THE EFFECT OF THE COMPOSITION OF CONCRETE ON BIODIVERSITY AND ECOLOGY ON BENTHIC INVERTEBRATES

Prepared by: Samiyra Abdus-Samad

Mentor: Shimrit Perkol-Finkel, Ph. D

MBRP

BIG PICTURE

- While coastal zones occupy less than 15% of Earth's land surface, they are inhabited by nearly two thirds of the human population, making coastal development and urbanized seascapes inevitable

PROBLEM

- Coastal and marine infrastructures around the world are causing a decrease in coastal marine biodiversity and ecology in those areas because they are built of a poor substrate that also brings in invasive species to the area.

HYPOTHESIS

- If concrete is a poor substrate then adding ECOncrete^{TM} to it will make marine infrastructures biologically and ecologically active because it alters its composition. In manipulating the concrete infrastructures, they should have the ability to provide valuable ecosystem services including nursing grounds, hubs that filter feeding organisms and shallow water habitats. It will also contribute to the structures durability, stability, and longevity (Sigalon, 2012).

ECONCRETE TM

Table 1: Physical parameters of the various innovative concrete matrices in comparison to Portland cement. In manipulating the concrete infrastructures, they should have the ability to provide valuable ecosystem services including nursing grounds, hubs that filter feeding organisms and shallow water habitats. It will also contribute to the structures durability, stability, and longevity (Sigalon, 2012).

Matrix	Water/ Cement Ratio	pH	Average Compression Strength (Mpa)	Weight (Kg/m^3)	Water Pressure Penetration Resistance (mm)	Chloride Penetration Resistance (Coulombs)
M1	0.3	9-10	32.5	2300-2500	<20	<1500
M2	0.3	9.5-10.5	48.5	2300-2500	<20	<1000
M3	0.3	9.5-10.5	39.3	2300-2500	<20	<1000
M4	0.3	9-10	31.1	1400-1800	NR	NR
M5	0.3	9-10	31.9	1400-1800	NR	NR
Portland	0.30 -0.25	12.5-13.5	32	2300-2500	<20	>2000

NR- Not relevant for high air content concrete

LOCALITY

Figure 1. Pier 101 on Governor's Island. This experiment was conducted at Pier 101. The boxes represent the location of each unit. One to four (left to right)

Figure 2. Pier 101 Governor's Island, New York, NY with Pier 101 marked as "A".

PROCEDURES

Steps for deploying units

- Lay four units (each with six 6x6 inch settlement tiles) flat on the Pier’s dock.
- Make sure each tiles has a numbered tag attached to its upper portion (tie with extra ties just in case one broke off).
- Put anchors on one side of each unit and tie them with a bowline knot to the unit roughly 1 foot away from its closet tiles.
- Attach the other end of each unit to the dock 10-15 feet apart
- Completely submerge the units into the Harbor
- Have a diver/snorkeler verify the setup is in place

