2.500	6+
289	07/15/14	VENDOVI	48.613683	122.614767	49	UNK	0	10	383.8	143.5	0.2308	5.95012	4.96634	0.16084	20.7	1.226	4
290	07/15/14	VENDOVI	48.613683	122.614767	49	M	0	0	707.4	285.5	13.4392	6.56160	5.65424	4.70725	27.8	2.116	6+
291	07/15/14	VENDOVI	48.613683	122.614767	49	M	1	0	989.5	339.5	8.4852	6.89720	5.82747	2.49932	30.0	2.428	6+
292	07/15/14	VENDOVI	48.613683	122.614767	49	UNK	0	0	125.8	47.9	0.0078	4.83469	3.86912	0.01628	12.9	0.513	2
293	07/15/14	VENDOVI	48.613683	122.614767	49	M	2	0	775.6	339.4	52.5720	6.65364	5.82718	15.48969	30.0	2.427	6+
294	07/15/14	VENDOVI	48.613683	122.614767	49	F	0	0	876.7	344.3	17.5751	6.77616	5.84151	5.10459	30.2	2.455	6+

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
295	07/15/14	VENDOVI	48.613683	122.614767	49	F	2	10	566.9	219.3	2.3224	6.34018	5.39044	1.05901	24.8	1.716	5
296	07/15/14	VENDOVI	48.613683	122.614767	49	M	2	0	982.5	357.6	3.8178	6.89010	5.87942	1.06762	30.7	2.530	6+
297	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	1	1119.1	405.5	13.1190	7.02028	6.00512	3.23527	32.4	2.795	6+
298	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	655.9	262.3	2.6305	6.48601	5.56949	1.00286	26.8	1.978	6+
299	07/15/14	VENDOVI	48.613683	122.614767	49	F	1	0	656.1	237.5	10.6124	6.48631	5.47017	4.46838	25.7	1.828	6+
300	07/15/14	VENDOVI	48.613683	122.614767	49	F	0	0	945.1	374.6	9.3417	6.85129	5.92586	2.49378	31.3	2.625	6+
301	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	944.8	322.6	15.7712	6.85097	5.77641	4.88878	29.4	2.331	6+
302	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	0	865.3	328.6	1.5021	6.76308	5.79484	0.45712	29.6	2.365	6+
303	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	945.8	308.2	26.6183	6.85203	5.73075	8.63670	28.8	2.248	6+
304	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	0	898.2	325.1	2.5014	6.80039	5.78413	0.76942	29.5	2.345	6+
305	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	0	1254.0	401.1	43.4228	7.13409	5.99421	10.82593	32.3	2.771	6+
306	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	0	1039.9	357.3	5.4141	6.94688	5.87858	1.51528	30.7	2.528	6+
307	07/31/14	VENDOVI	48.613683	122.614767	48	F	2	0	1334.5	454.2	5.8825	7.19631	6.11854	1.29513	34.0	3.058	6+
308	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	7	536.8	184.3	10.1608	6.28563	5.21656	5.51319	23.0	1.495	5
309	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	1106.9	412.5	6.6666	7.00932	6.02224	1.61615	32.6	2.833	6+
310	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	5	910.4	284.2	3.1557	6.81388	5.64968	1.11038	27.8	2.108	6+
311	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	1140.6	361.3	2.9881	7.03931	5.88971	0.82704	30.8	2.550	6+
312	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	942.6	383.3	4.3643	6.84864	5.94882	1.13861	31.6	2.673	6+
313	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	1008.6	336.1	6.7450	6.91632	5.81741	2.00684	29.9	2.408	6+
314	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	663.1	288.5	2.8925	6.49693	5.66470	1.00260	28.0	2.133	6+
315	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	1085.9	339.4	11.1481	6.99016	5.82718	3.28465	30.0	2.427	6+
316	07/31/14	VENDOVI	48.613683	122.614767	48	F	3	0	1105.5	356.7	48.9559	7.00805	5.87690	13.72467	30.7	2.525	6+
317	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	3	579.9	283.8	2.4352	6.36286	5.64827	0.85807	27.8	2.106	6+
318	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	0	989.7	290.5	42.5347	6.89740	5.67160	14.64189	28.1	2.145	6+
319	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	477.8	232.8	1.7109	6.16919	5.45018	0.73492	25.5	1.799	6+
320	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	1330.3	414.9	46.0262	7.19316	6.02804	11.09332	32.7	2.846	6+
321	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	700.7	266.4	3.9374	6.55208	5.58500	1.47800	27.0	2.003	6+
322	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	0	932.1	353.7	4.4129	6.83744	5.86845	1.24764	30.5	2.508	6+
323	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	861.0	295.4	82.4633	6.75809	5.68833	27.91581	28.3	2.174	6+
324	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	0	930.0	251.9	18.1379	6.83518	5.52903	7.20044	26.4	1.916	6+
325	07/31/14	VENDOVI	48.613683	122.614767	48	F	2	0	682.8	318.7	2.9942	6.52620	5.76425	0.93950	29.2	2.309	6+
326	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	627.4	305.9	8.4244	6.44158	5.72326	2.75397	28.7	2.235	6+
327	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	1334.3	461.5	13.1935	7.19616	6.13448	2.85883	34.3	3.097	6+
328	07/31/14	VENDOVI	48.613683	122.614767	48	F	3	0	1099.2	521.7	6.8282	7.00234	6.25709	1.30884	36.1	3.414	6+
329	07/31/14	VENDOVI	48.613683	122.614767	48	F	2	0	633.7	256.4	2.8644	6.45158	5.54674	1.11716	26.6	1.943	6+
330	07/31/14	VENDOVI	48.613683	122.614767	48	F	2	0	834.2	401.2	5.2320	6.72647	5.99446	1.30409	32.3	2.772	6+
331	07/31/14	VENDOVI	48.613683	122.614767	48	UNK	2	0	531.9	248.1	1.3142	6.27646	5.51383	0.52971	26.2	1.893	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
332	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	940.3	331.2	1.8528	6.84620	5.80272	0.55942	29.7	2.380	6+
333	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	1351.7	352.5	56.8838	7.20912	5.86505	16.13725	30.5	2.501	6+
334	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	1196.4	452.8	5.9078	7.08707	6.11545	1.30473	34.0	3.051	6+
335	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	658.3	243.6	1.4795	6.48966	5.49553	0.60735	26.0	1.865	6+
336	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	1	694.0	307.6	2.0542	6.54247	5.72880	0.66782	28.8	2.245	6+
337	07/31/14	VENDOVI	48.613683	122.614767	48	F	3	0	407.1	240.9	5.6280	6.00906	5.48438	2.33624	25.9	1.849	6+
338	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	0	1260.9	374.1	1.9339	7.13958	5.92452	0.51695	31.3	2.622	6+
339	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	0	646.9	248.5	0.1390	6.47219	5.51544	0.05594	26.2	1.895	6+
340	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	834.8	315.1	34.4068	6.72719	5.75289	10.91933	29.1	2.288	6+
341	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	1223.2	411.9	19.7791	7.10923	6.02078	4.80192	32.6	2.830	6+
342	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	0	1078.5	328.1	0.6704	6.98333	5.79332	0.20433	29.6	2.363	6+
343	07/31/14	VENDOVI	48.613683	122.614767	48	M	0	0	603.6	228.4	16.7537	6.40291	5.43110	7.33525	25.3	1.772	6+
344	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	16	913.3	297.1	2.0854	6.81706	5.69407	0.70192	28.3	2.184	6+
345	07/31/14	VENDOVI	48.613683	122.614767	48	M	2	0	820.6	299.9	33.4804	6.71004	5.70345	11.16385	28.4	2.200	6+
346	07/31/14	VENDOVI	48.613683	122.614767	48	M	1	0	627.9	224.5	2.0243	6.44238	5.41388	0.90169	25.1	1.748	6+
347	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	796.4	358.1	11.6395	6.68010	5.88081	3.25035	30.7	2.533	6+
348	07/31/14	VENDOVI	48.613683	122.614767	48	M	3	0	1202.3	437.5	12.4538	7.09199	6.08108	2.84658	33.5	2.969	6+
349	07/31/14	VENDOVI	48.613683	122.614767	48	F	0	0	861.3	354.5	4.0711	6.75844	5.87071	1.14841	30.6	2.512	6+
350	07/31/14	VENDOVI	48.613683	122.614767	48	F	1	0	861.2	303.5	37.4116	6.75833	5.71538	12.32672	28.6	2.221	6+
351	08/12/14	CONE	48.592000	122.676317	36	M	0	0	556.7	270.9	44.6999	6.32203	5.60175	16.50052	27.2	2.029	6+
352	08/12/14	CONE	48.592000	122.676317	36	F	1	1	715.5	269.0	1.8949	6.57298	5.59471	0.70442	27.1	2.018	6+
353	08/12/14	CONE	48.592000	122.676317	36	F	1	0	1284.5	363.8	1.4043	7.15812	5.89660	0.38601	30.9	2.564	6+
354	08/12/14	CONE	48.592000	122.676317	36	M	0	0	805.6	349.1	0.4664	6.69159	5.85536	0.13360	30.4	2.482	6+
355	08/12/14	CONE	48.592000	122.676317	36	F	1	0	697.3	283.3	18.0400	6.54722	5.64651	6.36781	27.7	2.103	6+
356	08/12/14	CONE	48.592000	122.676317	36	M	1	0	695.3	232.6	0.5811	6.54434	5.44932	0.24983	25.5	1.798	6+
357	08/12/14	CONE	48.592000	122.676317	36	F	1	0	657.6	311.9	2.5692	6.48860	5.74268	0.82373	28.9	2.270	6+
358	08/12/14	CONE	48.592000	122.676317	36	F	1	0	583.5	286.2	6.7925	6.36904	5.65669	2.37334	27.9	2.120	6+
359	08/12/14	CONE	48.592000	122.676317	36	F	0	11	350.2	144.0	0.1612	5.85850	4.96981	0.11194	20.7	1.229	4
360	08/12/14	CONE	48.592000	122.676317	36	F	0	0	376.0	206.9	15.9354	5.92959	5.33224	7.70198	24.2	1.639	5
361	08/12/14	CONE	48.592000	122.676317	36	M	0	6	950.1	250.1	2.3603	6.85657	5.52186	0.94374	26.3	1.905	6+
362	08/12/14	CONE	48.592000	122.676317	36	UNK	0	6	546.3	154.7	0.1524	6.30317	5.04149	0.09851	21.4	1.301	4
363	08/12/14	CONE	48.592000	122.676317	36	UNK	1	27	656.5	223.5	0.0061	6.48692	5.40941	0.00273	25.0	1.742	6+
364	08/12/14	CONE	48.592000	122.676317	36	M	0	0	745.4	298.9	11.7082	6.61392	5.70011	3.91710	28.4	2.194	6+
365	08/12/14	CONE	48.592000	122.676317	36	M	1	0	570.9	196.6	1.9724	6.34721	5.28117	1.00326	23.7	1.574	5
366	08/12/14	CONE	48.592000	122.676317	36	M	0	0	611.3	268.6	0.4460	6.41559	5.59322	0.16605	27.1	2.016	6+
367	08/12/14	CONE	48.592000	122.676317	36	UNK	0	5	413.2	167.4	0.1362	6.02393	5.12039	0.08136	22.1	1.385	4
368	08/12/14	CONE	48.592000	122.676317	36	F	1	1	205.2	95.5	0.2642	5.32399	4.55913	0.27665	17.3	0.887	3

