5.0 Fish

The levees surrounding Hamilton Army Airfield were breached on April 25, 2014, reconnecting San Pablo Bay to 648 acres of aquatic and terrestrial tidal marsh habitat. In doing so, a large expanse of tidal and seasonal wetland, transitional ecotone and upland environments was made accessible to colonizing resident, migratory, and special-status species. Once part of an extensive network of tidal wetlands along the western margin of San Pablo Bay, the Hamilton Wetlands Restoration Site (Hamilton) is one of the few remaining tidal wetlands, restored or natural, within the region. Biological monitoring has been conducted annually from 2015 through 2020 to understand how wildlife use the constantly evolving site. Monitoring data collected at Hamilton will have broad applications and will inform future restoration efforts within the region.

The purpose of annual fish monitoring is to document fish species richness, abundance, and distribution within Hamilton. The documentation of annual changes in fish assemblage throughout the course of the site's evolution serves as an important variable in evaluating the overall efficacy of the site in supporting aquatic species. Additionally, a monitoring dataset collected over multiple, sequential years may provide insight into how the San Francisco Bay fish community will respond to climatic shifts in precipitation, temperature, and water quality.

5.1 Methods and Conditions

5.1.1 Fish Sampling Methods

On May 7 & 8, 2020 ESA conducted the sixth consecutive year of spring fish sampling at the Hamilton Wetlands Restoration Project. **Table 5-1** lists the dates these surveys were conducted each year, along with the monitoring year each survey event was associated with. This report documents the sampling results and compares the 2020 (Year 5) survey results with previous survey years.

Table 5-1. Fish Survey Dates, All Years

Monitoring Year	Calendar Year	Dates
Year 0	2015	April 21 & 22
Year 1	2016	May 4 & 5
Year 2	2017	April 27 & 28
Year 3	2018	May 14 & 15
Year 4	2019	May 6 & 7
Year 5	2020	May 7 & 8

The same fish sampling methodology has been maintained throughout the six sampling years (2015-2020). Each annual survey utilized identical sampling equipment, occupied the same survey locations within the site, and occurred within the same seasonal window (late April to early May). The diversity of the aquatic environment within Hamilton is such that, in order to comprehensively sample the range of potential fish habitat, multiple sampling methods are required. Consistent with previous survey years, during the 2020 (Year 5) survey a 40-foot beach seine was used to sample the nearshore areas within the main and tertiary tidal channels. Seining was conducted from the berms that flank both of these channels. Since seining is a depth-limited method, an otter trawl was used to survey the in-channel habitat within the main, secondary and tertiary tidal channels. The net head line dimensions of the otter trawl are 12 feet wide by 3 feet high. Sampling locations are shown in **Figure 32**.

All fishes captured were identified to the species level when possible, measured (total length in mm), and returned to the channel in which they were caught. The sampling results represent a snapshot of the species abundance and distribution at a given point in time, and are not assumed to be representative of all species that may be present within the site.