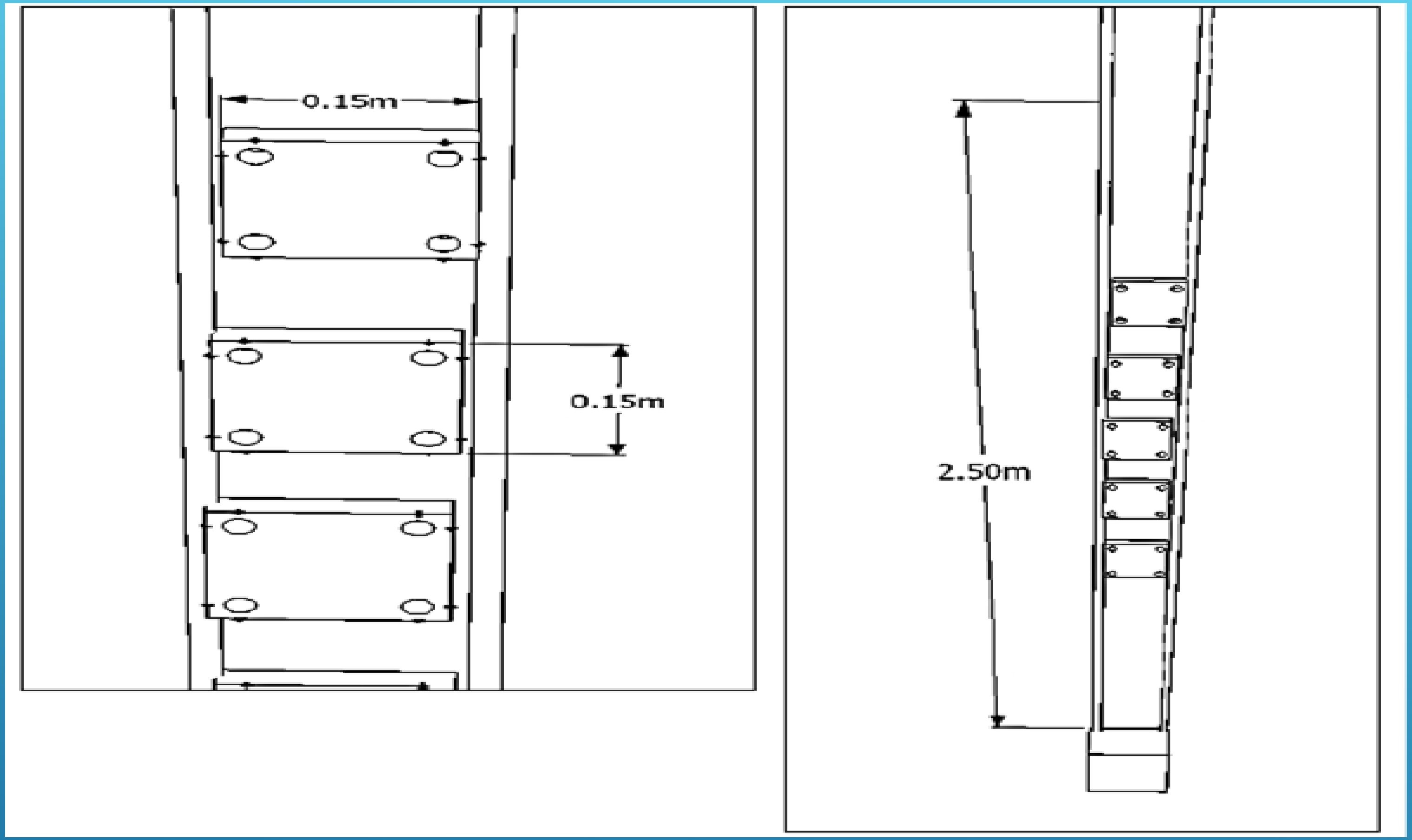

Figure 1. Schematic illustration of the concrete test units composed of 6x6 inch tiles attached to ropes. Each unit is placed randomly on the ropes to see which depth will affect the benthic build up on the matrices.

Steps for collecting data

- Pull units up from out the water
- Untie the anchor from the units and unhook the units from the dock
- Place it in a bucket with water
- Bring it to the Rubbermaid tubs for examination
- Identify the unit be examined
- Before getting data from each tile, identify tiles number and take a picture of the rough and smooth sides
- Write down the amounts of each invertebrate down on the info sheet and if there are any new invertebrates, catalog them
- (if needed) get samples of any invertebrates that need further examination
- On the smooth side of each tiles, section it off into quadrants
- Take samples of two out of the four and put them into labeled tubes

Item	Quantity	Function
Magnifying glass	5	Viewing organisms
Rubbermaid tubs	4	Storing units after retrieval
Digital dissection scope (AmScope)	1	Viewing and photographing invertebrates
Tweezers and needles	4	Examine invertebrates
Info sheets		Notes and data
Electrical ties	1	Tying units that break off
Carabineers	4	To secure onto anchor knot
Field guides	3	Identification
50ml test tubes		To hold samples taken back to the lab for sampling
1x1cm Grids	2	Surveying invertebrates
Surgical gloves	A box	In case of stingers on tiles
Spectrometer	1	Chlorophyll
Buckets with line	2	Supplying water for the units
Line roll (8mm)	1	Tie to the anchors in order to pull up the units
Aprons	8	To protect you
Alcohol		Storing samples of organisms
Camera	2	To fit into the stereoscope and take photos of the units before they are extracted from the Harbor
Anchors	3	To secure the units to the seabed
6x6 inch tiles	16	Used to test the experiment on
scraper	2	Used to take benthic organisms and algae off tiles to collect data
Buckets	6	Contain units and collect water to place them into

RESULTS

- June 2012 was the third month that the units were monitored and little to no invertebrates was seen on the tiles. August 2012 was the sixth month that the units were monitored with a visible increase in the amount of benthic invertebrates but the data shows otherwise. There are five different matrices with different compositions each has a tough (T) and a smooth (S) side.

