Caspian Tern Research on the Lower Columbia River

FINAL 2000 Season Summary

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This Final 2000 Season Summary has been prepared for the Bonneville Power Administration and the Interagency Caspian Tern Working Group for the purpose of assessing project accomplishments. This report is not for citation without permission of the authors.

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Methods: The numbers of Caspian terns breeding in the Columbia River Estuary (i.e., Rice and East Sand islands, see Map 1) and up-river (i.e., Three Mile Canyon and Crescent islands, see Map 2) were estimated using aerial photographs taken of each colony near the end of the incubation period. Direct counts of adult terns in aerial photos were corrected to estimate the number of breeding pairs at each colony using ground counts of incubating and non-incubating terns on plots. Productivity (number of fledglings raised per breeding pair) at the East Sand Island tern colony was estimated using aerial photos taken of the colony just prior to the fledging period. Direct counts of all terns (adults and juveniles) in aerial photos were corrected to estimate the number of fledglings on the colony using ground counts of adults and fledglings on plots. Productivity at all other colonies was estimated from ground counts of all fledglings on each colony just prior to fledging.

Results and Discussion: The estimates of the number of breeding pairs that attempted to nest at the Rice Island and East Sand Island colonies in 2000 were 588 and 8,513 pairs, respectively (see Figure 1 for weekly counts of individual terns on the Rice Island and East Sand Island colonies in 2000). Caspian terns did not attempt to breed on any other islands in the Columbia River Estuary in 2000. We estimated that 90 and 4,841 young terns were fledged from the Rice Island and East Sand Island colonies, respectively. This corresponds to productivity of 0.15 and 0.57 fledglings/breeding pair at Rice Island and East Sand Island, respectively.

The estimates of the number of breeding pairs that attempted to nest at the Three Mile Canyon Island and Crescent Island tern colonies in 2000 were 260 and 571 pairs, respectively. No young were fledged at the Three Mile Canyon Island tern colony this season due to mink predation on eggs and young chicks. We estimated that 390 young were fledged from the Crescent Island tern colony in 2000, or 0.68 fledglings/breeding pair.

Coastal Sites

Methods: Aerial surveys along the southern Washington Coast (i.e., Willapa Bay and Grays Harbor, see Map 2) were conducted on a weekly basis throughout the breeding season to identify newly established tern colonies outside the Columbia River Estuary. The Washington Department of Fish and Wildlife (WDFW) and its contractors monitored nesting terns along the northern Washington Coast (i.e., Puget Sound). Ground counts were conducted by WDFW to estimate the number of breeding terns and fledglings at the Asarco Industrial Site on the shores of Commencement Bay, near Tacoma, WA. For more information on the Asarco tern colony, contact Chris Thompson (WDFW) at thompcwt@dfw.wa.gov.

Results and Discussion: Although terns were commonly observed foraging and roosting in Willapa Bay and Grays Harbor throughout the 2000 breeding season, terns did not attempt to breed at either location in 2000. This suggests that suitable tern nesting habitat (i.e., upland island or mainland sites that are unvegetated, unoccupied by other colonial nesting birds, and without mammalian predators) is not currently available in Willapa Bay or Grays Harbor.

Caspian terns once again nested at the Asarco Industrial Site, near Tacoma, WA in 2000, as they did in 1999. This colony site is in the midst of an EPA Superfund site, so designated because of heavy metal contamination of soils near the former copper smelter. Terns nested on the top of a flat mound of reclaimed earth (about 1,000 ft x 150 ft x 30 feet high) that was covered by a thick black rubber tarp on which WDFW and its contractors had placed about 350 flattened sand mounds (diameter about two feet) as artificial nest sites for the terns. Tern decoys were also used to attract terns to nest on the mound. The number of adult terns counted at the Asarco colony varied from ca. 1,100 birds early in the season (May and June) to ca. 2,000 birds late in the season (July and August; Ann Edwards, University of Washington, personal communication). Higher counts late in the breeding season were likely due to terns immigrating to the Asarco site from other colony sites, including the colonies in the Columbia River Estuary (based on re-sightings of terns previously banded in the Columbia River Estuary, see below). Terns successfully raised young at the Asarco colony, with ca. 500-600 chicks fledged (Ann Edwards, University of Washington, personal communication). Estimates of the number of breeding pairs and productivity at the Asarco colony are not yet available. Other than the two colonies in the Columbia River Estuary, the Asarco colony was the only Caspian tern colony along the coasts of Washington and Oregon in 2000.