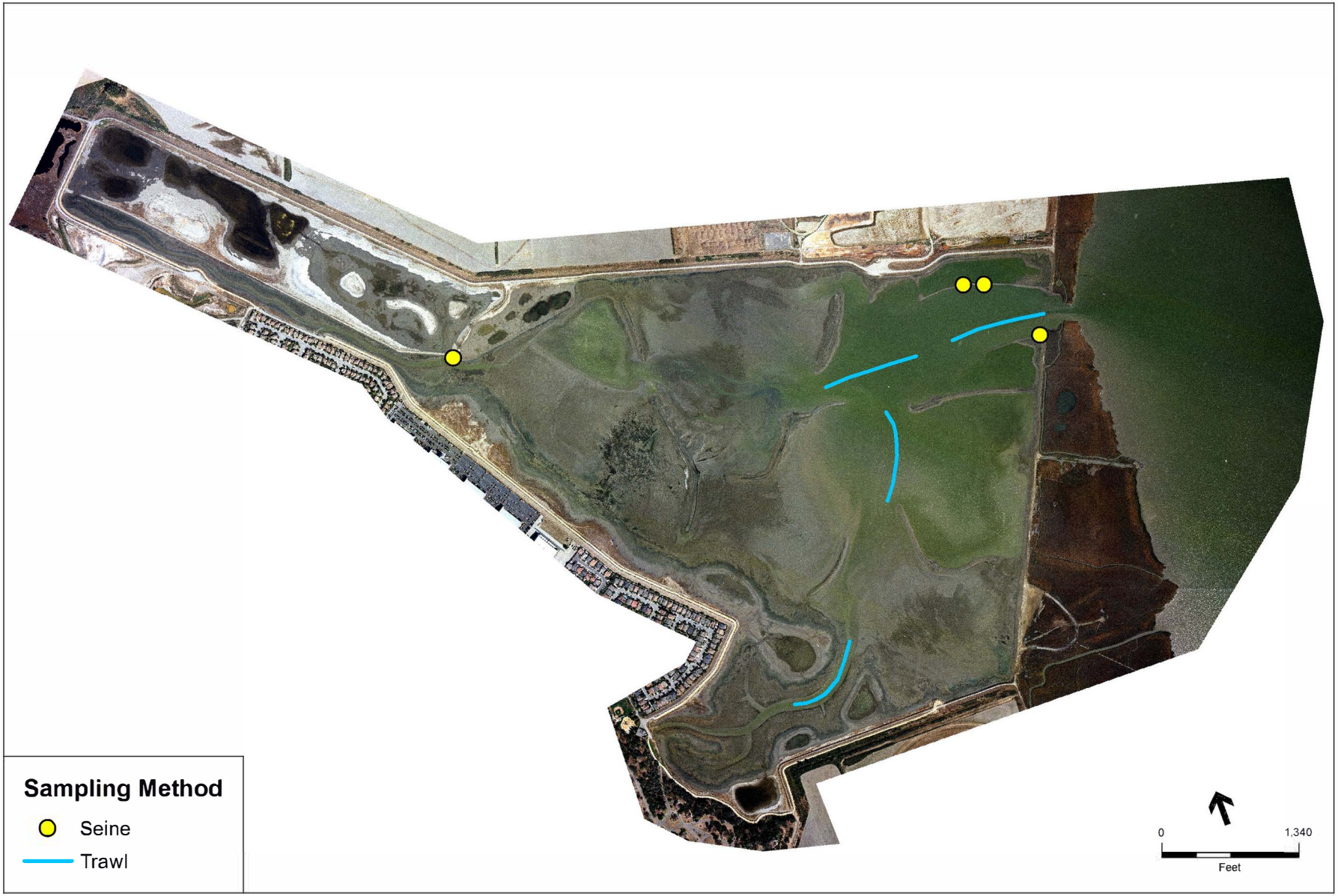
5.2 Fish Sampling Results

5.2.1 Species Composition

During the sampling event, the field team captured and identified 1,345 individual fish representing 6 families and 9 species (**Table 5-3**)

Table 5-2. Fish Species Present in the Project Site – 2020 (Year 5)

Common Name	Scientific Name	Family
Native Species		
Bay Pipefish	*Syngnathus leptorhynchus*	*Syngnathidae*
Northern Anchovy	*Engraulis mordax*	*Engraulidae*
California Halibut	*Paralichthys californicus*	*Paralichthyidae*
Pacific Staghorn Sculpin	*Leptocottus armatus*	*Cottidae*
Topsmelt	*Atherinops affinis*	*Atherinopsidae*
Non-Native Species		
Chameleon Goby	Tridentiger trigonocephalus	Gobiidae
Mississippi Silverside	Menidia beryllina	Atherinopsidae
Shimofuri Goby	Tridentiger bifasciatus	Gobiidae
Yellowfin Goby	Acanthogobius flavimanus	Gobiidae
* Chameleon, shimofuri, and shokihaze gobies are known to hybridize in the San Francisco Bay-Delta. It is unclear to what extent the gobies observed were of hybrid stock.		



SOURCE: ESA (2019)

Hamilton Wetlands Monitoring . D180888.00

Figure 32
Fish Sampling Locations

5.2.2 Site Conditions

Fish sampling was conducted in the spring in all years and timed to coincide with tidal elevations of sufficient depth to support both navigation and collection. Typically, sampling commences around a low tide, with the seining and trawling occurring on an incoming tide. Tidal elevations for the sampling dates are reported in **Table 5-2**.