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
369	08/12/14	CONE	48.592000	122.676317	36	UNK	0	2	352.3	105.9	0.3625	5.86448	4.66250	0.34230	18.1	0.963	3
370	08/12/14	CONE	48.592000	122.676317	36	UNK	1	0	628.8	229.3	0.5335	6.44381	5.43503	0.23266	25.3	1.778	6+
371	08/12/14	CONE	48.592000	122.676317	36	M	3	0	650.6	208.9	2.2788	6.47790	5.34186	1.09086	24.3	1.651	5
372	08/12/14	CONE	48.592000	122.676317	36	UNK	1	1	471.0	102.4	0.1566	6.15486	4.62889	0.15293	17.9	0.938	3
373	08/12/14	CONE	48.592000	122.676317	36	F	1	0	459.7	203.3	1.7545	6.13057	5.31468	0.86301	24.0	1.616	5
374	08/12/14	CONE	48.592000	122.676317	36	F	2	0	503.0	235.3	1.3529	6.22059	5.46086	0.57497	25.6	1.815	6+
375	08/12/14	CONE	48.592000	122.676317	36	F	1	15	411.0	177.0	1.5434	6.01859	5.17615	0.87198	22.6	1.448	4
376	08/12/14	CONE	48.592000	122.676317	36	F	1	0	622.0	287.6	1.6289	6.43294	5.66157	0.56638	27.9	2.128	6+
377	08/12/14	CONE	48.592000	122.676317	36	F	1	0	297.2	106.1	0.1162	5.69441	4.66438	0.10952	18.1	0.964	3
378	08/12/14	CONE	48.592000	122.676317	36	UNK	2	1	579.4	288.5	1.2456	6.36199	5.66470	0.43175	28.0	2.133	6+
379	08/12/14	CONE	48.592000	122.676317	36	UNK	0	0	665.7	213.0	0.0194	6.50084	5.36129	0.00911	24.5	1.677	5
380	08/12/14	CONE	48.592000	122.676317	36	F	1	0	419.8	154.5	0.5711	6.03978	5.04019	0.36964	21.3	1.300	4
381	08/12/14	CONE	48.592000	122.676317	36	M	0	0	557.3	273.1	1.2633	6.32310	5.60984	0.46258	27.3	2.042	6+
382	08/12/14	CONE	48.592000	122.676317	36	F	1	0	499.2	182.7	1.0774	6.21301	5.20785	0.58971	22.9	1.485	5
383	08/12/14	CONE	48.592000	122.676317	36	F	1	0	588.0	273.7	10.2103	6.37673	5.61203	3.73047	27.3	2.046	6+
384	08/12/14	CONE	48.592000	122.676317	36	M	1	0	644.3	159.3	19.3044	6.46816	5.07079	12.11827	21.6	1.332	4
385	08/12/14	CONE	48.592000	122.676317	36	UNK	1	10	379.5	208.5	0.2108	5.93885	5.33994	0.10110	24.3	1.649	5
386	08/12/14	CONE	48.592000	122.676317	36	UNK	0	0	309.4	148.3	0.1020	5.73463	4.99924	0.06878	21.0	1.258	4
387	08/12/14	CONE	48.592000	122.676317	36	UNK	1	0	322.2	106.4	0.0636	5.77517	4.66721	0.05977	18.2	0.967	3
388	08/12/14	CONE	48.592000	122.676317	36	F	2	0	567.8	208.1	0.8533	6.34177	5.33802	0.41004	24.3	1.646	5
389	08/12/14	CONE	48.592000	122.676317	36	UNK	0	0	572.7	283.6	0.0391	6.35036	5.64756	0.01379	27.8	2.105	6+
390	08/12/14	CONE	48.592000	122.676317	36	M	0	0	603.8	236.3	4.0401	6.40324	5.46510	1.70973	25.7	1.821	6+
391	08/12/14	CONE	48.592000	122.676317	36	UNK	1	0	794.1	267.6	0.0539	6.67721	5.58949	0.02014	27.1	2.010	6+
392	08/12/14	CONE	48.592000	122.676317	36	UNK	2	0	679.0	194.4	1.2753	6.52062	5.26992	0.65602	23.6	1.560	5
393	08/12/14	CONE	48.592000	122.676317	36	UNK	0	0	525.6	211.9	0.2159	6.26454	5.35611	0.10189	24.5	1.670	5
394	08/12/14	CONE	48.592000	122.676317	36	F	0	0	685.9	246.1	20.4549	6.53073	5.50574	8.31162	26.1	1.881	6+
395	08/12/14	CONE	48.592000	122.676317	36	UNK	0	0	246.8	97.1	0.0558	5.50858	4.57574	0.05747	17.5	0.899	3
396	08/12/14	CONE	48.592000	122.676317	36	M	0	0	738.2	271.8	4.7927	6.60421	5.60507	1.76332	27.3	2.035	6+
397	08/12/14	CONE	48.592000	122.676317	36	M	1	0	415.9	174.8	0.9300	6.03044	5.16364	0.53204	22.5	1.433	4
398	08/12/14	CONE	48.592000	122.676317	36	UNK	1	0	402.7	183.3	0.0701	5.99819	5.21112	0.03824	23.0	1.488	5
399	08/12/14	CONE	48.592000	122.676317	36	UNK	1	0	482.2	193.2	0.9221	6.17836	5.26373	0.47728	23.5	1.552	5
400	08/12/14	CONE	48.592000	122.676317	36	F	1	0	537.0	255.8	10.6463	6.28600	5.54440	4.16196	26.5	1.939	6+
401	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	948.1	399.2	3.6189	6.85446	5.98946	0.90654	32.2	2.761	6+
402	08/19/14	SINCLAIR	48.610700	122.679467	17	F	1	0	518.2	235.0	8.2177	6.25036	5.45959	3.49689	25.6	1.813	6+
403	08/19/14	SINCLAIR	48.610700	122.679467	17	F	2	16	455.7	197.8	0.8634	6.12183	5.28726	0.43650	23.8	1.581	5
404	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	0	0	562.0	235.8	1.4070	6.33150	5.46298	0.59669	25.6	1.818	6+
405	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	858.6	335.5	11.2058	6.75530	5.81562	3.34003	29.9	2.405	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
406	08/19/14	SINCLAIR	48.610700	122.679467	17	F	1	0	433.8	191.6	3.1479	6.07258	5.25541	1.64295	23.4	1.542	5
407	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	0	0	401.5	127.6	0.0858	5.99521	4.84890	0.06724	19.6	1.117	3
408	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	835.3	331.4	5.6612	6.72779	5.80333	1.70827	29.7	2.381	6+
409	08/19/14	SINCLAIR	48.610700	122.679467	17	M	2	0	324.6	116.6	0.6562	5.78259	4.75875	0.56278	18.9	1.039	3
410	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	584.6	244.6	0.3401	6.37093	5.49962	0.13904	26.0	1.871	6+
411	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	914.2	305.8	3.5388	6.81805	5.72293	1.15723	28.7	2.234	6+
412	08/19/14	SINCLAIR	48.610700	122.679467	17	F	2	0	464.1	203.8	3.4041	6.14010	5.31714	1.67031	24.1	1.619	5
413	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	1204.3	346.6	13.4446	7.09365	5.84817	3.87900	30.3	2.468	6+
414	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	777.0	289.1	3.0945	6.65544	5.66677	1.07039	28.0	2.137	6+
415	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	5	561.2	244.5	13.8214	6.33008	5.49922	5.65292	26.0	1.871	6+
416	08/19/14	SINCLAIR	48.610700	122.679467	17	F	1	0	452.7	153.1	17.7815	6.11523	5.03109	11.61430	21.3	1.290	4
417	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	0	1	376.3	140.4	0.0369	5.93039	4.94450	0.02628	20.5	1.205	4
418	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	0	3	385.3	158.2	0.2220	5.95402	5.06386	0.14033	21.6	1.324	4
419	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	363.3	133.8	0.4230	5.89523	4.89635	0.31614	20.1	1.159	4
420	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	328.0	102.0	0.2126	5.79301	4.62497	0.20843	17.8	0.935	3
421	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	778.9	332.6	2.1897	6.65788	5.80694	0.65836	29.7	2.388	6+
422	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	8	526.2	226.9	1.3028	6.26568	5.42451	0.57417	25.2	1.763	6+
423	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	464.1	113.0	0.7324	6.14010	4.72739	0.64814	18.6	1.014	3
424	08/19/14	SINCLAIR	48.610700	122.679467	17	F	3	0	745.5	229.4	3.4426	6.61406	5.43547	1.50070	25.3	1.778	6+
425	08/19/14	SINCLAIR	48.610700	122.679467	17	M	1	0	684.0	256.4	3.5655	6.52796	5.54674	1.39060	26.6	1.943	6+
426	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	238.1	94.5	0.2871	5.47269	4.54860	0.30381	17.3	0.880	3
427	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	994.6	426.1	0.8457	6.90234	6.05467	0.19847	33.1	2.907	6+
428	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	2	0	292.3	182.8	0.3111	5.67778	5.20839	0.17019	23.0	1.485	5
429	08/19/14	SINCLAIR	48.610700	122.679467	17	M	1	0	548.6	230.2	10.3026	6.30737	5.43895	4.47550	25.4	1.783	6+
430	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	1030.2	351.8	2.8497	6.93751	5.86306	0.81003	30.5	2.497	6+
431	08/19/14	SINCLAIR	48.610700	122.679467	17	M	2	0	753.6	329.5	3.2910	6.62486	5.79758	0.99879	29.6	2.371	6+
432	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	0	5	300.4	87.0	0.0473	5.70511	4.46591	0.05437	16.6	0.824	3
433	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	877.6	323.2	21.3027	6.77719	5.77827	6.59118	29.4	2.335	6+
434	08/19/14	SINCLAIR	48.610700	122.679467	17	F	2	0	555.8	293.6	11.5702	6.32041	5.68222	3.94080	28.2	2.163	6+
435	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	519.5	189.1	3.6471	6.25287	5.24228	1.92866	23.3	1.526	5
436	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	722.7	305.8	8.0255	6.58299	5.72293	2.62443	28.7	2.234	6+
437	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	1	975.9	356.2	2.4190	6.88336	5.87549	0.67911	30.6	2.522	6+
438	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	825.8	332.3	1.1796	6.71635	5.80604	0.35498	29.7	2.387	6+
439	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	984.7	394.8	1.9810	6.89234	5.97838	0.50177	32.0	2.736	6+
440	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	481.4	192.7	2.2072	6.17670	5.26113	1.14541	23.5	1.549	5
441	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	1	0	277.7	106.4	0.0186	5.62654	4.66721	0.01748	18.2	0.967	3
442	08/19/14	SINCLAIR	48.610700	122.679467	17	M	1	0	517.2	202.0	3.0518	6.24843	5.30827	1.51079	24.0	1.608	5