Tern nesting habitat at the Asarco Superfund site will be removed prior to the return of Caspian terns to breeding colonies in 2001 (i.e., clean-up of heavy metal-contaminated soils). The terns that nested at the Asarco colony in 2000 will be forced to look for a new colony in 2001. We expect that at least some of these terns will attempt to relocate to colonies in the Columbia River Estuary.

Inland Sites (off the Columbia River)

Methods: Inland Caspian tern colony sites (off the Columbia River) were investigated in both Oregon and Washington in 2000. These surveys were conducted to determine the current status of Caspian tern colonies at inland locations where terns have historically bred. These sites were visited on 1-3 occasions late in the breeding season (i.e., late June and July). Counts of the number of adult and young terns were conducted at each colony site. Reliable estimates of the number of breeding pairs and productivity are not available for these colonies.

Results and Discussion: Three inland Caspian tern colonies were located off the Columbia River in eastern Washington (see Map 1 of Caspian tern colony sites in interior Washington). All three of these sites are located east of the mid-Columbia River and north of the Snake River. Solstice Island, located in Potholes Reservoir, was visited in

mid-June through mid-July, when as many as 210 adult terns and 154 chicks were counted on the colony. This site was revisited in mid-July, after it had been abandoned. There was evidence of human disturbance at or near the colony site (footprints, dog tracks, fire pits, used fireworks), which may have caused some nest failure. The disturbance occurred sometime between July 7 and July 18.

In late June, 30 adult terns were counted on Goose Island, located in Banks Lake just above Dry Falls Dam near Coulee City. No chicks were observed on the Goose Island colony; however, 10 adult terns were incubating eggs. When the site was revisited in mid-July, only one adult tern was observed on the colony. It appears that no young were produced at this site in 2000.

In early July, 37 adult terns and 18 chicks were observed on Harper Island in Sprague Lake. Our surveys of inland Washington suggest that these three locations were the only active Caspian tern colonies in eastern Washington off the Columbia River.

Four active Caspian tern colonies were documented in interior Oregon. Caspian tern breeding colonies were visited in the Warner Valley in southern Oregon near Lakeview and in Malheur National Wildlife Refuge in eastern Oregon near Burns. The two Warner Valley tern colonies were located on Pelican Island at the northern end of Crump Lake, and on a small, unnamed island at the north end on Summer Lake. Pelican Island was visited in late July, when ca. 250 adult terns and 50 chicks were counted on the colony. To our knowledge, this represents the first documented nesting record for Caspian terns on Crump Lake. Chicks were on average 1-2 weeks old, while some terns were still incubating eggs. In previous years, tern breeding was reported on Pelican Lake, which is just south of Crump Lake (<15 km). It does not appear that terns nested on Pelican Lake in 2000.

The Summer Lake tern colony was visited in early July, when 16 breeding pairs were counted (Marty St. Louis, ODFW, personal communication). This colony was smaller than was reported the previous year (38 breeding pairs), perhaps due to lower lake levels in 2000 providing easier access to the island for predators from the mainland (Marty St. Louis, ODFW, personal communication).

In late July, Caspian tern colonies were visited on two unnamed islands at the north end of Malheur Lake. These colonies were about the same size (ca. 100-150 breeding pairs) but differed in nesting chronology. The first colony had chicks that were about 3 weeks old on average, while there were terns brooding eggs and young chicks at the other colony. The latter colony may have been a re-nesting attempt after failure at another colony site, perhaps due to receding water levels providing a land bridge for mammalian predators to cross from the mainland. Unlike all the other tern colonies we have reported on thus far, the tern colonies on Malheur Lake were not on bare substrate, but instead amidst low-lying vegetation (salt grass) and, in some cases, amidst dense vegetation. All Caspian tern colonies in inland Oregon were on shallow lakes (1-6 feet deep) and in each case nesting chronology was delayed compared to tern colonies in the Columbia River Estuary or the lower Columbia River.