Table 5-3. Predicted Tide Height During Sampling Periods, All Years

Date	Tide Height* (ft MLLW) and Time (PST)
2015 (Year 0)	
April 21, 2015	High Tide: 6.56 (02:56)
	Low Tide: -0.78 (10:13)
	High Tide: 5.17 (16:32)
	Low Tide: 1.75 (22:15)
April 22, 2015	High Tide: 6.26 (03:40)
	Low Tide: -0.59 (11:04)
	High Tide: 4.97 (17:32)
	Low Tide: 2.04 (23:12)
2016 (Year 1)	
May 4, 2016	Low Tide: 0.13 (06:13)
	High Tide: 5.25 (11:56)
	Low Tide: 0.55 (18:09)
May 5, 2016	High Tide: 6.51 (12:01)
	Low Tide: -0.43 (07:01)
	High Tide: 5.38 (12:55)
	Low Tide: 0.81 (18:56)
2017 (Year 2)	
April 27, 2017	High Tide: 6.67 (01:44)
	Low Tide: -0.88 (08:51)
	High Tide: 5.4 (15:01)
	Low Tide: 1.30 (20:49)
April 28, 2017	High Tide: 6.75 (2:25)
	Low Tide: -1.05 (9:40)
	High Tide: 5.29 (15:59)
	Low Tide: 1.63 (23:38)

Table 5-2. Predicted Tide Height During Sampling Periods, All Years (Continued)

Date	Tide Height* (ft MLLW) and Time (PST)
2018 (Year 3)	
May 14, 2018	High Tide: 6.29 (12:20)
	Low Tide: -0.34 (07:29)
	High Tide: 4.98 (13:30)
	Low Tide: 1.35 (19:16)
May 15, 2018	High Tide: 6.54 (12:55)
	Low Tide: -0.75 (08:10)
	High Tide: 5.08 (14:24)
	Low Tide: 1.63 (19:59)
2019 (Year 4)	
May 6, 2019	High Tide: 6.21 (01:56)
	Low Tide: -0.58 (09:16)
	High Tide: 4.79 (15:40)
	Low Tide: 2.02 (19:03)
May 7, 2019	High Tide: 6.24 (02:31)
	Low Tide: -0.72 (09:58)
	High Tide: 4.33 (16:73)
	Low Tide: 2.29 (19:46)
2020 (Year 5)	
May 6, 2019	High Tide: 6.21 (01:56)
	Low Tide: -0.58 (09:16)
	High Tide: 4.79 (15:40)
	Low Tide: 2.02 (19:03)
May 7, 2019	High Tide: 6.24 (02:31)
	Low Tide: -0.72 (09:58)
	High Tide: 4.33 (16:73)
	Low Tide: 2.29 (19:46)
*At Petaluma River Entrance, San Pablo Bay, California, Sta.ID 9415252	

5.2.3 Main Tidal Channel

Over the two-day sampling event, eight seine hauls and four otter trawls were conducted within the main tidal channel (**Figure 17**). Each trawl was towed for approximately 10 minutes beginning at the time the gear was fully deployed to the bottom of the channel at a speed of approximately 1-1.5 knots.

Eight fish species were captured in the main tidal channel during the survey. The species assemblage was a mix of native and non-native, however non-native individuals dominated the catch (5 native species, 3 non-native species, 294 captured fish) (**Table 5-4**). Mississippi silversides, northern anchovy, and yellowfin goby were the most abundant species captured in the main tidal channel, both nearshore and in-channel, comprising over 89% of the total catch, combined. The benthic assemblage was dominated by yellowfin goby and Pacific staghorn sculpin.

In total, three pelagic species were recorded in the main tidal channel, the most common being juvenile Mississippi silverside (68%), northern anchovy (11%), and topsmelt (2%). Five benthic species comprised the remaining fish captured in the main tidal channel, Pacific staghorn sculpin (7%), non-native gobies (yellowfin and shimofuri goby, 11% combined), California halibut (1%), and bay pipefish (<1%).

5.2.4 Secondary and Tertiary Tidal Channels

The trawl was deployed within both the secondary and tertiary channels, but because of access difficulties the seine was deployed in portions of the tertiary channel network but not in the secondary channels. Each trawl followed the same methodology as the main channel, with the tow lasting approximately 10 minutes at 1-1.5 knots. This effort was similar to past sampling years.