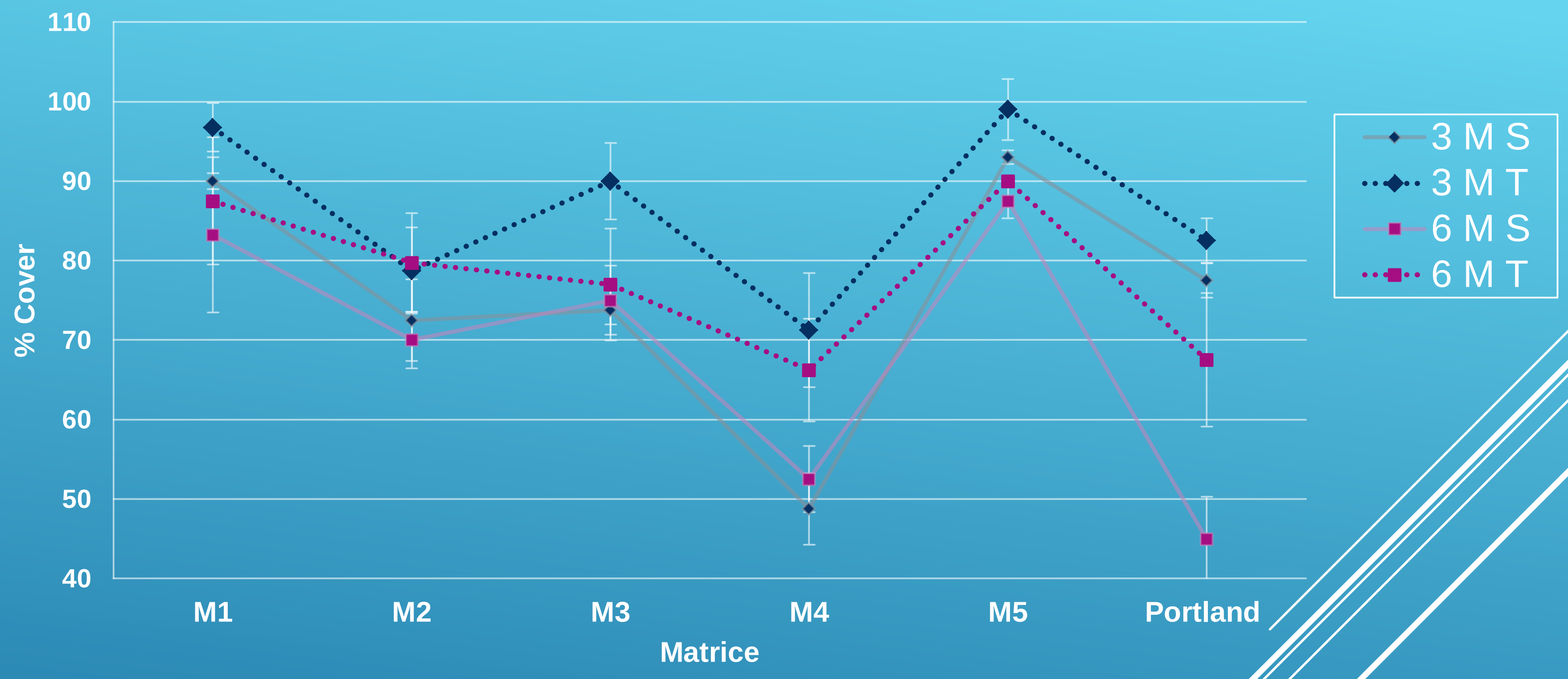

Figure 2. Averaged Percent Live Coverage at Pier 101 (June 2012 and August 2012). The graph above compares the live coverage on the tough and smooth sides of each matrice in both the sampling times. The third month's tough side of the tiles had a larger percent live coverage than the sixth month's tiles.