Diet Composition and Smolt Consumption Estimate

Lower Columbia River and Estuary

Methods: Because terns transport whole fish in their bills to their mates (courtship meals) and young (chick meals), taxonomic composition of the diet can be determined by direct observation of adults as they return to the colony with fish (e.g., bill load observations). Observation blinds were set up at the periphery of each tern colony on the lower Columbia River and estuary so that prey items could be identified with the aid of binoculars and spotting scopes. The target sample sizes were 350 bill load identifications per week at each tern colony in the estuary (i.e., Rice and East Sand islands) and 150 bill load identifications per week at each up-river tern colony (i.e., Crescent and Three Mile Canyon islands). Fish watches at the Rice Island and East Sand Island tern colonies were conducted concurrently twice each day, once each at high and low tide to control for potential tidal and time of day effects on diet. Prey items were identified to the lowest discernible taxon. We were confident in our ability to distinguish salmonids from non-salmonids and most non-salmonid taxa based on direct observations from blinds, but we did not attempt to differentiate between the various salmonid species. To assess the relative proportion of the various salmonid species in tern diets, we collected 10 bill load fish/week at the Rice Island and East Sand Island tern colonies by shooting Caspian terns returning to the colonies with whole fish carried in their bills (referred to hereafter as "dropped fish"). Dropped fish were not collected from the up-river tern colonies (i.e., Crescent and Three Mile Canyon islands) or late in the season at the Rice Island tern colony, due to the potential impact of our lethal sampling on those smaller colonies. Salmonids were identified as chinook salmon, sockeye salmon, coho salmon, steelhead, or unknown based on soft tissue or otolith analysis. A. Evans (OSU) and D. Markle (OSU) provided identifications of intact dropped fish, and M. Weiss from the Moss Landing Marine Lab provided identifications from otoliths. PIT tags placed in juvenile salmonids were also collected from the Rice Island and East Sand Island tern colonies in 2000. Those data are currently being analyzed and are available through the National Marine Fisheries Service.

Estimates of annual smolt consumption for the Rice Island and East Sand Island tern colonies were calculated using a bioenergetics modeling approach. In 2000, we also used a Monte Carlo simulation procedure to calculate reliable and narrower 95% confidence intervals for estimates of smolt consumption by terns.

Results and Discussion: Forty-seven percent of the identifiable fish delivered to the East Sand Island tern colony were juvenile salmonids (n = 5,387), compared to 90% at the Rice Island tern colony (n = 5,023; see Figure 2). The proportion of the diet that was salmonids remained high during the entire 16 week breeding season at the Rice Island tern colony (over 90% in 10 of 16 weeks, over 80% in all 16 weeks; see Figure 3). At East Sand Island, the proportion of the diet that was salmonids peaked at ca. 80% for three weeks in early to mid May, and averaged 36% of the diet for the remainder of the season (see Figure 3). We estimated that Caspian terns nesting on Rice and East Sand

islands consumed 0.7 million (95% confidence interval = 0.4 – 0.9 million) and 6.7 million (95% c.i. = 5.3 – 8.4 million) juvenile salmonids in 2000, respectively. In total, terns nesting in the Columbia River Estuary consumed 7.3 million juvenile salmonids (95% c.i. = 5.7 – 9.3 million), or approximately 6.4% (95% c.i. = 4.4% - 8.1%) of the estimated 115 million out-migrating smolts that reached the estuary during the 2000 migration year (the estimated number of smolts that survived to the estuary in 2000 was provided by H. Pollard, NMFS). Of the all juvenile salmonids consumed, we estimate that 46% were coho salmon (best estimate = 3.3 million, 95% c.i. = 2.5 – 4.4 million), 35% were chinook salmon (best estimate = 2.6 million, 95% c.i. = 2.1 – 3.1 million), and 19% were steelhead (best estimate = 1.4 million, 95% c.i. = 1.1 – 1.9 million).

