HISTORIAL COMPARISON OF DOCK COMMUNITY COMPOSITION IN JENSEN MARINA, SAN JUAN ISLAND, WASHINGTON

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ABSTRACT:

This research project is based on the historical survey and resurvey of Jensen Marina, San Juan Island, Washington from 1974 and 2008(*Barner, A and Rodgers, T 2008, Kelsey. W 1974*). These studied provided present and absent data for a variety of intertidal species living in the dock communities. Species recorded were measured in percent coverage for 2008 and this study. Non- native, invasive species were recorded and taken into considerations. Other variables such as float type and animal diversity were recorded. Over the 44-year time span, species diversity increased with a higher number of total species and an increase in individual abundances. Factors such as styrofoam bare space and general level of erosion were measured and taken into consideration. As the dock communities change, the surrounding ecosystems will follow. It is important to continuously record the changing ecological communities to determine human impacts over time.

INTRODUCTION:

Dock communities provide important implications for the species richness and abundance of individual ecosystems. Dock communities are described as a grouping of multiple species in a single dock ecosystem, these ecosystems can vary depending on the resources available for each species. Many species observed on docks include sessile, non, mobile, invertebrate or algal species. Many include filamentous algae, anemone, sponge, tunicate, and bryozoan species. These important intertidal individuals create a new ecosystem in dock communities. Intertidal dock communities are vital in marine ecosystems due to their influx of new settling animals. Many settling species attach themselves to the underside of boats, and without proper maintenance, can erode into the paint layer of the boats exterior. If traveling long distances, these animals can essentially “hitch hike” to a new location and resettle, becoming an invasive, or non-native species(*Sutherland, J 1974, Stachowicz, J 1999, Freestone, A 2011, Young, C 1985*) . However, if the boat is properly maintained this should mitigate the risk of transferring species from one location to another.

Dock communities can be detrimentally impacted by the chemicals used in cleaning boats; however, are increasingly susceptible to boats that are not regularly washed. Neglecting to properly clean the boats regularly allows zoonotic and planktonic species to settle on the boat, if

harbored in a new area, the settling species can spawn or migrate to docks and introduce non-native species into the habitat. Introducing these invasive species can have a negative impact due to an abundance of new resources, decreased competition, and lack of predation (*Sutherland, J 1974).* However, according to Piers Dunstan, increased invasion rates can increase species richness in marine ecosystems (*Dunstan, P et al 2003, Wonham, M 2005*).

A secondary impact on the species richness and abundance rates on dock ecosystems is the light availability given to the community *(Freestone, A 2011, Young, C 1985*). At Jensen Marina, separate boat mooring slips were studied for both covered and uncovered locations on the dock. Covered locations were confined by a metal ceiling allowing little light exposure to the slip floats. Uncovered locations were not restricted by a metal covering, allowing light exposure. The presence and abundance of light on the slip floats greatly impacts the structure of the community. Without light, photosynthetic organisms would not thrive, and therefore are not expected to be present in covered communities.

Float substrates can influence the overall health of the surrounding marine ecosystems. As the Styrofoam floats, used at Jensen Marina, erode, small particles of styrofoam break and enter the surrounding marine habitats (*Nicholson, Tod*). These particles continue to break down and can be mistaken for zoonotic species by mobile vertebrates and plankton consuming faunae (*Clean Water Action 2011*). The structure of the floats and rate of erosion determines which sessile invertebrates settle.

In this study, I hypothesize a change community structure at Jensen Marina with a decrease in algae species and increase in diatom and hydroid species on covered floats. On uncovered floats I predict an increase in algae species with a decrease of invertebrate presence. The ecological re-survey of Jensen Marina will focus on determining species composition over time. In recording percent coverage of different marine organisms, a comparison can be made between species abundance recorded in 2018 and species previously recorded in 2008 (*Barner, Allison and Rodgers, Tanya 2008)* and 1974 (*Kelsey et al 1974*). These observations will provide data on changes in the intertidal dock ecosystems over a 44-year period. These results can be used for further survey comparison and in comparing species abundance in different ecosystems around San Juan Island. Between 1974 and 2008, precise data was recorded by Allison Barner and Tanya Rodgers of mean percent coverage in 2008 compared to present/absent data provided by

Kelsey in 1974. This study is being conducted to increase the data set provided for Jensen Marina in pursuit of new data to explain possible changes in ecosystem structure.