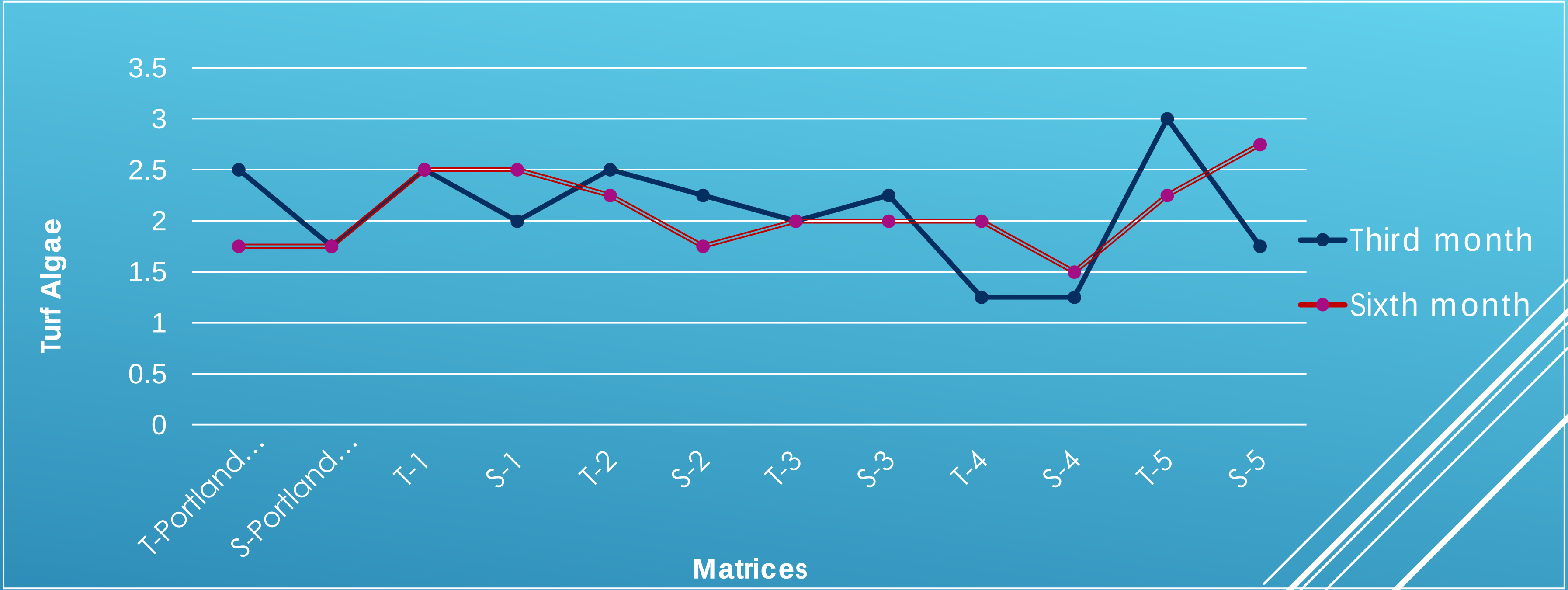

Figure 3. Averaged Turf Algae at Pier 101 (June 2012 and August 2012). The graph above shows the difference in the visible amounts of turf algae each tiles had. The amount of turf algae that was found in both times of monitoring varied.