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
443	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	0	2	322.2	117.9	0.0313	5.77517	4.76984	0.02655	19.0	1.049	3
444	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	1	713.7	283.6	3.8221	6.57046	5.64756	1.34771	27.8	2.105	6+
445	08/19/14	SINCLAIR	48.610700	122.679467	17	UNK	1	1	695.9	195.9	0.1388	6.54521	5.27760	0.07085	23.7	1.569	5
446	08/19/14	SINCLAIR	48.610700	122.679467	17	M	1	0	849.2	328.5	1.2483	6.74429	5.79454	0.38000	29.6	2.365	6+
447	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	660.5	234.3	5.2175	6.49300	5.45660	2.22685	25.6	1.809	6+
448	08/19/14	SINCLAIR	48.610700	122.679467	17	M	0	0	787.0	267.8	0.7350	6.66823	5.59024	0.27446	27.1	2.011	6+
449	08/19/14	SINCLAIR	48.610700	122.679467	17	F	0	0	624.0	343.3	4.3217	6.43615	5.83860	1.25887	30.2	2.449	6+
450	08/19/14	SINCLAIR	48.610700	122.679467	17	M	1	0	354.2	145.2	1.0507	5.86986	4.97811	0.72362	20.8	1.237	4
451	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	12	450.0	170.5	0.0405	6.10925	5.13874	0.02375	22.3	1.405	4
452	09/04/14	LOPEZ*	48.565217	122.892100	42	M	1	13	375.6	119.4	0.1084	5.92852	4.78248	0.09079	19.1	1.059	3
453	09/04/14	LOPEZ*	48.565217	122.892100	42	F	1	0	433.4	176.1	1.1136	6.07166	5.17105	0.63237	22.6	1.442	4
454	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	234.6	79.5	0.0019	5.45788	4.37576	0.00239	16.0	0.767	3
455	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	748.6	202.4	15.8954	6.61820	5.31025	7.85346	24.0	1.610	5
456	09/04/14	LOPEZ*	48.565217	122.892100	42	F	1	0	973.3	439.7	0.7088	6.88069	6.08609	0.16120	33.6	2.981	6+
457	09/04/14	LOPEZ*	48.565217	122.892100	42	F	0	0	331.0	112.5	0.0964	5.80212	4.72295	0.08569	18.6	1.010	3
458	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	1	660.3	231.3	2.5179	6.49269	5.44372	1.08859	25.4	1.790	6+
459	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	207.5	68.9	0.1189	5.33513	4.23266	0.17257	15.0	0.685	2
460	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	577.8	258.1	0.6320	6.35923	5.55335	0.24487	26.7	1.953	6+
461	09/04/14	LOPEZ*	48.565217	122.892100	42	F	0	0	800.0	270.2	1.9640	6.68461	5.59916	0.72687	27.2	2.025	6+
462	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	538.1	240.4	0.6383	6.28804	5.48230	0.26552	25.8	1.846	6+
463	09/04/14	LOPEZ*	48.565217	122.892100	42	F	0	0	980.6	399.9	4.8951	6.88816	5.99121	1.22408	32.2	2.764	6+
464	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	268.5	100.4	0.1985	5.59285	4.60916	0.19771	17.7	0.923	3
465	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	822.7	307.3	5.3078	6.71259	5.72782	1.72724	28.7	2.243	6+
466	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	389.1	111.7	0.1397	5.96384	4.71582	0.12507	18.5	1.005	3
467	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	1	397.2	128.0	0.0018	5.98444	4.85203	0.00141	19.7	1.119	3
468	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	8	492.8	177.4	0.1829	6.20010	5.17841	0.10310	22.7	1.450	4
469	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	614.0	212.6	0.1229	6.41999	5.35941	0.05781	24.5	1.674	5
470	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	345.3	137.0	0.9225	5.84441	4.91998	0.67336	20.3	1.181	4
471	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	214.1	64.7	0.0083	5.36644	4.16976	0.01283	14.6	0.651	2
472	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	508.4	204.6	0.1273	6.23127	5.32106	0.06222	24.1	1.624	5
473	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	3	392.8	144.9	0.3554	5.97330	4.97604	0.24527	20.8	1.235	4
474	09/04/14	LOPEZ*	48.565217	122.892100	42	M	1	0	598.4	217.0	0.3925	6.39426	5.37990	0.18088	24.7	1.702	5
475	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	442.6	139.4	0.0967	6.09267	4.93735	0.06937	20.4	1.198	4
476	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	886.8	275.4	2.5576	6.78762	5.61822	0.92869	27.4	2.056	6+
477	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	6	427.1	166.7	1.3982	6.05702	5.11620	0.83875	22.1	1.380	4
478	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	559.9	219.6	1.1788	6.32776	5.39181	0.53679	24.9	1.718	5
479	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	303.2	121.6	0.6296	5.71439	4.80074	0.51776	19.2	1.075	3