The secondary and tertiary channels showed similar species diversity (7 total species) as observed in the main channel, but significantly less overall abundance (61 individuals). Topsmelt were the most abundance species observed (69% of total catch). Other pelagic species included northern anchovy (5% of total catch) and Mississippi silverside (2% of total catch). Benthic species including yellowfin goby (16%), Pacific staghorn sculpin (7%) and Chameleon goby (2%) were observed within the secondary and tertiary tidal channels. Overall, trawl catches in the secondary and tertiary channels were very low in the 2020 survey.

5.3 Comparison Between Survey Years

Over the six years of sampling at the Site, the field team captured and identified 9,164 individual fish representing 22 families and 28 species (**Table 5-5**). Total catch of individuals was highest in 2015 (n = 2,843) and lowest in 2018 and 2019 (n = 697 and n = 988, respectively) (**Table 5-6**).

Table 5-4. Fishes Captured in the Main, Secondary and Tertiary Channels, 2020 (Year 5)

	Main Tidal Channel				Secondary Tidal Channels				Tertiary Tidal Channels			
		Total Length (mm)				Total Length (mm)				Total Length (mm)		
Species	**Count**	**Mean**	**Min**	**Max**	**Count**	**Mean**	**Min**	**Max**	**Count**	**Mean**	**Min**	**Max**
Seine												
Northern Anchovy	8	37	20	55	No seine in secondary tidal channel							
California Halibut	3	132	57	265								
Mississippi Silverside	198	34	8	50					15	81	68	115
Pacific Staghorn Sculpin	20	55	36	125								
Shimofuri Goby	1	70	70	70								
Topsmelt	6	27	24	30					1	32	32	32
Yellowfin Goby	29	39	31	50					10	52	30	66
Trawl												
Bay Pipefish	1	145	145	145								
California Anchovy	24	38	21	73	2	54	35	72				
Mississippi Silverside	3	30	30	30	1	30	30	30				
Yellowfin Goby	1	30	30	30	1	30	30	30	1	63	63	63

Table 5-5. Fish Species Present in the Project Site – 2015 through 2020

Common Name	Scientific Name	Family
Native Species		
Bat Ray	Myliobatis californica	Myliobatidae
Bay Pipefish	Syngnathus leptorhynchus	Syngnathidae
Northern Anchovy	Engraulis mordax	Engraulidae
California Halibut	Paralichthys californicus	Paralichthyidae
California Tonguefish	Symphurus atricaudus	Cynoglossidae
Chinook salmon	Oncorhynchus tshawytscha	Salmonidae
Diamond Turbot	Hypsopsetta guttulata	Pleuronectidae
Leopard Shark	Triakis semifasciata	Triakidae
Longjaw Mudsucker	Gillichthys mirabilis	Oxudercidae
Pacific Herring	Clupea pallasii	Clupeidae
Pacific Staghorn Sculpin	Leptocottus armatus	Cottidae
Prickly Sculpin	Cottus asper	Cottidae
Sacramento Splittail	Pogonichthys macrolepidotus	Cyprinidae
Shiner Surfperch	Cymatogaster aggregata	Embiotocidae
Speckled sanddab	Citharichthys stigmaeus	Paralichthyidae
Starry flounder	Platichthys stellatus	Pleuronectidae
Threespine Stickleback	Gasterosteus aculeatus	Gasterosteidae
Topsmelt	Atherinops affinis	Atherinopsidae
Tule perch	Hysterocarpus traskii	Embiotocidae
Walleye Surfperch	Hyperprosopon argenteum	Embiotocidae
Non-Native Species		
American Shad	Alosa sapidissima	Clupeidae
Chameleon Goby	Tridentiger trigonocephalus	Gobiidae
Mississippi Silverside	Menidia beryllina	Atherinopsidae
Rainwater Killifish	Lucania parva	Fundulidae
Shimofuri Goby	Tridentiger bifasciatus	Gobiidae
Shokihaze Goby	Tridentiger barbulatus	Gobiidae
Striped Bass	Morone saxatilis	Moronidae
Yellowfin Goby	Acanthogobius flavimanus	Gobiidae