METHODS:

Approach

This research was based on an ecological survey of W. Kelsey's research on Marine Dock communities in 1974. In 2008, Allie Barner and Tanya Rodgers performed a resurvey of the same dock communities. This resurvey of both studies collected data from the same dock areas. One slip measured in 2008 was not remeasured due to erosion and safety concerns. Variables such as covered/uncovered, percent coverage, float types, and boat traffic were previously recorded for comparison. This study focused on the variables of float types, covered/uncovered, and percent coverage. Percent coverage was recorded using a 25x25cm quadrat and recording the abundance of species present.

Site Information

Used primarily for mooring boats, docks vary in size, shape, type, use, and location. The dock studied, Jensen Marina, is a floating dock created in 1910, used for small boat mooring (*Boatyard services).* The main walkway is made from wooden pilings; attached is the main dock, made from wood. The first two sub-docks are comprised of wooden walkways held by Styrofoam floats. The third attached dock, and last dock, is used for medium boat mooring with plastic air floats. Floating docks are used in locations with variable tidal heights. Jensen Marina, located 1.2 miles southeast of the Friday Harbor Ferry Terminal, is a lower boat traffic area. It is a smaller cove which decreases the water current moving through from the main channel and does not have high boat traffic. (*Boatyard services*)

Jensen marina is populated by privately owned, non-commercial, boats, which are stored at the docks year-round. These are build surrounding highly populated areas and are impacted greatly by their surrounding communities. Due to the high human impact on the dock community, marine animals in the surrounding areas can be greatly impacted by the location of the dock. Jensen Marina, like many others, has an area for servicing private boats out of the water. Servicing comprises washing the boats via power wash or soap, engine maintenance, and resealing the paint (*Boatyard services, Boat Cleaning Tips, Spray-Linning*). The ecosystems of

individuals growing on the docks can be greatly impacted by the chemicals used during each of these processes.

Three surveys spanning 44 years were conducted at Jensen Marina on San Juan Island, Washington, USA. Jensen Marina consists of two rows of individual docks, the first containing slips on both sides of the entrance. The second dock consisting of only slips on the right. This Marina is subject to extreme variable tidal heights; During low tide events, private boat owners have difficulty moving the boats from the marina (*Nicholson, Tod*). Wood is used for the dock structure with creosol treated pilings. The float type taken into consideration was Styrofoam, covered and uncovered by black plastic sheeting. Boat traffic is not high in this marina due to the tide restrictions (*Mike*).

Historical Surveys

The 2008 studies were conducted at the last four slips of the different dock sites and considered different variables such as percent covered, float types, and boat traffic. Percent coverage of the dock was recorded as covered or uncovered with docks that had a roof/ceiling and those that didn't, respectively. The float type taken into consideration was Styrofoam floats that were both covered and uncovered by black plastic. Finally, boat traffic was recorded as high or low depending on the dock. Jensen marina is a low boat traffic area with each of the different slips having a variable amount of traffic (*Barner, A and Rodgers, T 2008, Kelsey, W. 1974*).

Contemporary Surveys

At each dock 25cm X 25cm quadrats were placed in the different slips to record the percent coverage of sessile invertebrate species. Historically, only eight full quadrats were measured at the marina. To expand the study and provide a more reliable and broad range of data, fourteen slips were measured (See figure 1). Only Jensen Marina was sampled due to having a larger data set from both 1974 and 2008 studies for mean percent coverage. Species of kelp were recorded by the percent coverage of the holdfast. The quadrat sites were chosen by placing a transect tape along the length of the slip and using a random number generator for quadrat placement. The quadrat was placed with the top of the quadrat at the water line. If the float was not long enough to include the length of the whole quadrat, a second quadrat was placed neighboring the first and the two separate halves were recorded as a single quadrat. For the exception of one slip, the

quadrat was always flipped to the left. Species seen were recorded as an abundance and percent coverage with total numbers of individuals recorded growing on other species and substrate type (*Barner, A and Rodgers, T 2008, Kelsey, W. 1974*). Species that were unidentifiable at the site were taken back to Friday Harbor Labs for further identification. All collections and observations were made May 2018(*Kozloff, E et all, 1990,1996, 2000, Harbo, R 2011).* Tide heights were not pertinent for this study as all the docks are floating.