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
480	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	740.6	309.4	0.2220	6.60746	5.73463	0.07175	28.8	2.255	6+
481	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	2	212.8	71.0	0.1115	5.36035	4.26268	0.15704	15.2	0.701	2
482	09/04/14	LOPEZ*	48.565217	122.892100	42	F	1	0	730.3	250.9	0.5585	6.59346	5.52505	0.22260	26.3	1.910	6+
483	09/04/14	LOPEZ*	48.565217	122.892100	42	F	0	0	670.7	267.8	2.3197	6.50832	5.59024	0.86621	27.1	2.011	6+
484	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	549.1	210.3	0.1445	6.30828	5.34854	0.06871	24.4	1.660	5
485	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	792.4	334.6	3.0602	6.67507	5.81294	0.91458	29.8	2.400	6+
486	09/04/14	LOPEZ*	48.565217	122.892100	42	F	1	0	888.8	305.9	5.5026	6.78987	5.72326	1.79882	28.7	2.235	6+
487	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	451.4	173.7	1.9323	6.11235	5.15733	1.11244	22.5	1.426	4
488	09/04/14	LOPEZ*	48.565217	122.892100	42	M	1	0	591.6	218.3	1.3814	6.38283	5.38587	0.63280	24.8	1.710	5
489	09/04/14	LOPEZ*	48.565217	122.892100	42	M	1	0	530.7	146.9	15.3123	6.27420	4.98975	10.42362	20.9	1.249	4
490	09/04/14	LOPEZ*	48.565217	122.892100	42	F	0	0	816.4	310.6	7.1524	6.70490	5.73851	2.30277	28.9	2.262	6+
491	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	0	721.5	264.2	3.4454	6.58133	5.57671	1.30409	26.9	1.989	6+
492	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	0	0	593.9	259.3	0.5381	6.38671	5.55799	0.20752	26.7	1.960	6+
493	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	655.3	250.2	0.8139	6.48509	5.52226	0.32530	26.3	1.905	6+
494	09/04/14	LOPEZ*	48.565217	122.892100	42	F	0	4	369.4	142.4	5.1273	5.91188	4.95864	3.60063	20.6	1.218	4
495	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	10	397.2	161.4	0.0671	5.98444	5.08389	0.04157	21.7	1.345	4
496	09/04/14	LOPEZ*	48.565217	122.892100	42	UNK	1	1	819.3	323.7	0.3778	6.70845	5.77982	0.11671	29.4	2.337	6+
497	09/04/14	LOPEZ*	48.565217	122.892100	42	M	2	0	1114.2	418.7	5.4853	7.01589	6.03715	1.31008	32.9	2.867	6+
498	09/04/14	LOPEZ*	48.565217	122.892100	42	M	1	0	380.7	194.5	0.9707	5.94201	5.27043	0.49907	23.6	1.560	5
499	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	3	404.9	178.9	0.0231	6.00364	5.18683	0.01291	22.7	1.460	5
500	09/04/14	LOPEZ*	48.565217	122.892100	42	M	0	0	1093.0	287.3	23.6273	6.99668	5.66053	8.22391	27.9	2.126	6+
501	09/23/14	CONE*	48.592000	122.676317	19	M	0	8	316.6	122.2	0.6747	5.75764	4.80566	0.55213	19.3	1.079	3
502	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	704.8	314.9	5.3190	6.55791	5.75226	1.68911	29.0	2.287	6+
503	09/23/14	CONE*	48.592000	122.676317	19	UNK	1	0	627.1	278.3	0.3402	6.44111	5.62870	0.12224	27.5	2.073	6+
504	09/23/14	CONE*	48.592000	122.676317	19	UNK	0	0	554.6	277.2	0.3237	6.31825	5.62474	0.11677	27.5	2.067	6+
505	09/23/14	CONE*	48.592000	122.676317	19	F	2	0	526.9	196.7	3.3006	6.26701	5.28168	1.67799	23.7	1.574	5
506	09/23/14	CONE*	48.592000	122.676317	19	F	0	19	417.3	196.6	1.2110	6.03381	5.28117	0.61597	23.7	1.574	5
507	09/23/14	CONE*	48.592000	122.676317	19	UNK	1	0	852.5	335.1	0.4454	6.74817	5.81443	0.13292	29.8	2.403	6+
508	09/23/14	CONE*	48.592000	122.676317	19	UNK	1	0	573.9	186.7	1.8203	6.35246	5.22950	0.97499	23.2	1.510	5
509	09/23/14	CONE*	48.592000	122.676317	19	M	1	0	591.6	261.9	0.4445	6.38283	5.56796	0.16972	26.8	1.976	6+
510	09/23/14	CONE*	48.592000	122.676317	19	M	1	2	351.1	155.2	2.3854	5.86107	5.04471	1.53698	21.4	1.304	4
511	09/23/14	CONE*	48.592000	122.676317	19	M	0	0	288.5	114.4	1.4243	5.66470	4.73970	1.24502	18.7	1.024	3
512	09/23/14	CONE*	48.592000	122.676317	19	F	2	0	659.6	315.2	3.9751	6.49163	5.75321	1.26114	29.1	2.289	6+
513	09/23/14	CONE*	48.592000	122.676317	19	UNK	0	0	823.6	290.5	0.4705	6.71368	5.67160	0.16196	28.1	2.145	6+
514	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	573.0	303.4	5.1374	6.35089	5.71505	1.69328	28.6	2.220	6+
515	09/23/14	CONE*	48.592000	122.676317	19	UNK	2	0	539.8	190.0	0.8990	6.29120	5.24702	0.47316	23.3	1.531	5
516	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	841.5	319.8	10.2755	6.73519	5.76770	3.21310	29.2	2.315	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
517	09/23/14	CONE*	48.592000	122.676317	19	M	0	0	654.4	282.4	1.5293	6.48372	5.64332	0.54154	27.7	2.097	6+
518	09/23/14	CONE*	48.592000	122.676317	19	UNK	2	0	554.5	234.2	0.2599	6.31807	5.45618	0.11097	25.6	1.808	6+
519	09/23/14	CONE*	48.592000	122.676317	19	UNK	1	0	414.9	176.4	0.3227	6.02804	5.17275	0.18294	22.6	1.444	4
520	09/23/14	CONE*	48.592000	122.676317	19	M	1	0	932.8	338.2	5.4939	6.83819	5.82364	1.62445	30.0	2.420	6+
521	09/23/14	CONE*	48.592000	122.676317	19	F	3	0	725.0	308.6	2.2310	6.58617	5.73205	0.72294	28.8	2.250	6+
522	09/23/14	CONE*	48.592000	122.676317	19	M	0	1	470.7	196.7	1.3784	6.15422	5.28168	0.70076	23.7	1.574	5
523	09/23/14	CONE*	48.592000	122.676317	19	UNK	0	1	201.6	88.3	0.4138	5.30629	4.48074	0.46863	16.8	0.834	3
524	09/23/14	CONE*	48.592000	122.676317	19	M	0	12	520.5	224.4	0.7618	6.25479	5.41343	0.33948	25.1	1.748	6+
525	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	532.4	231.2	2.3000	6.27740	5.44328	0.99481	25.4	1.790	6+
526	09/23/14	CONE*	48.592000	122.676317	19	F	1	0	795.1	325.4	4.3286	6.67847	5.78506	1.33024	29.5	2.347	6+
527	09/23/14	CONE*	48.592000	122.676317	19	M	2	0	549.5	267.4	0.5109	6.30901	5.58875	0.19106	27.1	2.009	6+
528	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	636.7	299.2	0.2185	6.45630	5.70111	0.07303	28.4	2.196	6+
529	09/23/14	CONE*	48.592000	122.676317	19	M	0	1	584.2	246.0	0.4756	6.37024	5.50533	0.19333	26.1	1.880	6+
530	09/23/14	CONE*	48.592000	122.676317	19	F	3	0	932.5	371.5	3.7454	6.83787	5.91755	1.00818	31.2	2.607	6+
531	09/23/14	CONE*	48.592000	122.676317	19	M	1	0	515.0	244.1	1.5445	6.24417	5.49758	0.63273	26.0	1.868	6+
532	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	498.3	213.4	8.1717	6.21120	5.36317	3.82929	24.5	1.679	5
533	09/23/14	CONE*	48.592000	122.676317	19	M	1	8	556.1	209.2	0.7372	6.32095	5.34329	0.35239	24.3	1.653	5
534	09/23/14	CONE*	48.592000	122.676317	19	M	2	0	397.4	188.9	3.5379	5.98494	5.24122	1.87290	23.3	1.524	5
535	09/23/14	CONE*	48.592000	122.676317	19	F	2	0	580.8	232.2	1.7464	6.36441	5.44760	0.75211	25.5	1.796	6+
536	09/23/14	CONE*	48.592000	122.676317	19	F	0	0	632.9	294.9	2.0270	6.45031	5.68664	0.68735	28.2	2.171	6+
537	09/23/14	CONE*	48.592000	122.676317	19	UNK	0	0	201.3	96.1	0.0118	5.30480	4.56539	0.01228	17.4	0.892	3
538	09/23/14	CONE*	48.592000	122.676317	19	F	0	1	569.6	263.7	10.9547	6.34493	5.57481	4.15423	26.9	1.986	6+
539	09/23/14	CONE*	48.592000	122.676317	19	M	0	0	650.7	332.2	1.7157	6.47805	5.80574	0.51647	29.7	2.386	6+
540	09/23/14	CONE*	48.592000	122.676317	19	UNK	2	0	816.4	364.8	0.4618	6.70490	5.89935	0.12659	31.0	2.570	6+
541	09/23/14	CONE*	48.592000	122.676317	19	M	2	0	552.4	229.5	1.4008	6.31427	5.43590	0.61037	25.3	1.779	6+
542	09/23/14	CONE*	48.592000	122.676317	19	M	3	0	722.7	276.8	3.9137	6.58299	5.62330	1.41391	27.5	2.064	6+
543	09/23/14	CONE*	48.592000	122.676317	19	UNK	2	0	380.4	137.2	0.1391	5.94122	4.92144	0.10138	20.3	1.183	4
544	09/23/14	CONE*	48.592000	122.676317	19	M	2	0	740.6	245.7	2.5845	6.60746	5.50411	1.05189	26.1	1.878	6+
545	09/23/14	CONE*	48.592000	122.676317	19	M	0	2	485.8	235.6	1.7374	6.18580	5.46214	0.73744	25.6	1.817	6+
546	09/23/14	CONE*	48.592000	122.676317	19	UNK	2	0	569.5	257.2	0.3251	6.34476	5.54985	0.12640	26.6	1.948	6+
547	09/23/14	CONE*	48.592000	122.676317	19	UNK	2	4	574.4	212.3	0.1838	6.35333	5.35800	0.08658	24.5	1.672	5
548	09/23/14	CONE*	48.592000	122.676317	19	UNK	3	0	760.7	313.0	0.8628	6.63424	5.74620	0.27565	29.0	2.276	6+
549	09/23/14	CONE*	48.592000	122.676317	19	M	0	0	640.8	259.7	1.9546	6.46272	5.55953	0.75264	26.7	1.963	6+
550	09/23/14	CONE*	48.592000	122.676317	19	M	1	0	676.6	263.6	1.8656	6.51708	5.57443	0.70774	26.9	1.986	6+
551	10/15/14	CANOE*	48.561255	122.923875	23	F	2	0	741.7	345.9	6.5485	6.60894	5.84615	1.89318	30.3	2.464	6+
552	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	837.7	331.2	5.5016	6.73066	5.80272	1.66111	29.7	2.380	6+
553	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	0	786.6	297.8	1.2998	6.66772	5.69642	0.43647	28.4	2.188	6+

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554	10/15/14	CANOE*	48.561255	122.923875	23	M	2	0	943.6	432.2	34.0095	6.84970	6.06889	7.86893	33.3	2.940	6+
555	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	0	420.1	183.9	0.2596	6.04049	5.21439	0.14116	23.0	1.492	5
556	10/15/14	CANOE*	48.561255	122.923875	23	F	0	0	535.1	237.9	3.6601	6.28245	5.47185	1.53850	25.7	1.831	6+
557	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	566.6	283.3	2.2929	6.33965	5.64651	0.80935	27.7	2.103	6+
558	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	0	616.4	269.7	0.4114	6.42390	5.59731	0.15254	27.2	2.022	6+
559	10/15/14	CANOE*	48.561255	122.923875	23	F	0	0	528.4	227.1	6.8454	6.26985	5.42539	3.01427	25.2	1.764	6+
560	10/15/14	CANOE*	48.561255	122.923875	23	F	1	0	436.1	191.1	1.4976	6.07787	5.25280	0.78367	23.4	1.538	5
561	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	457.4	152.1	2.4763	6.12556	5.02454	1.62807	21.2	1.284	4
562	10/15/14	CANOE*	48.561255	122.923875	23	M	2	0	453.4	204.1	0.4677	6.11677	5.31861	0.22915	24.1	1.621	5
563	10/15/14	CANOE*	48.561255	122.923875	23	M	1	0	458.5	208.9	1.4217	6.12796	5.34186	0.68056	24.3	1.651	5
564	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	496.8	257.4	3.4853	6.20819	5.55063	1.35404	26.6	1.949	6+
565	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	0	399.5	180.2	0.5682	5.99021	5.19407	0.31532	22.8	1.468	5
566	10/15/14	CANOE*	48.561255	122.923875	23	M	2	0	487.1	260.3	2.3540	6.18847	5.56183	0.90434	26.7	1.966	6+
567	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	1	383.3	213.0	0.2209	5.94882	5.36129	0.10371	24.5	1.677	5
568	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	415.1	234.4	0.3397	6.02852	5.45703	0.14492	25.6	1.809	6+
569	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	20	465.4	158.7	0.1796	6.14290	5.06702	0.11317	21.6	1.328	4
570	10/15/14	CANOE*	48.561255	122.923875	23	UNK	2	0	467.6	206.7	0.5539	6.14761	5.33127	0.26797	24.2	1.637	5
571	10/15/14	CANOE*	48.561255	122.923875	23	M	1	0	412.4	166.9	1.1445	6.02199	5.11739	0.68574	22.1	1.382	4
572	10/15/14	CANOE*	48.561255	122.923875	23	M	2	0	774.8	353.2	1.0418	6.65260	5.86703	0.29496	30.5	2.505	6+
573	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	514.8	276.4	1.9498	6.24378	5.62185	0.70543	27.5	2.062	6+
574	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	663.5	374.5	0.8340	6.49753	5.92559	0.22270	31.3	2.624	6+
575	10/15/14	CANOE*	48.561255	122.923875	23	F	1	0	656.0	276.8	4.5815	6.48616	5.62330	1.65517	27.5	2.064	6+
576	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	0	150.3	78.2	0.1286	5.01263	4.35927	0.16445	15.9	0.757	3
577	10/15/14	CANOE*	48.561255	122.923875	23	M	1	0	718.8	281.1	0.8707	6.57758	5.63871	0.30975	27.7	2.090	6+
578	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	0	506.5	206.5	0.3431	6.22752	5.33030	0.16615	24.2	1.636	5
579	10/15/14	CANOE*	48.561255	122.923875	23	M	2	1	635.1	259.2	0.3541	6.45378	5.55760	0.13661	26.7	1.960	6+
580	10/15/14	CANOE*	48.561255	122.923875	23	M	1	0	641.9	311.2	1.4297	6.46443	5.74044	0.45942	28.9	2.266	6+
581	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	0	407.1	171.9	0.1726	6.00906	5.14691	0.10041	22.4	1.414	4
582	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	603.7	253.4	2.9301	6.40308	5.53497	1.15631	26.4	1.925	6+
583	10/15/14	CANOE*	48.561255	122.923875	23	UNK	2	0	741.0	327.5	1.0067	6.60800	5.79149	0.30739	29.5	2.359	6+
584	10/15/14	CANOE*	48.561255	122.923875	23	F	2	0	682.8	300.7	4.6947	6.52620	5.70611	1.56126	28.5	2.205	6+
585	10/15/14	CANOE*	48.561255	122.923875	23	F	1	0	402.9	249.5	4.8006	5.99869	5.51946	1.92409	26.3	1.901	6+
586	10/15/14	CANOE*	48.561255	122.923875	23	M	2	1	465.9	168.6	1.2320	6.14397	5.12753	0.73072	22.2	1.393	4
587	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	891.9	349.3	3.2861	6.79335	5.85593	0.94077	30.4	2.483	6+
588	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	0	489.8	205.2	0.1236	6.19400	5.32399	0.06023	24.1	1.628	5
589	10/15/14	CANOE*	48.561255	122.923875	23	M	1	0	546.9	238.4	1.7129	6.30427	5.47395	0.71850	25.8	1.834	6+
590	10/15/14	CANOE*	48.561255	122.923875	23	F	0	0	749.2	361.0	8.2027	6.61901	5.88888	2.27222	30.8	2.549	6+

