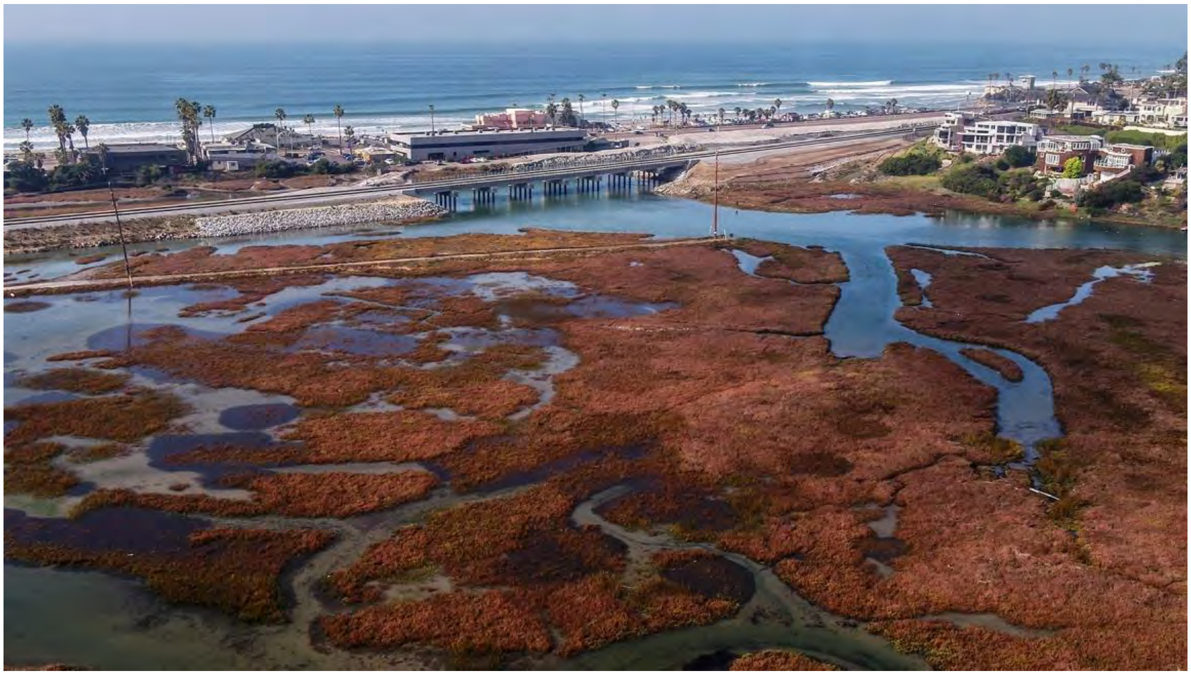
APPENDIX F

2020 SAN ELIJO LAGOON RESTORATION PROJECT POST--CONSTRUCTION FISH AND INVERTEBRATE ASSESSMENT; 2021 SAN ELIJO LAGOON RESTORATION PROJECT POST-CONSTRUCTION FISH AND INVERTEBRATE ASSESSMENT



SAN ELIJO LAGOON RESTORATION PROJECT

Post-Construction Fish and Invertebrate Assessment

Prepared for:
California Department of Transportation
California Coastal Commission
The Nature Collective
San Diego Association of Governments

Prepared by:
Andres Deza
AZED Environmental, LLC
azed.environmental@gmail.com

Contributors:
Anthony Basilio, Ross Collins,
Kendall Hines, Katherine McPherson, Sarah Mishek,
Laura Reid, Dalia Ruiz & Cassandra Willson

TABLE OF CONTENTS

SAN ELIJO LAGOON RESTORATION PROJECT

1. Introduction

This document reports the activities and findings from the post-construction monitoring surveys of San Elijo Lagoon (SEL) in Cardiff by the Sea, CA. Contracted by The Nature Collective, AZED Environmental LLC performed independent post-construction fish and invertebrate density and richness surveys within SEL for the California Coastal Commission. Surveys took place in the fall of 2020 (late September to mid-October) after the construction activities associated with the restoration effort were completed. These data will be compared to pre-construction monitoring data collected by AZED Environmental LLC as a way to measure the performance of the San Elijo Lagoon Restoration Project (SELRP) now that construction efforts have been completed.

2. Site Background

The San Elijo Lagoon Restoration Plan seeks to restore lagoon functions and services to the extent practicable following degradation associated with urbanization of the lagoon's watershed. Urbanization has accelerated freshwater storm flows, generated year-round urban run-off and increased chemical and nutrient levels within the lagoon. Hydraulic efficiency within the channels and tidal inlet of the lagoon has been reduced due to infrastructure that obstructs water flow, including Coast Highway 101, the North County Transit District railroad, Interstate 5 and a weir in the eastern lagoon basin. Subsequently, a degradation of water quality including elevated bacterial levels have led to beach closures during moderate to large storm events.

The SELRP seeks to restore tidal influence to the lagoon and enhance freshwater fluvial flows out of the lagoon. This would, in turn, restore the physical (soils and hydrology) and biological (biogeochemical/water quality and habitat) functions that have been degraded over the years.

The SELRP proposes to modify the channels and habitats throughout the entire 960-acre lagoon. These modifications are expected to improve lagoon habitats that support sensitive coastal wetland plant and animal species. Restoration is expected to take approximately three years with the restoration of each of the three lagoon basins conducted in sequence, beginning with the Central Basin, followed by the Eastern Basin and finally the Western Basin. Upon completion of restoration construction, a minimum of 10 years of post-construction biological monitoring will be initiated for all wetland habitats. A minimum of five years of monitoring will be initiated for all restored upland habitats. In addition, long-term monitoring of selected parameters will be conducted for the life of the project, defined as 50 years post-construction.

3. Survey Methods

3.1 Benthic Invertebrate Surveys

Benthic invertebrate community composition includes two components: average total density and average number of species per location surveyed. These are relative standards, which will be used to evaluate the SELRP against measurements taken at reference wetlands in Southern California, as well as potentially against pre-restoration conditions within SEL. Sampling methods at SEL and reference wetlands were based on those of the long-standing SONGS San Dieguito Wetland restoration program (Page et al, 2022).

During the post-construction monitoring period, benthic invertebrate populations were sampled in the fall months ranging from late September to mid-October in order to characterize invertebrate food resources for fish and bird populations. Eighteen (18) sampling stations were located in tidally influenced areas throughout the lagoon with nine (9) stations located in main channels and nine (9) stations located in tidal creeks (Figure 1). Of the 18 sampling stations, only historical locations that were tidally influenced prior to construction activities (2017) were incorporated into the overall monitoring summary; therefore, locations located east of the I-5 freeway are considered to be contingency locations. The methods used to assess invertebrate communities are summarized below:

- **Epifauna:** Epifauna, such as the California Horn Snail (*Cerithidea californica*) were sampled by counting live individuals in 0.25 X 0.25 m quadrats. Each of the 18 sampling stations were composed of 5 substations where epifauna was assessed. Data collection at each of the substation (18 sampling stations x 5 substation = 90 substations) consisted of counting individual epifauna present within three pairs of 0.25 X 0.25 m quadrats, which were spaced uniformly and confined to intetidal mudflat habitat. Upper, middle, and lower tidal elevations of the mudflat habitat each had their own independent pair of quadrats.

- **Infauna:** Infaunal sampling, as with epifauna sampling, was confined to the intertidal mudflats of the restored lagoon and were sampled in conjunction with the epifaunal assessment. Three sets of uniformly spaced cores (10-cm and a 3.5-cm diameter core) were collected at each substation located at the 18 sampling stations described above for epifauna. Infaunal core samples were taken at the same elevations as the epifaunal samples upper, middle, and lower tidal elevations of the mudflat habitat. Deep burrowing infauna (clams and ghost shrimp) were sampled using a 10-cm diameter core expressed into the sediment to a depth of 50 cm. The 10-cm diameter cores were sieved through a 3-mm screen in the field. All infauna collected using the 10-cm diameter cores were identified, counted and released.

- Smaller invertebrates (mostly annelids) were sampled using a 3.5-cm diameter core expressed into the sediment to a depth of 6 cm. The 3.5-cm diameter cores were preserved in the field in 10% buffered formalin and subsequently processed in the laboratory by sieving the core through a 0.5-mm mesh screen. The organisms retained by the 0.5-mm mesh were preserved in alcohol and identified to as low a taxonomic level as possible. All sorted specimens were archived for more detailed identification based on availability of resources and changes in project goals.

- **Metrics:** Density of a given station consists of the combination of all methods outlined above. For each community, density was standardized to number of individuals per 100 cm^2 for each quadrat/core and then averaged across quadrats/cores at a given sampling station. Results from each method where then summed for each given sampling station in order to obtain the overall density of invertebrates per station. Species richness was standardized to the number of unique species per sampling location (i.e. quadrats and cores combined). Additionally, unique species of macroinvertebrates captured during the seine and enclosure trapping described in section 3.2 (Fish Assemblage Surveys) are also included in the species richness metric, however, these species are not included in the invertebrate density metric.