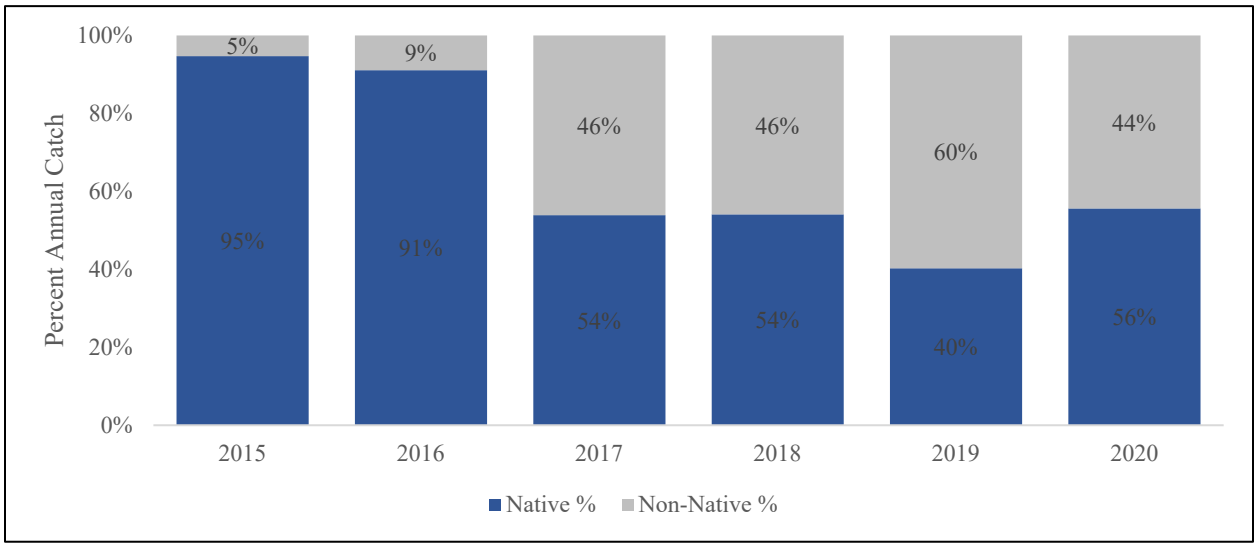
* Chameleon, shimofuri, and shokihaze gobies are known to hybridize in the San Francisco Bay-Delta. It is unclear to what extent the gobies observed were of hybrid stock.

Table 5-6. Comparison between Survey Years

Species	2015	2016	2017	2018	2019	2020
Marine						
Bat ray	3	4	0	0	0	0
Bay pipefish	3	1	0	1	0	1
Northern anchovy	2439	981	854	57	96	313
California halibut	11	10	30	4	0	3
California tonguefish	20	3	0	0	0	0
Diamond turbot	1	7	0	1	0	0
Speckled sanddab	0	0	0	1	0	0
Starry flounder	0	0	0	37	0	0
Leopard shark	12	0	0	2	0	0
Shiner surfperch	4	1	0	1	0	0
Walleye surfperch	1	0	0	0	0	0
Topsmelt	142	290	4	99	0	407
Pacific herring	0	2	1	14	0	0
Estuarine						
Chameleon goby	15	101	24	99	16	1
Pacific staghorn sculpin	45	7	63	153	263	24
Prickly sculpin	10	0	0	0	0	0
Rainwater killifish	1	3	3	3	3	0
Shimofuri goby	7	0	0	6	5	1
Shokihaze goby	119	22	65	6	21	0
Yellowfin goby	1	0	755	205	255	65
Longjaw mudsucker	0	4	0	0	0	0
Mississippi silverside	0	0	0	0	52	530
Unidentified larval goby	0	0	0	0	40	0
Anadromous						
American shad	6	0	0	0	0	0
Chinook salmon	0	0	1	0	0	0
Striped bass	2	3	2	1	3	0
Freshwater (Brackish)						
Threespine stickleback	1	11	39	7	33	0
Tule perch	0	0	0	0	1	0
Sacramento splittail	0	0	0	0	2	0
Species Origin (overall subtotal)						
Native	13	12	7	12	6	5
Non-Native	7	4	4	6	7	4
Total Numbers	**2843**	**1450**	**1841**	**697**	**792**	**1345**

