4 Results

4.1 Fish

A total of 4,859 individual fish representing 27 species were encountered and identified during the fish community and entrainment sampling events in 2010 (Table 4). Entrained fish encountered comprised 15 of the 27 species and accounted for 10.95% (532) of the total number of fish from all 2010 sampling. Fish community monitoring accounted for the rest of the fish. The fish entrained were encountered while assessing 7.23% of the overall slurry output of the dredge. Extrapolated totals for each entrained species observed are also presented in the results section of this document.

Of the 27 species encountered, 18 were introduced and 9 were native. The three most abundant species in order of abundance were threadfin shad, white catfish, and striped bass. All three species are non-native and accounted for 73.44% of the total in 2010. This year marks the first in which threadfin shad were more commonly encountered than white catfish. Native fishes made up 4.81% of the total number of fish encountered, an increase over the 0.92% from 2009. The increase was largely due to high numbers of entrained river lamprey in the SRDWSC.

Lampreys were the most common native fish encountered during 2010 sampling (n =156), all of which were encountered during entrainment sampling. Several of the individuals were clearly identified as lamprey, but eluded capture and escaped through the entrainment screen. Lampreys not escaping through the entrainment screen were collected for field and laboratory morphological examination to determine species.

Table 4. Ranked List of Fish Encountered from All Sites for All 2010 Monitoring Combined

Rank	Percent	No.	Common Name	Genus	Species Name	Origin	Demersal/ Pelagic	Rule: Status*
1	50.85	2471	threadfin shad	*Dorosoma*	*petenense*	Introduced	pelagic	
2	13.93	677	white catfish	*Ameiurus*	*catus*	Introduced	demersal	
3	8.66	421	striped bass	*Morone*	*saxatilis*	Introduced	pelagic	
4	6.22	302	American shad	*Alosa*	*sapidissima*	Introduced	pelagic	
5	6.19	301	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced	demersal	
6	3.89	189	channel catfish	*Ictalurus*	*punctatus*	Introduced	demersal	
7	3.21	156	river lamprey *	*Lampetra*	*ayresii*	Native	demersal	DFG: SSC
8	2.41	117	wakasagi	*Hypomesus*	*nipponensis*	Introduced	pelagic	
9	0.91	44	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced	demersal	
10	0.88	43	redear sunfish	*Lepomis*	*microlophus*	Introduced	pelagic	
11	0.66	32	bluegill	*Lepomis*	*macrochirus*	Introduced	pelagic	
12	0.56	27	starry flounder	*Platichthys*	*stellatus*	Native	demersal	MSA: MEC with EFH
13	0.49	24	Sacramento splittail	*Pogonichthys*	*macrolepidotus*	Native	pelagic	AFS: VU. IUCN: EN DFG: SSC
14	0.27	13	delta smelt	*Hypomesus*	*transpacificus*	Native	pelagic	ESA: endangered; DFG : EN
15	0.16	8	tule perch	*Hysterocarpus*	*traskii*	Native	pelagic	
15	0.16	8	brown bullhead	*Ameiurus*	*nebulosus*	Introduced	demersal	
16	0.10	5	bigscale logperch	*Percina*	*macrolepida*	Introduced	demersal	
16	0.10	5	Shokihaze goby	*Tridentiger*	*barbatus*	Introduced	demersal	
17	0.08	4	black crappie	*Pomoxis*	*nigromaculatus*	Introduced	pelagic	
18	0.04	2	green sturgeon	*Acipenser*	*medirostris*	Native	demersal	ESA: threatened UCN: NT
18	0.04	2	white sturgeon	*Acipenser*	*transmontanus*	Native	demersal	IUCN: LC
18	0.04	2	Inland silverside	*Menidia*	*beryllina*	Introduced	pelagic	
18	0.04	2	warmouth	*Lepomis*	*gulosus*	Introduced	pelagic	
19	0.02	1	Pacific staghorn sculpin	*Leptocottus*	*armatus*	Native	demersal	
19	0.02	1	prickly sculpin	*Cottus*	*asper*	Native	demersal	
19	0.02	1	blue catfish	*Ictalurus*	*furcatus*	Introduced	demersal	
19	0.02	1	golden shiner	*Notemigonus*	*crysoleucas*	Introduced	pelagic	
TOTAL		4,859						

Percent Native = 4.81 Number Native Species = 9 (potentially 10**) Introduced Species = 18

NOTE:: 5 wakasagi, 1 shimofuri goby, 1 yellowfin goby, and1 striped bass were dead prior to encounter; 2 American shad, 2 striped bass, 3 channel catfish and 3 white catfish were injured prior to encounter; capture disposition of 1 splittail, 1 threadfin shad, and 1 white catfish undetermined.

**river lamprey numbers include 70 specimens that were observed on entrainment screen but could not be captured; though most likely river lamprey, one or more of these 70 un-examined/unidentified specimens had potential to be Pacific, rather than river, lamprey.

* Status Key (IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded 24 February 2011.)

ESA: federal Endangered Species Act	FPT Federally proposed for listing as Threatened; FT Federally listed as Threatened
CESA: California Endangered Species Act	ST State-listed as Threatened; SE State-listed as Endangered
CDFG: California Dept of Fish and Game	SSC Species of Special Concern
MSA: Magnuson-Stevens Sustainable Fisheries Act	MEC-EFH Marine Estuarine Composite – designated Essential Fish Habitat
IUCN: International Union for Conservation of Nature	EN Endangered; NT Near Threatened; LC Least Concern
AFS: American Fisheries Society	TH Threatened; VU vulnerable

One golden shiner (*Notemigonus crysoleucas*) represented the only new fish species encountered in 2010 that had not been encountered in prior years' monitoring. The total number of species encountered during 2006 through 2010 monitoring is now thirty-four. Moyle (2002) describes approximately 55 species currently inhabiting the Delta, though not all 55 could be expected to utilize the deeper water channel habitat of the project area.

The most commonly encountered fish during fish community monitoring was the threadfin shad (57.07%). However, the most common fish encountered in entrainment monitoring was the shimofuri goby (46.43%). Shimofuri goby comprised only 1.25% of the trawl monitoring samples.

Introduced species of fishes have dominated the fish community and entrainment samples from almost all locations during all years of this study (2006-2010). The top six species encountered in 2010 are all introduced and together comprise 89.74% of the individual fish encountered. SRDWSC and lower SDWSC reaches continue to have higher percentages of native fish than upper SDWSC reaches, while upper SDWSC reaches have the highest diversity of species.

4.1.1 Special-status Species

Nine species of native fish were encountered in 2010. Two green sturgeon were encountered during community sampling, the only green sturgeon encountered since 2006. Longfin smelt were encountered in 2006, 2007, and 2008, and delta smelt were encountered in 2007 and 2008, but neither was encountered in 2009. Delta smelt but not longfin smelt were encountered in 2010. High numbers of river lamprey and Sacramento splittail were encountered in 2010 relative to previous years. All of the delta smelt encountered in 2010 were from the S-31 portion of the SRDWSC. CNDDB status information for all special status species encountered in 2010 is provided in Table 4. Additional status and life history information for these species and all other special-status species that use the DWSCs during some or all of their life cycle is provided in Appendix A. Table 30 provides location and additional information for encounters with listed species. White sturgeon data is also provided in Table 30 as surrogate for green sturgeon due to the dearth of green sturgeon encounters.

Starry flounder was the thirteenth most commonly encountered fish species in 2010 and the second most common native fish. Starry flounder is a special-status species under the Magnuson-Stevens Fishery Conservation and Management Act, as an estuarine composite species with essential fish habitat within the project area as described in Amendment 11 of the Pacific Coast Groundfish Fisheries Management Plan (PFMC 1998).

4.2 Entrainment Monitoring

Entrainment monitoring was conducted with the mobile entrainment screen at all sites in 2009 and 2010, dispensing with the sample cell method due to its inability to sample significant amounts of the dredge's output of dredged material (slurry). A total of 532 fish were encountered using the entrainment screen in 2010. The percent of dredge output monitored varied from 5.38 to 22.31 among the sites and averaged 7.23 overall. Table 5 presents a ranked list of all fish encountered during 2010 entrainment monitoring, while Tables 6 through 9 present the list of entrained fish segregated by river channel and by dredge reach. Shimofuri goby were the most commonly entrained species in 2010, comprising 46.64%of the entrained individuals. River lamprey and white catfish were second and third respectively. Other than lamprey, six delta smelt and one Sacramento splittail were other native species entrained in 2010. The six delta smelt encountered during 2010 entrainment monitoring in the Man-made portion of the SRDWSC were the first ESA listed species encountered during entrainment monitoring since implementation of the program in 2006. Shimofuri goby were also the most commonly entrained fish in 2009. In 2008, channel catfish and white catfish were first and second, while shimofuri goby were a distant seventh, comprising only 2.16% of all fish encountered. River lamprey have been among the top five species entrained since 2008, comprising 5.40% of entrained individuals in 2008, 4.71% in 2009, and 29.32% in 2010.

Table 5. Ranked List of Fish Encountered in All Sites During 2010 Entrainment Monitoring

Rank	Percent	Number	Common Name	Genus	Species Name	Origin
1	46.43	247	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced
2	16.17	86	river lamprey	*Lampetra*	*ayresii*	Native
3	13.35	71	white catfish	*Ameiurus*	*catus*	Introduced
4	13.16	70	lamprey, unidentified	*all*	*spp.*	Native
5	3.57	19	channel catfish	*Ictalurus*	*punctatus*	Introduced
6	2.07	11	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced
7	1.88	10	wakasagi	*Hypomesus*	*nipponensis*	Introduced
8	1.13	6	delta smelt	*Hypomesus*	*transpacificus*	Native
9	0.75	4	striped bass	*Morone*	*saxatilis*	Introduced
10	0.38	2	brown bullhead	*Ameiurus*	*nebulosus*	Introduced
10	0.38	2	American shad	*Alosa*	*sapidissima*	Introduced
11	0.19	1	splittail	*Pogonichthys*	*macrolepidotus*	Native
11	0.19	1	bluegill	*Lepomis*	*macrochirus*	Introduced
11	0.19	1	Shokihaze goby	*Tridentiger*	*barbatus*	Introduced
11	0.19	1	threadfin shad	*Dorosoma*	*petenense*	Introduced
TOTAL		532				

Percent Native = 30.83 Number Native Species = 3 (potentially 4) Introduced Species = 12

NOTE: total numbers include 2 wakasagi, 1 yellowfin goby and 1 shimofuri goby encountered dead prior to entrainment. Disposition prior to encounter could not be determined for 1 white catfish and the single threadfin shad.

4.2.1 Sacramento River Deep Water Ship Channel

Four different dredge reaches in the SRDWSC were dredged and monitored in 2010, two in the man-made portion of the channel and two in the natural portion downstream of the man-made portion. Table 6 provides the details of the fish entrained at all four sites combined, and Tables 7a-d provides details of the entrained fish at each site.

Table 6. Summary Results of Entrainment Monitoring Events for All SRDWSC Locations

Rank	Percent	Number	Common Name	Origin
1	55.63	242	shimofuri goby	Introduced
2	19.31	84	river lamprey	Native
3	16.09	70	lamprey, unidentified species *	Native
3	2.30	10	wakasagi	Introduced
4	2.07	9	white catfish	Introduced
5	1.61	7	yellowfin goby	Introduced
6	1.38	6	delta smelt	Native
7	0.46	2	American shad	Introduced
7	0.46	2	striped bass	Introduced
8	0.23	1	Sacramento splittail	Native
8	0.23	1	channel catfish	Introduced
8	0.23	1	brown bullhead	Introduced
TOTAL		435		

Percent Native = 37.01 Number Native Species = 3 (potentially 4*) Introduced Species = 9

NOTE: numbers include 2 wakasagi, 1 yellowfin goby and 1 shimofuri goby in dead condition prior to entrainment; the capture condition of the single splittail encountered could not be determined (only rear 1/3 body collected);

* Likely river lamprey, not available for closer morphometric examination.

The top three species entrained in the SRDWSC were shimofuri goby, river and unidentified lamprey (treated as a single species) and wakasagi, in order of abundance. River lamprey were much more abundant than in previous years. Only a single wakasagi had been previously encountered while conducting entrainment monitoring (in 2009). The six delta smelt and single Sacramento splittail entrained in 2010 were the first of these species observed to be entrained since inception of monitoring. The splittail was a large adult that appeared to have been sliced in half during the dredging process (Figure 10).

Figure 10. Examples of Fish Injured by Dredge Activity

Man-made Channel 1 Dredge Reach – S-31 A DMP Site:

This year was the first year since the inception of fish monitoring that this reach had been dredged. It is associated with the S-31 DMP site and is downstream of the Man-made Channel reaches dredged in 2009 and 2008 that also utilized the S-31 DMP site. Substrates in this portion of the SRDWSC were primarily silty sand. Approximately 3,826,650 gallons, or 6.26%, of the total slurry volume dredged at this site was sampled during the five entrainment monitoring events conducted there. A total of 61 fish were observed during entrainment monitoring at this dredge reach (Table 7a). Lamprey have been entrained at this DMP every year since 2008. Wakasagi were entrained at this DMP in 2009 and 2010.

Table 7a. Summary Results of Entrainment Events for Man-made Channel 1 Reach — S-31 A DMP

Rank	Percent	Number	Common Name	Origin
1	86.89	53	shimofuri goby	Introduced
2	3.28	2	white catfish	Introduced
2	3.28	2	wakasagi	Introduced
2	3.28	2	yellowfin goby	Introduced
3	1.64	1	lamprey, unidentified species *	Native
3	1.64	1	brown bullhead	Introduced
TOTAL		61		

Percent Native = 1.64 Number Native Species = 1 Introduced Species = 5

NOTE: 1 of the 2 yellowfin goby was dead prior to encounter with dredge and entrainment sampling gear. * Likely a river lamprey

Man-made Channel 2 Dredge Reach – S-31B and C DMP Sites:

This Man-made Channel reach associated with the S-31 DMP site is downstream of the 2010 Dredge Reach 1. This year was the first that this reach has been dredged since fish monitoring was instituted. Substrates were mostly silty-sand, interspersed with areas of gravel and mud. Approximately 13,102,096 gallons (5.59%) of the total slurry volume dredged at this site was sampled during the nine entrainment events conducted there. A total of 227 fish were observed during entrainment monitoring at this reach (Table 7b). Most importantly, six delta smelt and a single adult Sacramento splittail were documented from this reach. Native lamprey and the introduced smelt (wakasagi) were also entrained at this location.

Table7b. Summary Results of Entrainment Events for Man-made Channel 2 Reach — S-31 B & C DMP

Rank	Percent	Number	Common Name	Origin
1	82.82	188	shimofuri goby	Introduced
2	3.52	8	wakasagi	Introduced
3	3.08	7	white catfish	Introduced
3	3.08	7	river lamprey *	Native
4	2.64	6	delta smelt	Native
5	2.20	5	yellowfin goby	Introduced
6	0.88	2	striped bass	Introduced
6	0.88	2	American shad	Introduced
7	0.44	1	splittail	Native
7	0.44	1	channel catfish	Introduced
TOTAL		227		

Percent Native = 6.16 Number Native Species = 3 * Introduced Species = 7

NOTE: 2 wakasagi and 1 shimofuri considered dead prior to encounter with dredge/entrainment sampling gear; the disposition of the single splittail (adult) encountered was assumed alive prior to entrainment with severed rear 1/3 of fish documented.

* 2 of total river lamprey were specimens not identified to species, and were likely river lamprey.

Rio Vista Bridge Dredge Reach – Sandy Beach DMP Site:

This natural channel reach upstream of the Rio Vista Bridge was dredged for the first time in 2010. The Sandy Beach DMP was last used in 2008, but the dredge reach was further downstream. Substrates were mostly sand, with pockets of silty mud rich with organic debris (decomposing plant material and peat). Approximately 748,566 gallons or 10.83% of the total slurry volume dredged at this reach was sampled during the single entrainment event conducted there. A total of 69 fish, all lamprey, were observed during entrainment monitoring at this reach (Table 7c).

Table 7c. Summary Results of Entrainment Events for Rio Vista Bridge Reach – Sandy Beach DMP

Rank	Percent	Number	Common Name	Origin
1	59.42	41	river lamprey	Native
2	40.58	28	lamprey, unidentified species *	Native
TOTAL		69		

Percent Native = 100

NOTE: * the 28 unidentified lamprey slipped through entrainment screen mesh prior to further examination; these lamprey were likely river lamprey.

Rio Vista South Dredge Reach – Sandy Beach DMP Site:

This natural channel reach downstream of the Rio Vista Bridge was dredged for the first time in 2010. The Sandy Beach DMP was last used in 2008, but the dredge reach was further downstream. Substrates were mostly sandy, with pockets of silty mud rich with organic debris (decomposing plant material and peat). Approximately 1,844,416 gallons (7.46%) of the total slurry volume dredged was sampled during the single entrainment event at this reach. A total of 81 fish, 80 lamprey and one shimofuri goby were observed during entrainment monitoring at this reach (Table 7d)

Table 7d. Summary Results of Entrainment Events for Rio Vista South Reach – Sandy Beach DMP

Rank	Percent	Number	Common Name	Origin
1	50.62	41	river lamprey	Native
2	48.15	39	lamprey, unidentified species *	Native
3	1.23	1	shimofuri goby	Introduced
TOTAL		81		

Percent Native = 98.77 Number Native Species = 1 * Introduced Species = 1

* NOTE: the 39 unidentified lamprey were observed on entrainment sampling screen prior to escape through mesh. It is likely these were also river lamprey. However, further examination of these specimens for species identification was not possible.

4.2.2 Stockton Deep Water Ship Channel Locations

Seven different dredge reaches in the SDWSC were monitored for entrainment of fish in 2010. Table 8 provides the details of the fish entrained at all reaches combined. Tables 9a through 9d provide details of the fish entrained at each monitored reach where more than one fish was observed to be entrained. Entrainment monitoring was not conducted at Spud Island and Antioch Bridge – West as dredge operations at these reaches were of very short duration (less than 24 hours). Fish community monitoring was conducted during the period of active dredging at these two reaches. Fish were not encountered during entrainment monitoring events at Antioch Bridge – East, nor from Lower Bradford Dredge Reach (see Table 10). At the Light 19 Dredge Reach only one fish, a shimofuri goby, was encountered while entrainment sampling during the two events conducted in 2010. Higher numbers of fish were encountered in the upper SDWSC reaches during both fish community and entrainment monitoring. The top three species entrained from the SDWSC, in order of abundance, were white catfish, channel catfish, and shimofuri goby. Only two native fish, both river lamprey, were encountered during entrainment monitoring at all SDWSC reaches in 2010.

Table 8. Summary Results of Entrainment Monitoring Events for All SDWSC Locations

Rank	Percent	Number	Common Name	Origin
1	63.92	62	white catfish	Introduced
2	18.56	18	channel catfish	Introduced
3	5.15	5	shimofuri goby	Introduced
4	4.12	4	yellowfin goby	Introduced
5	2.06	2	river lamprey	Native
5	2.06	2	striped bass	Introduced
6	1.03	1	threadfin shad	Introduced
6	1.03	1	Shokihaze goby	Introduced
6	1.03	1	brown bullhead	Introduced
6	1.03	1	bluegill	Introduced
TOTAL		97		

Percent Native = 2.06 Number Native Species = 1 Introduced Species = 9

NOTE: disposition prior to encounter could not be determined for 1 white catfish and 1 threadfin shad specimen.

Scour Pond Dredge Reach – Scour Pond DMP Site:

Reaches using the Scour Pond DMP were dredged for the first time in 2008 and again in 2009. The reach dredged in 2010 was in the lower portion of the same reach dredged in 2008, downstream of the reach dredged in 2009. Substrates in this reach of the lower SDWSC were primarily sand. Approximately 6,425,055 gallons of slurry or 10.83% of the total slurry volume dredged at this reach was sampled during four entrainment sampling events conducted there. A total of 4 fish, 3 yellowfin goby and 1 Shokihaze goby were encountered during entrainment sampling at this reach in 2010 (Table 9a). Eleven entrainment sampling events were conducted in 2008 with a total result of 13 fish collected, including native lamprey. No entrainment monitoring was conducted at this reach in 2009. Low numbers of fish were encountered in trawl surveys of this area in all years as well.

Table 9a. Summary Results of Entrainment Events for Scour Pond Reach – Scour Pond DMP

Rank	Percent	Number	Common Name	Origin
1	75	3	yellowfin goby	Introduced
2	25	1	Shokihaze goby	Introduced
TOTAL		4		

Percent Native = 0 Number Native Species = 0 Introduced Species = 2

Upper Bradford Dredge Reach – Bradford Island DMP Site:

Reaches using the Bradford Island DMP were dredged in 2008, though the reaches dredged in 2010 were further upstream than those dredged in 2008. Substrates in this reach were silty sand. Approximately 3,400,340 gallons or 8.1% of the total slurry volume dredged at this reach was sampled during two entrainment sampling events conducted there. A total of 3 fish, two river lamprey and a brown bullhead, were encountered during entrainment sampling at this reach during 2010 (Table 9b). No fish were encountered during entrainment monitoring at this DMP in 2008. Few fish have been encountered during fish community sampling of Bradford Island dredge reaches as well, though in 2010, two green sturgeon were encountered.

Table 9b. Summary Results of Entrainment Events for Upper Bradford Reach – Bradford Island DMP

Rank	Percent	Number	Common Name	Origin
1	67	2	river lamprey	Native
2	33	1	brown bullhead	Introduced
TOTAL		3		

Percent Native = 67 Number Native Species = 1 Introduced Species = 1

Upper Roberts Island Dredge Reach – Roberts 1 DMP Site:

Fish community monitoring was conducted at this dredge reach for first time in 2009; though the 2009 reach was slightly downstream from the reach dredged in 2010. Substrates from this dredge reach were primarily mud. Approximately 1,855,394 gallons, or 22.31% of the total slurry volume produced, was sampled during the two entrainment surveys conducted at this reach. A total of Fifty-one fish were encountered during entrainment sampling at this reach during 2010 (Table 9c). All of the entrained fish were introduced species, dominated by white catfish that comprised 80.39% of the individuals encountered.

Table 9c. Summary Results of Entrainment Events for Upper Roberts Reach – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	80.39	41	white catfish	Introduced
2	9.80	5	channel catfish	Introduced
3	3.92	2	striped bass	Introduced
4	1.96	1	yellowfin goby	Introduced
4	1.96	1	shimofuri goby	Introduced
4	1.96	1	bluegill	Introduced
TOTAL		51		

Percent Native = 0 Number Native Species = 0 Introduced Species = 6

Turning Basin Dredge Reach– Roberts 1 DMP Site:

The section of the Turning Basin reach dredged in 2010 was just downstream of the reach dredged in 2009. It is adjacent to the East Complex of the Port of Stockton. Substrates from this dredge reach were primarily mud and silty sand, with relatively high levels of organic debris and trash. Approximately 3,461,143 gallons, or 5.78% of the total slurry volume produced at this site, was sampled during the four entrainment surveys conducted at this reach. A total of thirty-eight fish were encountered during entrainment sampling at this reach in 2010, dominated by white catfish and channel catfish which respectively comprised 55.26% and 34.21% of the individuals encountered.

Table 9d. Summary Results of Entrainment Events for Turning Basin Reach – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	55.26	21	white catfish	Introduced
2	34.21	13	channel catfish	Introduced
3	7.89	3	shimofuri goby	Introduced
4	2.63	1	threadfin shad	Introduced
TOTAL		38		

Percent Native = 0 Number Native Species = 0 Introduced Species = 4

NOTE: Capture disposition undetermined for 1 white catfish and the single threadfin shad encountered.

Extrapolated entrainment totals for each species encountered in each dredge reach where sampling occurred enables estimation of overall numbers of fish entrained at these locations. These extrapolations simply project the number of individuals encountered in each dredge reach for the proportion sampled of total material dredged in that reach. The totals were estimated without regard to the high likelihood of fish density patchiness throughout the length of each dredge reach, simply assuming that the fish density (or entrainment likelihood) for each species for the entire reach was the same as that in the sub-set of material assessed from that reach. Table 10 displays the extrapolated counts for each species for each dredge reach in 2010.

Based on these extrapolations, a total of approximately 7,828 fish may have been entrained by dredging operations at the DMP sites where entrainment sampling occurred in 2010. The estimates do not include totals from the few DMP sites where sampling did not take place due to the brevity of dredging operations. The total may therefore underestimate the overall number of fish entrained.