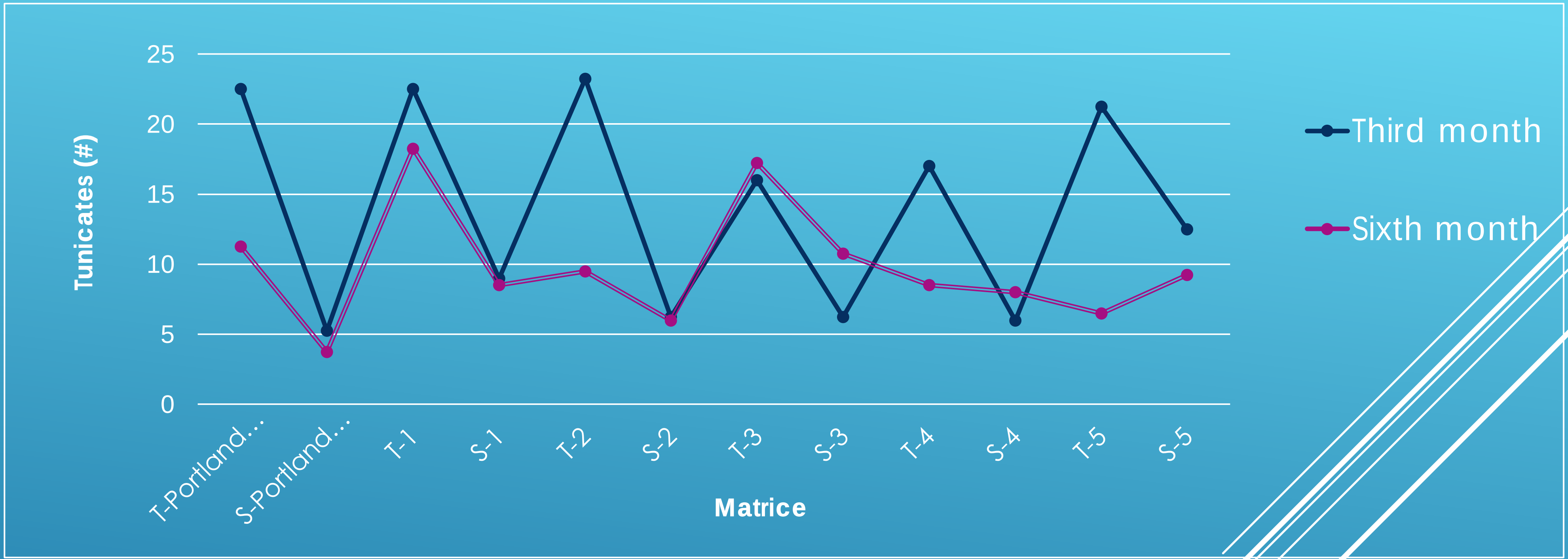

Figure 4. Averaged Number of Tunicates at Pier 101 (June 2012 and August 2012). This graph shows the difference in each tile's number of tunicates. The type of tunicate counted here was solitary tunicates. Based on this graph, the tough sides of each matrice have a larger amount of solitary tunicates growing on its surface than the smooth sides.