3.2 Fish Assemblage Surveys

As with invertebrates, fish community assessment consists of two relative standards: average total fish densities and average number of fish species per location surveyed. As is the case for invertebrates, the fish community within the restored areas of the San Elijo Lagoon will be compared to reference wetlands and pre-restoration conditions. Sampling methods at SEL and reference wetlands were based on those of the long-standing SONGS San Dieguito Wetland restoration program (Page et al, 2022).

Fish habitat created by restoration was primarily comprised of shallow subtidal channels. Intertidal channels are expected to develop and can be added to the post-construction monitoring program upon their development. However, for the purposes of this monitoring program, fish monitoring in main channel / basins habitats were confined to shallow (-1.5 to -3.6 ft. NGVD) subtidal habitats. Eighteen (18) sampling stations were located in tidally influenced areas throughout the lagoon with nine (9) stations located in main channels and nine (9) stations located in tidal creeks (Figure 1). Of the 18 sampling stations, only historical locations that were tidally influenced prior to construction activities (2017) were incorporated into the overall monitoring summary; therefore, locations located east of the I-5 freeway are considered to be contingency locations. Fish measurements were collected in the fall of 2020 in order to avoid nesting activities of the federally endangered Ridgeway Rail (formerly the Light-footed Clapper Rail). These methods are summarized below:

- **Seines:** Seining at each fish sampling station was conducted by blocking each end of an approximately 7-m long channel/creek segment using blocking nets. Blocking nets consist of bagless seines approximately 15.2 m x 1.8 m with 3.2 mm mesh. Small seines (approximately 7.6 x 1.8 m with 3.2-mm mesh) were used to sample the 7-m long area blocked by the blocking nets. The small seine was hauled across the blocked area (perpendicular to the long axis of the channel) to collect the fish trapped by the blocking nets (Figure 2a). Five replicate hauls were made at each station (18 stations total) and each station was visited on 3 distinct days. Additionally, all blocking nets were examined for fish that may have become trapped in small areas that are not covered by the smaller seine net. All organisms were processed in the field to the extent possible. Fish were identified to species, counted and returned to the water immediately, whenever possible. Any macroinvertebrates collected during seine hauls were identified to major taxonomic categories and released. Fish abundance was expressed in terms of density (number per m^2) for each seining event and then averaged across 3 days of seining at any given sampling station. Species richness was standardized to the number unique species per replicate (given that 3 days of seining at a given location is equal to one replicate).

- **Enclosures:** Enclosures were employed to sample demersal, burrowing fish. An enclosure trap was used to sample primarily gobies (family Gobiidae), small, burrowing fishes that are often poorly sampled by other methods. The enclosure trap is composed of a polypropylene sheet fixed as a 1-m-tall cylinder with a 0.43 m^2 sampling area (Figure 2b). The trap is thrown away from the sampler in an attempt to minimize the startling of any fish nearby. A BINCKE net is then swept inside the trap and fish are identified by species, counted, measured for length, and released. This is repeated until no fish are caught a total of 3 times. Enclosure trapping was conducted at 5 substations (similar to invertebrate methods) located at each of the 18 sampling stations. Thus, a total of 90 enclosure samples will be collected during each monitoring effort. Density was expressed in terms of number of individuals per m^2 for each enclosure and then averaged across enclosure at a given sampling station. Species richness of demersal, burrowing fish was standardized to number of unique species per sampling station.

- **Metrics:** Density of a given station consists of the combination of all methods outlined above. For each community, density was standardized to number of individuals per m^2 for each seine/enclosure station and results from each method where then summed for each given sampling station in order to obtain the overall density of fish per station. Species richness was standardized to the number of unique species per sampling location (i.e. seines and enclosures combined).

4. Results

4.1 Benthic Invertebrate Surveys

A comprehensive list of all invertebrates identified to the species level within SEL in 2020 are listed in Table 1. Additionally, the values for invertebrate density and species richness within main channel and tidal channel habitats are summarized in Table 2. Numbers from individual stations were variable across the tidal channels with stations TC1 and TC4 having the highest density values. These station's invertebrate density was approximately 50% greater than the average of all the historical sampling stations (TC's 1 – 6). Similar to that of the tidal channel stations, numbers from individual stations were variable across the main channels. The average main channel invertebrate density (MC 1 – 6) was marginally higher than that of the tidal channels. This is predominately because of main channel stations MC4 and MC8 having relatively higher densities than other stations. It is interesting to note that both stations TC9 and MC9 had the lowest invertebrate densities, which were similar in magnitude to one another and that these stations where located in the same newly restored region of the lagoon.

Like invertebrate density, species richness within the tidal and main channels stations were also variable. Additionally, invertebrate richness in the main channel stations was marginally higher than that of the tidal channels. However, it is unknown what factors are driving high variability in density and richness at some locations.

4.2 Fish Assemblage Surveys

A comprehensive list of all fish identified to the species level within SEL in 2020 are listed in Table 3. Additionally, the values for fish density and species richness within main channel and tidal channel habitats are summarized in Table 4. Tidal channel stations closer to the mouth of the lagoon tended to have lower fish densities compared to the tidal stations TC6 through TC9, which are located in more of the eastern portion of the lagoon. Main channel station fish densities were variable with the highest overall fish densities found in station MC2. Overall, the average main channel fish density within the historical sampling stations (MC 1 – 6) was marginally higher than that of the tidal channels (TC 1 – 6).

Like fish density, species richness within the tidal and main channels stations were also variable. Additionally, average fish richness in the main channel stations (MC 1 – 6) was higher than that of the tidal channels. It is unknown what factors are driving high variability in richness and richness at some locations.

5. Discussion

The post-construction monitoring was conducted in order to compare fish and invertebrate densities and species richness to pre-construction values, which served as a baseline to help track trends in how the biota have responded to the restoration efforts. Post-construction data is also compared to three reference wetlands in order to assess the success of these population metrics. The reference wetlands are: Carpinteria Salt Marsh (CSM), Point Mugu Lagoon (MUL) and the Tijuana Estuary (TJE). Should metrics fail to achieve success, comparison of standards to post-restoration data and to baseline data will be useful in determining if or when adaptive management measures should be implemented.

The density and species richness of invertebrates of SEL in 2020 are summarized in Figures 3 and 4 (invertebrates), while Figure 5 lists the density of the top 5 invertebrate species observed at SEL. The density and species richness of fish of SEL in 2020 are summarized in Figures 6 and 7, while Figure 8 lists the top 5 fish species observed in SEL. After only one year of monitoring it appears that all metrics of density and richness for both fish and invertebrates are at levels that are either similar to pre-construction levels or within the range of the three reference wetlands. Although further statistical analysis is needed to validate this statement. However, it should be noted that SEL is the lowest performing wetland in 2020 for invertebrate density and has had a slight decline since 2017. This may require extra attention as monitoring efforts continue into the future.

Appendix A – FIGURES

Figure 1: Map depicting sampling locations where fish and invertebrate surveys took place in fall of 2020

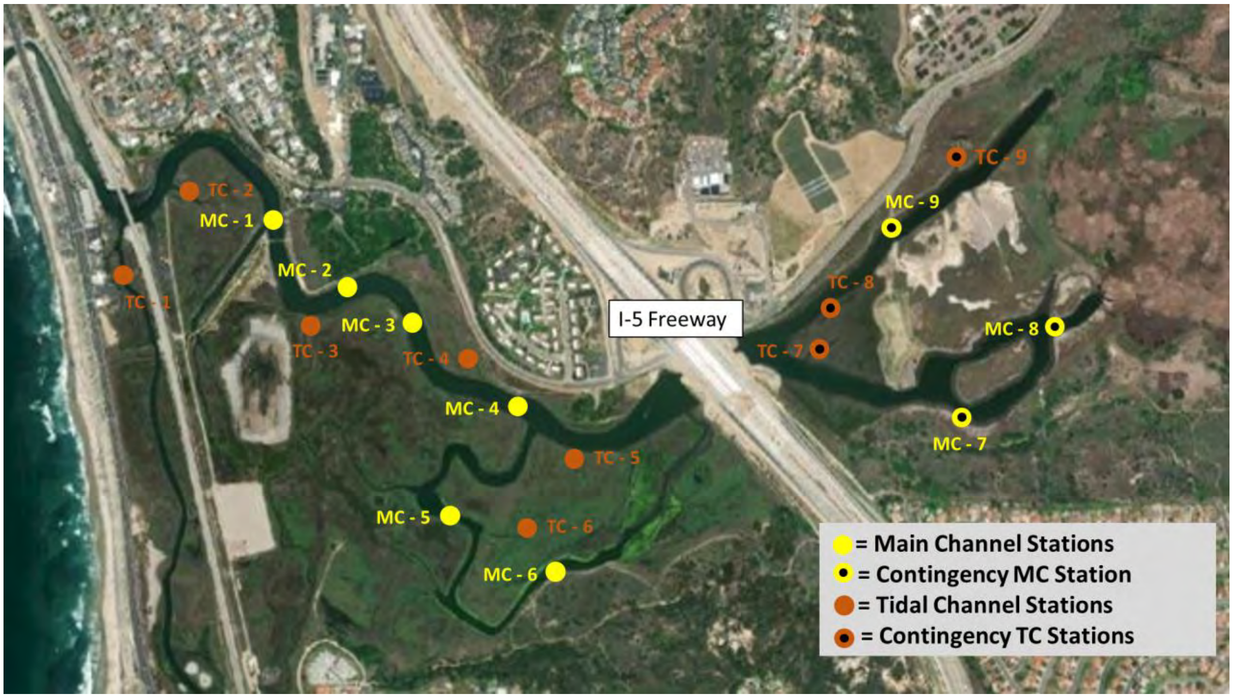


Figure 2a: (Top) Scientists using a combination of blocking nets and beach seine in order to assess fish assemblages