Table 10. Extrapolated Results of Fish Entrainment Events for All 2010 Dredge Reach Locations

River	SRDWSC				SDWSC									
Dredge Reach	MM Channel 1	MM Channel 2	Rio Vista Bridge	Rio Vista South	Scour	Antioch Bridge W	Antioch Bridge E	Light 19	Lower Bradford	Upper Bradford	Upper Roberts	Turning Basin	Spud Island	
DMP Site	S-31	S-31	Sandy Beach	Sandy Beach	Scour	Scour	Scour	McMormack	Bradford	Bradford	Roberts 1	Roberts 1	Roberts 2	
Sampled Percent	6.25	5.59	10.83	7.46	10.83	8.40	(trawl only)	9.76	8.76	8.10	22.31	5.78	(trawl only)	TOTAL
shimofuri goby	848	3363		13				10			4	52		4,290
river lamprey		89	379	550						25				1,043
lamprey, undet.	16	36	359	523										934
white catfish	32	125									184	363		704
wakasagi	32	143												175
channel catfish		18									22	225		265
yellowfin goby	32	89			28						4			153
delta smelt		107												107
striped bass		36									9			45
American shad		36												36
brown bullhead	16									12				28
splittail		18												18
bluegill											4			4
shokihaze goby					9									9
threadfin shad												17		17
TOTAL	976	4,060	738	1,086	37	0	(trawl only)	10	0	37	227	657	(trawl only)	7,828

Shaded rows indicate introduced fish species

4.3 Fish Community Monitoring

The following sub-sections describe the 2010 fish community sampling results by shipping channel and individual dredge reach. Table 11 provides the numbers of fish encountered from all locations. Table 12 summarizes the effort data for 2010 fish community sampling and provides a description of relative fish density at the trawl locations through the CPUE, metrically expressed as the number of fish collected per linear meter towed along the bottom.

The 2010 data are compared with previous years when relevant. Caution should be applied, though, when comparing the data across years as timing, exact locations (dredge reaches), effort, and environmental factors (such as rainfall and delta outflow) have all varied significantly during each year since 2006. In 2009, only 10.7% of the locations (river miles) had been previously dredged since monitoring began in 2006. In 2010, none of the reaches were the same as those dredged in 2009. Nonetheless, although the exact dredging reaches and trawl locations have changed from year to year, DMP sites have been fairly consistent. Due to this consistency, general comparisons within DMP sites can be made.

In 2010, non-native species accounted for 98.37% of the individual fish encountered during community monitoring, similar to previous years. Notably, Threadfin shad were encountered more frequently than white catfish for the first time since monitoring began and green sturgeon were encountered for the first time since 2006. Threatened or endangered fish encountered during trawling included 7 delta smelt and 2 green sturgeon. Higher numbers of Sacramento splittail were encountered in 2010 than in previous years. A single golden shiner was encountered at the Turning Basin dredge reach in the SDWSC, the first of its species to be encountered by this monitoring program. Species encountered previously, but absent in 2010 were: Sacramento blackfish, Sacramento pikeminnow, white crappie, longfin smelt, common carp, and largemouth bass. Shokihaze goby were present, but much less abundant than in previous years.

Table 11. Ranked Catch of Fish from All Sites during 2010 Fish Community Monitoring (Trawl Surveys)

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	57.07	2,470	threadfin shad	*Dorosoma*	*petenense*	Introduced
2	14.00	606	white catfish	*Ameiurus*	*catus*	Introduced
3	9.66	418	striped bass	*Morone*	*saxatilis*	Introduced
4	6.93	300	American shad	*Alosa*	*sapidissima*	Introduced
5	3.93	170	channel catfish	*Ictalurus*	*punctatus*	Introduced
6	2.47	107	wakasagi	*Hypomesus*	*nipponensis*	Introduced
7	1.25	54	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced
8	0.99	43	redear sunfish	*Lepomis*	*microlophus*	Introduced
9	0.76	33	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced
10	0.72	31	bluegill	*Lepomis*	*macrochirus*	Introduced
11	0.62	27	starry flounder	*Platichthys*	*stellatus*	Native
12	0.53	23	splittail	*Pogonichthys*	*macrolepidotus*	Native
13	0.18	8	tule perch	*Hysterocarpus*	*traskii*	Native
14	0.16	7	delta smelt	*Hypomesus*	*transpacificus*	Native
15	0.14	6	brown bullhead	*Ameiurus*	*nebulosus*	Introduced
16	0.12	5	bigscale logperch	*Percina*	*macrolepida*	Introduced
17	0.09	4	black crappie	*Pomoxis*	*nigromaculatus*	Introduced
17	0.09	4	Shokihaze goby	*Tridentiger*	*barbatus*	Introduced
18	0.05	2	white sturgeon	*Acipenser*	*transmontanus*	Native
18	0.05	2	green sturgeon	*Acipenser*	*medirostris*	Native
18	0.05	2	warmouth	*Lepomis*	*gulosus*	Introduced
18	0.05	2	Inland silverside	*Menidia*	*beryllina*	Introduced
19	0.02	1	blue catfish	*Ictalurus*	*furcatus*	Introduced
19	0.02	1	golden shiner	*Notemigonus*	*crysoleucas*	Introduced
19	0.02	1	prickly sculpin	*Cottus*	*asper*	Native
19	0.02	1	Pacific staghorn sculpin	*Leptocottus*	*armatus*	Native
TOTAL		4,328				

NOTE: of the total numbers 3 wakasagi and1 striped bass were dead prior to encounter; 2 American shad, 2 striped bass, 3 channel catfish and 3 white catfish were injured prior to encountering gear.

The CPUE in 2010 was higher at the Stockton Turning Basin reach than at all other fish community sampling locations (Figure 11). The upper reaches of the SDWSC have yielded the highest CPUE metrics during all years since 2006. These high CPUEs reflect the relatively large numbers of introduced white and channel catfish, threadfin shad, striped bass, American shad, and sunfish species compared with other locations where fish community sampling has occurred. A relatively high diversity of species has been encountered in these locations as well. Fish CPUE in 2010 was also relatively higher in the upper reaches of the SDWSC than at other locations during previous years due to high numbers of threadfin shad.

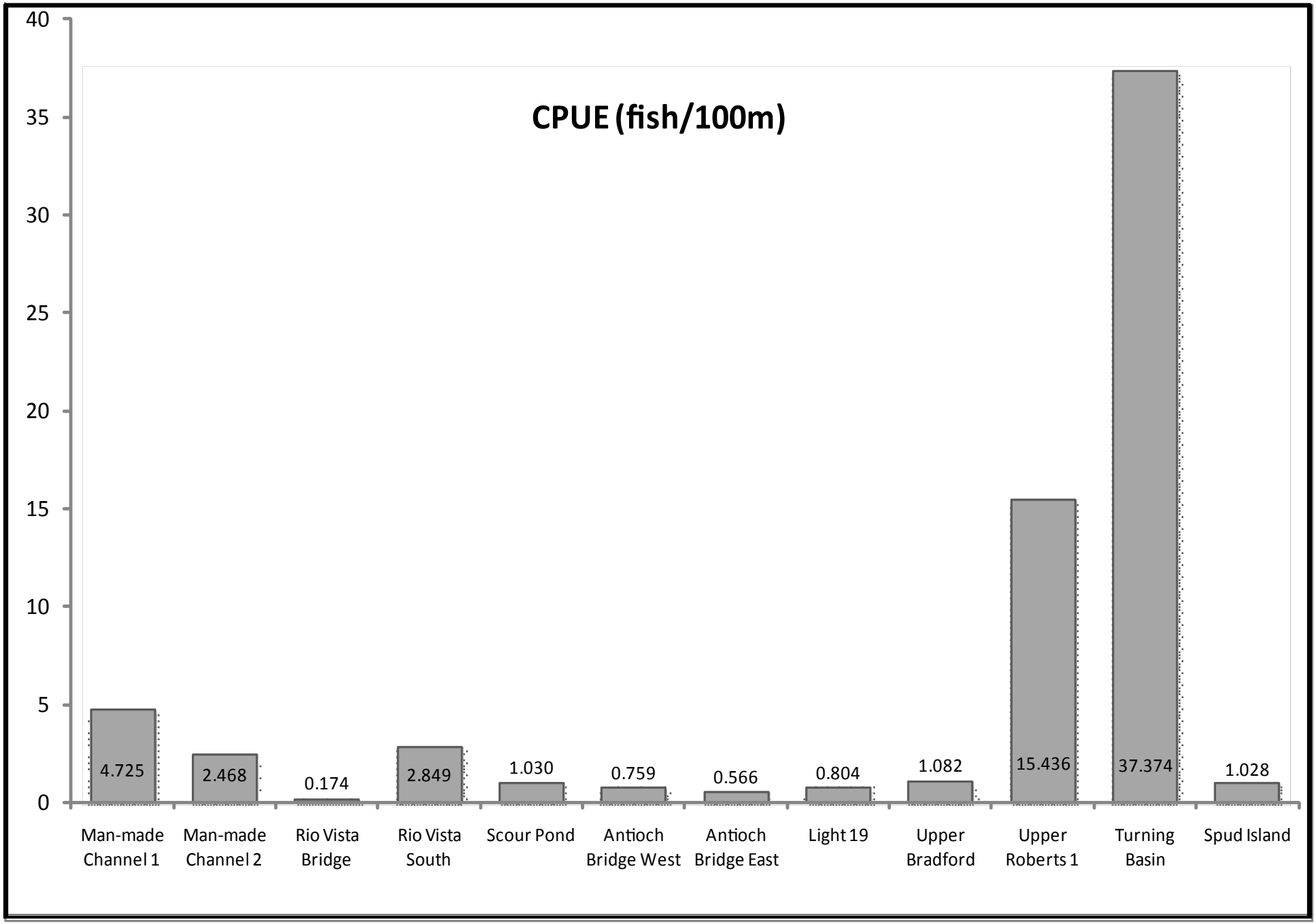


Figure 11. Fish Community Sampling CPUE Comparison Chart

Table 12. Summary Catch and Effort Data for Fish Encountered in Trawl Surveys

River Channel	Dredge Reach	CPUE Trawl Tows	CPUE Trawl Distance (m)	Vol. Sampled (m^3)	Percent Trawl Effort	No. of Fish	Percent of Total Catch	CPUE (fish/m)
SRDWSC	MM Channel 1	21	7,640	60,356	12.05	361	8.34	0.047
SRDWSC	MM Channel 2	41	14,910	117,789	23.51	368	8.50	0.025
SRDWSC	Rio Vista Bridge	5	1,720	13,588	2.71	3	0.07	0.002
SRDWSC	Rio Vista S	10	3,019	23,850	4.76	86	1.99	0.028
SDWSC	Scour Pond	19	9,710	76,709	15.31	100	2.31	0.010
SDWSC	Antioch Bridge W	5	2,240	17,696	3.53	17	0.39	0.008
SDWSC	Antioch Bridge E	5	2,120	16,748	3.34	12	0.28	0.006
SDWSC	Light 19	10	5,100	40,290	8.04	41	0.95	0.008
SDWSC	Upper Bradford	9	4,530	35,787	7.14	49	1.13	0.011
SDWSC	Upper Roberts	4	1,490	11,771	2.35	230	5.32	0.154
SDWSC	Turning Basin	18	8,110	64,069	12.79	3,031	70.05	0.374
SDWSC	Spud Island	5	2,820	22,278	4.45	29	0.67	0.010
TOTAL:		152	63,409	500,931		4,327		

4.3.1 Sacramento River Shipping Channel Locations

Table 13 provides the combined data for all fish encountered during fish community monitoring at all SRDWSC locations during 2010. Four different dredge reaches were monitored, two in the man-made portion of the shipping channel and two in the natural channel near Rio Vista. Fifteen species were encountered, five native and ten introduced. As in previous years, introduced species dominated in terms of individual fish encountered. White catfish was the most common, comprising 58.68%, followed by wakasagi and striped bass, comprising 13.08% and 7.21% respectively. Introduced species made up the top six species in terms of relative abundance, together comprising 92.05% of the individual fish encountered. Native fish comprised 5.13% of the individual fish encountered. Sacramento splittail were abundant relative to previous years. Starry flounder were also fairly abundant in the natural channel reaches. Delta smelt, prickly sculpin and white sturgeon were the other native species encountered, though in lower numbers. Delta smelt, Inland silverside, prickly sculpin and wakasagi were four species encountered in the SRDWSC that were not also encountered in the SDWSC.

Table 13. Summary Results of Fish Encountered in All SRDWSC Trawl Surveys

Rank	Percent	Number	Common Name	Origin
1	58.68	480	white catfish	Introduced
2	13.08	107	wakasagi	Introduced
3	7.21	59	striped bass	Introduced
4	6.48	53	shimofuri goby	Introduced
5	4.28	35	American shad	Introduced
6	2.32	19	channel catfish	Introduced
7	2.20	18	splittail	Native
8	1.83	15	starry flounder	Native
8	1.83	15	yellowfin goby	Introduced
9	0.86	7	delta smelt	Native
10	0.37	3	brown bullhead	Introduced
11	0.24	2	threadfin shad	Introduced
11	0.24	2	Inland silverside	Introduced
12	0.12	1	Shokihaze goby	Introduced
12	0.12	1	prickly sculpin	Native
12	0.12	1	white sturgeon	Native
TOTAL:		818		

Percent Native = 5.13 Number Native Species = 5 Number Introduced Species = 11

NOTE: of the total numbers 3 wakasagi, 2 white catfish and 1 striped bass were dead prior to encounter with sampling gear

Man-made Channel Dredge Reach 1 – S-31 A DMP Site:

Twenty-one successful trawl tows were conducted at this reach located between river mile 33.71 and 34.85 during five days of monitoring between September 20 and 28, 2010. The 2010 reach location, west of Clarksburg, was upstream of the reach dredged in 2009. The downstream 0.11 miles of the 2010 reach was previously dredged in 2008. In 2009, sampling was conducted on August 28, while in 2008 the monitoring was conducted from August 1 to 7. Figure 12 displays the trawl survey locations and DMP site for this dredge reach in 2010. Table 14a provides the abundance data for the fish encountered during fish community monitoring at this reach. In 2010, eleven species of fish represented by 361 individuals were encountered. All but one of the fish species was introduced. Two of the seven delta smelt encountered were from this site. White catfish were the most abundant fish, as they were at S-31 reaches in all previous years. In 2010, white catfish comprised 78.67% of the individual fish. Wakasagi and shimofuri goby were the second and third most abundant fish as they were in 2008 and 2009, comprising 8.03% and 5.54% respectively. The CPUE (described as total number of fish per meter trawled) in 2010 was 0.047; in 2009 it was 0.005, and 0.025 in 2008. This reach had the third highest CPUE among all reaches in 2010, and first amongst SRDWSC reaches.

Table 14a. Summary Results of Trawl Surveys in the Man-made Channel 1 Reach – S-31 A DMP

Rank	Percent	Number	Common Name	Origin
1	78.67	284	white catfish	Introduced
2	8.03	29	wakasagi	Introduced
3	5.54	20	shimofuri goby	Introduced
4	3.05	11	American shad	Introduced
5	1.94	7	striped bass	Introduced
6	0.83	3	brown bullhead	Introduced
7	0.55	2	delta smelt	Native
7	0.55	2	Inland silverside	Introduced
8	0.28	1	yellowfin goby	Introduced
8	0.28	1	threadfin shad	Introduced
8	0.28	1	channel catfish	Introduced
TOTAL		361		

Percent Native = 0.55 Number Native Species = 1 Introduced Species = 10
NOTE: Total numbers reflect 1 wakasagi and 1 striped bass encountered by gear as dead.

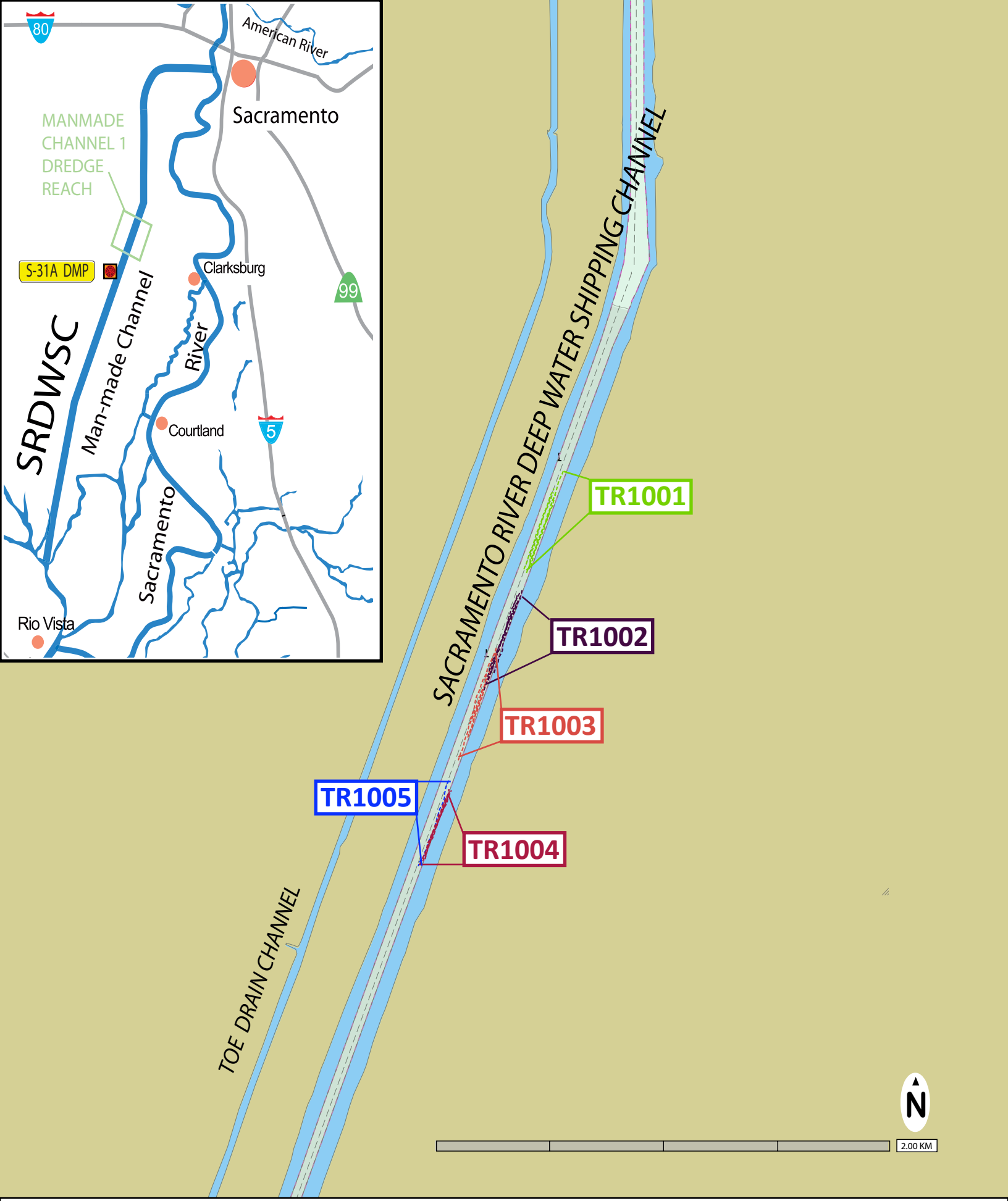


Figure 12. 2010 Fish Community Surveys for Man-Made Channel 1 Dredge Reach

Map Projection 1 : 10,000

Man-made Channel Dredge Reach 2 – S-31B and S-31C DMP Sites:

Forty-one successful trawl tows were conducted at this reach located west of Courtland, between river mile 27.95 and 30.87, during nine days of monitoring between September 29 and October 16, 2010. Fish community monitoring was conducted in this portion of the SRDWSC for the first time in 2010. Figure 13 displays the trawl survey locations and DMP site for this dredge reach. Table 14b provides the abundance data for the fish encountered during fish community monitoring at this reach. In 2010, eleven species of fish represented by a total of 368 individuals were encountered. White catfish, wakasagi, and shimofuri goby were the most abundant fish at this reach as at Man-made Channel 1, though wakasagi were encountered more frequently at Man-made Channel 2. They comprised 52.72%, 21.20%, and 8.15% respectively. Five delta smelt and a single white sturgeon were the only native fish encountered at this reach. This white sturgeon was one of only two encountered at all reaches in 2010. The CPUE was 0.025, fifth highest among all reaches in 2010, and third amongst SRDWSC sites.

Table 14b. Summary Results of Trawl Surveys in the Man-made Channel 2 Reach – S-31B & C DMP

Rank	Percent	Number	Common Name	Origin
1	52.72	194	white catfish	Introduced
2	21.20	78	wakasagi	Introduced
3	8.15	30	shimofuri goby	Introduced
4	5.43	20	American shad	Introduced
5	4.89	18	channel catfish	Introduced
6	3.53	13	striped bass	Introduced
7	2.17	8	yellowfin goby	Introduced
8	1.36	5	delta smelt	Native
9	0.27	1	white sturgeon	Native
9	0.27	1	threadfin shad	Introduced
TOTAL		368		

Percent Native = 1.63 Number Native Species = 2 Introduced Species = 8

NOTE: total numbers reflect gear encountering 2 dead wakasagi and 2 injured white catfish.

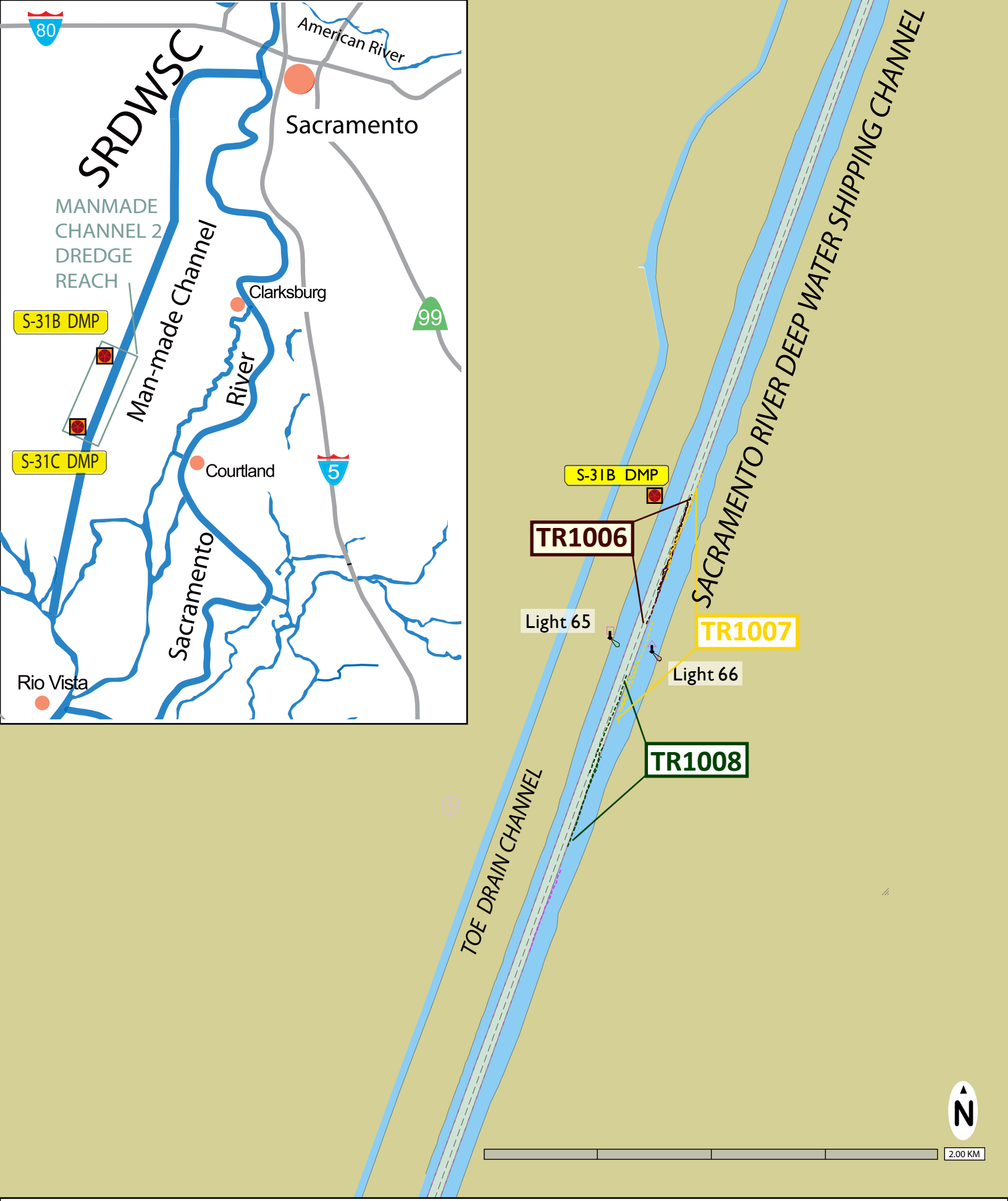


Figure 13a. 2010 Fish Community Surveys for Man-Made Channel 2 Dredge Reach North