One of the slips with recoded data from the 2008 study was not safe and therefore was not recorded. The safety of the docks was determined by looking at how closely the boat was to the dock, if there were additional wood covers over the slips, and if the slips had been eroded away. Erosion was a factor in recording data; if the slip took up less than one-third of the quadrat, data was not recorded. Due to lack of time, Friday Harbor and Roche Harbor Marinas were not used for data collection.

RESULTS:

Uncovered slips were observed to contain a higher mean percent coverage of red algae and diatom species compared to covered slips. Uncovered slips, overall, had a lower diversity of species recorded per quadrat with an increase percent coverage of bare styrofoam. Covered slips had an increase in *Bugula californica*, *Dendrobeania lichenoides, Serpulidae*, and *Sabellidae* mean percent coverages.

Comparing the data collected with the 2008 study, there is a drastic increase in mean percent coverage of bare styrofoam, increasing in uncovered slips from 2 percent coverage to 54.5. In covered slips, bare styrofoam percent coverage doubled to 10.41 percent from 6.5 percent coverage previously recorded. Uncovered bare styrofoam was not recorded during the 1974 study. *Bugula California* has increased in covered slips from previously collected in 2008 with a decrease in mean percent covered in uncovered slips. The 2008 study recorded a reduction in mean percent coverage of diatoms from 12 percent to 0.27 percent mean coverage in covered slips. In uncovered slips, the mean percent coverage decreased from 32.5 percent to 6.75 percent. A decrease in *Dendrobeania lichenoides* and brown filamentous algae was recorded compared to the 2008 study in covered docks. Sabellidae species increased in mean percent coverage in covered slips from 2008 to 2018 and were not recorded in uncovered slips. Increased abundance

of sessile invertebrate species such *Mytilus, Metridium farcimen, Scyphistoma, and Pododesmus macroschisma* were recorded compared to the previous 2008 and 1974 study.

The Kelsey 1974 study reported data as present/absent for the range of species found. Two increasing species not previously listed in 1974 include uncovered *Sabellidae* and covered *Scyphistoma*. Covered *Sabellidae* first appeared in the 2008 survey and has increase in mean percent cover form 0.5 percent to 1.75 percent in the last ten years. Covered *Scyphistoma* increased in mean percent cover from 1.75 percent to 9.6 percent in the last decade.

Many declining species recorded in 1974 that were either not currently present or decreasing overall include uncovered *Dendrobeania lichenoides*, uncovered brown filamentous algae, and covered diatoms. Decreasing species not present in 1974 or 2018 include uncovered *Dendrobeania lichenoides*, covered and uncovered brown leafy algae, covered and uncovered *Haliclona*, uncovered *Pyrua haustor*, covered and uncovered red leafy algae, and uncovered *Bugula californica*.

Species marked as present in only 1974 include covered *Pyrua haustor* and uncovered *Metridium farcimen*.

Twelve new, not previously noted, species were recorded including *Myxilla lacunosa*. All new species found were not recorded in both 2008 and 1974 studies. These species include covered *Balanus glandula*, Black styrofoam cover (covered and covered slips), covered *Chlamys hastata*, covered *Halocynthia aurantium*, covered *Hemigrapsus nudus*, covered Katharina tunicata, covered *Neoperiopsis*, covered *Pandalus danae*, and covered *Serpulidae*. Two species recorded in the 1974 study, including *Ascidia callosa* and *Chelyosoma productum* were not recorded in the 2008 or current study (*Barner, A and Rodgers, T 2008, Kelsey. W 1974*).