Figure 2b: (Bottom) Project personnel conducting infaunal core assessment as well as deploying enclosure trap with BINCKE net

Figure 3: Summary of invertebrate density data within the San Elijo Lagoon in 2020
(Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

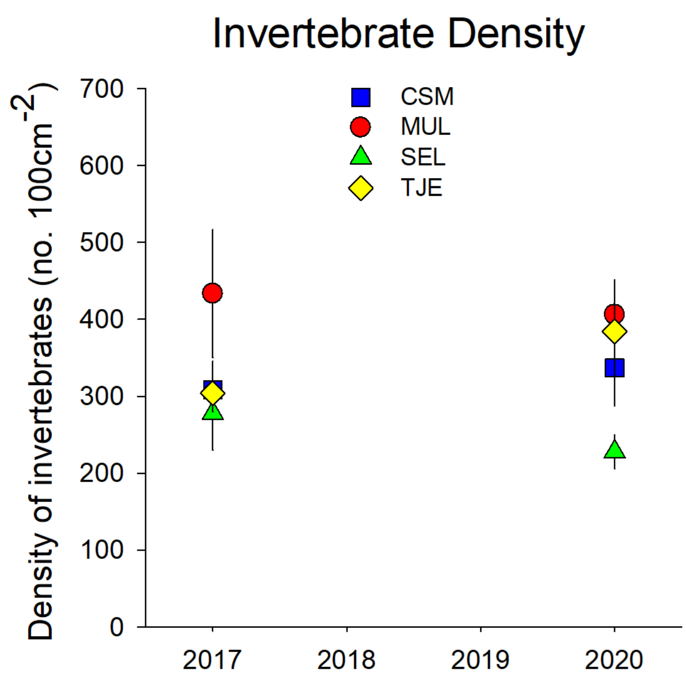


Figure 4: Summary of invertebrate species richness data within the San Elijo Lagoon in 2020 (Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

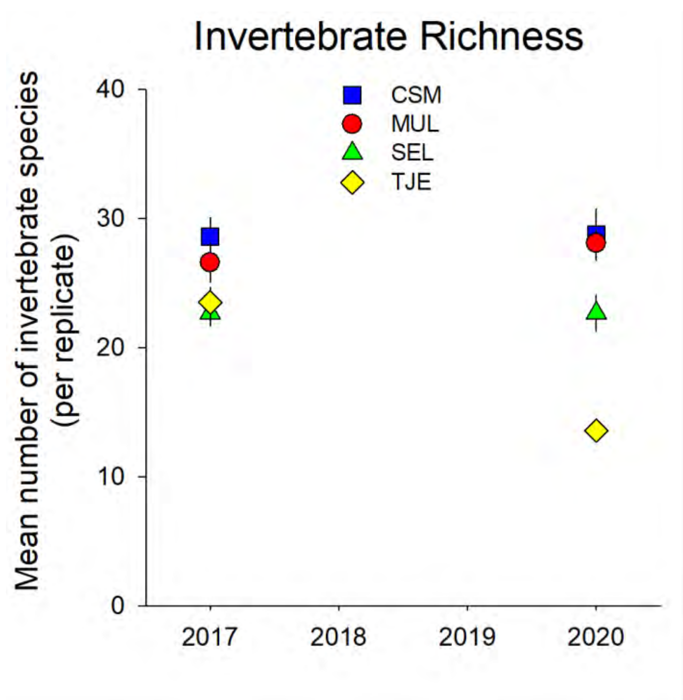


Figure 5: Summary of the top five invertebrate species present in San Elijo Lagoon in fall of 2020 (These calculations exclude the six contingency sites visited during the 2020 sampling season)

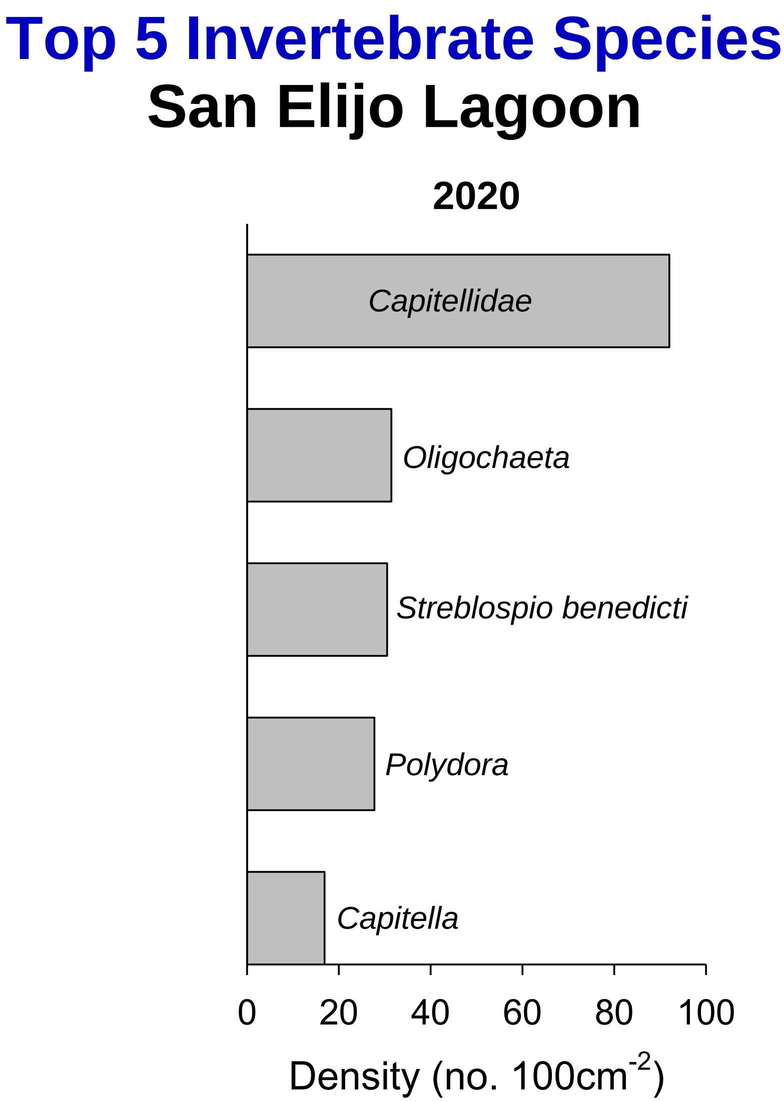


Figure 6: Summary of fish density data within the San Elijo Lagoon in 2020 (Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

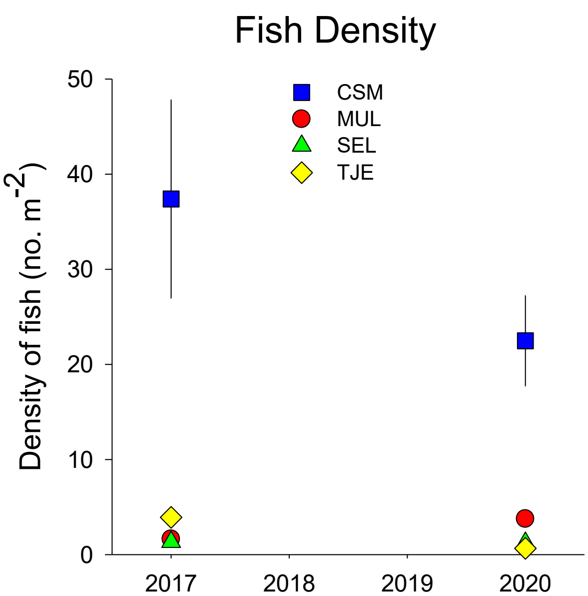


Figure 7: Summary of fish species richness data within San Elijo Lagoon in 2020 (Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