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
591	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	660.5	252.3	11.3252	6.49300	5.53062	4.48878	26.4	1.918	6+
592	10/15/14	CANOE*	48.561255	122.923875	23	UNK	1	0	339.4	195.0	0.0619	5.82718	5.27300	0.03174	23.6	1.563	5
593	10/15/14	CANOE*	48.561255	122.923875	23	M	1	0	391.2	185.7	0.1034	5.96922	5.22413	0.05568	23.1	1.504	5
594	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	0	293.9	178.6	0.5651	5.68324	5.18515	0.31641	22.7	1.458	5
595	10/15/14	CANOE*	48.561255	122.923875	23	F	1	1	600.6	284.1	3.1289	6.39793	5.64933	1.10134	27.8	2.107	6+
596	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	432.5	195.1	0.3808	6.06958	5.27351	0.19518	23.6	1.564	5
597	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	9	620.9	223.4	0.4186	6.43117	5.40896	0.18738	25.0	1.741	6+
598	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	637.8	319.3	0.7571	6.45802	5.76613	0.23711	29.2	2.312	6+
599	10/15/14	CANOE*	48.561255	122.923875	23	UNK	0	0	507.3	290.7	0.4728	6.22910	5.67229	0.16264	28.1	2.146	6+
600	10/15/14	CANOE*	48.561255	122.923875	23	M	0	0	549.6	252.6	0.5894	6.30919	5.53181	0.23333	26.4	1.920	6+
601	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	749.1	336.0	12.5180	6.61887	5.81711	3.72560	29.9	2.408	6+
602	03/17/15	VENDOVI*	48.613683	122.614767	20	M	1	0	834.4	343.7	54.3652	6.72671	5.83977	15.81763	30.2	2.451	6+
603	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	456.0	231.3	0.3857	6.12249	5.44372	0.16675	25.4	1.790	6+
604	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	532.8	211.8	23.9019	6.27815	5.35564	11.28513	24.5	1.669	5
605	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	1071.8	605.8	54.9798	6.97709	6.40655	9.07557	38.6	3.844	6+
606	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	482.2	204.0	12.9392	6.17836	5.31812	6.34275	24.1	1.620	5
607	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	886.1	375.2	63.6942	6.78683	5.92746	16.97607	31.3	2.628	6+
608	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	882.3	274.0	48.5030	6.78253	5.61313	17.70182	27.3	2.048	6+
609	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	797.2	305.5	43.6224	6.68111	5.72195	14.27902	28.7	2.233	6+
610	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	749.3	282.1	74.3457	6.61914	5.64226	26.35438	27.7	2.096	6+
611	03/17/15	VENDOVI*	48.613683	122.614767	20	M	1	0	495.6	174.3	21.6124	6.20577	5.16078	12.39954	22.5	1.430	4
612	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	6	403.1	154.6	22.0030	5.99918	5.04084	14.23221	21.3	1.300	4
613	03/17/15	VENDOVI*	48.613683	122.614767	20	M	2	0	676.0	312.9	54.1725	6.51619	5.74588	17.31304	29.0	2.275	6+
614	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	765.5	365.2	39.5178	6.64053	5.90045	10.82087	31.0	2.572	6+
615	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	712.8	294.3	6.4379	6.56920	5.68460	2.18753	28.2	2.167	6+
616	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	793.5	333.9	46.8464	6.67645	5.81084	14.03007	29.8	2.396	6+
617	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	571.5	233.7	39.6963	6.34826	5.45404	16.98601	25.5	1.805	6+
618	03/17/15	VENDOVI*	48.613683	122.614767	20	M	1	0	758.3	319.4	3.7909	6.63108	5.76644	1.18688	29.2	2.313	6+
619	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	838.1	300.8	35.1557	6.73114	5.70645	11.68740	28.5	2.205	6+
620	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	834.7	329.8	63.5768	6.72707	5.79849	19.27738	29.6	2.372	6+
621	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	288.8	103.5	1.9628	5.66573	4.63957	1.89643	17.9	0.946	3
622	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	710.2	327.5	28.7754	6.56555	5.79149	8.78638	29.5	2.359	6+
623	03/17/15	VENDOVI*	48.613683	122.614767	20	F	2	0	664.8	288.2	71.5623	6.49949	5.66365	24.83078	28.0	2.132	6+
624	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	362.6	171.6	34.8843	5.89330	5.14517	20.32885	22.3	1.413	4
625	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	579.8	272.0	64.9869	6.36268	5.60580	23.89224	27.3	2.036	6+
626	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	717.6	333.1	48.8064	6.57591	5.80844	14.65218	29.8	2.391	6+
627	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	855.2	335.6	53.4368	6.75134	5.81592	15.92277	29.9	2.405	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
628	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	679.2	256.6	9.7816	6.52092	5.54752	3.81200	26.6	1.944	6+
629	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	680.5	335.8	14.3211	6.52283	5.81652	4.26477	29.9	2.407	6+
630	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	969.1	425.0	62.9840	6.87637	6.05209	14.81976	33.1	2.901	6+
631	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	848.3	313.1	60.2883	6.74323	5.74652	19.25529	29.0	2.276	6+
632	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	736.4	328.5	45.2689	6.60177	5.79454	13.78049	29.6	2.365	6+
633	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	711.2	357.2	31.8043	6.56695	5.87830	8.90378	30.7	2.527	6+
634	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	632.2	325.8	18.0374	6.44921	5.78628	5.53634	29.5	2.349	6+
635	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	550.0	247.2	53.6283	6.30992	5.51020	21.69430	26.2	1.887	6+
636	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	8	718.9	284.3	44.0256	6.57772	5.65003	15.48561	27.8	2.109	6+
637	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	258.7	119.2	7.1929	5.55567	4.78080	6.03431	19.1	1.058	3
638	03/17/15	VENDOVI*	48.613683	122.614767	20	M	1	0	603.5	348.4	43.0709	6.40275	5.85335	12.36249	30.3	2.478	6+
639	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	335.8	163.7	21.9057	5.81652	5.09804	13.38161	21.9	1.361	4
640	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	327.8	160.4	10.8880	5.79240	5.07767	6.78803	21.7	1.339	4
641	03/17/15	VENDOVI*	48.613683	122.614767	20	F	0	0	975.0	309.5	99.0393	6.88244	5.73496	31.99977	28.8	2.256	6+
642	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	650.9	192.1	10.0861	6.47836	5.25802	5.25044	23.5	1.545	5
643	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	38	399.5	166.2	17.8744	5.99021	5.11319	10.75475	22.0	1.377	4
644	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	282.3	156.0	12.7934	5.64297	5.04986	8.20090	21.4	1.310	4
645	03/17/15	VENDOVI*	48.613683	122.614767	20	M	1	0	818.2	342.8	29.4848	6.70711	5.83715	8.60117	30.1	2.446	6+
646	03/17/15	VENDOVI*	48.613683	122.614767	20	M	0	0	871.4	371.6	73.3171	6.77010	5.91782	19.73011	31.2	2.608	6+
647	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	453.1	200.1	16.7071	6.11611	5.29882	8.34938	23.9	1.596	5
648	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	435.7	253.3	30.8814	6.07695	5.53457	12.19163	26.4	1.924	6+
649	03/17/15	VENDOVI*	48.613683	122.614767	20	M	1	0	710.1	374.8	36.1800	6.56541	5.92639	9.65315	31.3	2.626	6+
650	03/17/15	VENDOVI*	48.613683	122.614767	20	F	1	0	613.9	237.6	45.9857	6.41983	5.47059	19.35425	25.7	1.829	6+
651	03/26/15	CONE	48.592732	122.683675	22	M	0	0	337.3	130.1	23.3494	5.82097	4.86830	17.94727	19.8	1.134	3
652	03/26/15	CONE	48.592732	122.683675	22	F	1	0	264.5	165.7	22.6875	5.57784	5.11018	13.69191	22.0	1.374	4
653	03/26/15	CONE	48.592732	122.683675	22	F	0	0	333.6	140.5	22.2761	5.80994	4.94521	15.85488	20.5	1.205	4
654	03/26/15	CONE	48.592732	122.683675	22	F	0	0	240.1	108.5	9.1281	5.48106	4.68675	8.41300	18.3	0.982	3
655	03/26/15	CONE	48.592732	122.683675	22	M	0	0	397.9	184.1	11.1697	5.98620	5.21548	6.06719	23.0	1.494	5
656	03/26/15	CONE	48.592732	122.683675	22	M	0	0	450.7	195.4	30.6560	6.11080	5.27505	15.68884	23.6	1.566	5
657	03/26/15	CONE	48.592732	122.683675	22	F	0	0	387.5	162.8	25.2755	5.95972	5.09252	15.52549	21.8	1.355	4
658	03/26/15	CONE	48.592732	122.683675	22	F	1	0	251.5	143.1	30.6902	5.52744	4.96354	21.44668	20.6	1.223	4
659	03/26/15	CONE	48.592732	122.683675	22	F	0	0	463.8	187.2	43.7204	6.13945	5.23218	23.35491	23.2	1.514	5
660	03/26/15	CONE	48.592732	122.683675	22	M	0	0	173.0	77.1	8.7961	5.15329	4.34510	11.40869	15.8	0.749	2
661	03/26/15	CONE	48.592732	122.683675	22	F	2	6	347.3	162.9	27.4842	5.85019	5.09314	16.87182	21.8	1.355	4
662	03/26/15	CONE	48.592732	122.683675	22	F	1	0	355.8	153.4	29.2640	5.87437	5.03305	19.07692	21.3	1.292	4
663	03/26/15	CONE	48.592732	122.683675	22	F	1	20	343.7	152.2	1.1300	5.83977	5.02520	0.74244	21.2	1.284	4
664	03/26/15	CONE	48.592732	122.683675	22	F	0	0	445.8	209.9	55.5812	6.09987	5.34663	26.47985	24.4	1.657	5