See appendix

FIGURES:

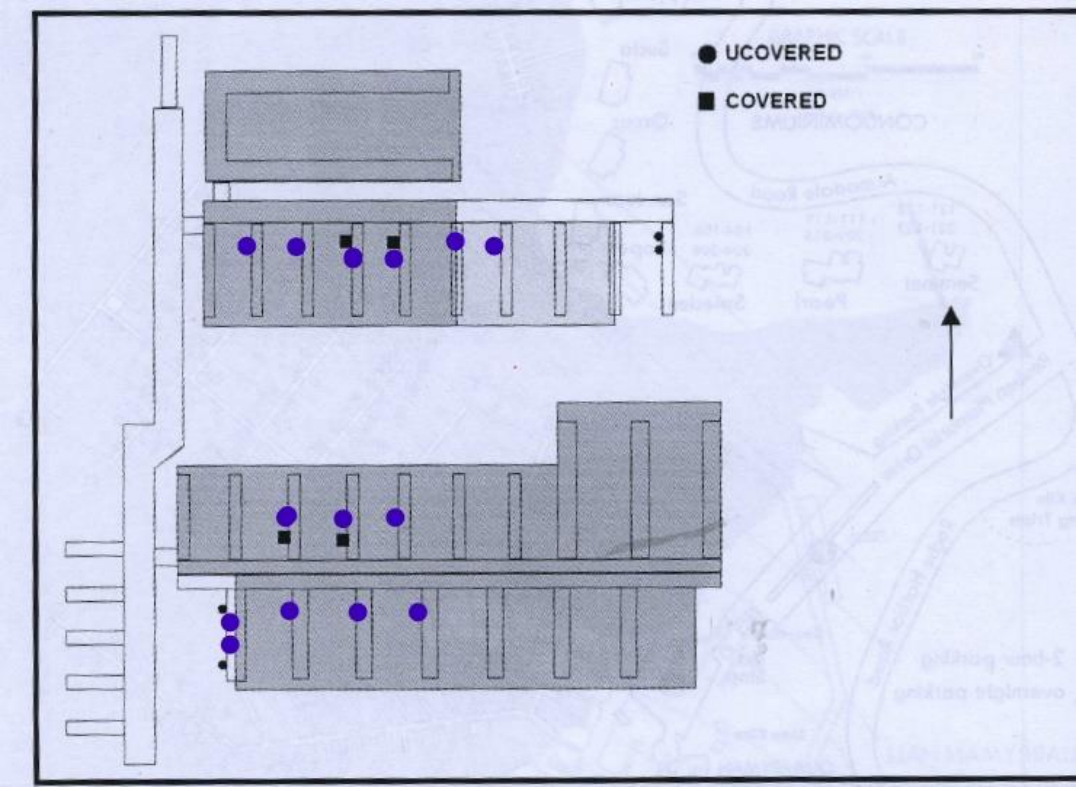

FIGURE 1: Image of the dock of Jensen Marina provided by Allie Barner and Tanya Rodgers, 2008. In black are the floats previously sampled in 2008 following the 1974 study. In blue are 2018 float samples. Areas covered in dark gray are covered with areas without highlight are uncovered. Note: the last two quadrats recorded on dock two were not sampled in this study due to erosion and safety concerns.