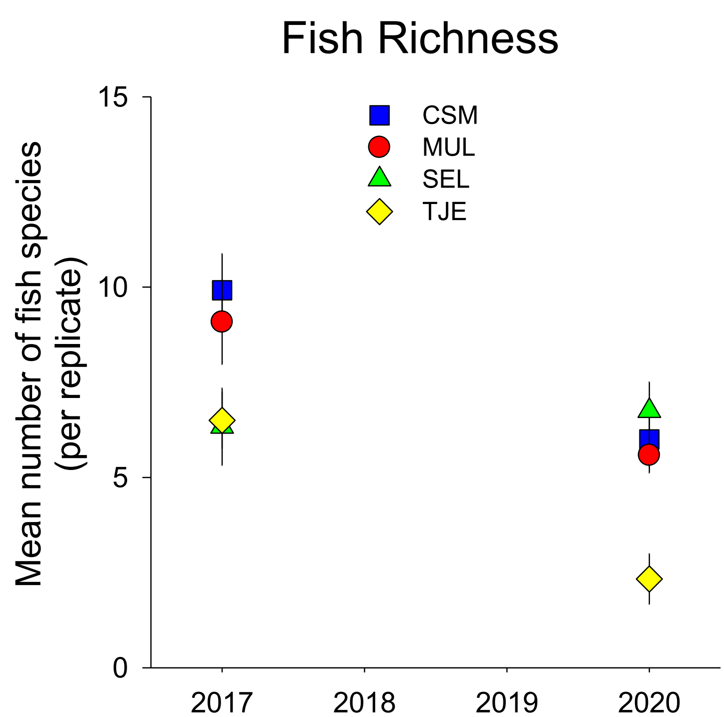
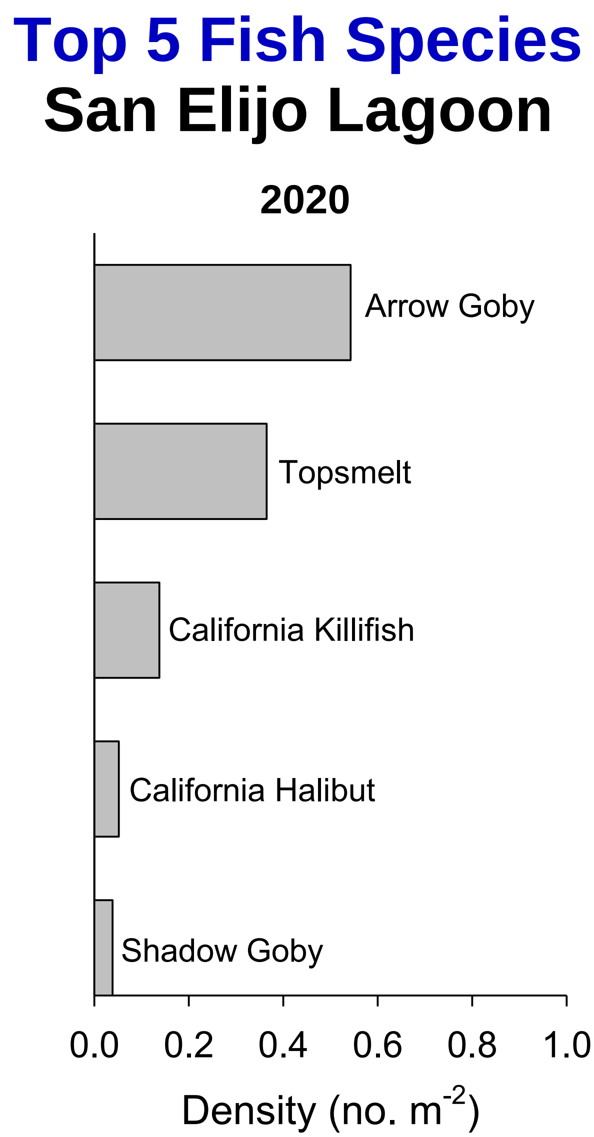


Figure 8: Summary of the top five fish species present in San Elijo Lagoon in fall of 2020 (These calculations exclude the six contingency sites visited during the 2020 sampling season)



Appendix B – TABLES

Table 1: Invertebrate species present during post-construction assessment for 2020

GENUS NAME	SPECIES NAME	COMMON NAME (IF AVAILABLE)
Acteocina	*inculta*	Rude Barrel-Bubble Snail
Aplysia	*californica*	California Seahare
Argopecten	*aequisulcatus*	Speckled Scallop
Armandia	*brevis*	
Bulla	*gouldiana*	Cloudy Bubble Snail
Cerithidea	*californica*	California Horn Snail
Grandidierella	*japonica*	
Hemigrapsus	*oregonenensis*	Yellow Shore Crab
Hippolyte	*californica*	Green Shrimp
Laevicardium	*armatus*	Egg Cockle
Melampus	*olivaceus*	Olive Ear Snail
Monocorophium	*insidiosum*	
Monocorophium	*uenoi*	
Musculista	*senhousia*	Asian Mussel
Nassarius	*tegula*	Covered-Lip Nassa
Navanax	*inermis*	California Aglaja
Pachygrapsus	*crassipes*	Striped Shore Crab, Lined Shore Crab
Penaeus	*californiensis*	Yellowleg Shrimp, Brown Shrimp
Prionospio	*llighti*	
Portunus	*xantusli*	Swimming Crab
Protothaca	*staminea*	
Sicyonia	*penicillata*	
Streblospio	*benedicti*	
Tagelus	*californianus*	California Jackknife Clam
Tellina	*Carpenter*	Carpenter Tellin
Uca	*crenulata*	Fiddler Crab
Venerupis	*philippinarum*	Japanese Littleneck Clam

Table 2: Summary of post-construction invertebrate densities and species richness for each sampling station surveyed within the San Elijo Lagoon

Sampling Station	Invert Density (# per 100 cm^2)	Invert Richness (# of species per replicate)
Tidal Channel		
TC1	283.77	20
TC2	134.81	24
TC3	185.68	27
TC4	297.12	13
TC5	182.78	18
TC6	268.21	28
TC7*	143.63	17
TC8*	207.44	21
TC9*	125.13	16
TC (1 – 6) Average	225.40	21.67
Main Channel		
MC1	127.68	25
MC2	273.59	25
MC3	187.70	22
MC4	381.14	30
MC5	254.14	18
MC6	157.60	22
MC7*	165.82	18
MC8*	335.22	17
MC9*	103.10	13
MC (1 – 6) Average	230.37	23.67
MC's (1 – 6) & TC's (1 – 6) Combined Average**	227.85	22.67

*Denotes contingency sites added in 2020, which are not included in the performance metric evaluations
**Denotes overall metric used to assess performance

Table 3: Fish species present during post-construction assessment for 2020

GENUS NAME	SPECIES NAME	COMMON NAME (IF AVAILABLE)
Acanthogobius	*flavimanus*	Yellowfin Goby
Anchoa	*compressa*	Deepbody Anchovy
Anisotremus	*davidsonii*	Sargo
Atherinops	*affinis*	Topsmelt
Atherinops	*californiensis*	Jacksmelt
Clevelandia	*ios*	Arrow Goby
Fundulus	*parvipinnis*	California Killifish
Gambusia	*affinis*	Mosquitofish
Gillichthys	*mirabilis*	Longjaw Mudsucker
Hypsoblennius	*gentilis*	Bay Blenny
Hypsopsetta	*guttulata*	Diamond Turbot
Leptocottus	*armatus*	Staghorn Sculpin
Mugil	*cephalus*	Striped Mullet
Paralabrax	*clathratus*	Kelp Bass
Paralabrax	*maculatofasciatus*	Spotted Sand Bass
Paralabrax	*nebulifer*	Barred Sand Bass
Paralichthys	*californicus*	California Halibut
Porichthys	*myriaster*	Specklefin Midshipman
Quietula	*y_cauda*	Shadow Goby
Sardinops	*sagax*	Pacific Sardine
Syngnathus	*auliscus*	Barred Pipefish
Syngnathus	*leptorhynchus*	Bay Pipefish
Urolophus	*halleri*	Round Stingray

Table 4: Summary of post-construction fish densities and species richness for each sampling station surveyed within the San Elijo Lagoon

Sampling Station	Fish Density (# per m^2)	Fish Richness (# of species per replicate)
Tidal Channel		
TC1	0.72	4
TC2	0.32	7
TC3	1.19	7
TC4	0.18	2
TC5	0.24	5
TC6	2.75	7
TC7*	2.74	7
TC8*	3.31	5
TC9*	1.80	4
TC (1 – 6) Average	0.90	5.33
Main Channel		
MC1	1.51	11
MC2	3.28	11
MC3	1.08	6
MC4	1.72	8
MC5	1.21	5
MC6	0.70	8
MC7*	1.56	9
MC8*	1.78	6
MC9*	2.11	7
MC (1 – 6) Average	1.58	8.17
MC's (1 – 6) & TC's (1 – 6) Combined Average**	1.24	6.75