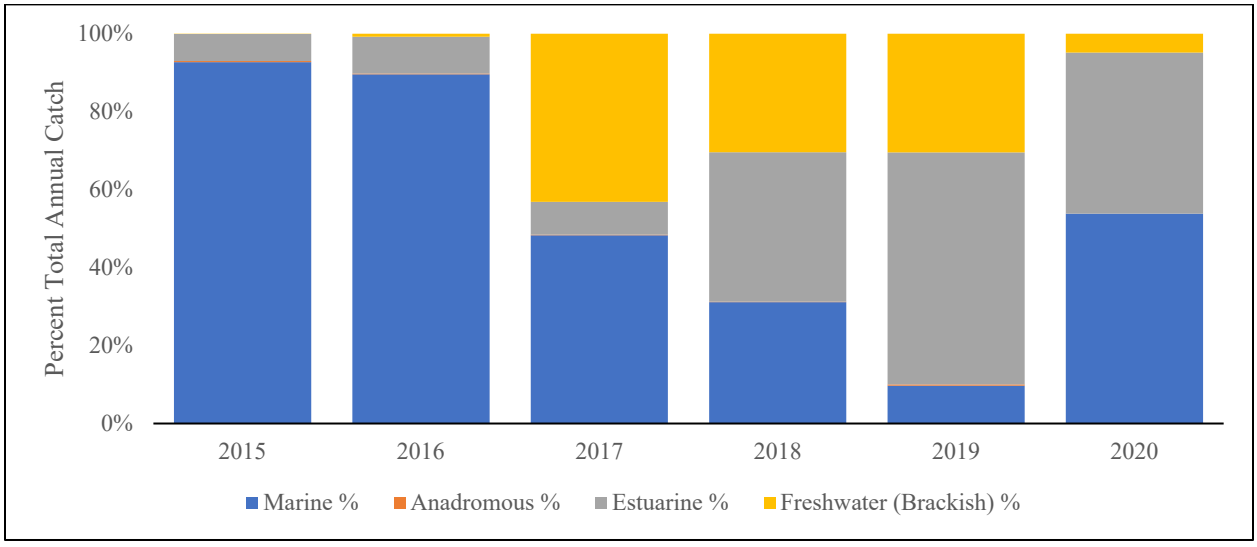
In the first two years of fish sampling at Hamilton, the majority of fish captured were native species. In 2017 and after, fish captured represented a more even split of native and non-native species (**Figure 33**).

Figure 33. Percent Catch of Native and Non-Native Fish Species



In addition to a shift from native fish dominance to a more even distribution of native and non-native species, a shift in life history composition was observed over the six years of sampling. In 2015 and 2016, catch was dominated by marine species, comprised mostly by northern anchovy in 2015 and northern Anchovy and topsmelt in 2016. In 2017 through 2019, an increase in the freshwater species, including threespine stickleback, was observed. In 2018, 2019, and 2020 invasive estuarine gobies were the most commonly encountered benthic species (**Figure 34**).

Figure 34. Percent Catch Shown by Life History



5.4 Invertebrates

Although no targeted invertebrate sampling was conducted as part of the survey effort, multiple species and age classes were observed and noted throughout the site from 2015 through 2019. During 2020 sampling however, very few shrimp were observed. In years with abundant shrimp, multiple species (Crangon franciscorum and Palaemon spp.) and age classes were observed. During these years, larval individuals were extremely abundant within all of the tidal channels. The high abundance of larval shrimp is important for the rearing larval and juvenile fish, and suggests a large amount of production at lower trophic levels. The combination of consistently high numbers of juvenile shrimp in 2015 through 2019 and domination of the fish assemblage by juveniles suggest that Hamilton is serving as an important rearing site for multiple species. It is unclear why the 2020 shrimp abundance was lower than previous years. Targeted sampling of invertebrates should be considered to further understand invertebrate trends within the site.

5.5 Discussion

The 2020 sampling season saw a small increase in the total number of fish recorded (over the preceding two years). However, overall species diversity remained low in 2020, consistent with catch observed in preceding survey year. During the 2019 survey, 988 individual fish were recorded, which increased to 1,345 individual fish in 2020. Overall, the 2020 fish catch increased from the previous two sampling years (**Table 5-6**).

Although there was a slight increase in abundance in 2020, diversity remained low and decreased from the 2019 sampling year. In 2019, 13 species were recorded (6 natives, 7 non-natives) and in 2020, only 9 species were recorded (5 natives, 4 non-natives). Native species diversity was the lowest in 2020 out of any year during the five-year survey history. However, in contrast to 2019, the 2020 surveys documented a greater number of native species relative to non-native species. The first year of sampling, 2015 had the highest abundance of individuals (n = 2,843) and highest species diversity (13 natives, 7 non-natives). 2016 was lower in abundance but similar in diversity.