Map Projection 1 : 10,000

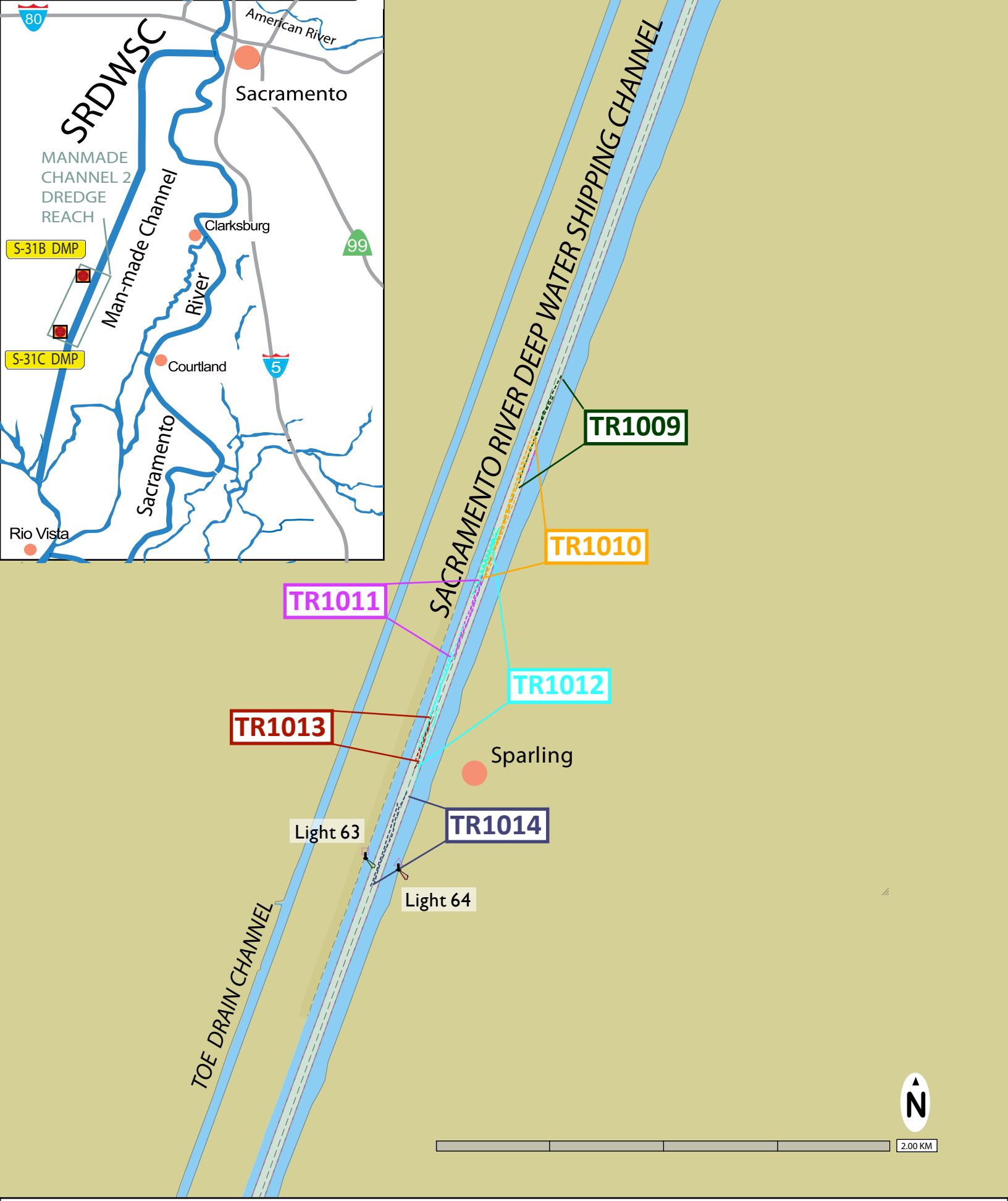


Figure 13b. 2010 Fish Community Surveys for Man-Made Channel 2 Dredge Reach South

Map Projection 1 : 10,000

Rio Vista Bridge Dredge Reach – Sandy Beach DMP Site:

Five successful trawl tows were conducted during one day of fish community monitoring at this reach on October 19, 2010. This reach is located between river mile 12.52 and 12.78 in the natural portion of the SRDWSC just upstream of the Rio Vista Bridge. Fish community monitoring was conducted in this portion of the channel for the first time in 2010. Figure 14 displays the trawl survey locations and DMP site for this dredge reach. Table 14c provides abundance data for fish encountered. Three species of fish represented by only 3 individuals were encountered at this site. Two of the three fish were natives, starry flounder and prickly sculpin. The CPUE was 0.002, lowest of all reaches monitored in 2010.

Table 14c. Summary Results of Trawl Surveys in the Rio Vista Bridge Reach – Sandy Beach DMP

Rank	Percent	Number	Common Name	Origin
1	33	1	starry flounder	Native
1	33	1	prickly sculpin	Native
1	33	1	American shad	Introduced
TOTAL		3		

Native Percent = 67 Number Native Species = 2 Introduced Species = 1

Rio Vista South Dredge Reach – Sandy Beach DMP Site:

Ten successful trawl tows were conducted at this reach during two days of monitoring on Oct 21 and 23, 2010. This reach is located between river mile 9.81 and 10.04 in the natural portion of the channel downstream of the Rio Vista Bridge. Fish community monitoring was also conducted in this portion of the SRDWSC in 2006. In 2006, monitoring was conducted from December 7 to December 11 when three days of monitoring occurred. Table 14d provides the abundance data for the fish encountered during fish community monitoring and Figure 15 displays the trawl survey locations. Eight species of fish, represented by 86 individuals were encountered. Striped bass, Sacramento splittail and starry flounder were the three most abundant species, comprising 45.35%, 20.93% and 16.28% of the fish encountered. White catfish was the only species among the eight species encountered in 2010 that was not also encountered in 2006. Tule perch, longfin smelt, and white sturgeon were encountered in 2006, but not in 2010. CPUE at this reach was 0.028 in 2010 and 0.02 in 2006. This site had the fourth highest CPUE in 2010 among all locations, and was second highest within SRDWSC reaches.

Table 14d. Summary Results of Trawl Surveys in the Rio Vista South Reach – Sandy Beach DMP

Rank	Percent	Number	Common Name	Origin
1	45.35	39	striped bass	Introduced
2	20.93	18	splittail	Native
3	16.28	14	starry flounder	Native
4	6.98	6	yellowfin goby	Introduced
5	3.49	3	shimofuri goby	Introduced
5	3.49	3	American shad	Introduced
6	2.33	2	white catfish	Introduced
7	1.16	1	Shokihaze goby	Introduced
TOTAL		86		

Native Percent = 37.21 Number Native Species = 2 Introduced Species = 6

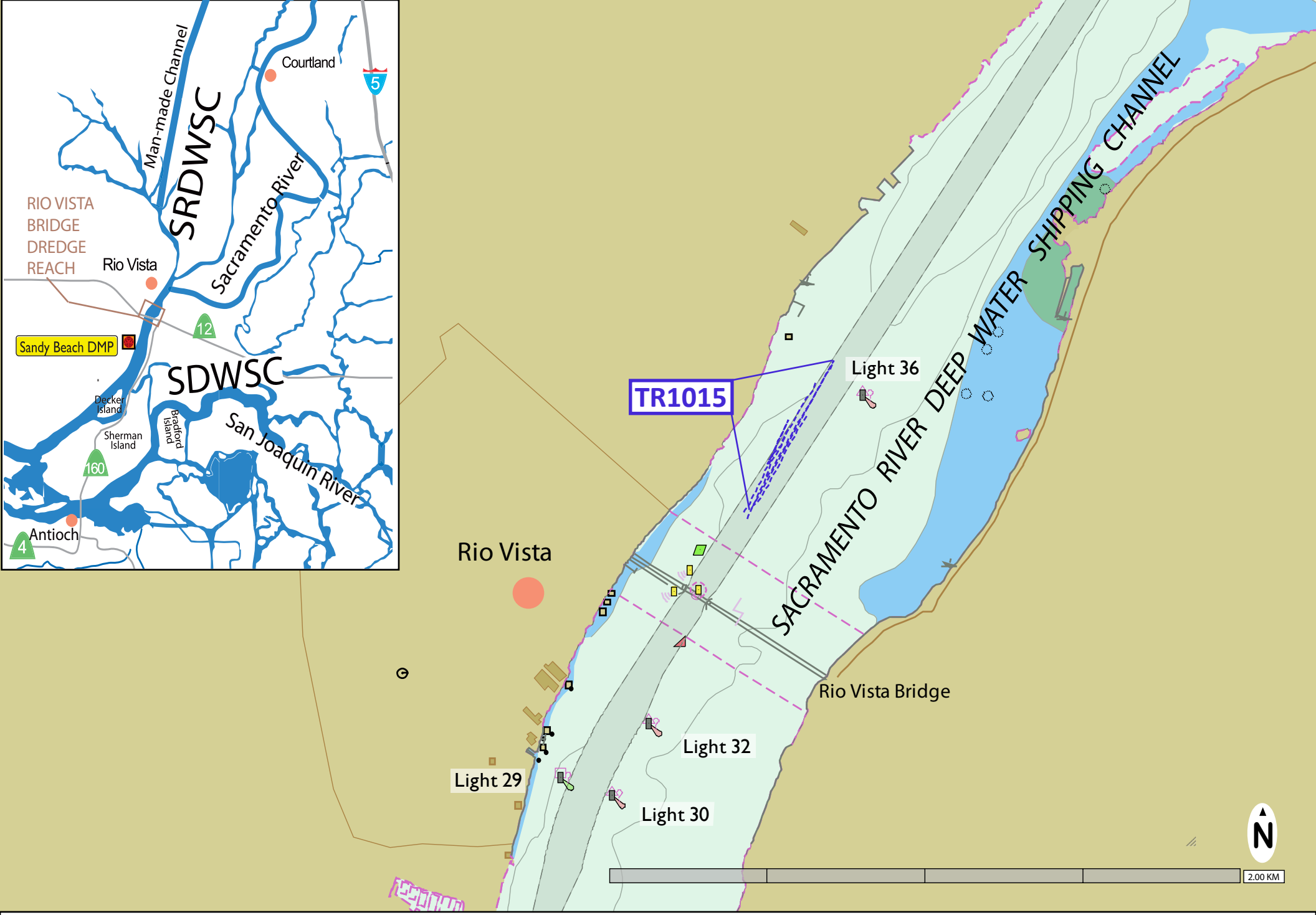


Figure 14. 2010 Fish Community Surveys for Rio Vista Bridge Dredge Reach

Map Projection 1 : 10,000

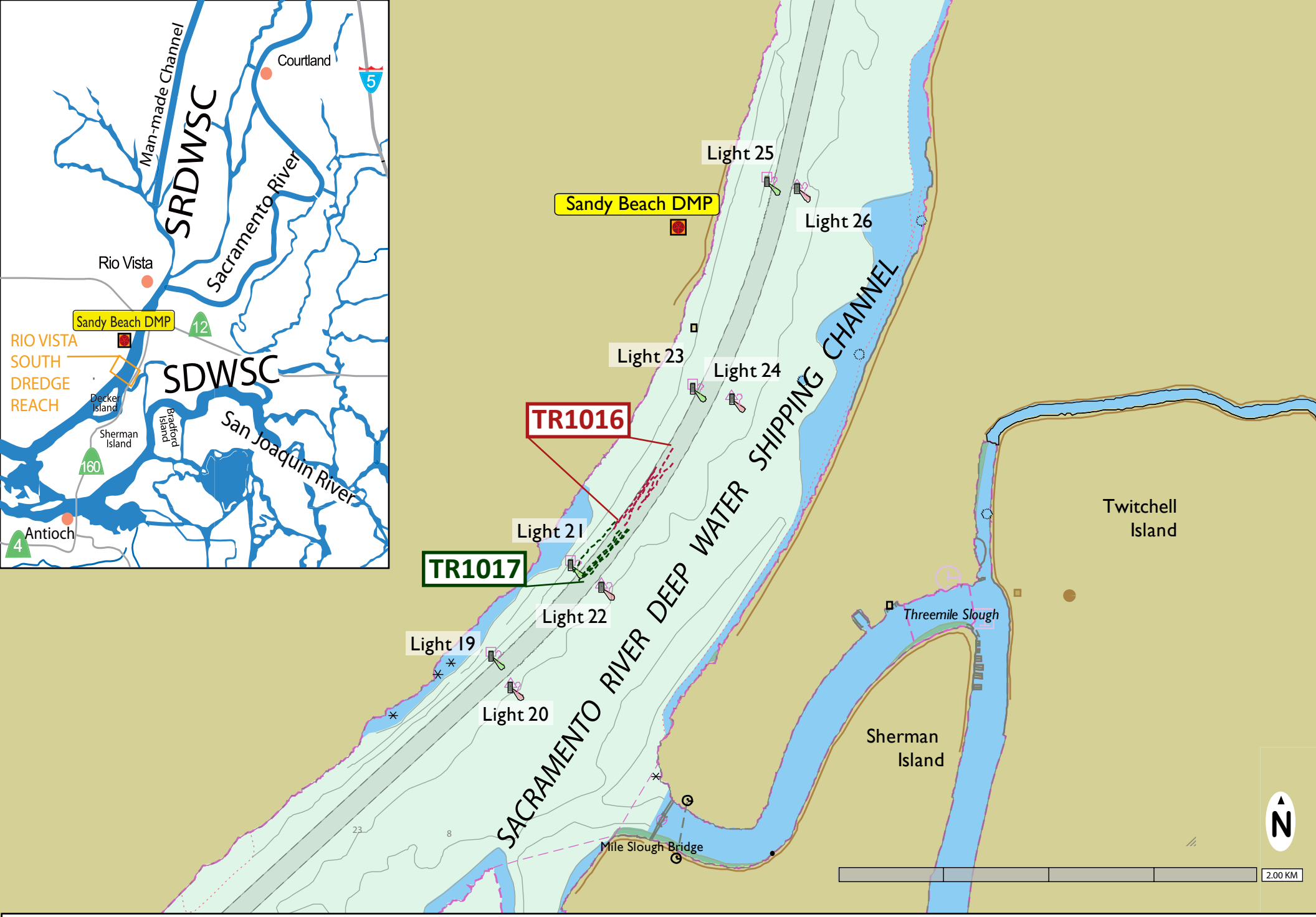


Figure 15. 2010 Fish Community Surveys for Rio Vista South Dredge Reach

Map Projection 1 : 10,000

4.3.2 Stockton Shipping Channel Locations

Table 15 provides the combined data for all fish encountered during fish community monitoring at all SDWSC locations during 2010. Eight differed dredge reaches were monitored. Sixteen species were encountered, six native and ten introduced. As in previous years, introduced species dominated in terms of individual fish encountered. Unlike previous years, however, threadfin shad were encountered more frequently than were white catfish, comprising 70.31% and 10.23% respectively. This was largely due to high shad abundance in the upper reaches of the SDWSC. The top nine most common species were introduced, and together they comprised 98.6% of the individual fish encountered. Striped bass was the most commonly encountered fish at the five lowermost reaches. Native fish comprised 0.83% of the individual fish encountered. Starry flounder were fairly abundant relative to previous years and also occurred further upstream. Tule perch and Sacramento splittail were also fairly abundant relative to previous years. The two green sturgeon were the first encountered since 2006. White sturgeon and Pacific staghorn sculpin were the only other native species encountered. Species encountered in the SDWSC that were not encountered in the SRDWSC were: redear sunfish, bigscale logperch, bluegill, black crappie, warmouth, tule perch, green sturgeon, blue catfish, golden shiner and pacific staghorn sculpin. Blue catfish and green sturgeon have been encountered in the SRDWSC in previous years but the other species have not.

Table 15. Summary Results of Fish Encountered in All SDWSC Trawl Surveys

Rank	Percent	Number	Common Name	Origin
1	70.31	2468	threadfin shad	Introduced
2	10.23	359	striped bass	Introduced
3	7.55	265	American shad	Introduced
4	4.30	151	channel catfish	Introduced
5	3.59	126	white catfish	Introduced
6	1.23	43	redear sunfish	Introduced
7	0.88	31	bluegill	Introduced
8	0.51	18	yellowfin goby	Introduced
9	0.34	12	starry flounder	Native
10	0.23	8	tule perch	Native
11	0.14	5	splittail	Native
11	0.14	5	bigscale logperch	Introduced
12	0.11	4	black crappie	Introduced
13	0.09	3	brown bullhead	Introduced
13	0.09	3	Shokihaze goby	Introduced
14	0.06	2	warmouth	Introduced
14	0.06	2	green sturgeon	Native
15	0.03	1	blue catfish	Introduced
15	0.03	1	golden shiner	Introduced
15	0.03	1	shimofuri goby	Introduced
15	0.03	1	white sturgeon	Native
15	0.03	1	Pacific staghorn sculpin	Native
TOTAL		3510		

Native Percent = 0.83 Number Native Species = 6 Introduced Species = 16
NOTE: 3 channel catfish, 2 American shad, 2 striped bass and 1 white catfish encountered in injured condition

Scour Pond Dredge Reach – Scour Pond DMP Site:

Nineteen successful trawl tows were conducted at this reach during four days of monitoring between October 26 and November 2. This dredge reach is located between river mile 5.42 and 6.17 near Kimball and West Islands. Fish community sampling was also conducted in this portion of the SDWSC in 2008. In 2008, the monitoring was conducted from September 11 to 27. Table 16a provides the abundance data for the fish encountered during fish community monitoring at this reaching 2010. Figure 16 displays the trawl survey locations. A total of 10 species represented by 100 individual fish were encountered. Striped bass were the most abundant, comprising 67% of the individual fish, followed by American shad and yellowfin goby comprising 13% and 6% respectively. Tule perch, starry flounder, and pacific staghorn sculpin were the native species encountered, and together they comprised 12% of the individual fish encountered. Ten total species were also encountered in 2008, though not the same ten. Bigscale logperch and Pacific staghorn sculpin were not encountered in 2008, and delta smelt and threadfin shad were not encountered in 2010. The other eight species co-occurred between years. CPUE at this reach was 0.010 in 2010 and 0.27 in 2008. In 2010, this CPUE was seventh lowest overall, and tied for fourth among the SDWSC reaches.

Table 16a. Summary Results of Trawl Surveys in the Scour Pond Reach – Scour Pond DMP

Rank	Percent	Number	Common Name	Origin
1	67	67	striped bass	Introduced
2	13	13	American shad	Introduced
3	6	6	yellowfin goby	Introduced
4	5	5	tule perch	Native
5	3	3	starry flounder	Native
6	2	2	channel catfish	Introduced
7	1	1	white catfish	Introduced
7	1	1	Shokihaze goby	Introduced
7	1	1	Pacific staghorn sculpin	Native
7	1	1	bigscale logperch	Introduced
TOTAL		100		

Percent Native = 12.00 Number Native Species = 3 Introduced Species = 7

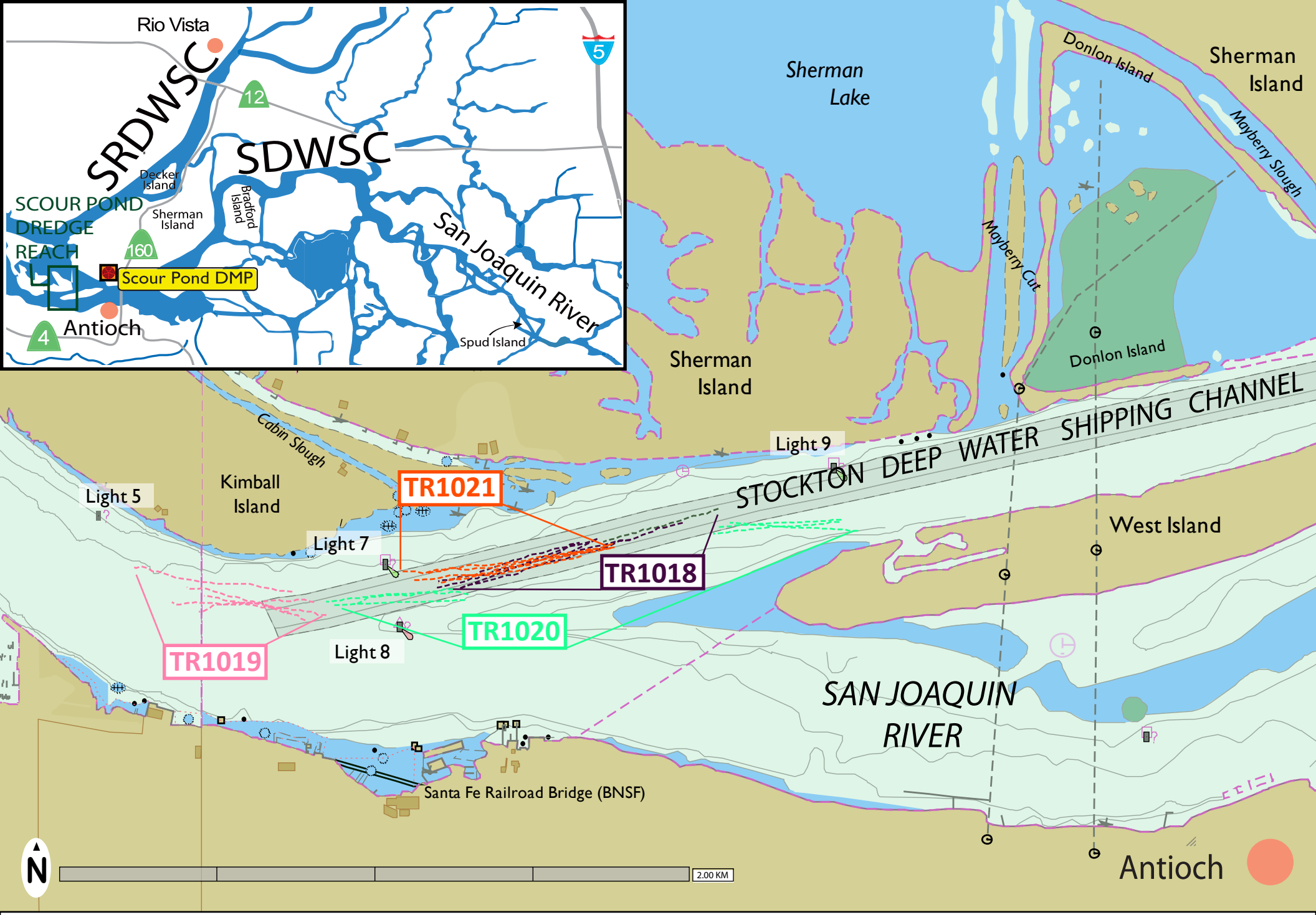


Figure 16. 2010 Fish Community Surveys for Scour Pond Dredge Reach

Map Projection 1 : 10,000

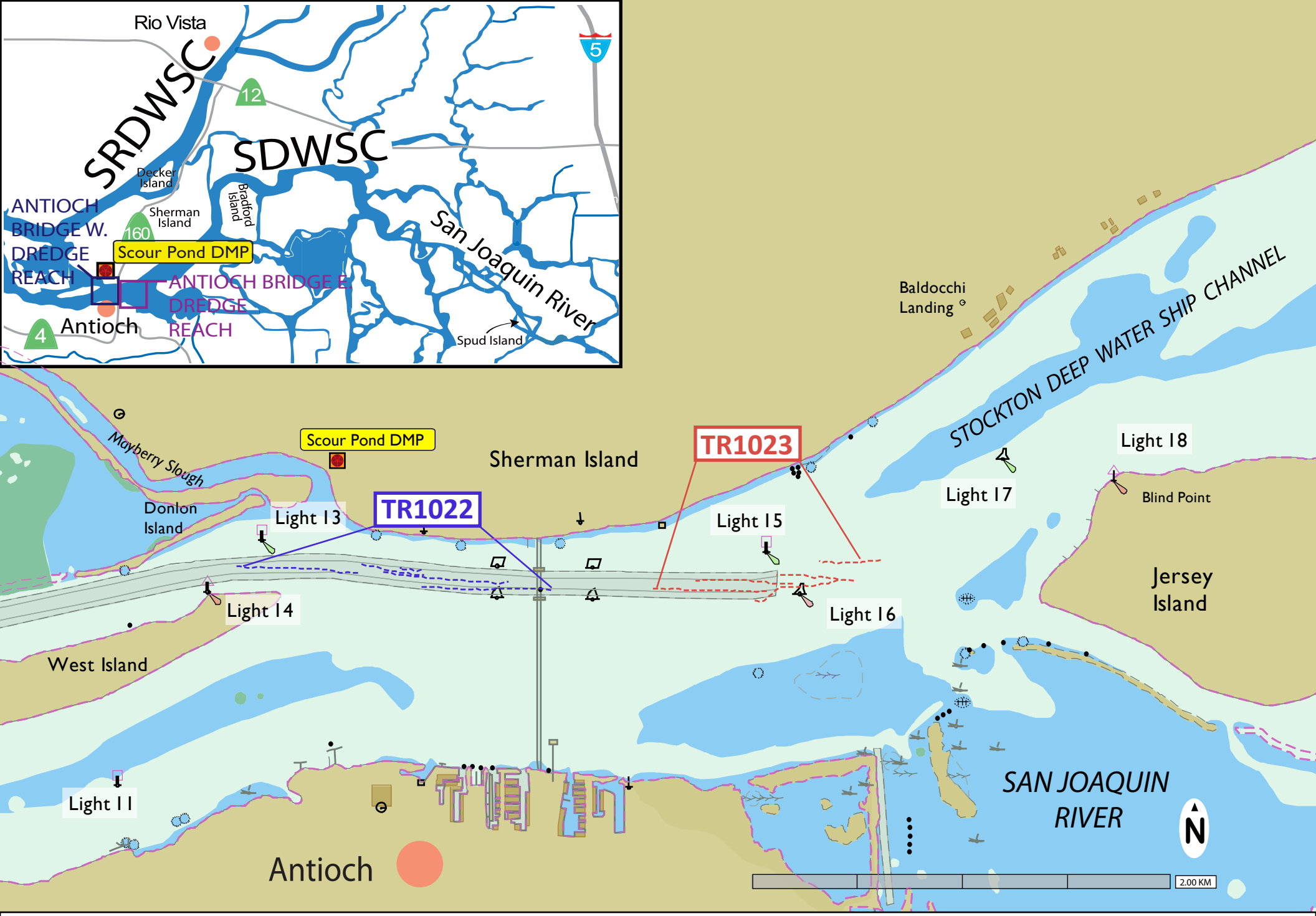


Figure 17. 2010 Fish Community Surveys for Antioch Bridge East and West Dredge Reaches

Map Projection 1 : 10,000

Antioch Bridge West Dredge Reach – Scour Pond DMP Site:

Five successful trawl tows were conducted on November 3, 2010. This reach is between river mile 8.33 and 8.45 on the west side of the bridge. Fish community sampling was also conducted in this portion of the SDWSC in 2008 and included the scour pond dredge reach also dredged in 2010. In 2008, the monitoring was conducted from September 11 to 27. Table 16b provides the abundance data for the fish encountered during fish community monitoring at this reach in 2010, and Figure 17 displays the trawl survey locations. A total of 4 species represented by 17 individual fish of were encountered. Striped bass were the most abundant, comprising 76.47% of the catch. The other species were yellowfin goby, tule perch, and starry flounder, comprising 11.76%, 5.88% and 5.88% respectively. CPUE at this reach was 0.008 in 2010 and 0.27 in 2008. In 2010, this was tied for eighth lowest overall, and tied for fourth among the SDWSC reaches.