*Denotes contingency sites added in 2020, which are not included in the performance metric evaluations
**Denotes overall metric used to assess performance

Appendix C – REFERENCES

Page, M., S. Schroeter, and D. Reed. 2022. 2021 Annual Report of the Status of Condition A: Wetland Mitigation. San Onofre Nuclear Generating Station (SONGS) mitigation program. Submitted to the California Coastal Commission July 2022. https://marinemitigation.msi.ucsb.edu/library/2021-annual-report-wetland-mitigation

Page, M., S. Schroeter, D. Reed, and M. Steele. 2022. Monitoring Plan for the SONGS' Wetland Mitigation Project. Report to the California Coastal Commission. https://marinemitigation.msi.ucsb.edu/library/songs-wetland-mitigation-monitoring-plan-updated-may-2022

SAN ELIJO LAGOON RESTORATION PROJECT

Post-Construction Fish and Invertebrate Assessment

Prepared for:

California Department of Transportation
California Coastal Commission
The Nature Collective
San Diego Association of Governments

Prepared by:

Andres Deza
AZED Environmental, LLC
azed.environmental@gmail.com

Contributors:

Ross Collins, Sarah Mishek,
Dalia Ruiz, Griffin Van Amringe,
Denise Weisman & Kelsey Woldt

TABLE OF CONTENTS

SAN ELIJO LAGOON RESTORATION PROJECT

1. Introduction

This document reports the activities and findings from the post-construction monitoring surveys of San Elijo Lagoon (SEL) in Cardiff by the Sea, CA. Contracted by The Nature Collective, AZED Environmental LLC performed independent post-construction fish and invertebrate density and richness surveys within SEL for the California Coastal Commission. Surveys took place in the fall of 2021 (late September to mid-October) after the construction activities associated with the restoration effort were completed. These data will be compared to pre-construction monitoring data collected by AZED Environmental LLC as a way to measure the performance of the San Elijo Lagoon Restoration Project (SELRP) now that construction efforts have been completed.

2. Site Background

The San Elijo Lagoon Restoration Plan seeks to restore lagoon functions and services to the extent practicable following degradation associated with urbanization of the lagoon's watershed. Urbanization has accelerated freshwater storm flows, generated year-round urban run-off and increased chemical and nutrient levels within the lagoon. Hydraulic efficiency within the channels and tidal inlet of the lagoon has been reduced due to infrastructure that obstructs water flow, including Coast Highway 101, the North County Transit District railroad, Interstate 5 and a weir in the eastern lagoon basin. Subsequently, a degradation of water quality including elevated bacterial levels have led to beach closures during moderate to large storm events.

The SELRP seeks to restore tidal influence to the lagoon and enhance freshwater fluvial flows out of the lagoon. This would, in turn, restore the physical (soils and hydrology) and biological (biogeochemical/water quality and habitat) functions that have been degraded over the years.

The SELRP proposes to modify the channels and habitats throughout the entire 960-acre lagoon. These modifications are expected to improve lagoon habitats that support sensitive coastal wetland plant and animal species. Restoration is expected to take approximately three years with the restoration of each of the three lagoon basins conducted in sequence, beginning with the Central Basin, followed by the Eastern Basin and finally the Western Basin. Upon completion of restoration construction, a minimum of 10 years of post-construction biological monitoring will be initiated for all wetland habitats. A minimum of five years of monitoring will be initiated for all restored upland habitats. In addition, long-term monitoring of selected parameters will be conducted for the life of the project, defined as 50 years post-construction.

3. Survey Methods

3.1 Benthic Invertebrate Surveys

Benthic invertebrate community composition includes two components: average total density and average number of species per location surveyed. These are relative standards, which will be used to evaluate the SELRP against measurements taken at reference wetlands in Southern California, as well as potentially against pre-restoration conditions within SEL. Sampling methods at SEL and reference wetlands were based on those of the long-standing SONGS San Dieguito Wetland restoration program (Page et al, 2022).

During the post-construction monitoring period, benthic invertebrate populations were sampled in the fall months ranging from late September to mid-October in order to characterize invertebrate food resources for fish and bird populations. Eighteen (18) sampling stations were located in tidally influenced areas throughout the lagoon with nine (9) stations located in main channels and nine (9) stations located in tidal creeks (Figure 1). Of the 18 sampling stations, only historical locations that were tidally influenced prior to construction activities (2017) were incorporated into the overall monitoring summary; therefore, locations located east of the I-5 freeway are considered to be contingency locations. The methods used to assess invertebrate communities are summarized below:

- **Epifauna:** Epifauna, such as the California Horn Snail (*Cerithidea californica*) were sampled by counting live individuals in 0.25 X 0.25 m quadrats. Each of the 18 sampling stations were composed of 5 substations where epifauna was assessed. Data collection at each of the substation (18 sampling stations x 5 substation = 90 substations) consisted of counting individual epifauna present within three pairs of 0.25 X 0.25 m quadrats, which were spaced uniformly and confined to intetidal mudflat habitat. Upper, middle, and lower tidal elevations of the mudflat habitat each had their own independent pair of quadrats.

- **Infauna:** Infaunal sampling, as with epifauna sampling, was confined to the intertidal mudflats of the restored lagoon and were sampled in conjunction with the epifaunal assessment. Three sets of uniformly spaced cores (10-cm and a 3.5-cm diameter core) were collected at each substation located at the 18 sampling stations described above for epifauna. Infaunal core samples were taken at the same elevations as the epifaunal samples upper, middle, and lower tidal elevations of the mudflat habitat. Deep burrowing infauna (clams and ghost shrimp) were sampled using a 10-cm diameter core expressed into the sediment to a depth of 50 cm. The 10-cm diameter cores were sieved through a 3-mm screen in the field. All infauna collected using the 10-cm diameter cores were identified, counted and released.

- Smaller invertebrates (mostly annelids) were sampled using a 3.5-cm diameter core expressed into the sediment to a depth of 6 cm. The 3.5-cm diameter cores were preserved in the field in 10% buffered formalin and subsequently processed in the laboratory by sieving the core through a 0.5-mm mesh screen. The organisms retained by the 0.5-mm mesh were preserved in alcohol and identified to as low a taxonomic level as possible. All sorted specimens were archived for more detailed identification based on availability of resources and changes in project goals.

- **Metrics:** Density of a given station consists of the combination of all methods outlined above. For each community, density was standardized to number of individuals per 100 cm^2 for each quadrat/core and then averaged across quadrats/cores at a given sampling station. Results from each method where then summed for each given sampling station in order to obtain the overall density of invertebrates per station. Species richness was standardized to the number of unique species per sampling location (i.e. quadrats and cores combined). Additionally, unique species of macroinvertebrates captured during the seine and enclosure trapping described in section 3.2 (Fish Assemblage Surveys) are also included in the species richness metric, however, these species are not included in the invertebrate density metric.

3.2 Fish Assemblage Surveys

As with invertebrates, fish community assessment consists of two relative standards: average total fish densities and average number of fish species per location surveyed. As is the case for invertebrates, the fish community within the restored areas of the San Elijo Lagoon will be compared to reference wetlands and pre-restoration conditions. Sampling methods at SEL and reference wetlands were based on those of the long-standing SONGS San Dieguito Wetland restoration program (Page et al, 2022).

Fish habitat created by restoration was primarily comprised of shallow subtidal channels. Intertidal channels are expected to develop and can be added to the post-construction monitoring program upon their development. However, for the purposes of this monitoring program, fish monitoring in main channel / basins habitats were confined to shallow (-1.5 to -3.6 ft. NGVD) subtidal habitats. Eighteen (18) sampling stations were located in tidally influenced areas throughout the lagoon with nine (9) stations located in main channels and nine (9) stations located in tidal creeks (Figure 1). Of the 18 sampling stations, only historical locations that were tidally influenced prior to construction activities (2017) were incorporated into the overall monitoring summary; therefore, locations located east of the I-5 freeway are considered to be contingency locations. Fish measurements were collected in the fall of 2021 in order to avoid nesting activities of the federally endangered Ridgeway Rail (formerly the Light-footed Clapper Rail). These methods are summarized below:

- **Seines:** Seining at each fish sampling station was conducted by blocking each end of an approximately 7-m long channel/creek segment using blocking nets. Blocking nets consist of bagless seines approximately 15.2 m x 1.8 m with 3.2 mm mesh. Small seines (approximately 7.6 x 1.8 m with 3.2-mm mesh) were used to sample the 7-m long area blocked by the blocking nets. The small seine was hauled across the blocked area (perpendicular to the long axis of the channel) to collect the fish trapped by the blocking nets (Figure 2a). Five replicate hauls were made at each station (18 stations total) and each station was visited on 3 distinct days. Additionally, all blocking nets were examined for fish that may have become trapped in small areas that are not covered by the smaller seine net. All organisms were processed in the field to the extent possible. Fish were identified to species, counted and returned to the water immediately, whenever possible. Any macroinvertebrates collected during seine hauls were identified to major taxonomic categories and released. Fish abundance was expressed in terms of density (number per m^2) for each seining event and then averaged across 3 days of seining at any given sampling station. Species richness was standardized to the number unique species per replicate (given that 3 days of seining at a given location is equal to one replicate).