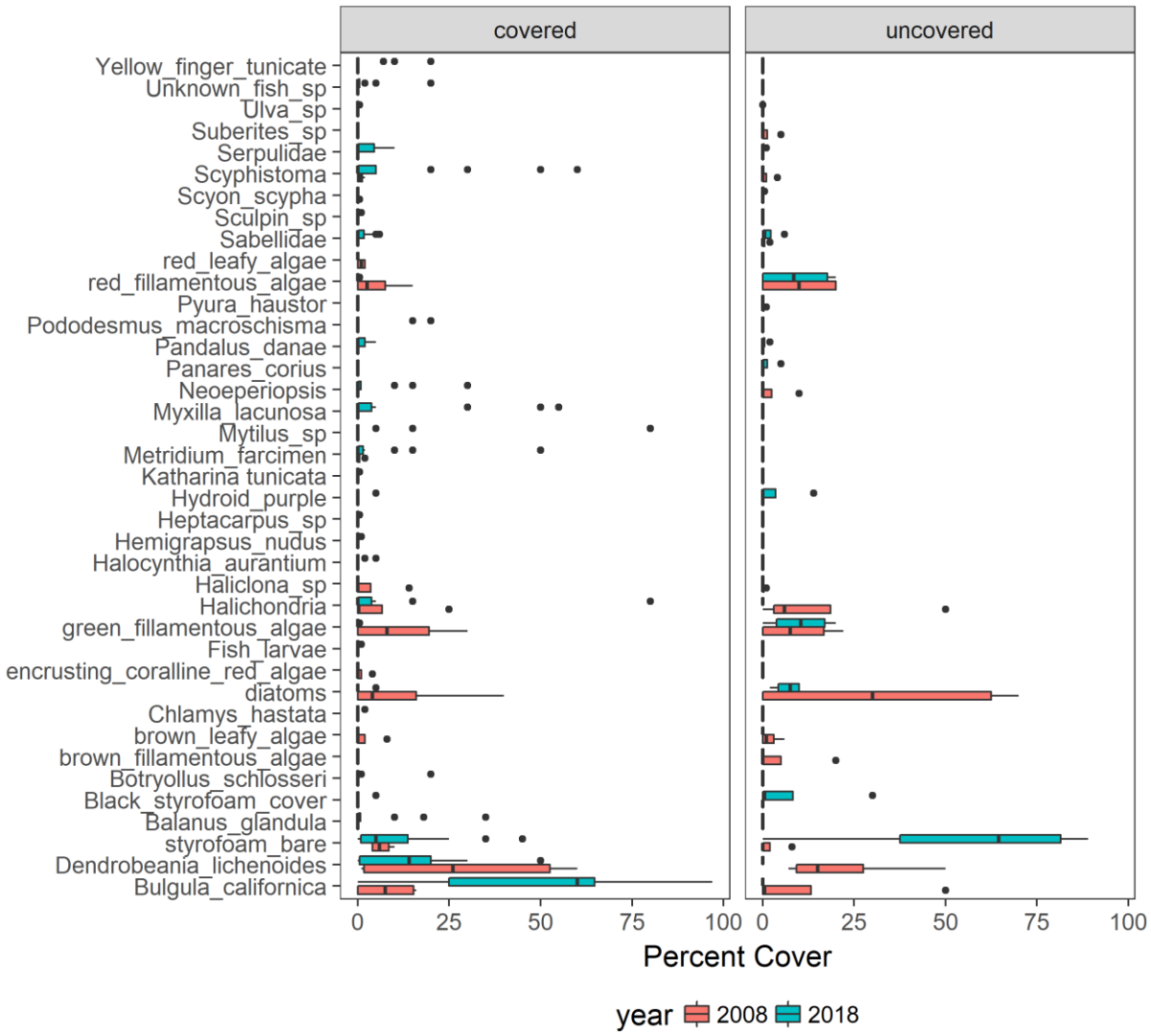

FIGURE 2 (a): Species percent cover recorded. Percent cover on x-axis with species on y-axis of all species recorded. Graph is separated by covered/uncovered. Variables shown on the graph represent years'2008 and 2018. Data from 1974 was not included in percent cover due to analyses marked as present/absent.