Fish catch in the 2015 and 2016 surveys were dominated by marine species. From 2017 through 2019 there began to be a shift in the habitat preferences of the species observed within the site. Beginning in 2017, a greater abundance of freshwater and estuarine species, with a commensurate decrease in the abundance of marine fishes, was observed. This changing pattern was exemplified in the increased abundance of the pelagic threespine stickleback (a freshwater/brackish) and the benthic invasive gobies (estuarine species). The 2019 survey year in particular had a low abundance of marine species. Increased precipitation during the 2019 water year, driving decreased salinities within San Pablo Bay, is likely responsible for the increase in estuarine and freshwater species present in the site relative to other survey years. In 2020, an increase in marine species were observed, including topsmelt, northern anchovy, and a California halibut.

In the 2019 and 2020 survey years a dramatic increase in the non-native Mississippi silverside population was documented. Mississippi silversides are a common invasive throughout the Sacramento-Bay Delta, particularly within tidal marsh habitat. Mississippi silversides were most

abundant during the 2020 sampling year, with 530 individuals captured. In 2019, 136 individual Mississippi silverside were captured. Silverside presence within site represents a recent colonization as no individuals were captured prior to 2019.

It remains unclear whether the fluctuations in species abundance and diversity, with declines in 2018 and 2019, and an increase in 2020, is a result of typical year-to-year fluctuations in population size, or a result of changes in hydrologic conditions within the site. While the number and abundance of individual species has fluctuated annually, the ratio of native to non-native species has normalized since 2016. Even with the recent decreases in abundance/diversity, monitoring over the past six years (2015 to 2020) has documented a diverse assemblage of species throughout the tidal wetland restoration site. The geomorphic condition of the site continues to evolve into a more sinuous, channelized environment which could be contributing to this shift in abundance. Phytoplankton abundance, biomass, and transport are strongly influenced by marsh geomorphology (Sherman et al. 2017). Thus, changes in site geomorphology may drive changes in prey availability, and ultimately influence the distribution and makeup of the fish community within the site. More likely, increased precipitation (2019 was the wettest year over the entire survey period) created an increasingly freshwater site, as was observed during the 2017 water year. This decrease in regional salinity appears to be causing a shift in the assemblage from marine species to more estuarine and freshwater (brackish) species, which in turn is lowering the overall species diversity (i.e., there is a larger pool of potential marine species compared to freshwater species that could potentially occur within the site). Data from the past six years suggest that as the site continues to evolve, the overall species diversity is shifting from a more native-dominated site to one with an equal mix of native and non-native species. This shift to a more non-native dominated assemblage would be consistent with the type of fish community found within the nearby Sonoma Baylands tidal wetland restoration site. **Table 5-7** provides a comparative summary of the six years of monitoring at the Hamilton site and over a decade of surveys at the Sonoma Baylands. Overall, restoration of the Hamilton site has been enormously beneficial to native fish species and the aquatic food web as a whole. Twenty native species have been documented within Hamilton over the six survey years, more than were ever documented in the 15 years if surveys at nearby Sonoma Baylands. Hamilton has also demonstrated the ability to support species with a wide range of life history requirements and salinity tolerances depending on hydrologic conditions within the site. Importantly, Hamilton has maintained its function as a nursery for juvenile native fish species, an important historic role for tidal marshes in the San Francisco Bay-Delta.

Table 5-7. Comparison Between Restoration Sites

Species	Hamilton Wetlands 2015 – 2019	Sonoma Baylands 1999 - 2014
Native Species		
Northern anchovy	X	X
Pacific herring	X	X
Topsmelt	X	X
Bay pipefish	X	X
Three-spined stickleback	X	X
Staghorn sculpin	X	X
Prickly sculpin	X	X
Longjaw mudsucker	X	X
Diamond turbot	X	X
Starry flounder	X	X
Shiner surfperch	X	
Walleye surfperch	X	
Bat ray	X	
Leopard shark	X	
California halibut	X	
California tonguefish	X	
Chinook salmon	X	
Speckled sanddab	X	
Tule perch	X	
Sacramento splittail	X	X
Longfin smelt		X
English sole		X
Arrow goby		X
Introduced Species		
Striped bass	X	X
American shad	X	X
Rainwater killifish	X	X
Shokihaze goby	X	X
Shimofuri goby	X	X
Chameleon goby	X	X
Yellowfin goby	X	X
Mississippi silverside	X	X
Brown bullhead		X