Table 16b. Summary Results of Trawl Surveys in the Antioch Bridge West Reach – Scour Pond DMP

Rank	Percent	Number	Common Name	Origin
1	76.47	13	striped bass	Introduced
2	11.76	2	yellowfin goby	Introduced
3	5.88	1	tule perch	Native
4	5.88	1	starry flounder	Native
TOTAL		17		

Percent Native = 11.76 Number Native Species = 2 Introduced Species = 2

Antioch Bridge East Dredge Reach – Scour Pond DMP Site:

Five successful trawl tows were conducted at this reach on November 5, 2010. The reach dredged in 2010 is between river mile 8.90 and 9.24, east of the bridge. It was the upper portion of the reach dredged in 2008, and was directly upstream of the reach dredged in 2009. In 2009, monitoring was conducted on August 28 and in 2008, from September 11 to 27. Table 16c provides the abundance data for the fish encountered during fish community monitoring at this reach in 2010. Figure 17 displays the trawl survey locations for this reach. A total of 4 species represented by 12 individual fish were encountered. Striped bass comprised 66.67% of the fish followed by starry flounder, yellowfin goby and bigscale logperch, comprising 16.67%, 8.33% and 8.33% respectively. The CPUE at this reach was 0.006 in 2010, 0.010 in 2009 and 0.027 in 2008. In 2010, this reach had the ninth lowest CPUE overall and was fifth among the SDWSC reaches.

Table 16c. Summary Results of Trawl Surveys in the Antioch Bridge East Reach – Scour Pond DMP

Rank	Percent	Number	Common Name	Origin
1	66.67	8	striped bass	Introduced
2	16.67	2	starry flounder	Native
3	8.33	1	yellowfin goby	Introduced
3	8.33	1	bigscale logperch	Introduced
TOTAL		12		

Percent Native = 16.67 Number Native Species = 1 Introduced Species = 3

Light 19 Dredge Reach – McCormack Pit DMP Site:

Ten successful trawl tows were conducted during two days of monitoring on November 9 and 11, 2010. This reach between Blind Point and Jersey Point, from river mile 11.17 to 11.33, was also dredged in 2006. The 2006 monitoring was conducted from October 17 through 26. The adjacent SDWSC reach at Light 21 was dredged and monitored in 2009. Table 16d provides abundance data. Figure 18 displays trawl survey locations. A total of 6 species represented by 41 individual fish were encountered. Striped bass comprised 75.61% of fish encountered, followed by American shad and tule perch, comprising 9.76% and 4.88% respectively. Tule perch and starry flounder were the only native species encountered, together comprising 7.32% of fish encountered. The CPUE at this reach was 0.008 in 2010 and 0.09 in 2006. In 2010, the CPUE for Light 19 ranked eighth overall, and tied for fourth among SDWSC reaches.

Table 16d. Summary Results of Trawl Surveys in the Light 19 Reach – McCormack Pit DMP

Rank	Percent	Number	Common Name	Origin
1	75.61	31	striped bass	Introduced
2	9.76	4	American shad	Introduced
3	4.88	2	tule perch	Native
3	4.88	2	Shokihaze goby	Introduced
4	2.44	1	starry flounder	Native
4	2.44	1	shimofuri goby	Introduced
TOTAL		41		

Percent Native = 7.32 Number Native Species = 2 Introduced Species = 4

Upper Bradford Island Dredge Reach – Bradford Island DMP Site:

Nine successful trawl tows were conducted during two days of monitoring on November 14 and 16, 2010. This reach is between river mile 15.06 and 15.44, near the entrance to Threemile Slough and Navigation Lights 28 and 29. Fish community monitoring was conducted in this portion of the SDWSC for the first time in 2010. Table 16d provides the abundance data. Figure 19 displays trawl survey locations. A total of 8 species represented by 49 individual fish were encountered. Striped bass were most common, followed by white catfish and threadfin shad, comprising 38.78%, 26.53% and 12.24%, respectively. Together they comprised 77.55% of the fish encountered. Starry flounder and green sturgeon were the only native fish encountered, comprising 8.16% and 4.08% respectively. The CPUE at this reach was 0.011, sixth highest among all 12 of 2010 reaches, and third highest among SDWSC reaches.

Table 16e. Summary Results of Trawl Surveys in the Upper Bradford Reach – Bradford Island DMP

Rank	Percent	Number	Common Name	Origin
1	38.78	19	striped bass	Introduced
2	26.53	13	white catfish	Introduced
3	12.24	6	threadfin shad	Introduced
4	8.16	4	starry flounder	Native
5	6.12	3	American shad	Introduced
6	4.08	2	green sturgeon	Native
7	2.04	1	channel catfish	Introduced
7	2.04	1	brown bullhead	Introduced
TOTAL		49		

Percent Native = 12.24 Number Native Species = 2 Introduced Species = 6

NOTE: 1 striped bass of total number was injured prior to encounter by sampling gear

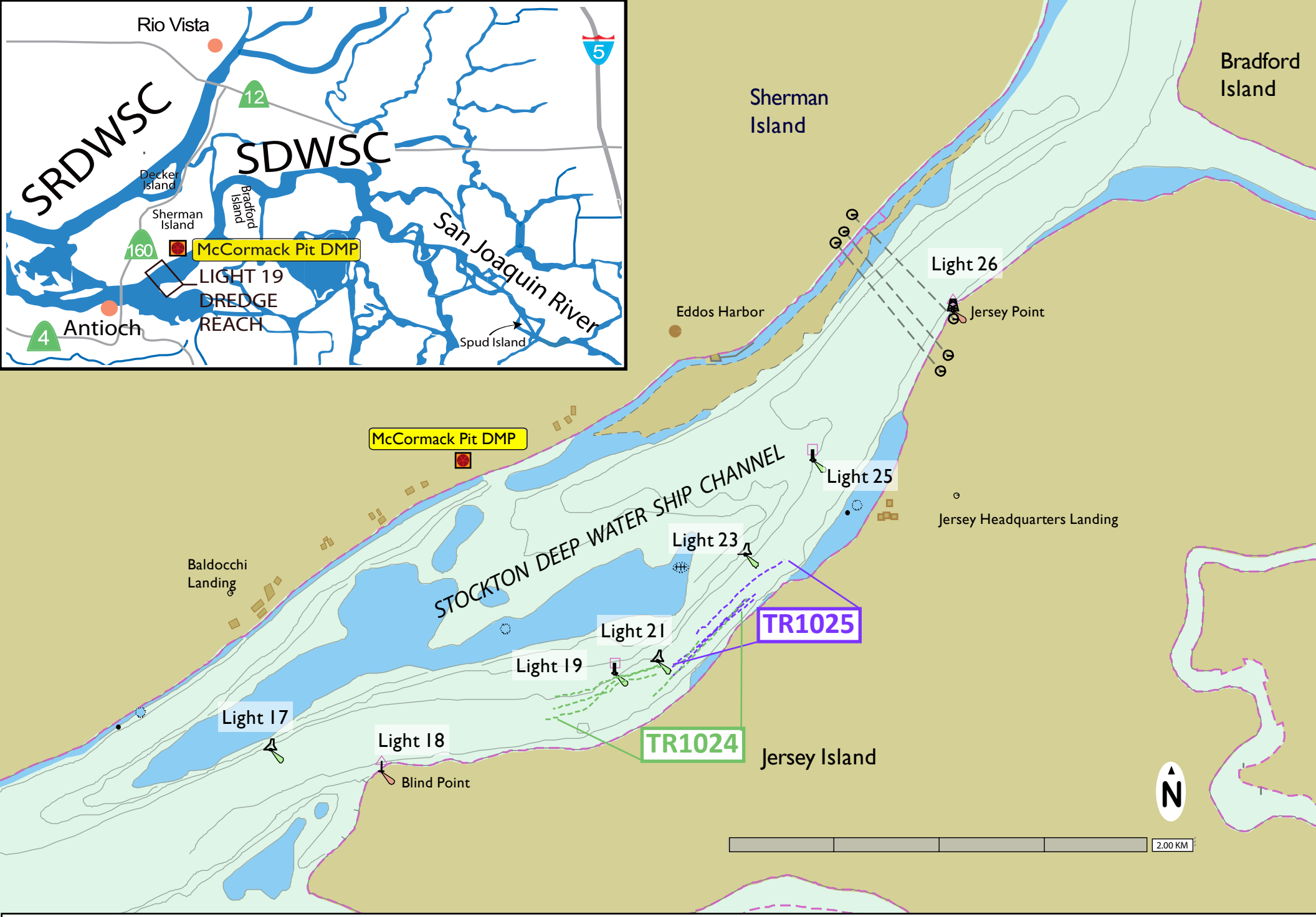


Figure 18. 2010 Fish Community Surveys for Light 19 Dredge Reach

Map Projection 1 : 10,000

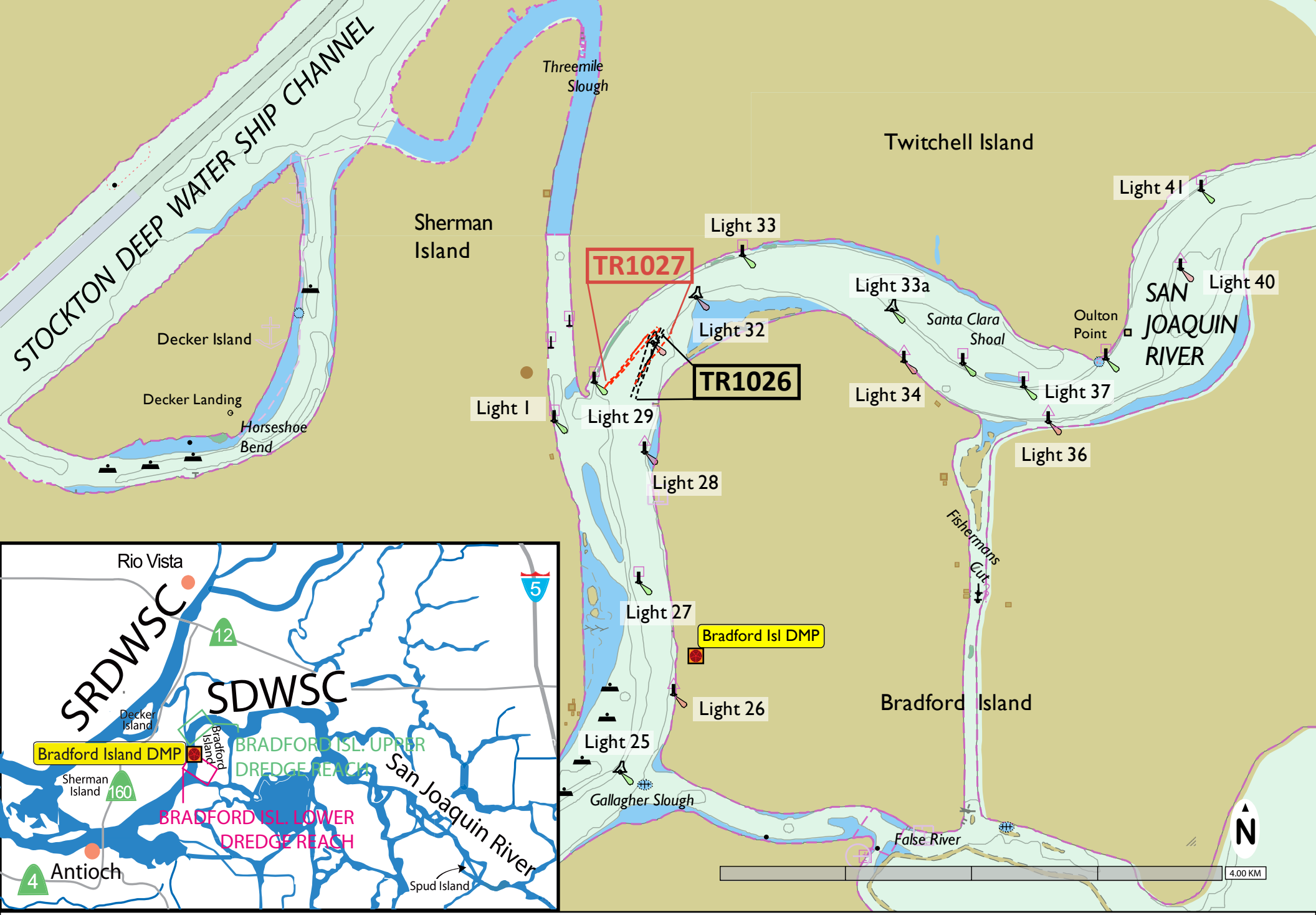


Figure 19. 2010 Fish Community Surveys for Upper and Lower Bradford Island Dredge Reaches

Map Projection 1 : 20,000

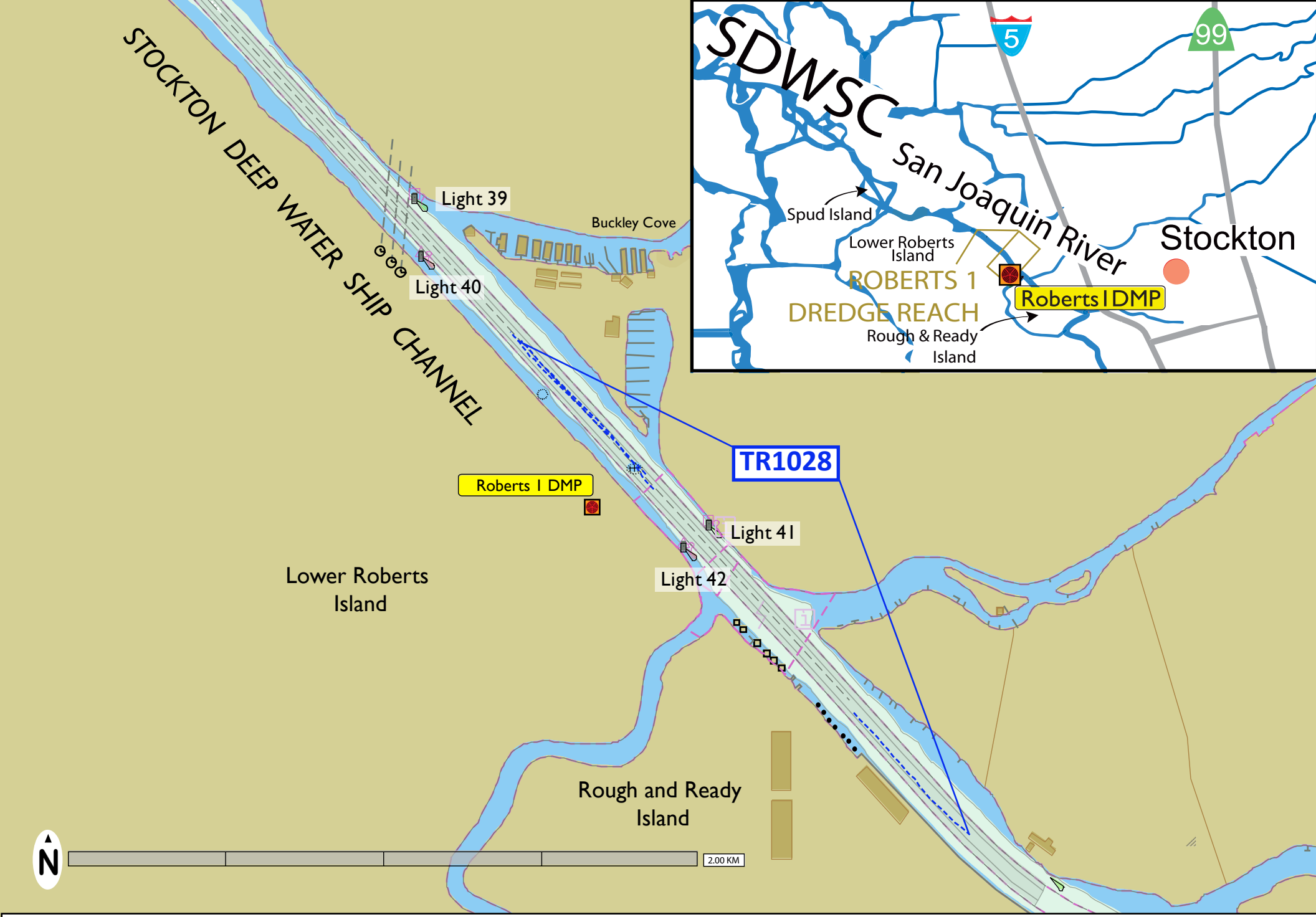


Figure 20. 2010 Fish Community Surveys for Upper Roberts 1 Dredge Reach

Map Projection 1 : 10,000

Upper Roberts Island Dredge Reach – Roberts 1 DMP Site:

Four successful trawl tows were conducted on November 20, 2010 just downstream of Rough and Ready Island. This reach is between river mile 37.08 and 37.88 and was also dredged in 2006, from September 30 to November 6, and again from November 1 through 9. Table 16f provides abundance data and Figure 20 displays trawl survey locations. A total of eight species represented by 230 fish were encountered. The most common species was threadfin shad, comprising 55.65% of individuals. White catfish and channel catfish followed in abundance, comprising 16.96% and 13.48% respectively. Three individual Sacramento splittail, comprising 1.3% of the total, were the only native fish species. CPUE at this reach was 0.154 in 2010 and 0.20 in 2006. It was second highest among all reaches in 2010 and second among SDWSC reaches.

Table 16f. Summary Results of Trawl Surveys in the Upper Roberts Reach – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	55.65	128	threadfin shad	Introduced
2	16.96	39	white catfish	Introduced
3	13.48	31	channel catfish	Introduced
4	6.96	16	striped bass	Introduced
5	3.91	9	American shad	Introduced
6	1.30	3	splittail	Native
6	1.30	3	bluegill	Introduced
7	0.43	1	blue catfish	Introduced
TOTAL		230		

Percent Native = 1.30 Number Native Species = 1 Introduced Species = 7

Turning Basin Dredge Reach – Roberts 1 DMP Site:

Eighteen successful trawls were conducted during 4 days of monitoring between November 23 and December 3, 2010. This reach was between river mile 39.77 and 39.66, and was also dredged in 2007 from November 2 through 13, and in 2006 from November 1 through 9. Abundance data is listed in Table 16g, and Figure 21 displays the trawl survey locations. A total of 16 species represented by 3,031 fish were encountered. Threadfin shad were the most common, comprising 76.97% of the individuals. American shad, striped bass, channel catfish and white catfish followed in abundance, comprising 7.75%, 6.20%, 3.79%, and 2.18% respectively. Introduced sunfish (redear sunfish, bluegill, black crappie and warmouth) are more common in the Turning Basin and Port of Stockton complex than anywhere else that has been monitored by this program since 2006, together comprising 2.54% of the individuals encountered in this reach. One individual each of Sacramento splittail, white sturgeon, and starry flounder represented the three native fishes at the 2010 Turning Basin, together comprising only 0.09% of the individual fish encountered. The starry flounder was the furthest upstream location documented for this species by this monitoring program, and the adult white sturgeon encountered this year was the largest of its species encountered to date. The CPUE at this reach was 0.374, the highest of all reaches in 2010. Prior CPUE for this dredge vicinity was 0.20 in 2006, and 0.84 in 2007, also the highest in both years.

Table 16g. Summary Results of Trawl Surveys in the Turning Basin Reach – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	76.97	2,333	threadfin shad	Introduced
2	7.75	235	American shad	Introduced
3	6.20	188	striped bass	Introduced
4	3.79	115	channel catfish	Introduced
5	2.18	66	white catfish	Introduced
6	1.42	43	redear sunfish	Introduced
7	0.92	28	bluegill	Introduced
8	0.30	9	yellowfin goby	Introduced
9	0.13	4	black crappie	Introduced
10	0.07	2	bigscale logperch	Introduced
10	0.07	2	warmouth	Introduced
10	0.07	2	brown bullhead	Introduced
11	0.03	1	splittail	Native
11	0.03	1	starry flounder	Native
11	0.03	1	white sturgeon	Native
11	0.03	1	golden shiner	Introduced
TOTAL		3,031		

Percent Native = 0.10 Number Native Species = 3 Introduced Species = 13
NOTE:: 2 American shad, 2 channel catfish, 1 striped bass and 1white catfish in injured condition prior to encounter

Spud Island Dredge Reach – Roberts 2 DMP Site:

Five successful trawl tows were conducted at this reach on December 6, 2010. This reach near Navigation Light 20 was also dredged in 2009. However, the 2010 reach was located between river mile 31.50 and 31.65 down-channel from the 2009 reach. Table 16h provides abundance data. Figure 22 displays locations. Seven total species represented by 29 individual fish were encountered. Striped bass were the most commonly encountered fish, comprising 55.17% of individuals. White catfish and channel catfish followed, comprising 24.14% and 6.90% of individuals encountered, respectively. A single Sacramento splittail represented the only native species, comprising 3.45% of individuals encountered. The CPUE at this reach was 0.10, seventh highest CPUE overall, and third among SDWSC reaches.