At the up-river tern colonies, 75% of the identifiable fish delivered to the Crescent Island tern colony were juvenile salmonids (n = 846), compared to 86% salmonids at the Three Mile Canyon Island tern colony (n = 331). This colony-specific diet composition was based on observations conducted up through mid-June, when terns were still nesting on both colonies (the Three Mile Canyon Island tern colony was abandoned during the third week in June due to mink predation). The proportion of salmonids in the diet of terns nesting at the Crescent Island colony based on observations throughout the nesting season (through July) averaged 61% (n = 1,804). Estimates of juvenile salmonid consumption by terns nesting at these two colonies are not yet available. PIT tags placed in juvenile salmonids were also collected from the Crescent Island and Three Mile Canyon Island tern colonies in 2000. Those data are currently being analyzed and are available through the National Marine Fisheries Service.

Coastal Sites

Methods: Visual identification of bill loads (see above) was also used to determine diet composition at the Asarco tern colony from mid May through the end of July. WDFW and its contractors observed bill loads on 3 days in May, 4 days in June, and 4 days in July. Dropped fish (see above) were not collected at the Asarco tern colony. For more information on the Asarco tern colony, contact Chris Thompson (WDFW) at thompcwt@dfw.wa.gov.

Results and Discussion: Fifty-two percent of the fish delivered to the Asarco tern colony were juvenile salmonids (n = 1,540). The percent of the diet that was salmonids was 55% in May, 64% in June, and 36% in July. Other prey types that were prominent in the diet were smelt, herring, and shiner perch (Chris Thompson, WDFW, personal communication).

Inland Sites (off the Columbia River)

Bill load observations were not used to determine diet composition at inland tern colonies (off the Columbia River) in 2000. At the tern colonies in Malheur Lake, the main forage fish available to terns was carp (R. Roy, USFWS, personal communication), and at the tern colonies in the Warner Valley the main prey was tui chub (M. St. Louis and C. Edwards, ODFW, personal communication). In Summer Lake, Crappie were also

abundant (C. Edwards, ODFW, personal communication). Diet composition and forage fish availability are unknown for the tern colonies in eastern Washington. At Solstice Island in Potholes Reservoir, however, 1,640 PIT tags, 52 radio tags, and 9 acoustic tags from juvenile salmonids were recovered from the tern colony. All of these tags were from smolts tagged and released in the Columbia River Basin in 2000; the Columbia River is over 30 miles from the Solstice Island tern colony. The PIT tags recovered were from fish released in the mid-Columbia River Basin (1,625 or 99%) and Snake River Basin (15 or 1%). Most of the PIT tags (1,218 or 74%) were from steelhead used in a Wells Dam survival study. Roughly 2% of the steelhead PIT tags used in that study were recovered on the Solstice Island tern colony. See Table 1 for species and release site information for all PIT tags recovered on Solstice Island in 2000.

Nest Site Fidelity

Methods: To collect information on colony site fidelity and dispersal, Caspian terns were captured and radio-tagged at the Rice Island colony prior to egg-laying, and at the East Sand Island colony during incubation. At Rice Island, we were interested in where the terns that formerly nested on Rice Island would choose to nest. Terns were captured at the Rice Island colony using rocket nets. Fifty captured terns were radio-tagged with tail-mounted transmitters, color-banded with a unique color combination of plastic leg bands, weighed, and measured. Once released, the birds' movements were monitored using both fixed receiving stations (located at Rice and East Sand islands) and mobile tracking from fixed-winged aircraft. Radio-tagged terns were determined to be nesting on Rice Island or East Sand islands based on repeated detections of a bird at the same colony location on successive nights.

On East Sand Island, we sought to determine where failed breeders might attempt to renest. Thirty terns were captured on the East Sand Island colony site during incubation using noose mats placed around their nests. These terns were radio-tagged, banded, and measured using the same methods as for the Rice Island terns. Twenty-three of the radio-tagged terns had the eggs removed from their nests to simulate removal by predators. Once released, the terns were monitored and nesting status determined as described above.