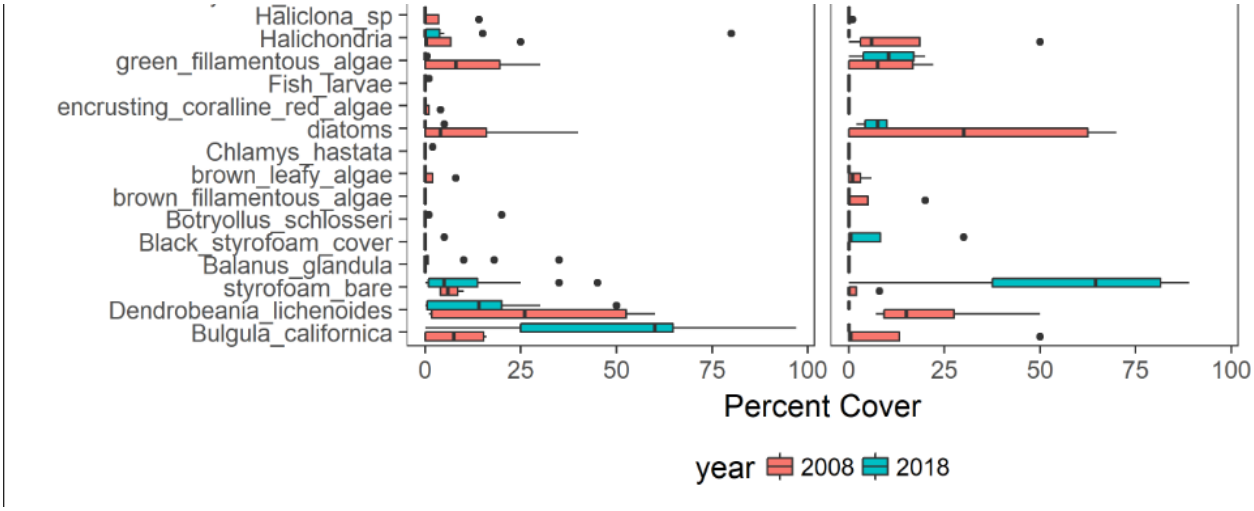

FIGURE 2(b): Species percent cover recorded and separated covered/ uncovered. Percent cover on x-axis with species on y-axis. Variables shown on the graph represent years'2008 and 2018. Data includes a summary of drastic changes in percent cover of multiple species.

DATA ANALYSIS:

RStudio was used for all data analysis. Raw data was uploaded into an excel spreadsheet and imported into R. The data used was then taken from wide format and placed in long format for better analysis. Once in Long format, variables such as species, percent cover, and year were separated and summarized into a table. Summary statistics were created to calculate mean percent cover for all data. A box plot was made using ggplot with the axis labeled as mean percent cover (Y) and Species (X). The box plot made was modified and separated into individual plots comparing covered and uncovered dock sites. The mean data was placed back into wide format and exported as an excel workbook file for further manipulation in excel.

The mean percent coverage tables represented contain data manually inputted from data collected and previous tables from Barner, A and Rodgers, T, 2008 study.

A comparison was made in excel in placing covered and uncovered side by side. This allowed for an easier comparison of species composition and abundance to be analyzed.

DISCUSSION:

As a resurvey of an ecological historical paper, the goal of the research is to calculate overall presence or absence data with mean percent coverage of each species. This work can be further

repeated and used as a resource in determining community composition of Jensen Marina with reference to other fouling communities. During this research, many species were found to increase in abundance, others decrease, and new species were found as introduced to the ecosystem. This data will give further insight to change in community structure over time with increase in boat traffic and urban development.

Twelve new species were recorded that were not noted in the 2008 or 1974 studies. This included the non-native Myxilla lacunosa species. Species previously identified as invasive, non-native, in the 2008 study included Haliclonia sp and Halichondria sp. seen at Jensen Marina (*Barner, A and Rodgers, T 2008, Kelsey, W. 1974*). Both species were observed in covered and uncovered in the current data collection. Many invasive species travel by settling on a boat or moving surface from one area to another. Once the animal has settled in a new area, it may take up an existing niche or cause and increase in competition in ecosystem communities. Without natural predators and plentiful resources, the non-native species will thrive in the new environment. However, I believe from preliminary research that the increase in invasive species has not caused a decline in native populations (*Wonham, M 2005, Dunstan, P 2003*). Instead, it could have created a more diverse ecosystem by decreasing abundance of individuals and increasing species diversity (*Sutherland, J 1974)*.