- **Enclosures:** Enclosures were employed to sample demersal, burrowing fish. An enclosure trap was used to sample primarily gobies (family Gobiidae), small, burrowing fishes that are often poorly sampled by other methods. The enclosure trap is composed of a polypropylene sheet fixed as a 1-m-tall cylinder with a 0.43 m^2 sampling area (Figure 2b). The trap is thrown away from the sampler in an attempt to minimize the startling of any fish nearby. A BINCKE net is then swept inside the trap and fish are identified by species, counted, measured for length, and released. This is repeated until no fish are caught a total of 3 times. Enclosure trapping was conducted at 5 substations (similar to invertebrate methods) located at each of the 18 sampling stations. Thus, a total of 90 enclosure samples will be collected during each monitoring effort. Density was expressed in terms of number of individuals per m^2 for each enclosure and then averaged across enclosure at a given sampling station. Species richness of demersal, burrowing fish was standardized to number of unique species per sampling station.

- **Metrics:** Density of a given station consists of the combination of all methods outlined above. For each community, density was standardized to number of individuals per m^2 for each seine/enclosure station and results from each method where then summed for each given sampling station in order to obtain the overall density of fish per station. Species richness was standardized to the number of unique species per sampling location (i.e. seines and enclosures combined).

4. Results

4.1 Benthic Invertebrate Surveys

A comprehensive list of all invertebrates identified to the species level within SEL in 2021 are listed in Table 1. Additionally, the values for invertebrate density and species richness within main channel and tidal channel habitats are summarized in Table 2. Numbers from individual stations were variable across the tidal channels with TC1, TC7 and TC8 exhibiting the most extreme values of invertebrate density. TC1 invertebrate density was approximately 50% greater than the average of the six historical sampling stations (TC 1 – 6), whereas TC7 and TC8 exhibited densities that were approximately 50% less than that same average. The individual densities from main channel stations were generally consistent and less variable than those of the tidal channels. Average invertebrate density in the main channel stations (MC1 – 6) was marginally higher than the tidal channels, driven primarily by MC3 which was notably higher than all other stations. It is interesting to note TC7 and MC9 had some of the lowest invertebrate densities, which were similar in magnitude to one another and that these stations were located in the same newly restored region of the lagoon.

As with invertebrate density, species richness within the tidal and main channels stations were variable. However, the variability within main channel stations tended to be more consistent and less variable than those of the tidal channels. It is unknown what factors are driving high variability in density and species richness at some locations.

4.2 Fish Assemblage Surveys

A comprehensive list of all fish identified to the species level within SEL in 2021 are listed in Table 3. Additionally, the values for fish density and species richness within main channel and tidal channel habitats are summarized in Table 4. Fish densities within the individual tidal channel stations were highly variable with TC3 and TC4 exhibiting the highest values of the historical sampling stations (TC 1 – 6). Fish densities within the main channel stations were also highly variable with the highest overall fish densities found in MC1. This highly elevated value can be attributed to significantly high densities of gobies during the period of monitoring. As a result, the overall average of fish density within the historical main channel stations (MC 1 – 6) was substantially higher than that of the tidal channels.

Overall, average fish species richness tended to be higher in the tidal channels (TC 1 – 6) than in the main channel stations. Location of station appears to impact richness with main channel stations closest to the mouth of the lagoon substantially higher than locations further to the east, with the exception of MC8 and MC9 which happen to be the furthest to the east of the SEL restoration project.

5. Discussion

The post-construction monitoring was conducted in order to compare fish and invertebrate densities and species richness to pre-construction values, which served as a baseline to help track trends in how the biota have responded to the restoration efforts. Post-construction data is also compared to three reference wetlands in order to assess the success of these population metrics. The reference wetlands are: Carpinteria Salt Marsh (CSM), Point Mugu Lagoon (MUL) and the Tijuana Estuary (TJE). Should metrics fail to achieve success, comparison of standards to post-restoration data and to baseline data will be useful in determining if or when adaptive management measures should be implemented.

The density and species richness of invertebrates of SEL in 2021 are summarized in Figures 3 and 4 (invertebrates), while Figure 5 lists the density of the top 5 invertebrate species observed at SEL. The density and species richness of fish of SEL in 2021 are summarized in Figures 6 and 7, while Figure 8 lists the top 5 fish species observed in SEL. Overall, the values for fish density and fish and invertebrate species richness seem to be within the range of either pre-restoration values of SEL or the range of values seen at the three-reference wetlands. However, further statistical analysis is needed to validate this statement. Unlike the other standards measured, invertebrate densities exhibited a general decline in 2021 with SEL as the lowest performing wetland. Additionally, SEL is currently below pre-restoration levels, which may require further scientific investigation as to why this phenomenon is occurring.

Appendix A – FIGURES

Figure 1: Map depicting sampling locations where fish and invertebrate surveys took place in fall of 2021

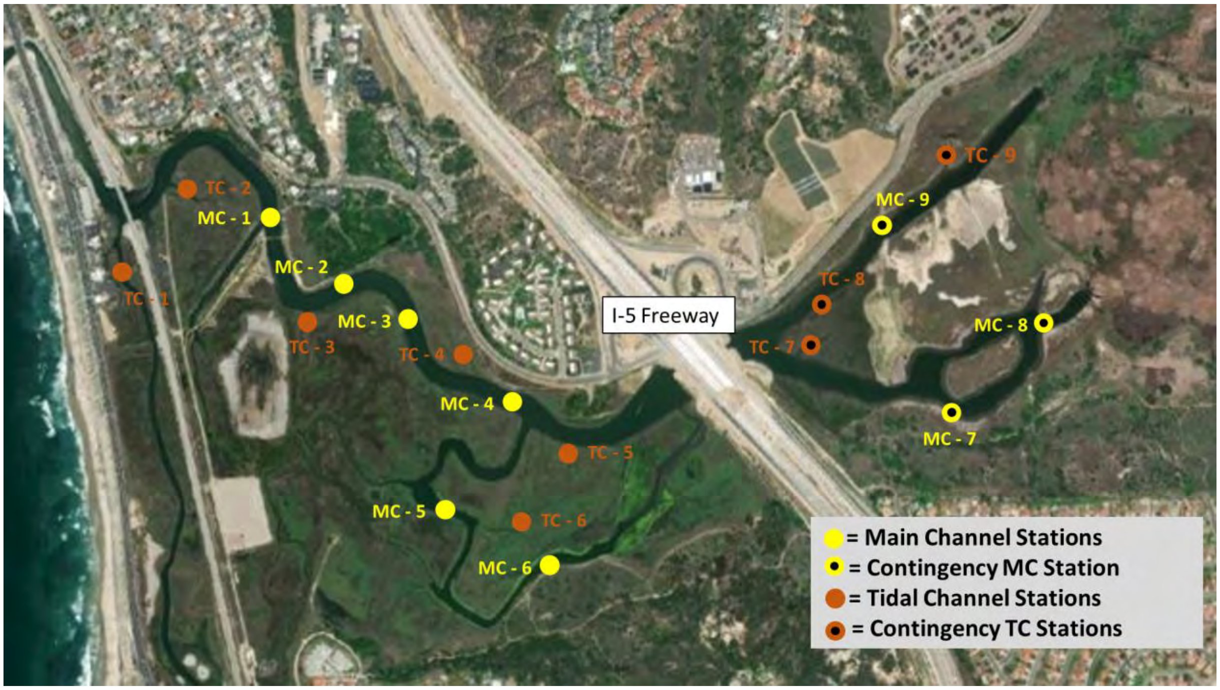


Figure 2a: (Top) Scientists using a combination of blocking nets and beach seine in order to assess fish assemblages

Figure 2b: (Bottom) Project personnel conducting infaunal core assessment as well as deploying enclosure trap with BINCKE net

Figure 3: Summary of invertebrate density data within the San Elijo Lagoon in 2021
(Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