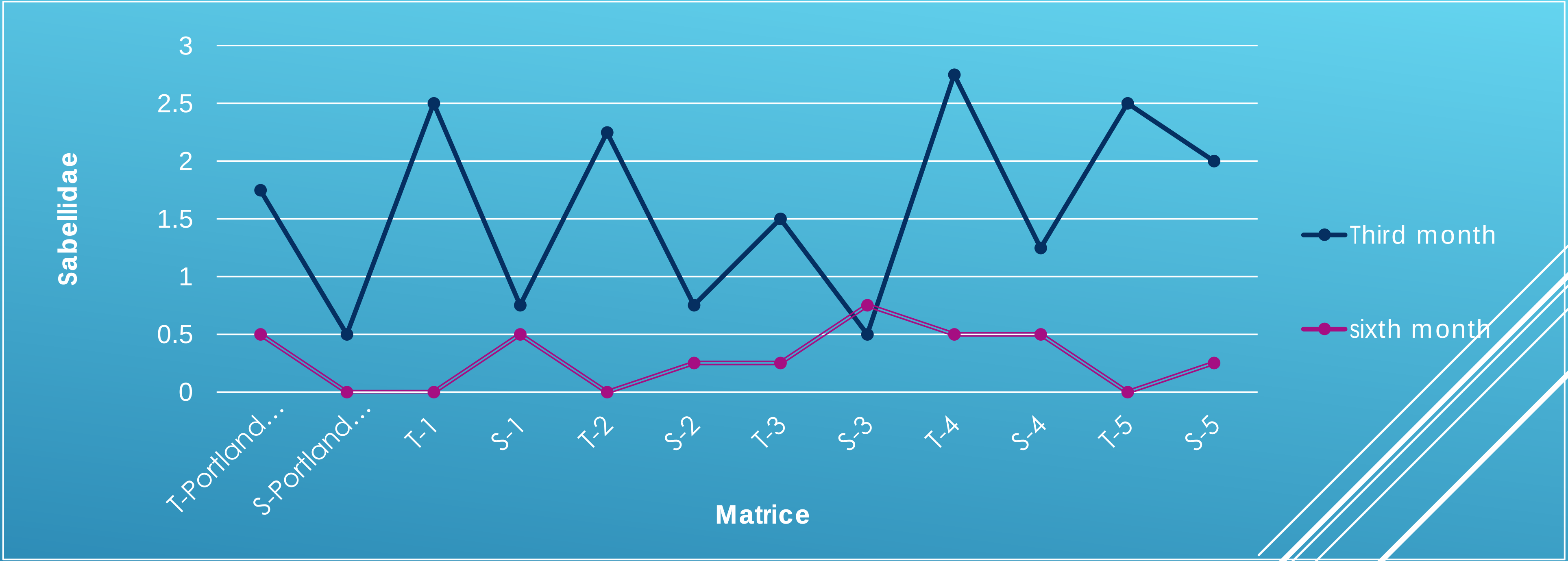

Figure 5. Average Number of Sabellidae at Pier 101 (June 2012 and August 2012). This graph shows the difference in the amount of Sabellidae each tiles and its surface had. Sabellidae is a worm that builds tubes out of parchment, sand, and bits of shell. The scale is 3-high 2-medium 1-low. Based on the graph, each tiles tough side had a larger amount of Sabellidae on its surface than the smooth side.

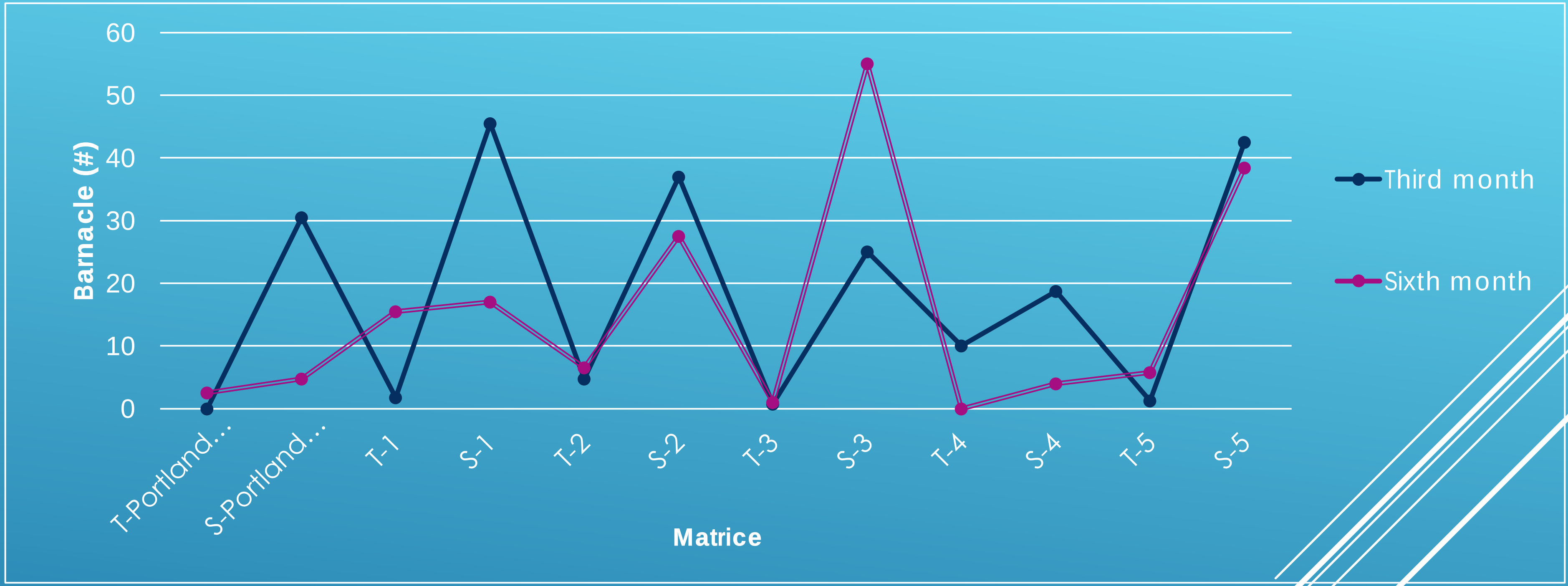

Figure 6. Averaged Number of Barnacles at Pier 101 (June 2012 and August 2012). This graph shows the difference in each tile's amount of Barnacles. Based on this graph, each tiles Tough surface has a smaller amount of barnacles than the tile's smooth surface.