The data collected for this study shows and increase in diatom and algae species in floats that are uncovered. This is most likely due to the increase in sun exposure, allowing for photosynthesis in uncovered dock areas. A significant mean coverage of quadrats was recorded as one of two Bryozoan species, *Bugula California* and *Dendrobeania lichenoides*. These species were most common in covered areas where sun exposure was minimal. An overall increase of vertebrae and mobile invertebrate species were recorded including unknown fish larvae, scuplin species, *Pandalus danae, Katharina tunicata*, *Mytilus species*, *Chlamys hastata*, and *hemigrapsus nudus (Kozloff, E et all, 1990,1996, 2000).* This could be due to an increase in habitat caused by an increase in bryozoan species and *Metridium farcimen*. *Bugula California* increased drastically from the 2008 study in areas not covered. This can be caused by increased potential habitat, not covered by algal or diatom species. Many of the percent coverages were dominated by multiple tunicate species. Docks provide an calm intertidal habitat suitable for tunicate and sponge species (*Habro 2011*). An invasive, non-native, sponge species *Myxilla Lacunosa*, not previously

recorded was found on multiple slips. This species is classified as an invasive, non-native, species, with a habitat spanning from the Aleutian Islands to northern British Columbia (*Harbo, R. 2011*). Previously only few Sabellidae species were recorded in the 1974 study for covered docks with no *Sabellidae* noted for uncovered floats. *Mytilus* increased in abundance during the 2018 data collection after no previous recordings in 2008. There was an expansion of Scyphistoma species coving the black plastic sheet. These species increases could be due to an increase in available space or the increase of resources in the area. A decrease in diatom and algae species mean percent coverage occurred with an increase in bare styrofoam for both covered and uncovered floats.

Bare styrofoam was also found in high abundance, specifically in uncovered areas. This could be due to the intense sun exposure, making it difficult for species to settle. A significant portion of the dock was covered in flakes of styrofoam that had broken off. All data had a mean percent coverage greater than 100 percent due to species settling on one another. Many floats had holes burrowed into them caused by River Otters. River otters should be taken into consideration when discussing styrofoam float erosion (*Nydam, M 2007*). Local river otters use the floats as burrowing spaces, taking the styrofoam off the floats to create a burrow for protection. These individuals can take the black plastic covering off the styrofoam and cause irreversible damage to the floats, leading to increased styrofoam outflow into the surrounding ecosystems.

Other considerations to be made during the data analyzation of the study is the chemical pollutants currently in the water column. According to Tod Nicholson, Director of the Port of Friday Harbor, many pollutants are accumulating on the shores of Jensen Marina including PCB's, Paah, copper, zinc, and metal from bottom paints. These all have health implications on the ecosystem and its organisms. Another source of pollutants is caused by the direct cleaning of boats while moored. During the data collection, two private boat owners were pressure washing the boats with soap. Likewise, many boat owners are recoating the paint of their vessels and therefore take their boats out of the water to repaint them, then place them back in once dried. These paints are toxic to humans as well as marine animals. These pollutants could have a direct impact on the surrounding marine ecosystems by producing a bottom up affect in the species individuals.

Differences between covered and uncovered floats were substantial with more algae and photosynthetic organisms growing in uncovered slips and an increase in invertebrate species settling in covered slips. This could also be due to an increase current flow towards the outside of the slips or due to the uncovered slip placement.

In conclusion, the Jensen Marina dock community has over time remained relatively stable in the settling species present in 1974. However, many new species recorded during this study and -2008 have increased in abundance over the 44-year time-period. The species diversity has overall increased with a decrease in abundance of individuals of a species and increase in number of species present. A large increase in bare styrofoam was noted for this study and the erosion taken into considerations when collecting data. The study, although relatively stable, is beneficial for the scientific community in understanding how different variables such as coverage, current levels, boat traffic, substrate type, and chemical impacts can effect intertidal marine ecosystems.

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APENDIX: Mean percent coverage for all species separated by study year and coverage from current data collection (2018) and data collected in 1974 and 2008. Current data and 2008 data recorded in mean percent coverage with 1974 data reported as present (1) and absent (0).