Table 16h. Summary Results of Trawl Surveys in the Spud Island Reach – Roberts 2 DMP

Rank	Percent	Number	Common Name	Origin
1	55.17	16	striped bass	Introduced
2	24.14	7	white catfish	Introduced
3	6.90	2	channel catfish	Introduced
4	3.45	1	threadfin shad	Introduced
4	3.45	1	Sacramento splittail	Native
4	3.45	1	bigscale logperch	Introduced
4	3.45	1	American shad	Introduced
TOTAL		29		

Percent Native = 3.45 Number Native Species = 1 Introduced Species = 6
NOTE: 1 of the 2 total channel catfish was in injured condition prior to encounter

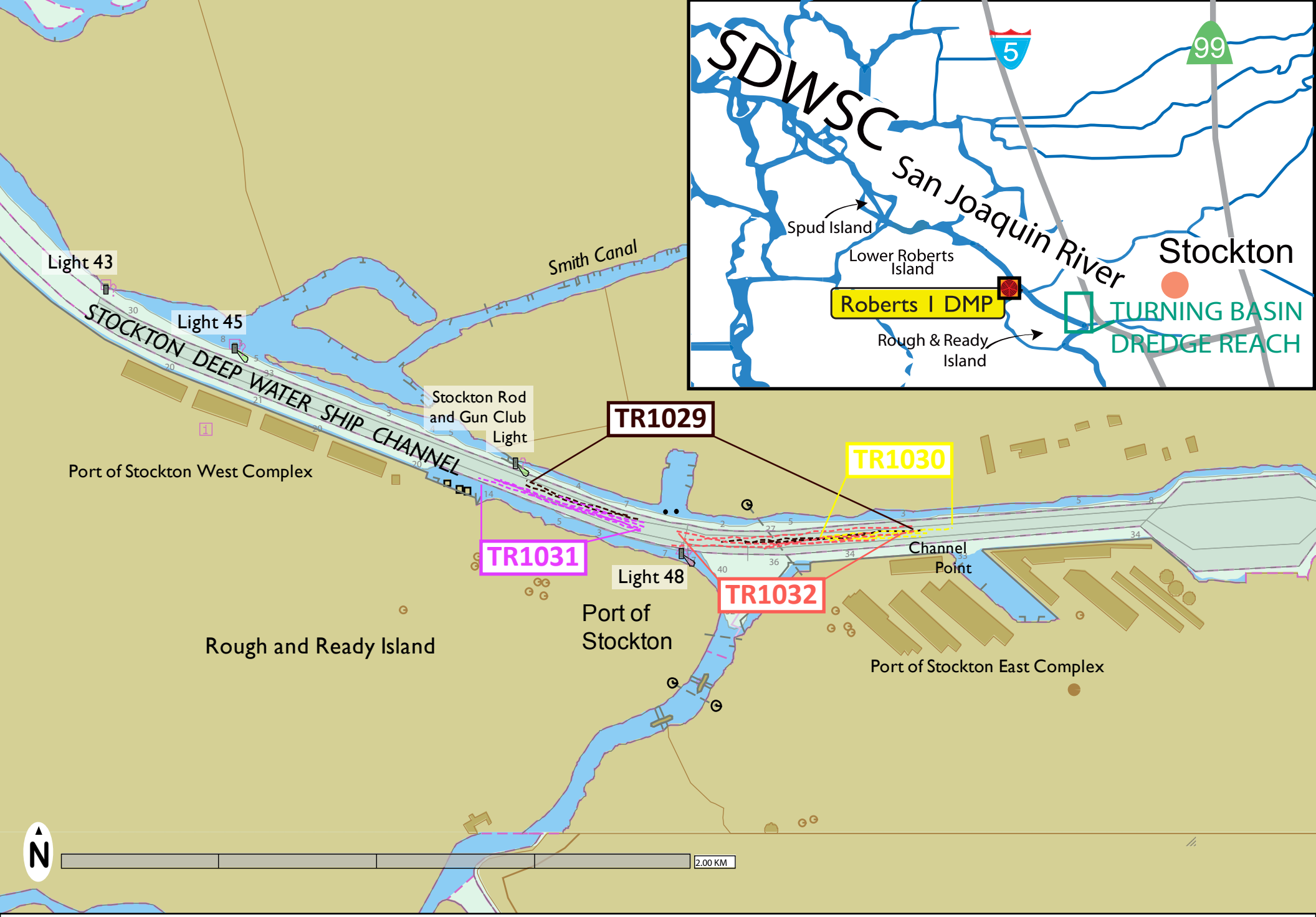


Figure 21. 2010 Fish Community Surveys for Turning Basin Dredge Reach

Map Projection 1 : 10,000

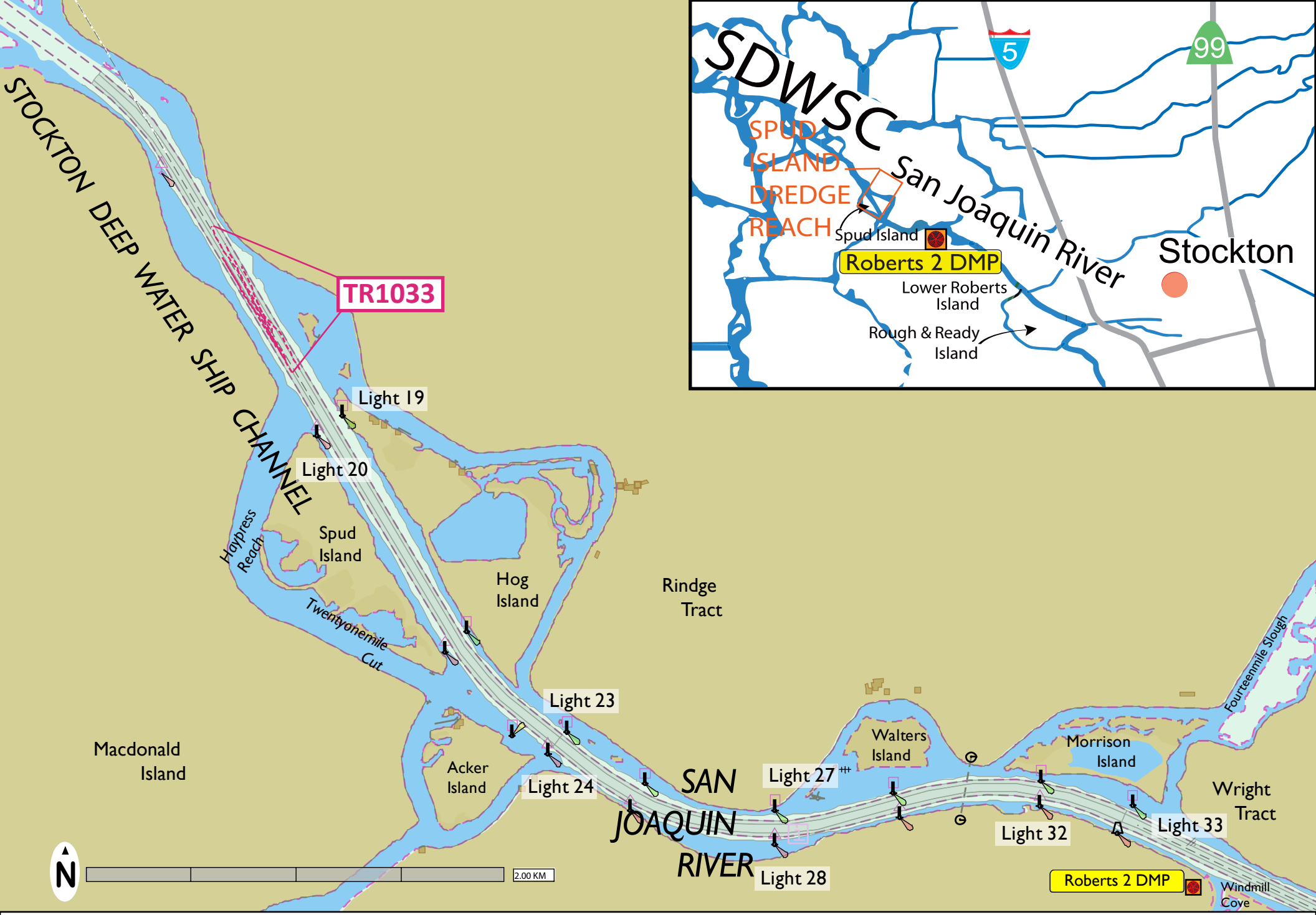


Figure 22. 2010 Fish Community Surveys for Spud Island Dredge Reach

Map Projection 1 : 10,000

4.4 Fish Length

For 15 of the 26 species encountered during fish community monitoring, 100% were measured for length prior to release. Those nine species encountered in large numbers (such as striped bass, white catfish, and threadfin shad) were sub-sampled to determine fish sizes while minimizing mortality by returning fish to the river as quickly as possible. Table 17 provides the summary length statistics for all measured fish from 2010 trawl surveys. Overall, 1,309 fish out of 4,327 encountered (30.25%) were measured for total, standard, or fork length.

Table 17. Summary Size Statistics for Fish Encountered in All Fish Community Monitoring for 2010

Common Name	Life Stage	Total Length Min (mm)	Total Length Max (mm)	*SD of Mean*	*Mean Length (mm)*	Total No. Measured	*Total No. Encountered*	*Percent Measured*
Native								
delta smelt	Juvenile	69	71	N.A.	70	2	2	100
delta smelt	Adult	95	119	9.7	102	5	5	100
green sturgeon	Juvenile	700	770	N.A.	735	2	2	100
Pac. staghorn sculpin	Adult	125	125	N.A.	N.A.	1	1	100
prickly sculpin	Adult	73	73	N.A.	N.A.	1	1	100
splittail	Juvenile	136	189	13.8	164	22	22	100
splittail	Adult	376	376	N.A.	N.A.	1	1	100
starry flounder	Juvenile	90	282	52.3	133	27	27	100
tule perch	Juvenile	114	114	N.A.	N.A.	1	1	100
tule perch	Adult	152	194	16.9	172	7	7	100
white sturgeon	Juvenile	340	340	N.A.	N.A.	1	1	100
white sturgeon	Adult	1365	1365	N.A.	N.A.	1	1	100
Non-native								
American shad	Juvenile	71	202	26.4	124	106	275	39
American shad	Smolt	195	316	34.8	248	25	25	100
bigscale logperch	Adult	84	125	19.1	103	5	5	100
black crappie	Adult	204	313	49.2	252	4	4	100
blue catfish	Juvenile	77	77	N.A.	N.A.	1	1	100
bluegill	Juvenile	73	73	N.A.	N.A.	1	1	100
bluegill	Adult	146	225	17.8	184	22	30	74
brown bullhead	Juvenile	79	136	N.A.	108	2	2	100
brown bullhead	Adult	146	278	60.2	189	4	4	100
channel catfish	Juvenile	50	246	63.8	121	80	165	48
channel catfish	Adult	335	383	22.9	354	4	5	80
golden shiner	Adult	204	204	N.A.	N.A.	1	1	100
redear sunfish	Juvenile	23	23	N.A.	N.A.	1	1	100
redear sunfish	Adult	142	265	26.9	198	35	42	83
shimofuri goby	Juvenile	22	45	6.9	35	37	39	95
shimofuri goby	Adult	46	75	8.4	55	15	15	100
Shokihaze goby	Adult	59	73	6.4	65	4	4	100
striped bass	Juvenile	62	342	69.1	158	297	391	76
striped bass	Adult	315	620	88.5	416	24	27	89
threadfin shad	Juvenile	56	117	15.0	90	73	987	7
threadfin shad	Adult	94	261	25.5	149	73	1,483	5
wakasagi	Juvenile	87	101	3.5	96	17	17	100
wakasagi	Adult	100	125	5.3	109	89	90	99
warmouth	Juvenile	125	125	N.A.	N.A.	1	1	100
warmouth	Adult	166	166	N.A.	N.A.	1	1	100
white catfish	Juvenile	48	238	58.6	159	236	479	49
white catfish	Adult	225	319	21.3	260	116	127	91
yellowfin goby	Adult	105	189	19.5	152	33	33	100

The majority of entrained fish were retained, examined, measured and returned to the river. Occasionally, fish were observed but not measured. There were a few reasons why individual entrained fish went unmeasured. There were fish that were visually identified to species but escaped collection over the end of the entrainment screen or through the screen mesh. These fish were documented in the entrainment results. Typically, they were individuals of the most common species (lamprey, gobies, and catfish), for which an abundance of length data has been collected. A few fish escaped on their way to the collection bucket and there were also a few partial (un-measurable) fish showing signs of damage from the dredge. Figure 23 provides some examples of fish encountered during 2010 monitoring. Table 18 provides the summary length statistics for all entrained fish that were measured. Overall, 86.33% of fish encountered during 2010 entrainment monitoring were measured prior to release or vouchering.

Table 18. Summary Size Statistics for Fish Encountered in All Entrainment Monitoring for 2010

Common Name	Life Stage	Total Length Min (mm)	Total Length Max (mm)	Std Dev of Mean	Mean Total Length	Number Measured	Number Captured	Percent Measured	
Native **									
delta smelt	juvenile	57	78	7.6	64	6	6	100	
river lamprey	Ammocoete	96	127	15.6	111	3	3	100	*
river lamprey	juvenile	111	191	14.5	140	81	83	98	*
Non-native									
American shad	Juvenile	64	77	N.A.	71	2	2	100	
bluegill	Adult	147	147	N.A.	N.A.	1	1	100	
brown bullhead	Adult	147	237	N.A.	192	2	2	100	
channel catfish	Juvenile	56	215	36.0	74	18	19	95	
shimofuri goby	Juvenile	21	46	5.9	34	112	170	66	
shimofuri goby	Adult	47	83	7.9	58	76	77	99	
Shokihaze goby	Adult	66	66	N.A.	N.A.	1	1	100	
striped bass	Juvenile	57	124	32.3	105	4	4	100	
threadfin shad	Juvenile	101	101	N.A.	N.A.	1	1	100	
wakasagi	Juvenile	68	68	N.A.	N.A.	1	1	100	
wakasagi	Adult	102	112	4.1	107	9	9	100	
white catfish	Juvenile	43	164	20.7	74	67	69	97	
white catfish	Adult	264	264	N.A.	264	2	2	100	
yellowfin goby	Adult	115	189	20.15	144	11	11	100	

* NOTE: does not include data from 70 unidentified (unexamined) lamprey specimens that escaped capture through screen

** NOTE: does not included data on the single splittail specimen of which only the rear 1/3 of adult fish was observed, with estimated TL = 400mm

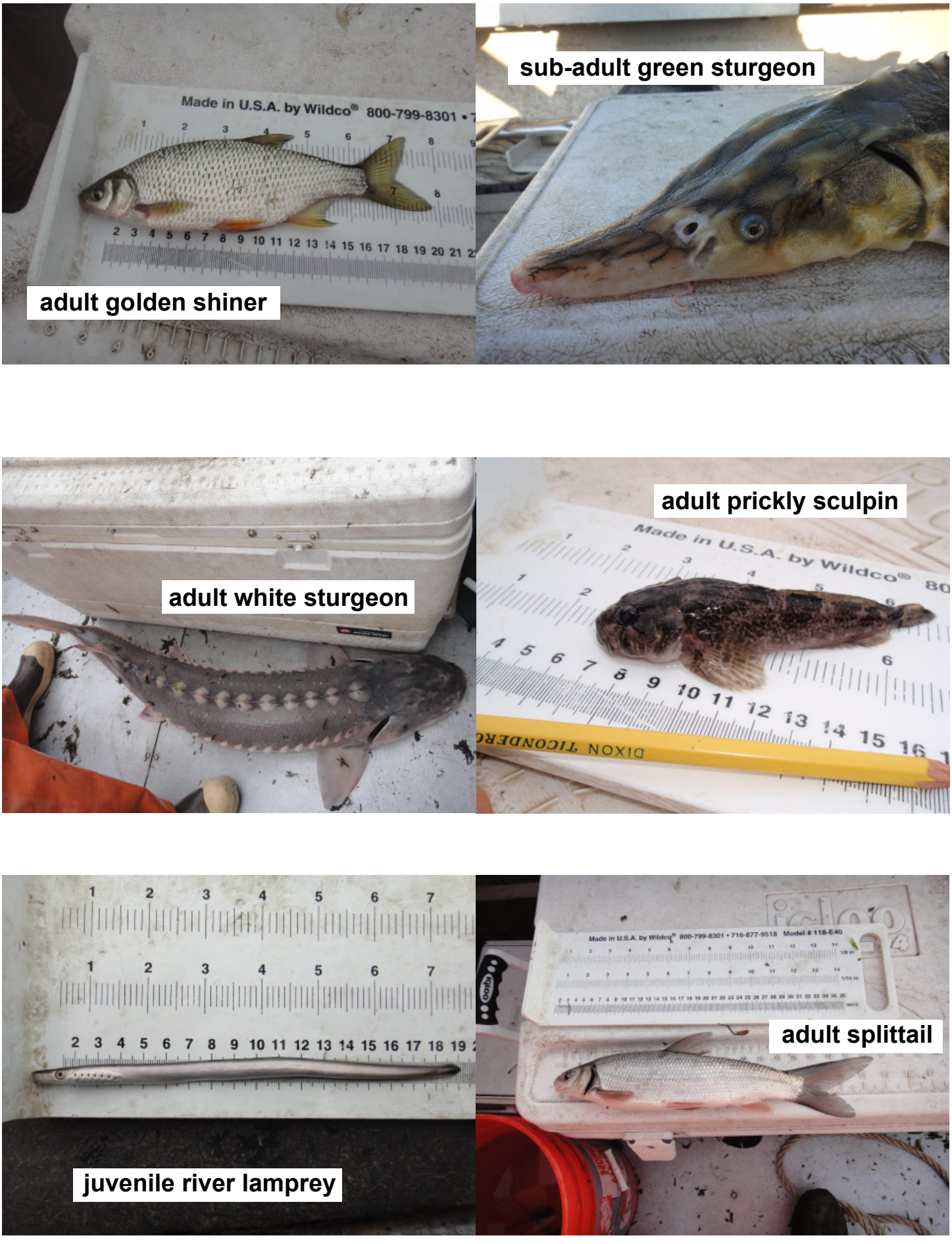


Figure 23. Examples of Specimens Collected during 2010 Fish Community Surveys

4.5 Invertebrates

Invertebrates have been encountered during both fish community and entrainment monitoring since project inception, though the sampling methods employed were designed specifically for collection of fish. Information on the numbers and species of invertebrates encountered continues to be collected due to its potential utility in assessments of the indirect impacts of maintenance dredging in the shipping channels. A total of 215,147 invertebrates were encountered during entrainment sampling in 2010 and 64,197 were encountered during fish community monitoring. The numbers for most invertebrate species are estimates (as described in methods). These estimates are necessary due to the large numbers encountered and the practical need to focus on the primary project objective of monitoring fish.

As in previous years, the most commonly encountered species in both types of sampling were Asian clams and Siberian prawns (*Exopalaeomon modestus)*, both introduced species. Large populations of these clams and shrimp exist in many of the sampled locations. Thus, clams and shrimp are commonly retained by the entrainment screen and in the cod-end of the trawl net. In addition, clam shells can persist long after death and frequently comprise a large percentage of the detritus left on the entrainment screen or mixed with the fish in the cod-end of the net.

Only two crayfish were encountered in 2010. One native signal crayfish (*Pacifasticus leniusculus*) was encountered in Trawl Survey 1031-3 on December 1, 2010 in the Turning Basin Reach. One non-native red swamp crayfish (*Procambarus clarkii*) was encountered on December 6 in the Spud Island Reach. This sampling program previously documented these same species in 2009 with presence at Spud Island and Roberts Island dredge reaches, all in the upper portion of the SDWSC.

The California floater (*Anodonta californiensis),* a native freshwater mussel, was again encountered in the entrainment samples from Man-made Channel reaches in the SRDWSC, but more often from the upper reaches of the SDWSC. This mussel species is a federal species of concern. The presence of the native mussels in our sampling coincides with large numbers of leeches (in the SDWSC), lamprey ammocoetes, and fine, organic and detritus rich sediments.

In 2010, the introduced overbite clam (*Corbula amurensis)* was found in the lowest SRDWSC reach, Rio Vista South, and the three most downstream dredge reaches in the SDWSC. These clams were previously encountered in the lower reaches of both shipping channels. The overbite clam comprised a far greater proportion of clams entrained in the Scour Pond reach than at other monitored dredge reaches where present. The lower ends of the Ship Channels are at the freshest limit of their salinity tolerance. Black Sea jellyfish *(Maeotias marginata)* were encountered only from fish community surveys in the Scour Pond dredge reach, the most saline location monitored to date by this program.

Other species of invertebrates such as mud crabs (*Rhithropanopeus harrisii*) and the Chinese mitten crab (*Eriocheir sinensis*) have been encountered in previous years, but were not encountered in 2010. Two introduced mud snails (*Cipangopaludina japonica)* were entrained in 2010. One was also encountered during fish community sampling. These snails were observed in 2008 and 2009 as well in very low numbers. Shells of native but displaced bivalves such as the bay mussel (*Mytilus edulus)* and the native oyster (*Ostreola conchaphila*) are occasionally found in the entrainment samples as well but are not enumerated. The probable source of these shells is transfer via ship bottom. Invertebrates encountered in 2010 are listed in Table 19 and Table 20 by respective sampling type.

Table 19. Ranked List of Invertebrates Encountered during 2010 Entrainment Monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	85.43	183,800	clam, Asian	*Corbicula*	*fluminea*	Introduced
2	9.11	19,608	Siberian prawn	*Exopalaemon*	*modestus*	Introduced
3	3.85	8,280	clam, overbite	*Corbula*	*amurensis*	Introduced
4	0.87	1,872	Oriental shrimp	*Palaemon*	*macrodactylus*	Introduced
5	0.65	1,400	Leech	Undetermined	undetermined	unknown
6	0.09	185	California floater	*Anondonta*	*californiensis*	Native
7	0.001	2	mud snail	*Cipangopaludina*	*japonica*	Introduced
TOTAL		215,147				

Table 20. Ranked List of Invertebrates Encountered during 2010 Fish Community Monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	91.43	58,614	Siberian prawn	*Exopalaemon*	*modestus*	Introduced
2	7.44	4,770	clam, Asian	*Corbicula*	*fluminea*	Introduced
3	1.04	664	Oriental shrimp	*Palaemon*	*macrodactylus*	unknown
4	0.07	42	California floater	*Anondonta*	*californiensis*	Native
5	0.02	10	clam, overbite	*Corbula*	*amurensis*	Introduced
6	0.01	4	Black Sea jellyfish	*Maeotias*	*marginata*	Introduced
7	0.002	1	signal crayfish	*Pacifasticus*	*leniusculus*	Native
7	0.002	1	red swamp crayfish	*Procambarus*	*clarkii*	Introduced
7	0.002	1	mud snail	*Cipangopaludina*	*japonica*	Introduced
TOTAL		64,297				

Total numbers of entrained invertebrates are extrapolated based on the number of organisms documented and the amount (gallons) of the total material dredged that was monitored, and have not been converted into organisms per square meter (or other density measurement). The extrapolated numbers are in some cases very large. However, they describe the estimated number of entrained invertebrate organisms across the entire dredge reach. The extrapolated totals are provided in Table 21. This information is presented because indirect impacts of dredging are in part based on impacts to benthic ecology such as community disturbance and prey removal. These types of impacts could harm listed and other species. Though not directly addressed by this sampling program, entrainment rates of invertebrates by dredge may be useful to assess indirect impacts. The introduced Asian clam was the dominant taxon at all DMP sites. Asian clams accounted for 85% of the predicted total of entrained invertebrates, similar to 2008 and 2009.

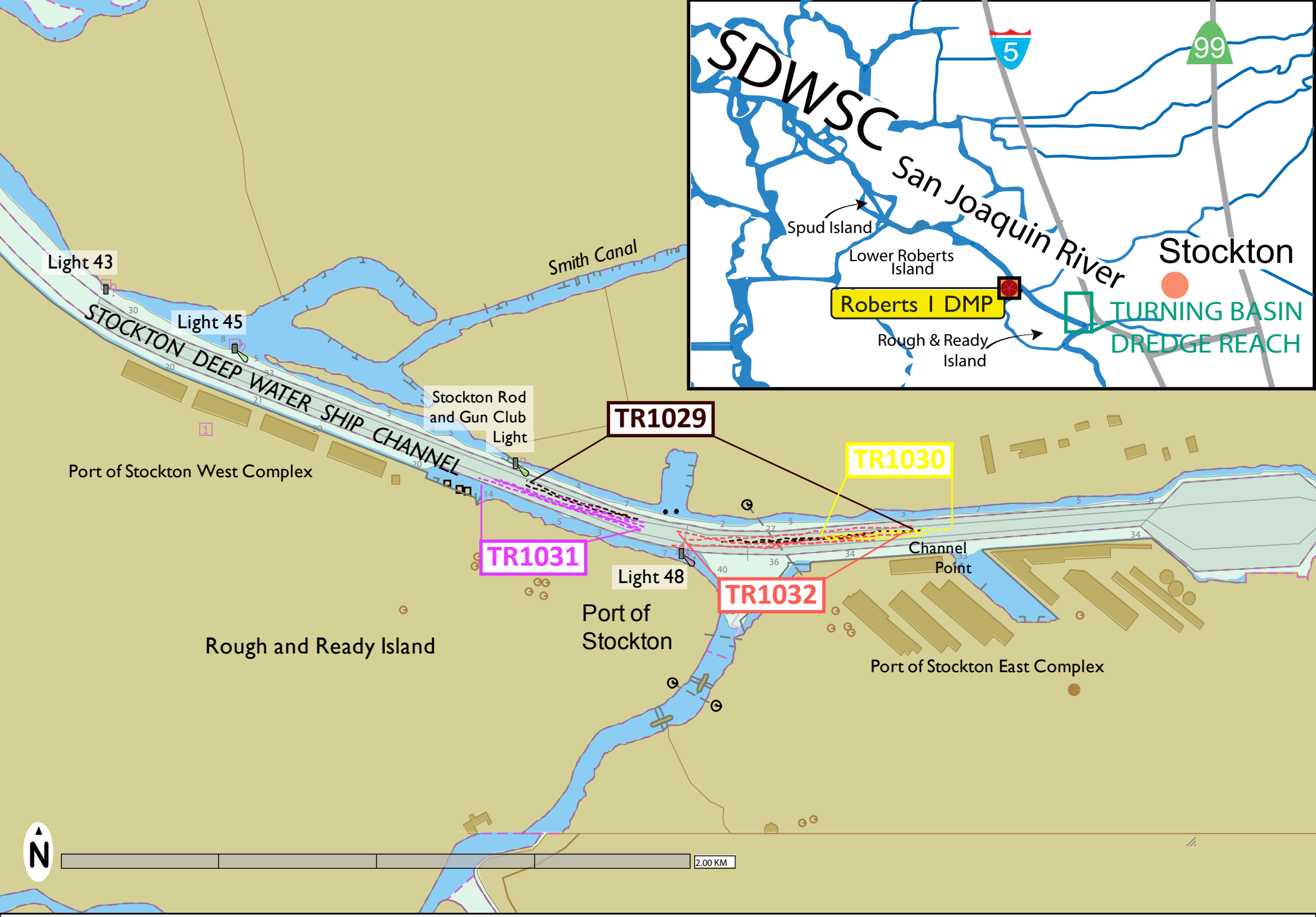


Figure 21. 2010 Fish Community Surveys for Turning Basin Dredge Reach

Map Projection 1 : 10,000

4.6 Bird and Marine Mammal Activity Observations

Observations of piscivorous birds were made at all 2010 trawl and DMP site locations during active monitoring periods. Few piscivorous birds were observed during entrainment and trawl surveys throughout the SRDWSC. The one exception was the October 13th entrainment survey at the Man-made Channel Reach 2 where a group of 15 gulls were milling around the DMP pond near the discharge point. Observations of piscivorous gulls and cormorants in the SDWSC were more numerous at Scour Pond Dredge Reach and the upstream reaches from the Upper Roberts through the Turning Basin. Small groups of terns were only observed at the Upper Bradford, Spud Island, and Upper Roberts locations. Very few fish-eating birds were observed during entrainment events in the SDWSC. By far, the larger flocks of gulls and cormorants were observed during trawl surveys in the Turning Basin Reach. These birds were perched on Port of Stockton buildings, flying over, or drifting in the channel during trawl surveys. Cormorant groups of 10 – 30 were regularly observed perched on the overhead power lines crossing the Turning Basin Reach at the Port of Stockton in late November. During the November 23rd trawl survey a large group of approximately 80 cormorants were seen actively feeding in the channel in front of the vessel. Additionally, larger groups of cormorants regularly perched on uncapped piles within Berth 8 and along shore near the fire dock and ramp located upstream and downstream of the Turning Basin Reach, respectively. Swainson's hawks were not observed during monitoring activities in channel reaches or at DMPs.