ANALYSIS

- Coastal and marine infrastructures around the world are causing a decrease in coastal biodiversity and ecology in those areas because they are made of a poor substrate. CMI is composed of a substrate that is toxic to the native species but brings in invasive species to the area that are equipped to withstand its parameters. Changing the composition of the infrastructures not only contributes to the structures' durability, stability, and longevity but we hypothesize that it will lead to an increase in species diversity, biomass, and oyster recruitment.
- This work examines an innovative approach of applying slight modifications to the composition and surface texture of concrete, aimed at facilitating marine grow and encouraging enhanced biogenic buildup (Shimrit & Ido, 2013). Out of the five matrices, three have shown more benthic build-up than Portland cement (matrice one, four, and five). This can be seen in the parameters tested in the field during monitoring times. These matrices have produced a larger amount of live coverage, Turf Algae, Tunicate (percentage), Sabellidae, and Barnacles. Other than the invertebrates that are expected to be found, there were several organisms found on the units that we did not expect but they did not affect our findings.

CONCLUSION

- Three of the five matrices tested (MI, M4 and M5) were found to be ecologically active, exhibiting enhanced recruitment capabilities in comparison to standard Portland cement.
- Enhanced recruitment capabilities of natural assemblages of marine flora and fauna onto concrete based CMI yields valuable structural, environmental and socio-economic advantages.

SUGGESTIONS

- Different seasons affected the types of benthic invertebrates that grew on the tiles.
- Use a better program to make the graphs in results
- Keep track of materials
- Monitor data more frequently

BIBLIOGRAPHY

- Connell, S. D. (2000) Floating Pontoons Create Novel Habitats for Subtidal Epibiota. *Journal of Experimental Marine Biology and Ecology,* 247**,** 183-194.
- Chapman, M. G. & Underwood, A. J. (2011) Evaluation of Ecological Engineering of "Armoured" Shorelines to Improve their Value as Habitat. *Journal of Experimental Marine Biology and Ecology,* 400**,** 302-313.
- EBM (2004) Environmental Best Management Practice Guideline for Concreting Contractors. Department of Environment and Conservation (NSW) Sydney.
- Lam, N. W. Y., Huang, R. & Chan, B. K. K. (2009) Variations in Intertidal assemblages and zonation patterns between vertical artificial seawalls and natural rocky shores: A case study from Victoria Harbour, Hong Kong. *Zoological Studies,* 48**,** 184-195.
- Lukens, R. R. & Selberg. C. (2004) Guidelines for Marine Artificial Reef Materials. *A Joint Publication of the Gulf and Atlantic States Marine Fisheries Commissions.*
- Perkol-Finkel,S. Sella, I. Ecologically Active Concrete for Coastal and Marine Infrastructures: Innovative Matrices and Designs. ECOncrete Tech LTD, 13 Namirover Street, Tel Aviv, Israel 69713.
- Perkol-Finkel, S. Sella, I. (2011). Biological performance of ECOncrete ™ in recruiting benthic flora and fauna in various marine environments. *Deployment and monitoring guidelines.* Tel-AVIV, Israel 66531. SeArc-Ecological Marine Consulting.
- Riklama Business Solutions LTD (2010). ECOncrete ™ Concrete Ecological Solutions. *ECOncrete*. Retrieved February 28, 2013, from http://www.searc-consulting.com/pages.yecms/econcrete
- Sigalon LTD (2012). ECOncrete ™ Concrete Ecological Solutions. Bridging Development and sustainability. *The Need.* Retrieved March 1, 2013, from http://www.econcretetech.com/
- Glasby, T. M., Connell, S. D., Holloway, M. G. & Hewitt, C. L. (2007) Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? Marine Biology, 151, 887-895.