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
665	03/26/15	CONE	48.592732	122.683675	22	F	0	0	384.9	154.5	31.3533	5.95298	5.04019	20.29340	21.3	1.300	4
666	03/26/15	CONE	48.592732	122.683675	22	M	0	0	499.0	171.4	28.9609	6.21261	5.14400	16.89667	22.3	1.411	4
667	03/26/15	CONE	48.592732	122.683675	22	F	1	0	552.1	189.6	43.4282	6.31373	5.24492	22.90517	23.3	1.529	5
668	03/26/15	CONE	48.592732	122.683675	22	M	0	0	428.4	182.3	16.2528	6.06006	5.20565	8.91541	22.9	1.482	5
669	03/26/15	CONE	48.592732	122.683675	22	M	0	4	265.7	139.1	20.2968	5.58237	4.93519	14.59152	20.4	1.196	4
670	03/26/15	CONE	48.592732	122.683675	22	F	0	0	369.7	179.4	11.9538	5.91269	5.18962	6.66321	22.8	1.463	5
671	03/26/15	CONE	48.592732	122.683675	22	F	0	0	224.6	105.8	6.6963	5.41432	4.66155	6.32921	18.1	0.962	3
672	03/26/15	CONE	48.592732	122.683675	22	M	0	0	389.7	171.7	11.9389	5.96538	5.14575	6.95335	22.3	1.413	4
673	03/26/15	CONE	48.592732	122.683675	22	F	0	0	427.3	173.8	25.7031	6.05749	5.15791	14.78890	22.5	1.427	4
674	03/26/15	CONE	48.592732	122.683675	22	F	0	0	315.1	152.6	21.8077	5.75289	5.02782	14.29076	21.2	1.287	4
675	03/26/15	CONE	48.592732	122.683675	22	F	1	0	363.9	152.4	25.0391	5.89688	5.02651	16.42986	21.2	1.286	4
676	03/26/15	CONE	48.592732	122.683675	22	M	1	0	683.3	225.3	29.2963	6.52693	5.41743	13.00324	25.1	1.753	6+
677	03/26/15	CONE	48.592732	122.683675	22	F	1	0	572.7	256.5	14.0145	6.35036	5.54713	5.46374	26.6	1.943	6+
678	03/26/15	CONE	48.592732	122.683675	22	F	1	0	350.6	150.6	25.9133	5.85965	5.01463	17.20671	21.1	1.273	4
679	03/26/15	CONE	48.592732	122.683675	22	F	0	0	253.8	104.8	16.6742	5.53655	4.65205	15.91050	18.0	0.955	3
680	03/26/15	CONE	48.592732	122.683675	22	F	0	0	376.1	190.8	29.8939	5.92986	5.25123	15.66766	23.4	1.537	5
681	03/26/15	CONE	48.592732	122.683675	22	M	0	0	305.7	120.4	9.6645	5.72260	4.79082	8.02699	19.2	1.066	3
682	03/26/15	CONE	48.592732	122.683675	22	F	1	0	313.6	152.6	19.4290	5.74812	5.02782	12.73198	21.2	1.287	4
683	03/26/15	CONE	48.592732	122.683675	22	F	2	0	502.1	207.7	42.4944	6.21880	5.33609	20.45951	24.3	1.644	5
684	03/26/15	CONE	48.592732	122.683675	22	M	1	2	412.6	166.9	34.8498	6.02248	5.11739	20.88065	22.1	1.382	4
685	03/26/15	CONE	48.592732	122.683675	22	UNK	1	0	306.8	131.0	0.1421	5.72620	4.87520	0.10847	19.9	1.140	3
686	03/26/15	CONE	48.592732	122.683675	22	M	0	0	547.8	174.2	23.5616	6.30591	5.16020	13.52560	22.5	1.429	4
687	03/26/15	CONE	48.592732	122.683675	22	M	1	0	392.2	135.7	8.9955	5.97177	4.91045	6.62896	20.2	1.172	4
688	03/26/15	CONE	48.592732	122.683675	22	F	0	0	307.2	173.5	7.8635	5.72750	5.15618	4.53228	22.4	1.425	4
689	03/26/15	CONE	48.592732	122.683675	22	M	0	0	508.1	162.9	31.5756	6.23068	5.09314	19.38343	21.8	1.355	4
690	03/26/15	CONE	48.592732	122.683675	22	F	0	0	235.9	94.9	13.4674	5.46341	4.55282	14.19115	17.3	0.883	3
691	03/26/15	CONE	48.592732	122.683675	22	F	0	0	336.2	128.1	35.7652	5.81771	4.85281	27.91975	19.7	1.120	3
692	03/26/15	CONE	48.592732	122.683675	22	F	0	2	297.7	166.1	23.6941	5.69609	5.11259	14.26496	22.0	1.376	4
693	03/26/15	CONE	48.592732	122.683675	22	F	1	0	225.8	111.0	19.5775	5.41965	4.70953	17.63739	18.5	1.000	3
694	03/26/15	CONE	48.592732	122.683675	22	M	1	0	169.4	83.1	2.0490	5.13226	4.42004	2.46570	16.3	0.794	3
695	03/26/15	CONE	48.592732	122.683675	22	F	1	0	382.9	175.9	34.7916	5.94777	5.16992	19.77919	22.6	1.441	4
696	03/26/15	CONE	48.592732	122.683675	22	M	1	0	431.4	232.7	15.1409	6.06704	5.44975	6.50662	25.5	1.799	6+
697	03/26/15	CONE	48.592732	122.683675	22	M	0	0	332.4	169.7	2.6593	5.80634	5.13403	1.56706	22.2	1.400	4
698	03/26/15	CONE	48.592732	122.683675	22	F	0	0	292.6	121.6	9.9309	5.67881	4.80074	8.16686	19.2	1.075	3
699	03/26/15	CONE	48.592732	122.683675	22	F	0	0	306.5	88.1	5.0475	5.72522	4.47847	5.72928	16.7	0.832	3
700	03/26/15	CONE	48.592732	122.683675	22	M	0	0	288.6	120.9	9.1058	5.66504	4.79496	7.53168	19.2	1.070	3
701	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	872.5	327.7	37.9441	6.77136	5.79210	11.57891	29.6	2.360	6+

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
702	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	627.4	246.3	4.9784	6.44158	5.50655	2.02127	26.1	1.882	6+
703	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	520.9	178.4	3.4563	6.25556	5.18403	1.93739	22.7	1.457	5
704	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	1308.9	462.9	82.9040	7.17694	6.13751	17.90970	34.3	3.105	6+
705	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	475.8	174.9	26.7731	6.16500	5.16421	15.30766	22.5	1.434	4
706	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	318.3	124.4	8.2974	5.76299	4.82350	6.66994	19.4	1.094	3
707	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	595.2	204.7	14.5611	6.38890	5.32155	7.11339	24.1	1.625	5
708	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	972.0	307.6	57.6045	6.87936	5.72880	18.72708	28.8	2.245	6+
709	04/15/15	ORCAS	48.601448	122.800528	31	F	0	1	786.2	270.6	78.6605	6.66721	5.60064	29.06892	27.2	2.028	6+
710	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	360.4	168.8	11.1016	5.88721	5.12871	6.57678	22.2	1.394	4
711	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	426.0	172.7	18.4220	6.05444	5.15156	10.66705	22.4	1.420	4
712	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	734.5	302.4	67.6200	6.59919	5.71175	22.36111	28.5	2.215	6+
713	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	379.7	160.5	6.4608	5.93938	5.07829	4.02542	21.7	1.340	4
714	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	811.5	237.6	90.2596	6.69888	5.47059	37.98805	25.7	1.829	6+
715	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	746.3	339.3	35.9055	6.61513	5.82688	10.58223	30.0	2.426	6+
716	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	468.2	181.1	19.1462	6.14890	5.19905	10.57217	22.9	1.474	5
717	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	326.1	167.7	2.7628	5.78720	5.12218	1.64747	22.1	1.387	4
718	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	983.7	414.2	18.9421	6.89132	6.02635	4.57318	32.7	2.843	6+
719	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	430.4	152.7	6.4206	6.06472	5.02848	4.20472	21.2	1.288	4
720	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	458.5	180.9	32.0385	6.12796	5.19794	17.71061	22.9	1.473	5
721	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	763.4	278.5	50.1218	6.63778	5.62942	17.99706	27.5	2.074	6+
722	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	739.8	229.5	20.1121	6.60638	5.43590	8.76344	25.3	1.779	6+
723	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	473.4	163.9	5.7474	6.15994	5.09926	3.50665	21.9	1.362	4
724	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	671.2	273.7	15.8345	6.50907	5.61203	5.78535	27.3	2.046	6+
725	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	565.7	245.0	12.1357	6.33806	5.50126	4.95335	26.1	1.874	6+
726	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	460.7	130.9	3.0655	6.13275	4.87443	2.34186	19.9	1.139	3
727	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	1288.4	361.5	111.9920	7.16116	5.89026	30.97981	30.8	2.552	6+
728	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	326.2	130.7	5.5077	5.78751	4.87290	4.21400	19.9	1.138	3
729	04/15/15	ORCAS	48.601448	122.800528	31	F	0	6	459.7	111.6	0.6907	6.13057	4.71492	0.61891	18.5	1.004	3
730	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	754.7	239.2	15.2508	6.62632	5.47730	6.37575	25.8	1.839	6+
731	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	652.1	254.8	19.9397	6.48020	5.54048	7.82563	26.5	1.933	6+
732	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	1164.4	367.1	38.8084	7.05996	5.90563	10.57162	31.0	2.583	6+
733	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	335.8	98.3	5.2405	5.81652	4.58802	5.33113	17.5	0.908	3
734	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	748.3	267.0	31.3224	6.61780	5.58725	11.73124	27.0	2.006	6+
735	04/15/15	ORCAS	48.601448	122.800528	31	M	0	0	523.8	182.9	24.5876	6.26111	5.20894	13.44319	23.0	1.486	5
736	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	612.8	230.1	1.9349	6.41804	5.43851	0.84090	25.4	1.783	6+
737	04/15/15	ORCAS	48.601448	122.800528	31	M	0	1	302.5	136.1	2.0595	5.71208	4.91339	1.51323	20.2	1.175	4
738	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	324.1	185.2	14.9348	5.78105	5.22144	8.06415	23.1	1.501	5