One sea lion was observed during the final day of trawling in the SRDWSC at the Rio Vista South location. Multiple sea lion observations were documented again in the SDWSC at the Scour Pond and Turning Basin dredge reaches. One sea lion was observed at Light 19. In one instance each at the Scour Pond and Turning locations a sea lion was observed actively eating larger fish during a trawl survey. An adult catfish was the prey observed in the Turning Basin dredge reaches, but the type of fish could not be determined for the Scour Pond observation.

4.7 Comparison of Monitoring Method Results

Assessments of relationships between the species, habits, and relative abundance of the fish encountered in the community and entrainment monitoring are made where enough data exists to reasonably make such assessments. Making these comparisons helps answer questions about the suitability of the fish community monitoring methodology for testing the hypotheses about the subset of species most susceptible to entrainment.

Fish were categorized into demersal (benthic and epi-benthic) and non-demersal (pelagic) fish types based descriptions in Moyle (2002), Wydoski and Whitney (2003), Nobriga et al. (2005), and Brown and May (2006). During 2010, demersal species encountered during fish community monitoring varied by dredge location; from 6.4% at the Turning Basin due to high numbers of threadfin shad, to 85.6% at S-31 due to abundant white catfish. Table 22 provides the data for the abundance of demersal fish encountered during entrainment and fish community monitoring. The abundance of demersal fishes encountered during entrainment monitoring was higher than during fish community monitoring at all locations where both sampling methods were conducted (Figure 24). This was true for 2008 and 2009 as well. During 2010 entrainment monitoring, there were 25 individual pelagic fish (4.52%) out of 532 total fish observed. The species included as pelagic are: wakasagi, delta smelt, striped bass, Sacramento splittail, threadfin shad, American shad, and bluegill. All of these species utilize the channel bottom at times, as all have been encountered during fish community monitoring.

Table 22. Percent Demersal Fishes by Location for 2010 Trawl and Entrainment Sampling

DR Location	Percent Demersal Entrained Fish	Extrapolated Total Entrained Fish	Percent Demersal Trawl Fish	CPUE (fish/100m)
MM Channel 1	96.72	976	85.60	4.73
MM Channel 2	91.63	4,060	67.93	2.47
Rio Vista Bridge	100	738	66.67	0.17
Rio Vista S.	100	1,086	30.23	2.85
Scour Pond	100	37	15.00	1.03
Antioch Bridge W.	Trawl Sampling Only	--	17.64	0.76
Antioch Bridge E.	No Fish Encountered	0	33.33	0.57
Light 19	100	10	9.76	0.80
Lower Bradford	No Fish Encountered	0	Entrainment Sampling Only	--
Upper Bradford	100	37	42.86	1.08
Upper Roberts	94.12	229	30.87	15.44
Turning Basin	97.37	657	6.47	37.37
Spud Island	Trawl Sampling Only	--	34.48	1.03

Presence in the fish community samples predicates presence in the entrainment samples with few exceptions as might be expected. However, relative abundance of species in the fish community samples does not directly correlate with relative abundance in the entrainment samples. In 2010, lamprey (n = 156, 29.33% of entrainment) were the only fish to be encountered during entrainment, but not during fish community monitoring. This was also true for 2009. They have been part of the fish community catch in the past, though never in high numbers (one in 2007 and 13 in 2006). Twelve additional fish species were encountered during fish community monitoring but not during entrainment monitoring: starry flounder, bigscale logperch, white sturgeon, green sturgeon, black crappie, redear sunfish, warmouth, tule perch, blue catfish, golden shiner, Pacific staghorn sculpin, and prickly

sculpin. None of these fishes were commonly encountered. The combined total of these species comprised 2.05% of all fish encountered during fish community monitoring.

Shimofuri goby was the most commonly entrained fish species for the first time in 2009 and was again in 2010, though it was not abundant during fish community monitoring. Table 23 provides additional details about species encountered during both types of sampling. White catfish, channel catfish, and wakasagi were all encountered with similar frequency during both monitoring modes. Threadfin shad, American shad, and striped bass were all encountered during both monitoring modes, but were far more commonly encountered during fish community monitoring.

Table 23. Entrainment and Trawl Percentage for Fish Species Observed in Both Monitoring Methods

Percent Catch of Entrainment	Entrainment Count	Percent Catch of Trawl	Trawl Count	Common Name	Origin	Demersal/ Pelagic
46.43	247	1.25	54	shimofuri goby	Introduced	Demersal
13.35	71	14.00	606	white catfish	Introduced	Demersal
3.57	19	3.93	170	channel catfish	Introduced	Demersal
2.07	11	0.76	33	yellowfin goby	Introduced	Demersal
1.88	10	2.47	107	wakasagi	Introduced	Pelagic
1.13	6	0.16	7	delta smelt	Native	Pelagic
0.75	4	9.66	418	striped bass	Introduced	Pelagic
0.38	2	6.93	300	American shad	Introduced	Pelagic
0.38	2	0.14	6	brown bullhead	Introduced	Demersal
0.19	1	57.07	2,470	threadfin shad	Introduced	Pelagic
0.19	1	0.72	31	bluegill	Introduced	Pelagic
0.19	1	0.53	23	splittail	Native	Pelagic
0.19	1	0.09	4	Shokihaze goby	Introduced	Demersal

Total length was measured for individual fish encountered during both entrainment and fish community monitoring. The difference in mean size among species encountered in both survey types allows assessment of correlations between the size of fish present around the dredge and the likelihood of entrainment. Length data for 2010 was partitioned by species and life stage, and then compared only where two or more fish were measured. This year, eight fish species were comparable between monitoring methods, with juveniles and adult length comparisons available for three of these. In 2009, 12 fish species were encountered in both monitoring methods. However, for 2009 entrainment monitoring, half of the comparable species were represented by only one measured individual. Comparison of fish in prior years did not separately examine length data by life stage. Figure 25 displays a bar chart comparison of the mean size of fishes encountered by both survey types.

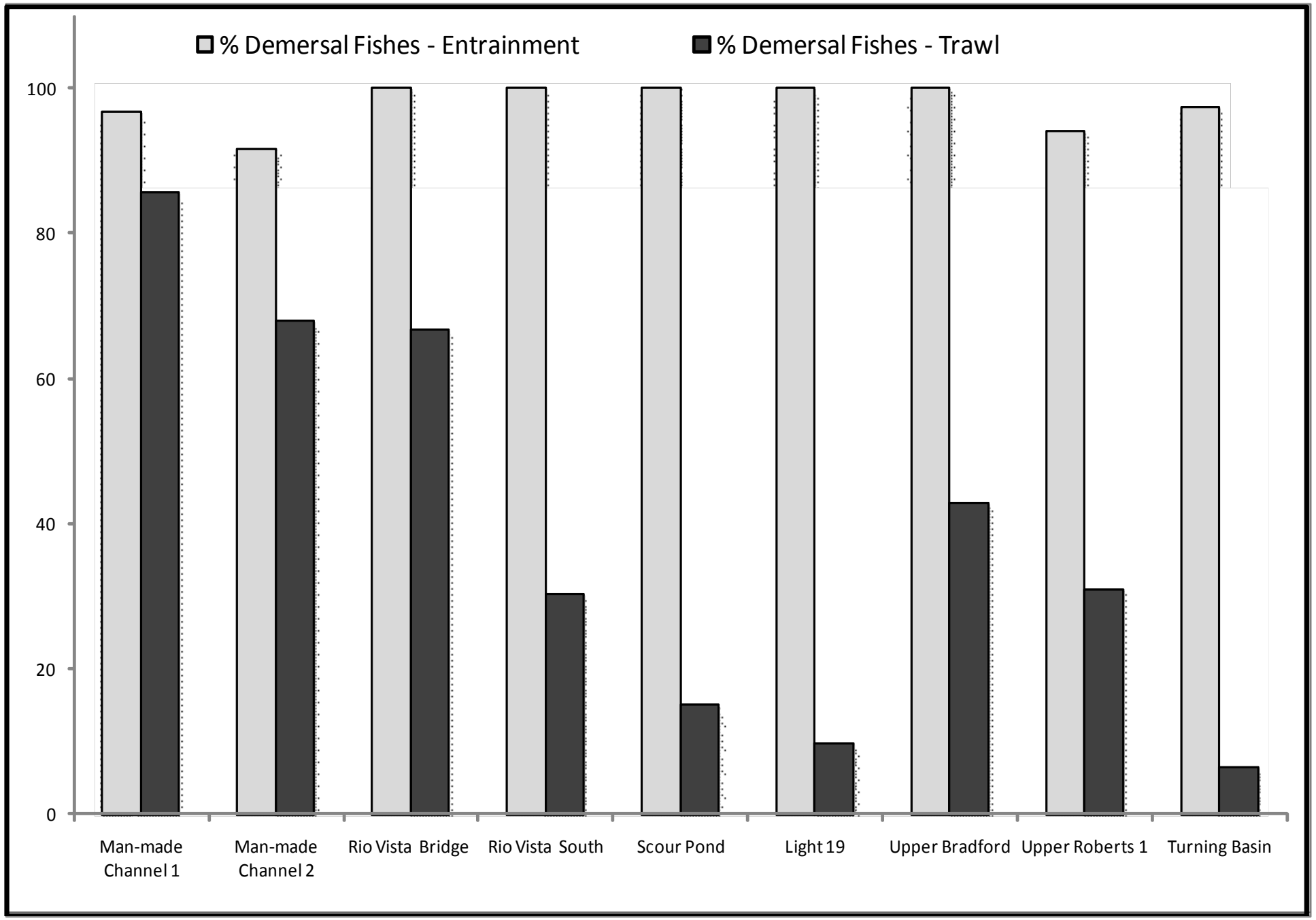
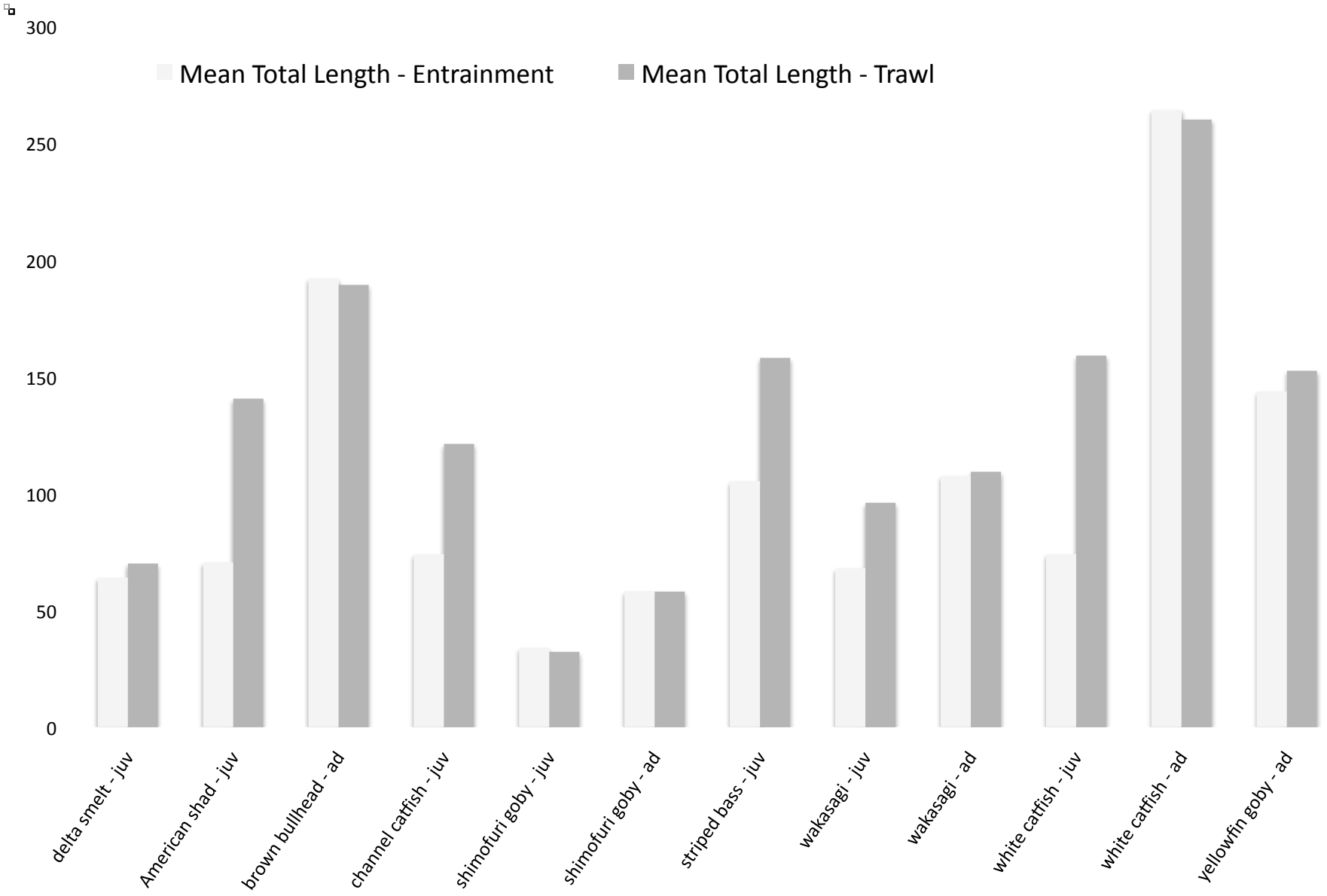


Figure 24. Demeral versus Pelagic Comparison Chart by Sampling Type


300
250
200
150
100
50
0
Mean Total Length - Entrainment
Mean Total Length - Trawl
delta smelt - juv
American shad - juv
brown bullhead - ad
channel catfish - juv
shimofuri goby - juv
shimofuri goby - ad
striped bass - juv
wakasagi - juv
wakasagi - ad
white catfish - juv
white catfish - ad
yellowfin goby - ad

4.8 Water Quality Monitoring

Surface and bottom measurements were acquired for all parameters except Secchi depth and were generally taken at the beginning and end of each set of five trawls for each fish community monitoring event. The complete multi-parameter results are presented in Appendix B. The water quality data discussed below are near bottom measurements.

Bottom water temperature readings exceeded 20°C in all monitoring locations until October 8. The maximum water temperature recorded for 2010 was 21.79°C in the man-made channel 2 reach of the SRDWSC on October 8 and the minimum temperature was 10.2°C in the Upper Turning Basin 3 days prior to completion of monitoring on December 3. Salinity was highest in the lowest reaches and nearly fresh in the man-made portion of the SRDWSC and the upper reaches of the SDWSC, as might be expected. The highest turbidity readings (generally above 100 ntu) were recorded in the Man-made Channel reaches, as was the case in previous years.

4.9 Level of Take

A stated objective of the monitoring program is to improve take estimates for maintenance dredging operations in the Delta. Original take estimates found in the 2006 FMP (Table 24) were based on the estimates developed for SDWSC and SRDWSC maintenance dredging (NMFS 2006a, b). The original estimates assumed exposure of listed fish to sampling gear would be less than 25% of potential exposure to dredging activities and associated shipping. This was an overestimate. No salmon or steelhead, and only 4 green sturgeon, have been encountered since monitoring began in 2006.

Table 24. ESA and CESA Incidental Take Allotments for 2010 Ship Channel Fish Monitoring

Potential Annual Incidental Take of NMFS Listed Fish for the SSC Fish Monitoring Program (original estimate 2006)				
Species	Juveniles		Adults	
	No.	Percent of Total ESU/DPS*	No.	Percent of Total ESU/DPS*
Sacramento River winter-run Chinook salmon	650	0.85	1	<1
Central Valley spring-run Chinook salmon	1,250	0.32	1	<1
Central Valley steelhead	70	0.15	2	<1
North American green sturgeon, Southern DPS	25 juveniles and adults combined (2% = 1 mortality)			
Potential Annual Incidental Take of NMFS Listed Fish for the SRSC Fish Monitoring Program (original estimate 2006)				
Species	Juveniles		Adults	
	No.	Percent of Total ESU/DPS*	No.	Percent of Total ESU/DPS*
Sacramento River winter-run Chinook salmon	650	0.85	1	<1
Central Valley spring-run Chinook salmon	1,250	0.32	1	<1
Central Valley steelhead	70	0.15	2	<1
North American green sturgeon, Southern DPS	25 juveniles and adults combined (2% = 1 mortality)			
Incidental Take of USFWS Listed Fish for the SRSC and SSC Fish Monitoring Program (established 2008)				
Species	Juveniles		Adults	
	non-lethal	lethal	non-lethal	lethal
Delta smelt	10 per week, lethal and non-lethal, no life history differentiation			
IEP-CESA Annual Incidental Take Allotments for the SRSC and SSC Fish Monitoring Program (updated annually)				
Species	Juveniles		Adults	
	non-lethal	lethal	non-lethal	lethal
Longfin smelt	150		150	

* ESU = evolutionarily significant unit DPS = distinct population segment

Estimates of take of delta smelt were not included in the original take estimates, as NMFS does not provide take estimates for these fish species, nor were they established during previous informal consultations with the USFWS. Encounters with delta smelt during previous fish community monitoring required re-initiation of consultation with USFWS which resulted in an amendment (file number 81420-2008-F-1775-1) to the prior USFWS Informal Consultation decision for maintenance dredging (Service File Number 1-1-04-F-0345), allowing monitoring take of up to ten delta smelt per week during normal dredging operational windows. Seven delta smelt were encountered in 2010.

Incidental and lethal take for longfin smelt during fish community monitoring was authorized under Program Element Number 2010-113 for inclusion in the amended IEP Scientific Collecting Permit 1440. The IEP permit allowed 150 adults and 150 juvenile longfin smelt in the take allotment for 2010 monitoring of this study, as described in the 2081a permit issued to J. Gold and S. Novotny. No longfin smelt were encountered or observed during fish community or entrainment monitoring in 2010.

4.10 Sampling Mortality

Some mortality among encountered fish is an unavoidable result of fish community and entrainment sampling, although in the case of the entrainment sampling, all entrained fish are assumed to die as a result of being entrained and then placed in a DMP site. De-watering of DMP sites is not conducted in an effort to save entrained fish that are still alive when de-watering occurs. Rather, it is conducted out of necessity to remove the water from the sites. Entrainment sampling probably reduces overall dredge entrainment mortality as live fish collected during sampling are returned to the river. In this sense, documentation of entrainment mortality serves a separate purpose than that of community monitoring mortality. This data may also prove useful for development of best management practices for dredging, as the entrainment screen methodology could be used to collect entrained fish and other organisms such as native mussels, and return them to the channel.

Table 25 provides mortality data for fish encountered during fish community monitoring and Table 26 provides mortality data from the entrainment monitoring. During fish community monitoring, a total of 756 individuals, or 17.46% of the individual fish encountered were recorded as mortalities during fish community monitoring. Threadfin shad comprised 86.68% of these mortalities, and accounted for 27.45% of the shad encountered. American shad, shimofuri goby, striped bass, and bigscale logperch also had relatively high mortality rates. All wakasagi and delta smelt were collected as required by CDFG, and thus not included in the mortality estimations. Wakasagi and delta smelt are relatively fragile fish, as are all smelts, and the mortality rate would probably be at least 50% if it were to be determined.

Table 25. Total Fish Mortality for 2010 Fish Community Monitoring

Common Name	Total Mortalities	Total Encountered *	Percent of Trawl Mortality	Percent Mortality for Species	Origin
threadfin shad	678	2,470	89.68	27.45	Introduced
American shad	39	300	5.16	13.00	Introduced
shimofuri goby	20	54	2.65	37.04	Introduced
striped bass	15	417	1.98	3.60	Introduced
bigscale logperch	2	5	0.26	40.00	Introduced
redear sunfish	1	43	0.13	2.33	Introduced
channel catfish	1	170	0.13	0.59	Introduced
TOTAL	756				

* excluding those fish that were dead prior to encounter with trawl sampling gear

100% mortality for all introduced wakasagi and delta smelt (n = 116) as preservation of these species a condition of scientific collecting permit

Lamprey experienced some mortality during entrainment sampling. Seventy lamprey escaped through the entrainment screen mesh and were counted as mortalities as were all entrained fish not released alive. Eighty-six lamprey were vouchered for further analysis. These fish and the vouchered fish were used to estimate total entrainment. However, the vouchered specimens were excluded from the mortality assessment.

Shimofuri goby had the highest entrainment mortality rates (69 individuals), accounting for 69% of all entrainment mortalities. Overall, entrainment monitoring resulted in 100 mortalities, or 28% of the fish entrained by the dredge. Native fish (excluding lamprey) comprised 1% of all sampling mortality, not including vouchered specimens.

Table 26. Total Fish Mortality for 2010 Entrainment Monitoring

Common Name	Total Mortalities	Total Encountered *	Percent Mortality	Percent Mortality for Species	Origin
shimofuri goby	69	246	69	28.05	Introduced
channel catfish	10	19	10	52.63	Introduced
yellowfin goby	6	10	6	60.00	Introduced
white catfish	7	71	7	9.86	Introduced
striped bass	2	4	2	50.00	Introduced
American shad	2	2	2	100.00	Introduced
threadfin shad	1	1	1	100.00	Introduced
splittail	1	1	1	100.00	Native
Shokihaze goby	1	1	1	100.00	Introduced
bluegill	1	1	1	100.00	Introduced
TOTAL	100				

* NOTE:: Total numbers include 1 white catfish, 1 threadfin shad, and 1 splittail whose capture disposition could not be determined - thus, assumed alive; and exclude 1 shimofuri goby and 1 yellowfin goby that were dead prior to entrainment encounter.

EXCLUDES VOUCHERED SPECIMENS (100% mortality for vouchered wakasagi, delta smelt, and river lamprey) AND lamprey observed on screen alive, but which escaped through screen mesh prior to collection – these are not counted in the total mortality estimation.

4.11 Vouchered Specimens

Overall, 211 fish were vouchered in 2010. The details are provided in Table 27. There were 86 lamprey vouchered for species assessment by Damon Goodman of the USFWS. Preserved lamprey specimens were delivered to Damon Goodman of the USFWS in Arcata, California, for morphological and potential genetic studies, and as an additional check on the initial field identification. The lamprey samples are housed at Humboldt State University after USFWS investigation and are made available to researchers if requested. All delta smelt, potential hybrids, and wakasagi are now required to be vouchered for further analysis by CDFG. In 2010, 7 delta smelt and 107 wakasagi were encountered during community monitoring while 6 delta smelt and 10 wakasagi were entrained. All of these fish were vouchered for CDFG. Vouchered specimens are described in detail in Table 27.