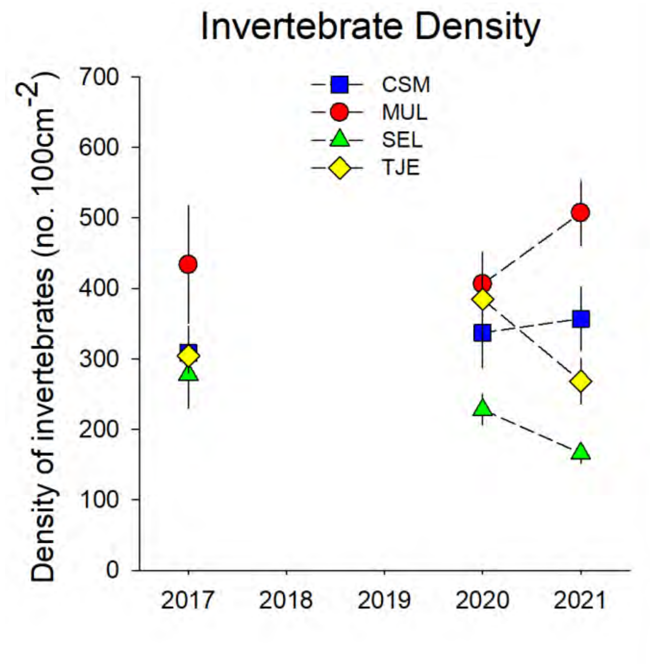


Figure 4: Summary of invertebrate species richness data within the San Elijo Lagoon in 2021 (Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

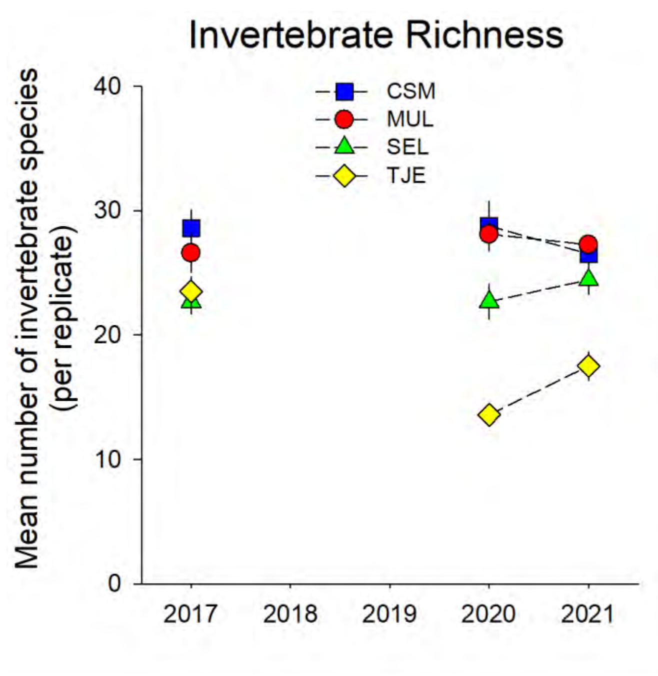


Figure 5: Summary of the top five invertebrate species present in San Elijo Lagoon in 2021 (These calculations exclude the six contingency sites visited during the 2021 sampling season)

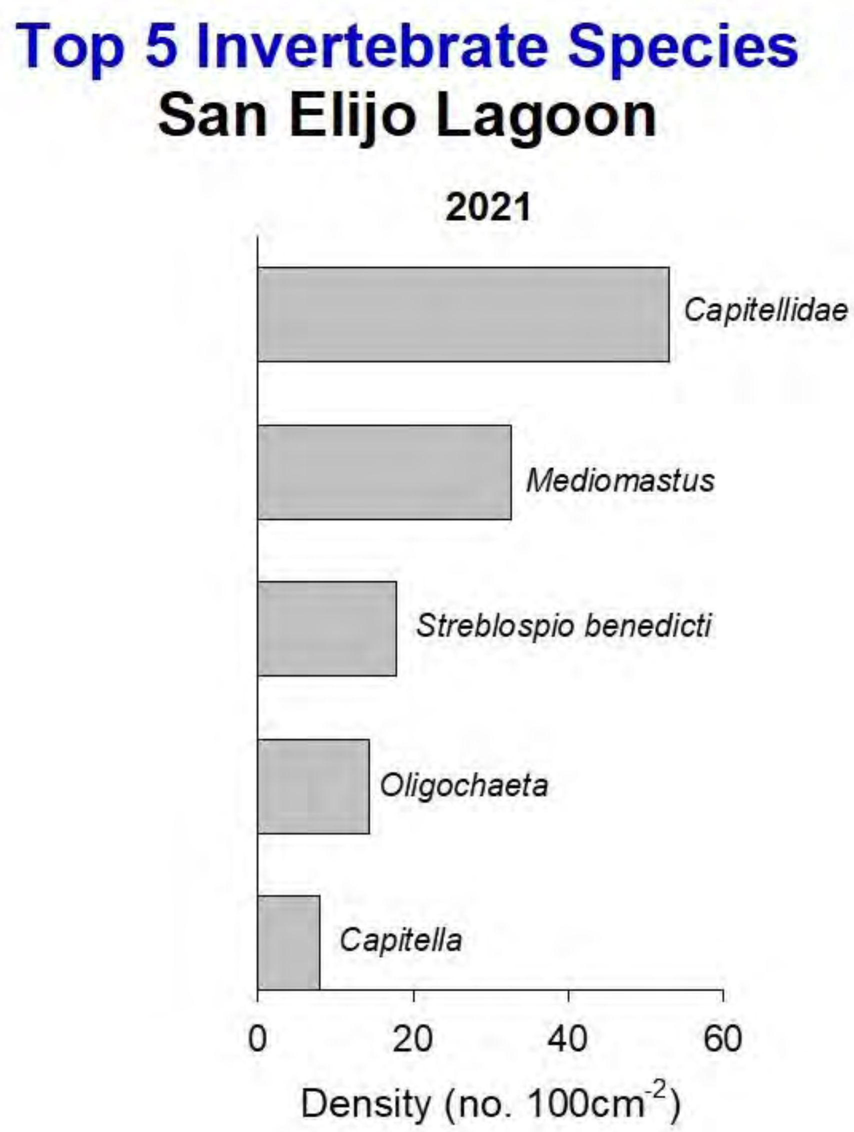


Figure 6: Summary of fish density data within the San Elijo Lagoon in 2021 (Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

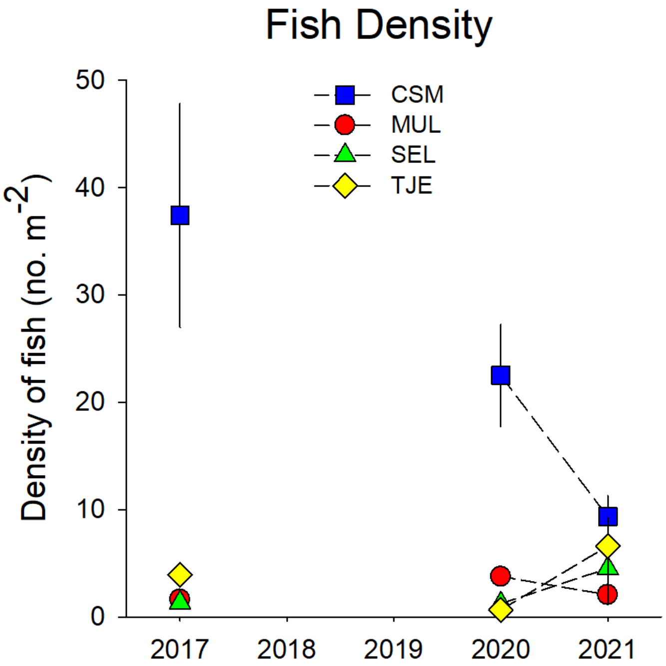


Figure 7: Summary of fish species richness data within the San Elijo Lagoon in 2021 (Combined average of main channel stations (1 – 6) & tidal channel stations (1 – 6))