Taxon	Covered/uncovered	2008	2018	1974
Bugula californica	covered	7.75	46.72222	1
Bugula californica	uncovered	12.75	0	0
Dendrobeania lichenoides	covered	28.25	14.55556	1
Dendrobeania lichenoides	uncovered	21.75	0	0
styrofoam bare	covered	6.5	10.41667	1
styrofoam bare	uncovered	2	54.5	0

Balanus glandula	**covered**	**0**	**4.111111**	**0**
Balanus glandula	**uncovered**	**0**	**0**	**0**
Black styrofoam cover	**covered**	**0**	**0.277778**	**0**
Black styrofoam cover	**uncovered**	**0**	**7.75**	**0**
Botryollus schlosseri	covered	0	2.277778	0
Botryollus schlosseri	uncovered	0	0	0
brown filamentous algae	covered	0	0	0
brown filamentous algae	uncovered	5	0	1
brown leafy algae	covered	2	0	0
brown leafy algae	uncovered	2	0	1
Chlamys hastata	**covered**	**0**	**0.222222**	**0**
Chlamys hastata	**uncovered**	**0**	**0**	**0**
diatoms	covered	12	0.277778	1
diatoms	uncovered	32.5	6.75	0
encrusting coralline red algae	covered	1	0	0
encrusting coralline red algae	uncovered	0	0	0
Fish larvae	covered	0	0.055556	0
Fish larvae	uncovered	0	0	0
green filamentous algae	covered	11.5	0.027778	0
green filamentous algae	uncovered	9.25	10.25	0
Halichondria	covered	6.375	14.44444	0
Halichondria	uncovered	15.5	0	0
Haliclona sp	covered	3.5	0	0
Haliclona sp	uncovered	0.25	0	0
Halocynthia aurantium	**covered**	**0**	**0.666667**	**0**
Halocynthia aurantium	**uncovered**	**0**	**0**	**0**
Hemigrapsus nudus	**covered**	**0**	**0.055556**	**0**
Hemigrapsus nudus	**uncovered**	**0**	**0**	**0**

Heptacarpus sp	covered	0	0.027778	1
Heptacarpus sp	**uncovered**	**0**	**0**	**0**
Hydroid purple	covered	0	0.555556	1
Hydroid purple	**uncovered**	**0**	**3.5**	**0**
Katharina tunicata	**covered**	**0**	**0.027778**	**0**
Katharina tunicata	**uncovered**	**0**	**0**	**0**
Metridium farcimen	covered	0.5	4.833333	1
Metridium farcimen	uncovered	0	0	1
Mytilus sp	covered	0	5.833333	1
Mytilus sp	uncovered	0	0	0
Myxilla lacunosa	covered	0	10.55556	0
Myxilla lacunosa	uncovered	0	0	0
Neoeperiopsis	covered	0	3.694444	0
Neoeperiopsis	uncovered	2.5	0	0
Panares corius	covered	0	0	0
Panares corius	**uncovered**	**0**	**1.25**	**0**
Pandalus danae	**covered**	**0**	**1.277778**	**0**
Pandalus danae	**uncovered**	**0**	**0.5**	**0**
Pododesmus macroschisma	**covered**	**0**	**1.944444**	**0**
Pododesmus macroschisma	uncovered	0	0	0
Pyura haustor	**covered**	**0**	**0**	**1**
Pyura haustor	**uncovered**	**0.25**	**0**	**0**
red filamentous algae	covered	5	0.027778	0
red filamentous algae	uncovered	10	9.25	0
red leafy algae	covered	1	0	0
red leafy algae	uncovered	0	0	0
Sabellidae	covered	0	1.361111	1
Sabellidae	uncovered	0.5	1.75	0
Sculpin sp	covered	0	0.083333	0
Sculpin sp	uncovered	0	0	0

Scyon scypha	**covered**	**0.125**	**0**	**1**
Scyon scypha	**uncovered**	**0**	**0.125**	**0**
Scyphistoma	covered	1.75	9.611111	0
Scyphistoma	uncovered	1	0	0
Serpulidae	**covered**	**0**	**2.777778**	**0**
Serpulidae	**uncovered**	**0**	**0.25**	**0**
Suberites sp	covered	0	0	0
Suberites sp	uncovered	1.25	0	0
Ulva sp	covered	0	0.027778	0
Ulva sp	uncovered	0	0.0125	1
Unknown fish sp	covered	0	1.833333	0
Unknown fish sp	uncovered	0	0	0
Yellow finger tunicate	covered	0	2.055556	0
Yellow finger tunicate	uncovered	0	0	0
Chelyoasoma productum	**covered**	**0**	**0**	**1**
Chelyoasoma productum	uncovered	0	0	0

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