Table 27. Vouchered Specimens Collected during 2010 Fish Monitoring

Species	Number Vouchered	River Channel	Method of Collection	Reason	Repository Location	Origin
delta smelt	7	SRDWSC	Bottom Trawl	Permit Requirement (IEP) - Further Studies; Confirm ID	CDFG - Bay-Delta Region	Native
delta smelt	6	SRDWSC	Entrainment Screen	Permit Requirement (IEP) - Further Studies; Confirm ID	CDFG - Bay-Delta Region	Native
wakasagi	107	SRDWSC	Bottom Trawl	Permit Requirement (IEP) - Further Studies; Confirm ID	CDFG - Bay-Delta Region	Introduced
wakasagi	10	SRDWSC	Entrainment Screen	Permit Requirement (IEP) - Further Studies; Confirm ID	CDFG - Bay-Delta Region	Introduced
inland silverside	2	SRDWSC	Bottom Trawl	species confirmation	CDFG - Bay-Delta Region	Introduced
river lamprey	83	SRDWSC	Entrainment Screen	species confirmation and other assessments	Humboldt State University	Native
river lamprey	2	SDWSC	Entrainment Screen	species confirmation and other assessments	Humboldt State University	Native
lamprey, undetermined	1	SRDWSC	Entrainment Screen	species confirmation and other assessments	Humboldt State University	Native
TOTAL:	218					

4.12 Combined Data for All Years

Tables 28 and 29 present combined fish entrainment and community monitoring data for all years (2006-2010) without regard to inter-annual differences in effort, location, methods or timing. The information presented in this manner provides an overall description of the fish species that have been present, and the subset of those species most susceptible to entrainment, in the portions of the shipping channels where and when maintenance dredging was occurring. Introduced species greatly outnumbered natives both by species and by number of individuals. The proportion of demersal to pelagic species was higher both in species and in numbers of individuals in the entrainment samples than it was in the fish community samples. Largely due to the presence of lamprey, individuals of native species are more commonly entrained than they are encountered in the fish community around the dredge. Except for delta smelt, all native species observed while entrainment monitoring were demersal, while half of the native species encountered in the fish community samples were pelagic.

Table 28. Combined Total Fish Encountered for All Entrainment Events 2006-2010

Rank	Percent	Number	Common Name	Origin	Demersal/ Pelagic
1	40.92	514	shimofuri goby	Introduced	Demersal
2	19.51	245	channel catfish	Introduced	Demersal
3	17.75	223	lamprey species *	Native	Demersal
4	12.98	163	white catfish	Introduced	Demersal
5	2.71	34	yellowfin goby	Introduced	Demersal
6	2.39	30	Shokihaze goby	Introduced	Demersal
7	0.80	10	wakasagi	Introduced	Pelagic
8	0.72	9	striped bass	Introduced	Pelagic
9	0.56	7	brown bullhead	Introduced	Demersal
10	0.48	6	delta smelt	Native	Pelagic
11	0.24	3	American shad	Introduced	Pelagic
11	0.24	3	bluegill	Introduced	Pelagic
12	0.16	2	Pacific staghorn sculpin	Native	Demersal
12	0.16	2	prickly sculpin	Native	Demersal
12	0.16	2	threadfin shad	Introduced	Pelagic
12	0.16	2	warmouth	Introduced	Pelagic
	Total	1,256			

Number of Species = 17 (5 native species) with 81.44% introduced species and 97.13% demersal

* includes river lamprey, Pacific lamprey, and observed but undetermined lamprey specimens; lamprey specimens from 2006 and 2007 that were not identified to species and treated as one species.

Table 29. Combined Total Fish Encountered for All Trawl Events 2006-2010

Rank	Percent	Number	Common Name	Origin	Demersal / Pelagic
1	52.20	18,989	white catfish	Introduced	Demersal
2	20.60	7,495	threadfin shad	Introduced	Pelagic
3	9.62	3,500	striped bass	Introduced	Pelagic
4	6.96	2,533	American shad	Introduced	Pelagic
5	4.59	1,669	channel catfish	Introduced	Demersal
6	2.52	918	longfin smelt	Native	Pelagic
7	0.72	261	wakasagi	Introduced	Pelagic
8	0.47	170	yellowfin goby	Introduced	Demersal
9	0.39	143	shimofuri goby	Introduced	Demersal
10	0.30	108	white sturgeon	Native	Demersal
11	0.27	99	starry flounder	Native	Demersal
12	0.27	98	Shokihaze goby	Introduced	Demersal
13	0.20	71	tule perch	Native	Pelagic
14	0.12	45	redear sunfish	Introduced	Pelagic
15	0.12	43	delta smelt	Native	Pelagic
16	0.12	42	splittail	Native	Pelagic
17	0.11	40	bluegill	Introduced	Pelagic
18	0.08	30	prickly sculpin	Native	Demersal
19	0.05	19	warmouth	Introduced	Pelagic
20	0.04	15	blue catfish	Introduced	Demersal
20	0.04	15	brown bullhead	Introduced	Demersal
20	0.04	15	common carp	Introduced	Demersal
21	0.04	13	lamprey species *	Native	Demersal
22	0.03	10	Sacramento blackfish	Native	Pelagic
23	0.02	7	black crappie	Introduced	Pelagic
24	0.02	6	bigscale logperch	Introduced	Demersal
25	0.01	5	Pacific staghorn sculpin	Native	Demersal
25	0.01	5	unidentified goby **	Introduced	Demersal
26	0.01	4	green sturgeon	Native	Demersal
27	0.01	3	white crappie	Introduced	Pelagic
27	0.01	3	Inland silverside	Introduced	Pelagic
28	0.01	2	Sacramento pikeminnow	Native	Pelagic
29	0.00	1	golden shiner ***	Introduced	Pelagic
29	0.00	1	largemouth bass	Introduced	Pelagic
	Total	36,378			

Number of species = 34 (13 native) with 96.31% introduced species and 58.78% demersal fishes

* includes river lamprey and Pacific lamprey, and observed but undetermined lamprey specimens assumed to be one of these two species; lamprey specimens from 2006 and 2007 were not identified to species and at the time, treated as one

** unidentified goby not treated as separate species, likely shimofuri or Shokihaze goby rather than an additional species

*** golden shiner was the only additional fish species not encountered in prior years

Green sturgeon, longfin smelt and delta smelt are the only special status (listed) species that have been encountered over all years of this monitoring program, though Pacific lamprey, river lamprey and Sacramento splittail are CDFG species of Concern. White sturgeon collection data are included here as surrogate data due to lack of green sturgeon data. Encounters with special status species are further described in Table 30, though only threatened and endangered species are included. Most lamprey were encountered during entrainment monitoring, although a few have been encountered during fish community monitoring. For the first time in 2010, a listed species was encountered during entrainment monitoring: six delta smelt in the SRDWSC. Aside from these six delta smelt, all of the special status fish were encountered during fish community monitoring.

Table 30. Special Status Fish Species Encountered by Location During All Years of Monitoring

Year	Dredge Reach Location	DMP Site	Rank	No.	Proportion Percentage	Species (common name)
2006	Decker Island	Decker Island	17	2	0.03	green sturgeon
2006	Sherman-Bradford	Bradford Island	5	2	1.60	longfin smelt
2006	Decker Island	Decker Island	1	881	47.72	longfin smelt
2006	Sandy Beach	Sandy Beach	5	8	4.12	longfin smelt
2006	Rio Vista	Rio Vista	7	4	2.52	longfin smelt
2006	Decker Island	Decker Island	5	75	4.06	white sturgeon
2006	Sandy Beach	Sandy Beach	9	3	1.55	white sturgeon
2006	Rough and Ready Island	Roberts 1	8	1	0.02	white sturgeon
2006	Sherman-Bradford	Bradford Island	5	2	0.16	white sturgeon
2006	Rio Vista	Rio Vista	8	3	1.89	white sturgeon
2007	Antioch Br - West Island	Scour Pond	6	1	2.08	longfin smelt
2007	Decker Island	Decker Island	5	1	0.53	longfin smelt
2007	Antioch Br - West Island	Scour Pond	6	1	2.08	delta smelt
2007	Decker Island	Decker Island	3	8	4.28	delta smelt
2007	Man-made Channel	S-31	5	2	3.28	delta smelt
2007	Antioch Br - West Island	Scour Pond,	5	3	6.25	white sturgeon
2007	Rough and Ready Island	Roberts 1	7	2	0.20	white sturgeon
2007	Decker Island	Decker Island	4	2	1.07	white sturgeon
2007	Man-made Channel	S-31	6	1	1.64	white sturgeon
2008	Antioch Br - West Island	Scour Pond	8	25	0.33	delta smelt
2008	Decker Island	Decker Island	9	21	0.27	longfin smelt
2008	Decker Island	Decker Island	16	7	0.09	white sturgeon
2009	Man-made Channel	S-31	7	5	1.11	white sturgeon
2009	Light 21	McCormack Pit	5	2	0.74	white sturgeon
2010	Upper Bradford	Bradford Island	6	2	4.10	green sturgeon
2010	Man-made Channel 1	S-31 A	7	2	0.55	delta smelt
2010	Man-made Channel 2	S-31 B & C	8	5	1.36	delta smelt
2010	Man-made Channel 2	S-31 B & C	4	6	2.64	delta smelt *
2010	Man-made Channel 2	S-31 B & C	11	1	0.12	white sturgeon
2010	Turning Basin	Roberts 1	11	1	0.03	white sturgeon

Species are listed by year and location of occurrence - Rank and proportion of species is calculated by location and monitoring method

* signifies these fish encountered during entrainment monitoring, all other fishes collected during fish community monitoring

Unshaded cells = Sacramento River Ship Channel; Shaded cells = Stockton Ship Channel

California Delta fish species are well documented by Turner and Kelly (1966), McGinnis (1984), Moyle (2002) and others. Some information gaps exist in details of life history and present range. For the majority of approximately 55 species of fish that now occur in the Delta, though, presence or absence in the channel bottom habitat is well understood. One of the central themes continuing to impact monitoring programs is the assessment of efficacy of methods in answering the research questions for the monitoring mandates. To that end, the authors have spent considerable effort describing here the fish species encountered in community and entrainment sampling. An alternate approach is to examine those species not encountered and then, for each species, to describe its rarity and the likelihood of its utilization of the channel bottom. Table 31 provides these details for all species not encountered during the lifetime of this project. Five species emerge from this assessment. Steelhead and Chinook salmon have not yet been encountered by this study. Although they are not extirpated from the sampling locations, these fish are very rare and not often observed using channel bottom habitat (NMFS 2006a, b). A similar scenario exists for hitch and hardhead. Although known to occur in the Delta, no specific information has been found that documents their presence in the channel bottom habitat that investigators are assessing. Finally, black bullhead have not been encountered either, though they are present in the Delta. Specific documentation of their occurrence in the channel bottom habitat is lacking. However, it would not be surprising if they did utilize this habitat. It is also possible that investigators have encountered these fish and misidentified them as brown bullhead. All other species known to occur in the Delta are rare and/or unlikely to utilize the channel bottom habitat, thus decreasing the likelihood of encountering them during trawl or entrainment sampling. The only new species encountered was the single golden shiner encountered during 2010 fish community monitoring.

Table 31. Delta Fishes Not Encountered in Trawl or Entrainment Surveys During All Years of Monitoring

Species	Genus	Species	Origin	Utilizes Channel Bottom Habitat	Rare in the Delta
Sacramento sucker	*Catostomus*	*occidentalis*	Native	No	No
steelhead	*Oncorhynchus*	*mykiss*	Native	No	Yes
Chinook salmon	*Oncorhynchus*	*tshawytscha*	Native	No	Yes
hitch	*Lavinia*	*exilicauda*	Native	No	Yes
riffle sculpin	*Cottus*	*gulosus*	Native	No	No
hardhead	*Mylopharodon*	*conocephalus*	Native	No	Yes
threespine stickleback	*Gasterosteus*	*aculeatus*	Native	No	No
topsmelt	*Atherinops*	*affinis*	Native	No	No
California roach	*Hesperoleucus*	*symmetricus*	Native	No	No
speckled dace	*Rhinichthys*	*osculus*	Native	No	No
American eel	*Anguila*	*rostrata*	Introduced	Questionable	Yes
black bullhead	*Ameiurus*	*melas*	Introduced	Questionable	No
pumpkinseed	*Lepomis*	*gibbosus*	Introduced	No	No
green sunfish	*Lepomis*	*cyanellus*	Introduced	No	No
smallmouth bass	*Micropterus*	*dolemieu*	Introduced	No	No
spotted bass	*Micropterus*	*punctulatus*	Introduced	No	No
goldfish	*Carrasius*	*auratus*	Introduced	No	No
western mosquitofish	*Gambusia*	*affinis*	Introduced	No	No
rainwater killifish	*Lucania*	*parva*	Introduced	No	No
fathead minnow	*Pimephales*	*promelas*	Introduced	No	No
red shiner	*Cyprinella*	*lutrensis*	Introduced	No	No

5 Discussion

5.1 Hypotheses

The methods used by this monitoring program were developed to assess the NMFS assumptions of levels of incidental take of listed salmonids and green sturgeon during SRDWSC and SDWSC maintenance dredging. NMFS assumed that take of these species would be low and required that a monitoring program be developed and conducted to determine level of take, and also required the continued development of measures to avoid, minimize, and monitor the impacts of maintenance dredging on listed salmonids, green sturgeon and their habitat.

The hypotheses were developed prior to the initiation of 2006 monitoring as the means to convert the monitoring requirements into heuristically testable assumptions and questions. They are repeated here again for clarity:

H^1: Maintenance dredging of the SDWSC and SRDWSC will result in take of listed and other fishes through direct dredge entrainment.

H^2: There is a correlation between presence of fish in the dredging areas and entrainment by the dredge.

H^2a: Differential use of the water column will result in different entrainment levels among fishes present in the project areas; that is, demersal fish that are associated with the channel bottom (benthic and epibenthic species) will be entrained in higher numbers than water column (pelagic) fish.

H^1: This hypothesis has been tested during all years of this monitoring program. In 2010, H^1 again proved to be partially correct. Fish species were entrained, though none were threatened or endangered species. Sacramento splittail and threadfin shad were entrained for the first time. River lamprey were entrained at much higher rates than previously documented.

When the 2010 entrainment data is extrapolated, based on the percentage of total dredge output sampled, the total number of fish entrained from this project across all sites is approximately 7,828 fish, very similar to the 7,500 fish estimated in 2009. This figure is likely to vary from year to year as both the number and composition of species change. These changes may come about as a result of future unforeseeable environmental perturbations / changes and as a result of (planned) changes to the monitoring methods, effort, and locations.

One pattern that is beginning to emerge is that a large number of the entrained species have been native fish. This is largely due to the presence of river lamprey, but also due to entrainment of Sacramento splittail, prickly sculpin and staghorn sculpin. To date, the only listed species observed to have been entrained is delta smelt. This does not ensure that other listed species have not been entrained over this time period, nor does it guarantee that listed species have not been subjected to take from dredging impacts other than direct entrainment. Fish community monitoring has shown that listed fish species occasionally occur within the dredging reach, although in relatively low numbers. Therefore, these fish are potentially subjected to take in the form of harm or harassment from dredge and monitoring activities.

H^2 and H^2a: These hypotheses are important because a goal of this monitoring program is to provide information to management agencies about both susceptibility to entrainment and presence of listed and other species utilizing the dredged areas. The data set has gained strength through the use of the mobile entrainment screen by allowing assessment of an order of magnitude more of the dredge output than was previously possible with the sampling cell method. Increasing the amount of dredge

material monitored increases the accuracy of the comparison between the species utilizing the channel bottom and those that are entrained. Fish community assessments conducted in conjunction with entrainment monitoring provides information useful for determining the likelihood of entrainment. Simply stated, rarity in the environment decreases entrainment rates. However, rarity in the environment also confounds our ability to assess likelihood of entrainment based on described behavioral differences among species of interest. The investigators have been faced so far with interpreting potential for incidental take based on data from of non-special status species. NMFS predicted that take of green sturgeon would be higher than listed salmonids based partly on the differential (demersal vs. non-demersal or pelagic) habits of these fish. Thus, H^2 and H^2a provide the framework to assess whether demersal fish actually are entrained at higher rates than pelagic fish.

Classification of fish species as demersal or pelagic was based on general feeding habit and habitat preferences, following Moyle (2002), Wydoski and Whitney (2003), Nobriga et al. (2005), and Brown and May (2006). Other environmental factors that may affect whether a species occupies demersal habitat, such as altered habitat and altered predator-prey relationships, were not considered due to lack of site-specific information. These altered environmental and ecological factors may affect migratory, diel, and feeding behavior of Delta fishes with potential for greater overlap of pelagic and demersal behaviors (Feyrer and Healey 2002, 2003; Norbriga et al. 2005). A recent study conducted in December 2010 (Bennett et al. 2011), indicated that delta smelt presence in the navigation channel varies substantially with the tide. Delta smelt appear to migrate into the shallow areas near the shoreline during ebb tides and move back into the channel during flood tides. A possible explanation of this behavior assumes that delta smelt are able to exploit tidal currents to move upstream, while utilizing shallow areas for feeding and predator avoidance.

With the exception of lamprey, entrained fish continue to represent a subset of the fish observed in the fish community samples though relative abundance of species varies dramatically between entrained species and species utilizing the channel around the dredge. Pelagic fish are comparatively rare in the entrainment samples but not in the trawl survey samples. Four species – white catfish, channel catfish, and wakasagi and delta smelt – all had similar proportions of individuals observed during entrainment and community monitoring. This has not been true previously for catfish species. Wakasagi and delta smelt were present in upper reaches of the man-made portion of the SRDWSC in 2010. Both species were encountered during entrainment monitoring, delta smelt for the first time. This is the first demonstration of vulnerability to entrainment by delta smelt as based upon encounters during both fish community and entrainment monitoring. Longfin smelt were frequently encountered during 2006 community monitoring. However, since very little entrainment monitoring was conducted in 2006, a similar assessment of vulnerability to entrainment cannot be utilized.

River lamprey and unidentified lamprey assumed to be river lamprey were again observed during entrainment monitoring but not during fish community monitoring. Most of the lampreys encountered have exhibited characteristics of the free-swimming macropthalmic juvenile phase of development. These fish, though smaller than adults, share some of their characteristics: large, well-developed eyes, developing teeth, white/silver side and ventral coloration and bluish to black dorsal coloration. Though capable of migration, the large numbers of lamprey entrained in 2010 suggest they dwell or burrow into the sediment to try to escape the dredge cutter head. Most importantly, they are strong swimmers with an ideal size and shape to escape through the trawl mesh, although one specimen was encountered in 2007 using the same-sized trawl net. The size of the trawl net mesh is larger than the size of the entrainment screen holes. This may increase chances of small lamprey that would be retained by the entrainment screen instead being able to escape through the trawl net. Thus, for lamprey it can be assumed that fish community monitoring, as currently conducted, may not be capable of establishing a relationship between abundance in the channel and the entrainment rates.

In addition, several demersal species encountered during community monitoring in 2010 were not observed in entrainment monitoring. These species consisted of: green sturgeon, white sturgeon, starry flounder, blue catfish, and Pacific and staghorn sculpin. This difference between entrainment and fish community monitoring results may be due to: a low occurrence of these species; low sampling efficiency at the corresponding DMP site; and/or avoidance behavior around the dredge. Together, these demersal fish only made up 0.78% of the total fish encountered in trawl sampling (34 individuals). This is also very similar to what occurred in 2009. Only one white sturgeon has been observed as entrained since 2006. This fish was observed by one of RISG crew during 2006 operations at the Bradford Island DMP site. The fish appeared unharmed after traveling through the dredge pipeline and was returned to the river by the fill crew. No sturgeon, starry flounder, blue catfish, or carp have been observed during entrainment sampling. In comparison, starry flounder are occasionally encountered in the fish community catch but common carp are rarely encountered. Both of these species are considered demersal, though the flounder probably is more demersal than the carp. Because both species are strong swimmers, they may be able to avoid the dredge and both can grow large enough to afford some protection from entrainment as well. This indicates that for these species, either swimming ability or rarity in the dredging locations explains lack of entrainment.

Higher percent of encountered fish were measured in 2010 relative to previous years. The most robust fish length data from 2010 has allowed comparison between more fish species, and within species, between adult and juvenile life stages. Differences in the 2010 overall mean total length of fishes (Figure 23) demonstrate that smaller sized juveniles are entrained among white and channel catfish, striped bass, and American shad than those encountered during fish community monitoring. However, in 2010, for seven of the eleven comparable fish and life stages, no length differences are apparent. Among the commonly encountered entrained fish species in 2009, mean total length was smaller than that of those same species encountered in fish community monitoring. In 2008, an unequal variance t-test of significance was performed for channel catfish and white catfish that indicated a significant difference showing smaller channel catfish and white catfish were more susceptible to entrainment than larger fish of the same two species. This relationship was also likely to be stronger than could be demonstrated, as the larger catfish are more able to avoid the trawl net and thus are not represented in the fish community data. Observations of fish subject to sea lion predation demonstrate that larger catfish are present in the monitored reaches than are encountered during fish community or entrainment monitoring. The 2010 length data demonstrated that smaller catfish (white and channel) continue to be more commonly entrained than those that are encountered fish community monitoring. However, the expanded comparison across the greater numbers of fish species garnered this year demonstrates no apparent size difference for the majority of the fish species encountered while conducting both monitoring methods. Future sampling should bolster data strength and provide more detailed information about which species and sizes of fish are most vulnerable to entrainment.

In order to fully test H^2a, more knowledge of the fish inhabiting the dredging sites is needed. This knowledge will be provided by future sampling efforts from this monitoring program and by other studies of Delta fish. The IEP sponsors several long-term status and trends studies, such as the Estuarine and Marine Fish Abundance and Distribution Survey and the Fall Midwater Trawl Survey. There are also other recent studies such as those initiated by the Pelagic Organism Decline (POD) work team. These and other studies will continue to be used to assess the vulnerability of Delta fishes to dredge entrainment. Comparing data across studies will always be problematic since there are substantial differences in timing, methods, and locations. Substantial data gaps still exist in many critical areas of the life history and population biology of listed and other Delta fish species. The lack of basic biological information for some Delta species is compounded by the rapid changes (declines) that some populations are currently experiencing (Bennett 2005; IEP 2008).

Several other factors add additional complications to the hypothesis testing and analysis of vulnerability to entrainment. Among the 34 fish species encountered during fish community monitoring in all years, only 15 can be readily defined as demersal rather than pelagic. These species include: sculpin, goby, catfish, sturgeon, flounder, lamprey, and carp. The trawl net samples from the channel bottom up into the water column while it is open during the tow. The exact height of the cork-line above the bottom has not been determined, but may approach one-third of the total water column height at times and so reach into the zone that pelagic fish may be utilizing. In comparison, the dredge cutter head stays buried in or very close to the channel bottom while entrainment sampling is conducted. The pelagic species may utilize the entire water column in some cases and others may engage in diurnal migrations to the surface or the bottom. Within species, behavioral differences based on life stage also hamper generalized discussion of water column usage. Additionally, the described behaviors for individual species are often based on observations from all of the inland California water bodies in which they occur (Moyle 2002), rather than at specific navigation channel locations. There is some knowledge of which specific areas of the Delta are used by individual species and of how seasonal fluctuations impact species presence in the shipping channel. Yet, many gaps remain for specific Delta locations and groups of fishes (Moyle 2002; Feyrer and Healey 2002, 2003; Bennett 2005; Nobriga et al. 2005; Brown and May 2006).

5.2 Sampling Design Efficiency

The magnitude of percentage increase in the total volume of dredged material monitored in 2010 relative to prior years may be attributed to the exclusive use of the entrainment screen in 2010 at all DMP sites and continued refinement of the device and methodology of use. With continued use of the pneumatic-assisted Y-valve (installed in 2008) and refinement of its operation during initial uses in 2009 and again in 2010, the dredge pumping rate could usually remain unaltered while the output was diverted from the DMP site to the monitoring screen. The efficiency of entrainment monitoring has thus improved over prior years; when there was more need to idle the dredge to divert material for entrainment monitoring.

The entrainment monitoring goal of 6% of dredge output was not achieved at all sites, though a total of 7.23% of the overall output was monitored. Several reaches did not have any entrainment monitoring conducted at all, due to the brevity (less than 24 hours of dredging) of operations. Dredge slurry with abundant organic debris created, at times, a short-term build-up of mixed sediment and debris on the screen surface. Occasionally, the flow of organic material caused the discharge to over-top the sides and/or run off the dump-end of the screen. Also in 2010, there were several occurrences of rapid overwhelming of the screen due to excessive volume of clams and clam shells, clay balls, and at times gravel and rock. These incidences of over-topping or overwhelming were infrequent and short-lived, usually lasting between 15 to 60 seconds in the case of the over-topping. Because the discharge stream could not be adequately screened or observed for potential organisms during these occurrences, screen operators noted the duration of the event and reduced the total time for that entrainment sample accordingly. During incidences of overwhelming, the dredge material was diverted and sampling discontinued until the screen could be cleared and sampling resumed.