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
739	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	228.4	157.9	11.3792	5.43110	5.06196	7.20659	21.5	1.322	4
740	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	550.4	214.7	7.9839	6.31065	5.36924	3.71863	24.6	1.687	5
741	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	603.6	199.2	5.0364	6.40291	5.29431	2.52831	23.8	1.590	5
742	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	377.2	158.2	2.1674	5.93278	5.06386	1.37004	21.6	1.324	4
743	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	1052.0	415.5	92.0987	6.95845	6.02948	22.16575	32.8	2.850	6+
744	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	291.2	109.6	1.3440	5.67401	4.69684	1.22628	18.4	0.990	3
745	04/15/15	ORCAS	48.601448	122.800528	31	M	1	0	631.1	256.8	11.5406	6.44746	5.54830	4.49400	26.6	1.945	6+
746	04/15/15	ORCAS	48.601448	122.800528	31	F	1	5	816.8	290.2	56.9761	6.70539	5.67057	19.63339	28.0	2.143	6+
747	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	448.1	201.2	6.8842	6.10502	5.30430	3.42157	23.9	1.603	5
748	04/15/15	ORCAS	48.601448	122.800528	31	F	0	0	362.1	122.7	2.7113	5.89192	4.80974	2.20970	19.3	1.082	3
749	04/15/15	ORCAS	48.601448	122.800528	31	F	1	0	389.9	163.2	2.3900	5.96589	5.09498	1.46446	21.9	1.357	4
750	04/15/15	ORCAS	48.601448	122.800528	31	M	2	0	749.6	290.3	35.3260	6.61954	5.67091	12.16879	28.0	2.144	6+
751	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	476.6	150.5	3.6633	6.16668	5.01396	2.43409	21.1	1.273	4
752	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	344.7	128.9	1.3336	5.84267	4.85904	1.03460	19.7	1.126	3
753	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	5	517.5	161.4	4.4311	6.24901	5.08389	2.74542	21.7	1.345	4
754	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	287.8	128.4	4.7858	5.66227	4.85515	3.72726	19.7	1.122	3
755	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	288.5	123.3	4.4066	5.66470	4.81462	3.57388	19.4	1.087	3
756	04/30/15	LOPEZ	48.564997	122.892145	37	F	2	1	439.8	172.5	6.1112	6.08632	5.15040	3.54272	22.4	1.418	4
757	04/30/15	LOPEZ	48.564997	122.892145	37	F	1	0	899.7	272.6	6.3805	6.80206	5.60801	2.34061	27.3	2.039	6+
758	04/30/15	LOPEZ	48.564997	122.892145	37	F	1	0	563.6	220.8	8.9227	6.33434	5.39726	4.04108	24.9	1.725	6+
759	04/30/15	LOPEZ	48.564997	122.892145	37	M	1	0	525.2	226.7	4.0062	6.26378	5.42363	1.76718	25.2	1.762	6+
760	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	379.4	152.4	0.6978	5.93859	5.02651	0.45787	21.2	1.286	4
761	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	697.4	220.2	3.2845	6.54736	5.39454	1.49160	24.9	1.722	6+
762	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	742.4	175.5	47.8023	6.60989	5.16764	27.23778	22.6	1.438	4
763	04/30/15	LOPEZ	48.564997	122.892145	37	F	1	0	234.4	82.8	0.1531	5.45703	4.41643	0.18490	16.3	0.792	3
764	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	709.5	214.5	31.6589	6.56456	5.36831	14.75939	24.6	1.686	5
765	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	357.3	132.2	2.6466	5.87858	4.88432	2.00197	19.9	1.148	3
766	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	547.9	162.1	2.5122	6.30609	5.08821	1.54978	21.8	1.350	4
767	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	622.4	252.4	21.3593	6.43358	5.53102	8.46248	26.4	1.919	6+
768	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	1040.7	185.8	44.5106	6.94765	5.22467	23.95619	23.1	1.505	5
769	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	483.8	184.5	19.9611	6.18167	5.21765	10.81902	23.0	1.496	5
770	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	773.6	314.5	27.7872	6.65105	5.75098	8.83536	29.0	2.285	6+
771	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	4	219.0	83.9	0.1534	5.38907	4.42963	0.18284	16.4	0.800	3
772	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	885.2	339.7	37.7060	6.78581	5.82806	11.09979	30.0	2.429	6+
773	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	631.5	261.8	5.7444	6.44810	5.56758	2.19419	26.8	1.975	6+
774	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	771.3	228.2	18.2022	6.64808	5.43022	7.97642	25.3	1.771	6+
775	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	766.3	230.5	20.7740	6.64157	5.44025	9.01258	25.4	1.785	6+

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
776	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	1	778.2	260.7	46.5201	6.65698	5.56337	17.84430	26.8	1.969	6+
777	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	839.0	314.9	60.2571	6.73221	5.75226	19.13531	29.0	2.287	6+
778	04/30/15	LOPEZ	48.564997	122.892145	37	M	2	0	706.8	215.6	5.8800	6.56075	5.37342	2.72727	24.7	1.693	5
779	04/30/15	LOPEZ	48.564997	122.892145	37	M	1	0	455.3	155.0	3.0547	6.12096	5.04343	1.97077	21.4	1.303	4
780	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	9	425.0	168.0	0.6721	6.05209	5.12396	0.40006	22.1	1.389	4
781	04/30/15	LOPEZ	48.564997	122.892145	37	M	1	0	869.6	348.0	8.1031	6.76803	5.85220	2.32848	30.3	2.476	6+
782	04/30/15	LOPEZ	48.564997	122.892145	37	F	1	0	712.7	153.9	13.6423	6.56906	5.03630	8.86439	21.3	1.296	4
783	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	894.6	192.6	9.3452	6.79638	5.26062	4.85213	23.5	1.548	5
784	04/30/15	LOPEZ	48.564997	122.892145	37	M	1	0	552.4	139.6	2.7810	6.31427	4.93878	1.99212	20.4	1.199	4
785	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	558.3	196.5	14.2692	6.32490	5.28066	7.26168	23.7	1.573	5
786	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	28	945.2	290.9	32.1636	6.85140	5.67298	11.05658	28.1	2.147	6+
787	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	509.8	205.2	13.8147	6.23402	5.32399	6.73231	24.1	1.628	5
788	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	13	551.6	109.1	9.4271	6.31282	4.69226	8.64079	18.4	0.986	3
789	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	7	627.4	239.9	44.2750	6.44158	5.48022	18.45561	25.8	1.843	6+
790	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	501.4	172.5	3.8968	6.21740	5.15040	2.25901	22.4	1.418	4
791	04/30/15	LOPEZ	48.564997	122.892145	37	F	1	3	600.2	214.6	13.2224	6.39726	5.36878	6.16142	24.6	1.687	5
792	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	3	690.4	146.0	12.0063	6.53727	4.98361	8.22349	20.8	1.243	4
793	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	874.6	303.0	20.2180	6.77377	5.71373	6.67261	28.6	2.218	6+
794	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	826.4	344.0	4.1309	6.71708	5.84064	1.20084	30.2	2.453	6+
795	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	13	410.8	136.5	0.4008	6.01811	4.91632	0.29363	20.2	1.178	4
796	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	781.8	170.2	30.1188	6.66160	5.13697	17.69612	22.3	1.403	4
797	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	709.3	280.3	19.5767	6.56428	5.63586	6.98420	27.6	2.085	6+
798	04/30/15	LOPEZ	48.564997	122.892145	37	F	0	0	504.1	185.8	5.4881	6.22277	5.22467	2.95377	23.1	1.505	5
799	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	0	1343.5	504.1	41.1693	7.20303	6.22277	8.16689	35.6	3.322	6+
800	04/30/15	LOPEZ	48.564997	122.892145	37	M	0	16	553.5	146.9	13.0865	6.31626	4.98975	8.90844	20.9	1.249	4
801	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	485.6	189.6	0.7473	6.18539	5.24492	0.39415	23.3	1.529	5
802	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	534.2	183.3	8.6448	6.28077	5.21112	4.71620	23.0	1.488	5
803	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	309.1	155.1	3.5123	5.73366	5.04407	2.26454	21.4	1.304	4
804	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	3	553.5	223.4	11.8834	6.31626	5.40896	5.31934	25.0	1.741	6+
805	05/14/15	BLAKELY	48.583806	122.798836	46	F	2	0	522.8	215.6	2.1545	6.25920	5.37342	0.99930	24.7	1.693	5
806	05/14/15	BLAKELY	48.583806	122.798836	46	M	1	0	501.6	258.6	24.7287	6.21780	5.55528	9.56253	26.7	1.956	6+
807	05/14/15	BLAKELY	48.583806	122.798836	46	UNK	0	0	455.5	218.8	0.3374	6.12140	5.38816	0.15420	24.8	1.713	5
808	05/14/15	BLAKELY	48.583806	122.798836	46	F	2	1	883.6	291.2	22.2139	6.78400	5.67401	7.62840	28.1	2.149	6+
809	05/14/15	BLAKELY	48.583806	122.798836	46	F	2	0	529.8	235.3	3.1838	6.27250	5.46086	1.35308	25.6	1.815	6+
810	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	599.3	241.2	13.8431	6.39576	5.48563	5.73926	25.9	1.851	6+
811	05/14/15	BLAKELY	48.583806	122.798836	46	M	1	0	972.8	275.1	1.2867	6.88018	5.61713	0.46772	27.4	2.054	6+
812	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	508.1	203.3	34.3387	6.23068	5.31468	16.89065	24.0	1.616	5