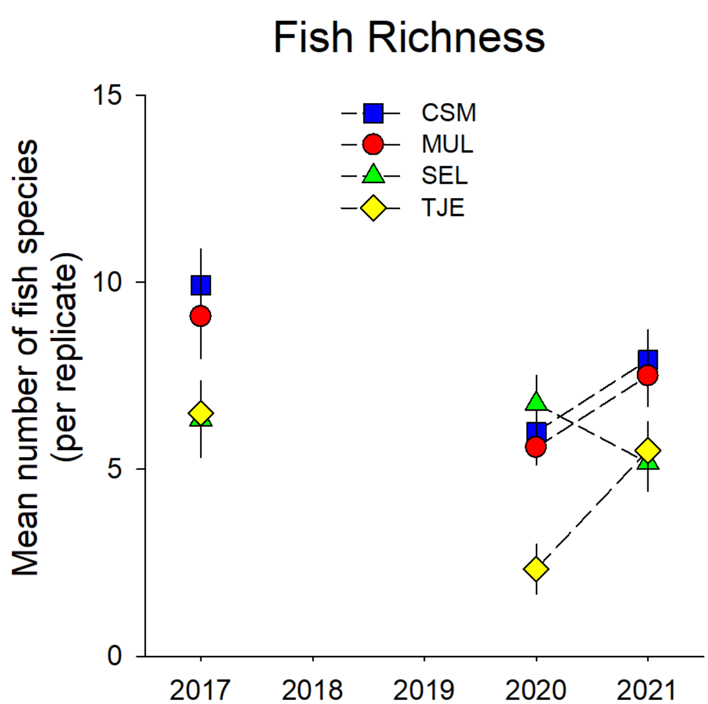
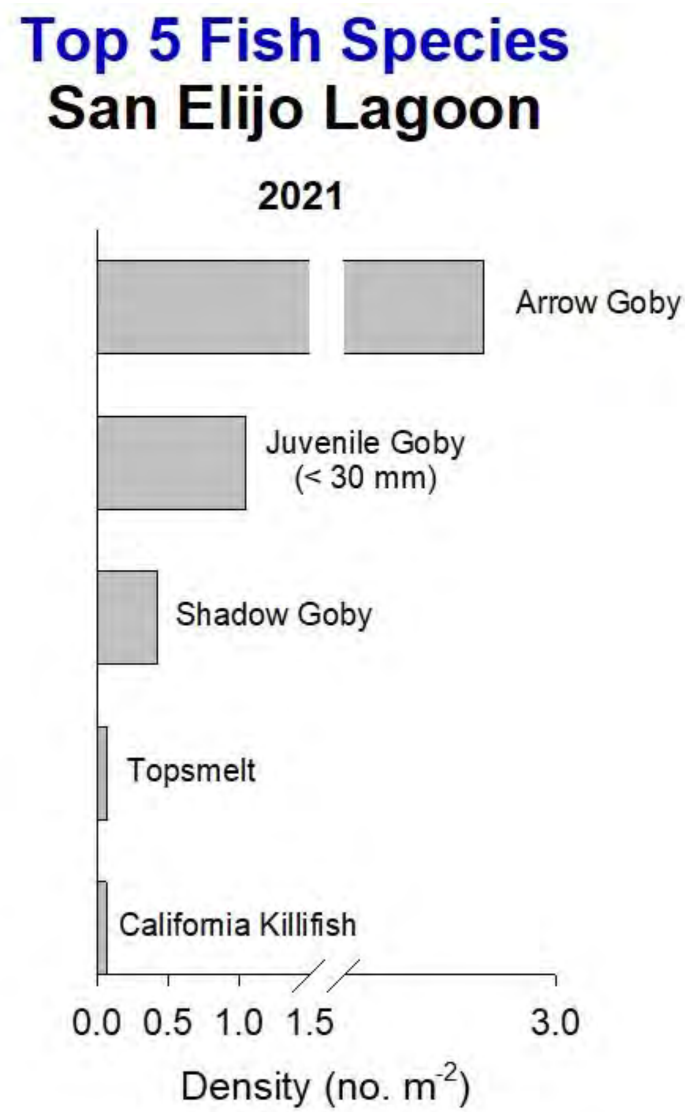


Figure 8: Summary of the top five fish species present in San Elijo Lagoon in 2021
(These calculations exclude the six contingency sites visited during the 2021 sampling season)



Appendix B – TABLES

Table 1: Invertebrate species present during post-construction assessment for 2021

GENUS NAME	SPECIES NAME	COMMON NAME (IF AVAILABLE)
Acteocina	*inculta*	Rude Barrel-Bubble Snail
Alpheus	*californiensis*	Snapping / Pistol Shrimp
Aplysia	*californica*	California Seahare
Argopecten	*aequisulcatus*	Speckled Scallop
Armandia	*brevis*	
Bulla	*gouldiana*	Cloudy Bubble Snail
Cerithidea	*californica*	California Horn Snail
Goniada	*brunnea*	
Grandidierella	*japonica*	
Hemigrapsus	*oregonenensis*	Yellow Shore Crab
Melampus	*olivaceus*	Olive Ear Snail
Monocorophium	*insidiosum*	
Musculista	*senhousia*	Asian Mussel
Nassarius	*tegula*	Covered-Lip Nassa
Navanax	*inermis*	California Aglaja
Neotrypaea	*californiensis*	Bay Ghost Shrimp
Octopus	*bimaculodies*	Two Spot Octopus
Pachygrapsus	*crassipes*	Striped Shore Crab, Lined Shore Crab
Penaeus	*californiensis*	Yellowleg Shrimp, Brown Shrimp
Portunus	*xantusli*	Swimming Crab
Prionospio	*llighti*	
Protothaca	*staminea*	
Streblospio	*benedicti*	
Tagelus	*californianus*	California Jackknife Clam
Tellina	*Carpenter*	Carpenter Tellin
Uca	*crenulata*	Fiddler Crab
Venerupis	*philippinarum*	Japanese Littleneck Clam

Table 2: Summary of post-construction invertebrate densities and species richness for each sampling station surveyed within the San Elijo Lagoon

Sampling Station	Invert Density (# per 100 cm^2)	Invert Richness (# of species per replicate)
Tidal Channel		
TC1	230.23	28
TC2	163.36	26
TC3	96.85	23
TC4	105.98	18
TC5	165.97	17
TC6	120.18	28
TC7*	68.78	19
TC8*	89.20	26
TC9*	116.34	17
Average TC (1 – 6)	147.10	23.33
Main Channel		
MC1	123.71	27
MC2	173.57	27
MC3	265.65	28
MC4	166.71	25
MC5	184.12	20
MC6	196.12	26
MC7*	229.07	22
MC8*	154.54	24
MC9*	103.10	20
Average MC (1 – 6)	184.98	25.50
MC's (1 – 6) & TC's (1 – 6) Combined Average**	166.038	24.42

*Denotes contingency sites added in 2020, which are not included in the performance metric evaluations
**Denotes overall metric used to assess performance

Table 3: Fish species present during post-construction assessment of 2021

GENUS NAME	SPECIES NAME	COMMON NAME (IF AVAILABLE)
Acanthogobius	*flavimanus*	Yellowfin Goby
Anchoa	*compressa*	Deepbody Anchovy
Atherinops	*affinis*	Topsmelt
Atherinops	*californiensis*	Jacksmelt
Clevelandia	*ios*	Arrow Goby
Ctenogobius	*sagittula*	Longtail Goby
Fundulus	*parvipinnis*	California Killifish
Gambusia	*affinis*	Mosquitofish
Gillichthys	*mirabilis*	Longjaw Mudsucker
Hypsoblennius	*gentilis*	Bay Blenny
Mugil	*cephalus*	Striped Mullet
Paralabrax	*clathratus*	Kelp Bass
Paralabrax	*maculatofasciatus*	Spotted Sand Bass
Paralichthys	*californicus*	California Halibut
Quietula	*y_cauda*	Shadow Goby
Sardinops	*sagax*	Pacific Sardine
Strongylura	*exilis*	California Needlefish
Syngnathus	*auliscus*	Barred Pipefish
Syngnathus	*leptorhynchus*	Bay Pipefish
Urolophus	*halleri*	Round Stingray

Table 4: Summary of post-construction fish densities and species richness for each sampling station surveyed within the San Elijo Lagoon

Sampling Station	Fish Density (# per m^2)	Fish Richness (# of species per replicate)
Tidal Channel		
TC1	1.82	8
TC2	0.04	3
TC3	3.04	6
TC4	3.25	7
TC5	1.50	4
TC6	0.89	7
TC7*	3.36	11
TC8*	3.40	7
TC9*	0.82	5
Average TC (1 – 6)	1.76	5.83
Main Channel		
MC1	40.64	9
MC2	1.87	8
MC3	0.51	2
MC4	0.10	3
MC5	0.48	2
MC6	0.15	3
MC7*	2.17	5
MC8*	5.85	8
MC9*	1.56	8
Average MC (1 – 6)	7.29	4.50
MC's (1 – 6) & TC's (1 – 6) Combined Average**	4.52	5.17

*Denotes contingency sites added in 2020, which are not included in the performance metric evaluations

**Denotes overall metric used to assess performance

Appendix C – REFERENCES

Page, M., S. Schroeter, and D. Reed. 2022. 2021 Annual Report of the Status of Condition A: Wetland Mitigation. San Onofre Nuclear Generating Station (SONGS) mitigation program. Submitted to the California Coastal Commission July 2022. https://marinemitigation.msi.ucsb.edu/library/2021-annual-report-wetland-mitigation

Page, M., S. Schroeter, D. Reed, and M. Steele. 2022. Monitoring Plan for the SONGS' Wetland Mitigation Project. Report to the California Coastal Commission. https://marinemitigation.msi.ucsb.edu/library/songs-wetland-mitigation-monitoring-plan-updated-may-2022