Improvements to the entrainment screen requested for 2011 should improve the predictive ability of the sampling. More robust entrainment estimates will help identify trends and further test the study hypotheses. Improvements requested for the sampling screen and changes related to these improvements are discussed in the adaptive management and recommendations sections.

A maximum of five daily trawls were performed during each day that fish community monitoring was conducted. No additional trawls were conducted at any sites. Based on an assessment of the species that have not been encountered during fish community surveys, we believe that five trawls accurately sample the community structure in the shipping channel. We recognize the possibility that increased monitoring would increase our understanding of the presence of the rare species, as well as refine our understanding of relative abundance and other population parameters of fishes that utilize the shipping channels such as tidal or diel fluctuations. However, any increase in fish community monitoring effort would increase sampling costs as well as increase mortality among sampled fish. Any increases to sampling frequency, tow duration, or change of sampling location must first be approved by CESA administrator Kelly Souza (CDFG).

5.3 Overview

The fish species encountered during all project years of fish community and entrainment monitoring are a subset of those described by Moyle (2002) for the Central Valley sub-province. The majority of the species described by Moyle as being present in the Delta, but have not been encountered while monitoring are species with the following traits: rare species; species not known to inhabit the channel bottoms, such as red shiner, and western mosquitofish; or species not known to occur in the areas being dredged, such as Sacramento sucker or topsmelt. Pelagic fish species with relatively high abundances in the Delta (i.e., striped bass and threadfin shad) have been commonly encountered during fish community monitoring but are rarely observed in the entrainment samples. Although 14 different native species (including river lamprey and other possible but unconfirmed *Lampetra spp.)* have been encountered in the community monitoring, the only native fish so far observed during all years of entrainment monitoring have been river lamprey. Pacific lamprey, Sacramento splittail, Pacific staghorn sculpin and prickly sculpin are also native fishes infrequently observed in entrainment monitoring.

Recent precipitous population declines in several species of Delta fish such as delta smelt, longfin smelt, threadfin shad, striped bass (CDFG 2009a,b,c), listed salmonids, and green sturgeon (NMFS 2006a,b) document the need for ongoing assessments of Delta fish populations. Since the 2006 inception of fish community monitoring for this study, several findings have come to light that either corroborate similar observations or, instead, contrast with those of others. These trends, observations, and monitoring outcomes are listed below.

- The introduced Shokihaze goby was not previously described as inhabiting the upper Delta by Moyle (2002), but this species ranked seventh in overall abundance in 2008 and twelfth overall during 2006 monitoring. In 2009, it was the ninth most abundant fish and in 2010 it dropped to sixteenth most abundant. The introduced shimofuri goby was eighth most abundant fish in 2008 and advanced to fifth most abundant in 2009. In 2010, it was seventh most abundant fish during community monitoring and was the most abundant entrained fish.
- The white sturgeon to green sturgeon ratio was approximately 40:1 in 2006, much higher than the 5:1 ratio described by Moyle (2002). The two green sturgeon encountered in 2010 were the first since 2006 and white sturgeon were also less common in 2010. Encounters with white sturgeon have occurred in both channels near the confluence of the two river systems, at Roberts 1 in the SDWSC and at S-31 in the SRDWSC. In 2010, the largest white sturgeon to date was encountered during fish community monitoring near the ore dock in the SDWSC Turning Basin at the Port of Stockton. The white sturgeon data generated by this program may provide useful surrogate data for the presence of green sturgeon in these locations.
- There were 895 longfin smelt encountered during fish community monitoring at lower SRDWSC locations in 2006, ranking first among native species and fourth among all species encountered. This occurred while steep declines in relative abundance were being documented in other locations in the Delta and SF Bay estuary. The 2006 monitoring appears to have coincided with the reported annual center of abundance of spawning adults near Rio Vista (Moyle 2002). In 2007, only two longfin smelt were encountered, while in 2008, 21 longfin smelt were encountered, all from the SRDWSC in late August and early September. The 2009 (CDFG) summer tow net survey (CDFG 2009b) documented presence of longfin smelt primarily from lower SF Bay sites between June and mid-August, and up to the lower end of Sherman Island during the last week in July. The Bay Study (CDFG 2009c) conducts both mid-water and otter trawl surveys throughout the SF Bay and in limited Delta locations over each month of the year. The overlap timing of dredge monitoring varies from year to year, as the timing and duration of dredging varies every year. The mid-water trawl survey of the 2008 Bay Study found areas of higher longfin smelt abundance occurred at, or downstream of, Chipps Island in October and

November, with presence at Decker Island in October. Fish community monitoring during 2008 found longfin smelt distributed downstream of Sherman Lake until November with presence near Decker Island in December.

- No longfin smelt were encountered in 2009 or 2010. The Bay Study data showed that longfin smelt were present downstream of dredging locations during the 2009 season. Some longfin smelt did move into the western Delta area that corresponds with some dredging locations in both channels in January of 2010, but had moved downstream again in February. This data set is available at: http://www.dfg.ca.gov/delta/projects.asp?ProjectID=BAYSTUDY.
- High abundance of longfin smelt in 2006 did not coincide with documented entrainment. However, less than 1% of the dredge output was monitored in 2006. Fish community monitoring by this program and by the ongoing agency studies cited, has documented that high abundance of longfin smelt have not co-occurred with the timing and locations of maintenance dredging since increasing the amount of the dredge output monitored in 2008.
- In 2007 the PODS progress report (IEP 2008) described the highest (worst) bloom on record of the algae (*Microcystis aeruginosa)* centered near Antioch. Significant efforts from the fish monitoring for maintenance dredging also took place in this region during fall 2007, and the CPUE numbers were at least an order of magnitude lower than previously measured by this study at any other location. The 2008 CPUE number at the Antioch dredge reach was higher than that of 2007 and similar to other lower river sites monitored this year. In 2009, very little monitoring was conducted in these locations. However, CPUE numbers here were again lowest among all sites. In 2010, CPUE numbers were again low in these locations.
- No delta smelt were encountered in 2006, or 2009. In 2010, 7 delta smelt were encountered while conducting fish community monitoring and 6 while entrainment monitoring, all in the SRDWSC between September 20th and October 16th. In 2008, 25 delta smelt were encountered during community monitoring; 22 of the specimens were encountered in the SRDWSC between August and early September. Of these 25 specimens, 21 were in the vicinity of Decker Island, one was from the Man-made Channel early in August, and the remaining three individuals were encountered near Antioch during a single night tow on September 21. In 2007, 11 delta smelt were encountered during November and December trawls. Of these 11 individuals, nine were from locations near the confluence of the San Joaquin and Sacramento rivers, and two were from the SRDWSC Man-made Channel near the Port of Sacramento. The CDFG fall mid water trawl study has documented very low abundance of delta smelt since 2006. This data set is available at: http://www.dfg.ca.gov/delta/projects.asp?ProjectID=FMWT
- The studies referenced above indicate that delta and longfin smelt populations remain very depressed and are typically found further downstream in the SF Bay-Delta system. However, documented presence in the lower river miles of both channels and areas of the Man-made Channel indicates potential for their continued presence during maintenance dredging operations. Occurrence of delta smelt and wakasagi during fish community and entrainment monitoring in 2010 reinforces the view that monitoring methods are appropriate for detecting longfin and delta smelt, even though not specifically designed for them, and that future presence of smelt species during maintenance dredging, should it occur, is likely to result in entrainment.
- The absence of listed salmonid encounters is not surprising given their very low populations, and the timing and location of maintenance dredging during 2006-2010.

5.4 Bird Activity Monitoring

Piscivorous bird presence around the dredge area is indicative of an abundance of fish in the area. Fish or invertebrates entrained by the dredge may also attract birds to the DMP sites. Sea lion presence has also been documented, since their presence in large freshwater rivers can indicate presence of large fish not successfully sampled by the trawl, such as salmonids. This is particularly true if feeding behavior can be observed.

Bird activity in the DMP site may also be a result of fish or other invertebrates being entrained by the dredge. However, it may also be an attraction response to sources of flowing water, or, as was observed in 2008 and 2009, predation of birds on newly displaced terrestrial prey previously occupying the DMP site. The few number of birds observed at 2010 DMP sites did not show any trends or patterns with numbers of fish entrained during sampling, or with fish CPUE levels of the dredge reaches.

Piscivorous bird activity was nearly absent at the beginning of the 2010 season. Observations of these birds increased in dredge reaches as the 2010 season progressed and followed the increase in CPUE in an upstream direction for the SDWSC. Piscivorous gulls and cormorants, with incidents of active feeding, were more frequently observed and numerous in the Turning Basin dredge reach than all other locations.

Sea lions were present during most of the monitoring at the Scour Pond and Turning Basin dredge reaches. Active sea lion predation was observed at these two locations. These observations suggest larger fish were present. The single sea lion observation made at Rio Vista South was of an animal moving through the area, while the sea lion at Light 19 was basking on a navigation buoy.

5.5 Adaptive Management Strategies and Recommendations for Future Monitoring Efforts

NMFS requires that adaptive management strategies be employed and discussed as part of this monitoring program. Since inception, the focus has been on testing and improving the project method through constant evaluation while monitoring is underway; followed by careful analysis of the annual monitoring results that includes comparisons with other available data. Adaptive management in past years specifically focused on improvements to entrainment monitoring methods and responding to the presence of delta and longfin smelt in fish community samples. Specifically pertinent previous adaptive management actions and recommendations for future actions are presented in the following sections.

5.5.1 Entrainment Monitoring

Modifications to monitoring methods for the 2009 monitoring incorporated the following changes

The mobile entrainment screen was used successfully at all DMP sites in 2009 and 2010, dispensing completely with the entrainment cell methodology and allowing a significant increase in sampled dredge output with no increase in sampling effort. Two of the cross bars on the screen were removed based on analysis of structural integrity impacts of removal that were deemed minimal versus vastly improved ease in material clearance off the screen.

Additional modifications utilized in 2010

The dump gate at the end of the screen was re-worked prior to the start of the 2010 sampling. The gate is now much easier to use. The first section of screen was removed and replaced with steel plate early during 2008 sampling due to washout of the axles under the screen by slurry dropping down from this forward section of the device. This decreased the effective area of the screen by approximately 20 percent. Frequent entrainment screen over-loading in some locations during 2009 sampling demonstrated the need to return to the originally engineered screen capacity. This section of plate was removed and replaced with the 3/8-inch punch-hole steel plate used in the rest of the device. Additional modifications to channel the dredge slurry away from the trailer axels were also incorporated. Hinged aluminum plates were installed on the first 3 sections of screen to eliminate slurry splashing over the sides of the screen during periods of high slurry discharge. Hinges allow opening of these lids for cleaning the debris that accumulates on the screen during use - a daily maintenance chore.

Recommendations for 2011 and beyond

The Y-valve currently in use to direct slurry to the entrainment screen or main DMP will be replaced prior to commencement of dredging in 2011. Intended to occur prior to commencement of dredging in 2010, valve was backordered. While the valve currently in use does work, the biologists doing the sampling must get off of the screen and walk over to the valve to direct the slurry away from the screen and back to the DMP, when the screen clogs with debris. This became a serious problem in 2009 and limited sampling effort at times during 2009 and 2010 sampling, due to frequent screen inundation at some locations. The new valve will be operable without the need to get off the screen or ask for help from the dredge crew. The new valve should result in the ability to sample more of the dredge output without an increase in the level of effort or cost, as the biologists should be able to spend more time sampling and less time clearing debris.

A new water pump and spray system was installed to increase the amount and pressure of water available to sort and clean entrained materials. This system still needs improvement in both areas. One possibility is use of a powered pressure washer mounted on the screen.

The screen was tilted at several locations to allow gravity to help move material off the screen. The screen should be modified to allow easier tilting once in use. Tilting allows the screen to be adjusted to the variety of slurry volume and pressure that occur due to changing discharge pipe lengths.

The screen still needs a better lighting system. The light plant provided by RISG is not able to position the light directly over the screen. Partial shadowing of the screen surface results, decreasing visibility for any entrained organisms on the shadowed portion of the screen. The screen should have additional lights mounted in such a way that none of the surface of the screen is shadowed. The lights should be very bright and should be as close to full spectrum as possible. Lack of useful lighting hinders the ability to conduct nighttime and early morning sampling.

Lampreys are among the least studied group of fishes in California. At least seven species occur in freshwater habitats within the state, and all are species of special concern in need of greater conservation efforts (Moyle et al., 2009). Four species may occur in the project area, Kern brook, western brook, river, and Pacific (Moyle, 2002). All four of these species were petitioned for listing under ESA in 2003. The USFWS denied the listing in 2004 largely due to lack of information (http://www.fws.gov/pacific/news/2004/lampreyNR.pdf). The USFWS has an ongoing West Coast lamprey conservation initiative in which they describe dredging as one of the significant impacts to west coast lampreys (http://www.fws.gov/pacific/fisheries/sp_habcon/lamprey/index.htm). Pacific and river lamprey have both been among the entrainment samples, though only a single Pacific lamprey has been identified to date. The rest have been river lamprey. The Pacific lamprey was identified without the benefit of USFWS genetic analyses and was possibly a misidentified river lamprey. Though Kern brook and western brook lamprey occur in the project area, none have been encountered.

High concentrations of river lamprey (relative to previous sampling) were entrained during 2010 dredge entrainment sampling near Rio Vista, possibly indicating an area of abundance not previously indentified. Lack of information on these endemic species is likely due to their being under-sampled by the sampling gear currently employed in the ongoing status and trends studies (Bay Study, Fall Mid-Water Trawl, Suisun Marsh Study, etc). The dredge monitoring entrainment project described here may be the most effective lamprey sampling study currently underway in the California Delta, even though the methods were not specifically developed to target lamprey. The fish community monitoring conducted for this program reflects similar results. Very few lamprey have been encountered in trawl survey samples. The authors assume this is due to the ability to wriggle through the net mesh, since the trawl net collects clams, shrimp, and other benthic fishes most effectively.

Due to the need for greater conservation measures for lamprey, and the possibility of future listings, we propose to continue to salvage and identify entrained lampreys. The current monitoring provides opportunity to better ascertain survival rates through the development of an entrained lamprey mortality study. Should survival rates be high, then it is likely that entrained lamprey salvage and release could be considered a viable best management practice for ongoing maintenance dredging and proposed channel deepening. The amount of assessed dredge slurry has increased yearly since the inception of daily monitoring in 2006. Increase in assessed volume has been accomplished without an increase in the level of effort or cost. Use of the entrainment screen at all sites starting in 2009 provided an order of magnitude increase over previous years. These incremental yearly increases are due to relatively small changes in the operation of the screen. It is anticipated that use of a new Y-valve in 2011 will result in further increased assessment. This and other future improvements will continue to provide important gains in the power of the entrainment monitoring to predict the total number and species of entrained organisms, while maintaining the currently funded level of effort.

5.5.2 Fish Community Monitoring

The following modifications to the fish community monitoring methods were incorporated in 2009

Upgrades were made to the computers and software of the sampling vessel, allowing improvements in navigation in the shipping channels as well as improvements in data acquisition and manipulation.

The following modifications to the fish community monitoring methods were incorporated in 2010

- A dissecting microscope and magnifying lenses were used on board the vessel to effectively differentiate wakasagi from delta smelt.
- Improvements to the database and electronic forms allowed more data to be directly entered while conducting the fish community monitoring.

Recommendations for 2011 and beyond

This monitoring program has been requested to participate in sturgeon tracking studies being conducted by the Biotelemetry Laboratory at UC Davis. The goals of the studies are to provide increased knowledge of habitat use and migration patterns of green and white sturgeon. The studies are funded in part by US Bureau of Reclamation and USACE - San Francisco district. The intended participation of this dredge monitoring program will be to tag green and white sturgeon encountered during fish community monitoring. This will increase the number of tagged fish in the study and provide valuable information that would otherwise not be generated. Permit amendments required to tag sturgeon are being sought through CDFG and NMFS. If permission is granted, project biologists will receive training in sturgeon tagging prior to commencement of 2011 fish community monitoring. If conducted, sampling would be conducted as described in this plan, except when sturgeon are encountered. When encountered, they will be placed in a container of river water while the rest of the catch is rapidly processed, and then they will be tagged and released. Details of the tagging methods will be added to the FMP if a revision or addenda for tagging is conducted.

5.6 Conclusions

Key conclusions of the 2010 monitoring program are:

- Fisheries monitoring requirements stipulated by the NMFS BOs (NMFS 2006a, b) for the SDWSC and SRDWSC were successfully met during the 2010 dredge season.

- The fish community in the Delta continues to be dominated by non-native fish; fish community and entrainment monitoring data continues to exhibit significant inter-annual variation.

- Entrainment sampling efficiency and the quantitative capability of entrainment monitoring was increased substantially by improvements to the mobile entrainment screen. Continued improvements will yield additional gains.

- Take of listed and other species during future dredging events may be predicted by presence of these species in the fish community samples.

- Lamprey species are particularly susceptible to dredge entrainment and should be a focus of management agency attention due to their sensitive status. Though not currently listed, likelihood of future listing is high.

- Delta smelt and wakasagi encountered during entrainment and fish community monitoring indicates that longfin and delta smelt would be entrained if dredging coincides with presence of these listed species.

- The requested permit extension to dredge in the upper reaches of the SDWSC in early December was granted, in part, because of the ability of this monitoring program to demonstrate impacts to listed species.

6 References

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. U. S. Army Corps of Engineers, North Pacific Division. Fish Passage Development and Evaluation Program. Portland, OR.

Bennett, W. 2005. Critical assessment of the delta smelt population. San Francisco Estuary and Watershed Science. 3(2): article 1 (September 2005).

Bennett, W. 2011. (Personal Communication). *How did I get here? Tinkering with turbidity, tides, and twilight for migrating delta smelt.* University of California Davis. Symposium Presentation *at* 2011 IEP Annual Workshop March 30, 2011, Folsom, California.

Brown, L. R., and J. T. May. 2006. Variation in spring nearshore resident fish species composition and life histories in the lower Sacramento-San Joaquin watershed and delta (California). San Francisco Estuary and Watershed Science. 4(2): article 1 (September 2006). Available: http://repositories.cdlib.org/jmie/sfews/vol4/iss2/art1. (2007).

Buell, J. W. 1992. Fish entrainment monitoring of the Western-Pacific Dredge *R W Lofgren* during operations outside the preferred work period. Report of Buell and Associates to Western-Pacific Dredging Company.

California Department of Fish and Game (CDFG). 2008a. IEP endangered species take reporting. Resources Agency, Department of Fish and Game. Available: http://www.delta.dfg.ca.gov./data/esa/. (March 2008).

———. 2008b. California natural diversity database, special animals (865 taxa), February 2008. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPAnimals.pdf. (February 2008).

———. 2008c. CDFG Biogeographic Data Branch and Habitat Conservation Branch web pages. Available: http://www.dfg.ca.gov/bdb/pdfs/TEAnimals.pdf and http://www.dfg.ca.gov/hcpb/species/SDWSC/SDWSCfish/SDWSCfish.shtml. (February 2008).

———. 2008d. Bay-Delta region fall midwater trawl indices. Available: http://www.delta.dfg.ca.gov/data/mwt/charts.asp. (January 29, 2008).

———. 2009a. Bay-Delta region fall midwater trawl indices. Available: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=FMWT. (January 12, 2009).

_____. 2009b. Bay-Delta region summer townet survey – delta smelt indices and fish distribution maps. Available: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=TOWNET. (January 12 and February 9, 2009).

_____. 2009c. Bay-Delta region San Francisco Bay study – Otter trawl survey and mid-water trawl survey delta smelt and longfin smelt indices and fish distribution maps. Available: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=BAYSTUDY. (January 12 and February 12, 2009).

California Department of Water Resources (CDWR). 2009. California data exchange center. Available: http://cdec.water.ca.gov/. (April 23, 2009).

Dean, S., and B. Illowsky. Hypothesis testing of single mean and single proportion: assumptions. Available at: http://cnx.org/content/m17002/1.7/. (February 7, 2009).

Feyrer, F., and M. P. Healey. 2002. Structure, sampling gear and environmental associations, and historical changes in the fish assemblage of the southern Sacramento-San Joaquin delta. California Fish and Game 88(3):126–138.

———. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin delta. Environmental Biology of Fishes 66:123–132.

Goodman, D. H., Kinziger, A. P., Reid, S. B., and Docker, M. F. 2009. Morphological diagnosis of *Entosphenus* and *Lampetra* ammocoetes (Petromyzontidae) in Washington, Oregon, and California. American Fisheries Society Symposium. 72: 223-232, 2009.

Howard, J. 2010. The other Freshwater Mussels: Native Freshwater Species in California. Delta Science Program Brown Bag series. 2010

Interagency Ecological Program (IEP). 2008. Pelagic organism decline progress report: 2007 synthesis of results. California Environmental Protection Agency, State Water Resources Control Board. Available: http://www.waterrights.ca.gov/baydelta/pelagicorganism.html. (January 15, 2008).

Mari-Gold Environmental Consulting and Novo Aquatic Sciences (MEC and NAS). 2010. Stockton and Sacramento Deepwater Ship Channel Maintenance Dredging 2010 fish community, entrainment and water quality monitoring report. Prepared for U.S. Army Corps of Engineers, Sacramento District. Submitted April 2010.

———. 2011. Fish Monitoring and Water Quality Plan: Stockton Deep Water Ship Channel and Sacramento Deep Water Ship Channel Maintenance Dredging and Dredged Material Placement Projects. Prepared for U.S. Army Corps of Engineers, Sacramento District. Submitted April 2011.

McGinnis, S. M. 1984. Freshwater fishes of California. University of California Press, Berkeley.

Moore, D. S. 1995. The basic practice of statistics. W.H. Freeman. New York.

Moore, D. S. and G. P. McCabe. 1993. Introduction to the practice of statistics. W.H. Freeman. New York.

Moyle, P. B. 2002. Inland fishes of California, revised and expanded. University of California Press. Berkeley.

Moyle, P. B., Brown, L. R., Chase, S. D., and Quinones, R. M. 2009. Status and conservation of lampreys in California. American Fisheries Society Symposium 72:279 -292, 2009.

Nobriga, M. L., F. Feyrer, R. D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies, and biomass. Estuaries 28(5):776–785.

NMFS (National Marine Fisheries Service). 2006a. Biological and conference opinion for the Stockton deep water ship channel maintenance dredging and levee stabilization project. SWR-2004-SA-9121: JSS, April 4, 2006. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

———. 2006b. Biological opinion for the Sacramento deep water ship channel (SDWSC) maintenance dredging and bank protection project. SWR-2006/00041, August 29, 2006. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

O'Rear, T.J. and P. B. Moyle. 2010. Long Term and Recent Trends in Fishes and Invertebrates in Suisun Marsh. Interagency Ecological Program. 232, Spring 2010.

Pacific Fishery Management Council (PFMC). 1998. Final environmental assessment/regulatory impact review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan. October 1998.

SWCA Environmental Consultants (SWCA). 2007. 2007–2008 fisheries monitoring plan for the Stockton and Sacramento Deep Water Ship Channel ID/IQ Maintenance Dredging operations and IEP program element 2007-113. Report to U.S. Army Corps of Engineers, Sacramento District. Submitted to IEP/CDFG and USACE July 31, 2007. SWCA, Portland.

———. 2008. Stockton and Sacramento Deep Water Ship Channel Maintenance Dredging Project 2007 fish community and entrainment monitoring report. Report to U.S. Army Corps of Engineers, Sacramento District. Submitted March 2008. SWCA, Portland.

———. 2009. Stockton and Sacramento Deep Water Ship Channel Maintenance Dredging Project 2008 fish community and entrainment monitoring report. Report to U.S. Army Corps of Engineers, Sacramento District. Submitted March 2008. SWCA, Portland.

Turner, J. L., and D. W. Kelly. 1966. Ecological studies of the Sacramento-San Joaquin Delta - Part 2, Fishes of the Delta. California Department of Fish and Game.

U.S. Fish and Wildlife Service (USFWS). 2004. 90-day finding on a petition to list three species of lampreys as threatened or endangered, Notice of Petition Finding. Federal Register 69:270 (December 27, 2004):77158–77167.

Wang, J.C.S. 2007. Spawning, early life stages, and early life histories of the Osmerids found in the Sacramento-San Joaquin Delta of California. Tracy Fish Collection Facility Studies. Volume 38. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service.

Wydoski, R. S., and R. R. Whitney. 2003. Inland fishes of Washington, 2nd edition. American Fisheries Society. Bethesda, Maryland.