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
813	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	714.7	237.2	2.6285	6.57186	5.46890	1.10814	25.7	1.826	6+
814	05/14/15	BLAKELY	48.583806	122.798836	46	UNK	0	0	323.6	165.6	0.0152	5.77951	5.10958	0.00918	22.0	1.373	4
815	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	630.2	234.9	1.0545	6.44604	5.45916	0.44891	25.6	1.812	6+
816	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	1108.3	262.1	13.6866	7.01058	5.56873	5.22190	26.8	1.977	6+
817	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	590.9	289.8	33.2190	6.38165	5.66919	11.46273	28.0	2.141	6+
818	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	558.8	181.9	28.4909	6.32579	5.20346	15.66295	22.9	1.479	5
819	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	1	475.1	192.0	1.1314	6.16353	5.25750	0.58927	23.4	1.544	5
820	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	516.1	225.2	6.6376	6.24630	5.41699	2.94742	25.1	1.753	6+
821	05/14/15	BLAKELY	48.583806	122.798836	46	M	1	0	439.3	184.9	2.6868	6.08518	5.21982	1.45311	23.1	1.499	5
822	05/14/15	BLAKELY	48.583806	122.798836	46	UNK	0	0	255.9	108.4	0.2486	5.54479	4.68583	0.22934	18.3	0.981	3
823	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	608.5	213.8	4.5767	6.41100	5.36504	2.14065	24.6	1.682	5
824	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	649.9	186.9	0.4262	6.47682	5.23057	0.22804	23.2	1.512	5
825	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	768.2	323.7	54.6459	6.64405	5.77982	16.88165	29.4	2.337	6+
826	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	269.8	132.9	0.6498	5.59768	4.88960	0.48894	20.0	1.153	4
827	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	654.0	277.7	20.5262	6.48311	5.62654	7.39150	27.5	2.070	6+
828	05/14/15	BLAKELY	48.583806	122.798836	46	M	1	0	448.9	185.4	1.1933	6.10680	5.22252	0.64364	23.1	1.502	5
829	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	335.1	158.5	2.7784	5.81443	5.06575	1.75293	21.6	1.326	4
830	05/14/15	BLAKELY	48.583806	122.798836	46	F	2	0	499.8	177.1	1.1935	6.21421	5.17671	0.67391	22.6	1.448	4
831	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	472.8	182.2	6.0080	6.15867	5.20510	3.29748	22.9	1.481	5
832	05/14/15	BLAKELY	48.583806	122.798836	46	F	2	0	378.2	163.1	1.5242	5.93542	5.09436	0.93452	21.8	1.357	4
833	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	316.6	140.2	0.6562	5.75764	4.94307	0.46805	20.5	1.203	4
834	05/14/15	BLAKELY	48.583806	122.798836	46	M	1	0	409.2	145.3	14.3459	6.01420	4.97880	9.87330	20.8	1.238	4
835	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	568.6	272.8	6.6542	6.34318	5.60874	2.43922	27.3	2.041	6+
836	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	475.8	238.5	6.3910	6.16500	5.47437	2.67966	25.8	1.834	6+
837	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	625.0	254.1	32.1389	6.43775	5.53773	12.64813	26.5	1.929	6+
838	05/14/15	BLAKELY	48.583806	122.798836	46	M	1	0	664.1	278.5	19.2899	6.49843	5.62942	6.92636	27.5	2.074	6+
839	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	308.0	150.5	0.0464	5.73010	5.01396	0.03083	21.1	1.273	4
840	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	494.6	251.4	13.9159	6.20375	5.52705	5.53536	26.3	1.913	6+
841	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	415.4	193.6	5.2047	6.02924	5.26579	2.68838	23.5	1.554	5
842	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	1	360.3	169.9	1.8542	5.88694	5.13521	1.09135	22.2	1.401	4
843	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	443.8	229.1	1.1726	6.09537	5.43416	0.51183	25.3	1.777	6+
844	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	468.8	210.2	2.6249	6.15018	5.34806	1.24876	24.4	1.659	5
845	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	549.6	207.9	12.7778	6.30919	5.33706	6.14613	24.3	1.645	5
846	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	393.0	174.9	6.3657	5.97381	5.16421	3.63962	22.5	1.434	4
847	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	443.2	174.3	7.5472	6.09402	5.16078	4.33001	22.5	1.430	4
848	05/14/15	BLAKELY	48.583806	122.798836	46	M	0	0	310.5	160.1	0.3525	5.73818	5.07580	0.22017	21.7	1.337	4
849	05/14/15	BLAKELY	48.583806	122.798836	46	F	1	0	302.0	126.4	8.7960	5.71043	4.83945	6.95886	19.6	1.108	3

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No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
850	05/14/15	BLAKELY	48.583806	122.798836	46	F	0	0	477.2	199.3	1.6879	6.16794	5.29481	0.84691	23.8	1.591	5
851	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	601.4	281.3	25.1495	6.39926	5.63942	8.94046	27.7	2.091	6+
852	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	498.4	218.4	9.7268	6.21140	5.38633	4.45366	24.8	1.710	5
853	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	3	415.9	143.8	6.1023	6.03044	4.96842	4.24360	20.7	1.228	4
854	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	263.9	107.2	0.5256	5.57557	4.67470	0.49030	18.2	0.972	3
855	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	651.2	281.2	4.2456	6.47882	5.63907	1.50982	27.7	2.090	6+
856	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	523.3	241.5	17.2100	6.26015	5.48687	7.12629	25.9	1.853	6+
857	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	708.1	282.7	23.8907	6.56259	5.64439	8.45090	27.7	2.099	6+
858	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	9	372.1	166.8	3.8921	5.91916	5.11680	2.33339	22.1	1.381	4
859	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	8	413.9	192.6	14.9179	6.02562	5.26062	7.74553	23.5	1.548	5
860	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	408.8	192.3	0.9424	6.01323	5.25906	0.49007	23.5	1.546	5
861	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	539.1	201.7	2.1597	6.28990	5.30678	1.07075	24.0	1.606	5
862	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	514.5	197.0	3.2631	6.24320	5.28320	1.65640	23.7	1.576	5
863	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	470.4	199.9	18.0690	6.15358	5.29782	9.03902	23.9	1.594	5
864	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	701.0	261.0	25.1833	6.55251	5.56452	9.64877	26.8	1.970	6+
865	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	333.3	148.2	9.3416	5.80904	4.99856	6.30337	21.0	1.257	4
866	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	631.5	218.2	2.1923	6.44810	5.38541	1.00472	24.8	1.709	5
867	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	582.2	240.8	3.1865	6.36681	5.48397	1.32330	25.9	1.848	6+
868	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	638.0	257.0	8.9931	6.45834	5.54908	3.49926	26.6	1.946	6+
869	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	428.6	166.3	13.7104	6.06052	5.11379	8.24438	22.0	1.378	4
870	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	11	690.5	270.0	3.5458	6.53742	5.59842	1.31326	27.2	2.024	6+
871	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	559.7	233.7	4.8396	6.32740	5.45404	2.07086	25.5	1.805	6+
872	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	745.6	301.4	25.5635	6.61419	5.70844	8.48159	28.5	2.209	6+
873	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	2	314.0	123.0	1.1546	5.74939	4.81218	0.93870	19.3	1.084	3
874	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	289.9	124.1	2.9545	5.66954	4.82109	2.38074	19.4	1.092	3
875	05/28/15	CYPRESS	48.603067	122.725700	32	UNK	1	0	507.8	201.4	0.4355	6.23009	5.30529	0.21624	23.9	1.604	5
876	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	324.7	139.6	1.0713	5.78290	4.93878	0.76741	20.4	1.199	4
877	05/28/15	CYPRESS	48.603067	122.725700	32	M	2	0	499.0	236.2	9.0320	6.21261	5.46468	3.82388	25.6	1.820	6+
878	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	2	308.4	144.5	5.9736	5.73140	4.97328	4.13398	20.7	1.232	4
879	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	702.6	276.3	10.7076	6.55479	5.62149	3.87535	27.4	2.061	6+
880	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	384.5	168.4	3.0910	5.95194	5.12634	1.83551	22.2	1.392	4
881	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	661.0	247.8	11.1893	6.49375	5.51262	4.51546	26.2	1.891	6+
882	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	541.6	257.3	10.4939	6.29453	5.55024	4.07847	26.6	1.948	6+
883	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	856.3	360.0	126.3281	6.75262	5.88610	35.09114	30.8	2.543	6+
884	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	545.4	233.4	17.3528	6.30152	5.45275	7.43479	25.5	1.803	6+
885	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	880.9	262.9	42.4315	6.78094	5.57177	16.13979	26.9	1.982	6+
886	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	406.0	180.1	7.1802	6.00635	5.19351	3.98679	22.8	1.468	5

Table C1. Field and laboratory data from the Lummi Natural Resources Department 2013–2015 sea cucumber *Parastichopus californicus* study. MLLW = mean lower low water, POLY = polychaete worm, PARA = parasitic snail, ROUND = round, whole weight in air, SPLIT = split-and-drained weight in air, LN = natural log, and GSI = gonadosomatic index. Specific locations bearing asterisks (*) indicate specimens that were sampled for the purposes of future DNA analysis.

No.	DATE	SPECIFIC LOCATION	LAT	LONG	AVG DEPTH (MLLW)	SEX	POLY	PARA	ROUND WT (g)	SPLIT WT (g)	GONAD WT (g)	LN ROUND WT	LN SPLIT WT	GSI	EST. LENGTH (cm)	BODY SIZE INDEX	EST. AGE (Year)
887	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	388.2	150.7	2.6387	5.96152	5.01529	1.75096	21.1	1.274	4
888	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	0	727.9	314.6	17.0545	6.59016	5.75130	5.42101	29.0	2.285	6+
889	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	431.6	162.0	6.8134	6.06750	5.08760	4.20580	21.8	1.349	4
890	05/28/15	CYPRESS	48.603067	122.725700	32	F	0	0	534.8	215.4	3.1806	6.28189	5.37250	1.47660	24.6	1.692	5
891	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	726.2	227.6	27.1287	6.58783	5.42759	11.91946	25.2	1.767	6+
892	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	7	265.0	132.2	4.8865	5.57973	4.88432	3.69629	19.9	1.148	3
893	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	486.0	199.7	12.3057	6.18621	5.29682	6.16209	23.8	1.593	5
894	05/28/15	CYPRESS	48.603067	122.725700	32	UNK	1	4	448.2	188.2	0.9629	6.10524	5.23751	0.51164	23.2	1.520	5
895	05/28/15	CYPRESS	48.603067	122.725700	32	F	2	7	426.8	211.7	3.1018	6.05632	5.35517	1.46519	24.5	1.669	5
896	05/28/15	CYPRESS	48.603067	122.725700	32	UNK	0	0	259.1	104.8	0.8471	5.55721	4.65205	0.80830	18.0	0.955	3
897	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	10	276.7	124.1	0.7232	5.62293	4.82109	0.58276	19.4	1.092	3
898	05/28/15	CYPRESS	48.603067	122.725700	32	M	0	0	285.9	121.4	4.4892	5.65564	4.79909	3.69786	19.2	1.073	3
899	05/28/15	CYPRESS	48.603067	122.725700	32	M	1	0	291.6	171.0	1.5271	5.67538	5.14166	0.89304	22.3	1.409	4
900	05/28/15	CYPRESS	48.603067	122.725700	32	F	1	1	273.3	122.3	1.2070	5.61057	4.80648	0.98692	19.3	1.080	3

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