Results and Discussion: Of the 50 terns radio-tagged on Rice Island, 36 are known to have nested in the estuary. Of these 36 terns, 7 (14%) and 28 (78%) subsequently nested on Rice Island and East Sand Island, respectively. Efforts to capture terns using rocket-nets on Rice Island may have helped encourage terns to relocate to East Sand Island to nest. Also, the large number of terns that settled at the East Sand Island colony site prior to rocket-netting on Rice Island probably attracted terns to nest at East Sand Island. Of the 23 terns captured on East Sand Island whose eggs were removed, 14 (61%) are known to have renested. Of these 14 terns, 11 (79%) and 3 (21%) renested at the East Sand Island and Rice Island colonies, respectively. These results suggest that, under the conditions of the experiment, failed breeders at the East Sand Island colony are more likely to renest at that colony than elsewhere. The results may have been different,

however, if there had been alternative colony sites available for failed breeders to immigrate to other than Rice Island.

Foraging Ecology

Methods: Caspian terns were captured and radio-tagged at the Rice Island and East Sand Island colonies (see above). The foraging distributions of radio-tagged terns nesting on Rice and East Sand islands were monitored using fixed-winged aircraft each week from May through July. We flew 30 times to relocate radio-tagged terns over the 12-week nesting period, an average of 2.5 flights/week. Nesting status of all radio-tagged terns was determined as described above. Off-colony locations of radio-tagged terns were categorized as one of the following: (1) the Columbia River between the Astoria Bridge and Kelso/Longview, (2) the Columbia River between the Astoria Bridge and the mouth, (3) Willapa Bay and the Washington Coast between the mouth of the Columbia River and Willapa Bay, and (4) Grays Harbor and the Washington Coast between Willapa Bay and Grays Harbor (see Map 2).

Results and Discussion: The location of all off-colony detections for radio-tagged terns nesting on Rice Island (n = 21) were: 14 (67%) on the Columbia River above the Astoria Bridge, 6 (28%) on the Columbia River below the Astoria Bridge, 0 (0%) in Willapa Bay or vicinity, and 1 (5%) in Grays Harbor or vicinity. The location of all off-colony detections for radio-tagged terns nesting on East Sand Island (n = 225) were: 19 (8%) on the Columbia River above the Astoria Bridge, 151 (67%) on the Columbia River below the Astoria Bridge, 43 (19%) in Willapa Bay and vicinity, and 12 (5%) in Grays Harbor and vicinity. These data indicate that off-colony distribution, and presumably foraging distribution, of terns nesting at the two colonies in the estuary were markedly different. Terns nesting on East Sand Island were found outside the estuary along the Washington Coast more frequently (24% of all detections) than terns nesting on Rice Island (5% of all detections). During the brood-rearing period, Rice Island terns foraged significantly more in freshwater habitats higher in the estuary, where juvenile salmonids were apparently the primary prey available. Terns nesting on East Sand Island foraged primarily in brackish estuarine and marine habitats, where alternative prey were apparently more abundant, as indicated by diet composition (see above).

Post-Breeding Dispersal and Survival

Methods: To assess post-breeding dispersal and survival, both adult and juvenile terns were banded at various tern colonies throughout the Pacific Northwest in 2000. Terns were banded with a federal numbered metal leg band and a unique combination of colored leg bands that allows for the identification of terns from a distance (i.e., at roosts or on colony). Adult terns were banded at the Rice Island (n = 589), East Sand Island (n = 30), and Asarco colonies (n = 12). Fledgling terns were banded at the East Sand Island (n = 364), Crescent Island (n = 69), Solstice Island (n = 44), and Asarco colonies (n = 125). Fledgling terns were captured on colony by herding nearly fledged birds into

holding pens. Once captured, fledgling terns were immediately transferred to pheasant holding crates supplied by ODFW, and kept out of direct sunlight until banded and released. Resightings of banded terns were reported to us through the web page, by phone, or by e-mail. Project staff, other researchers, and agency personnel reported most of the Resightings of banded terns.

Results and Discussion: Over 8,723 Resightings of color-banded terns had been reported as of August 1, and many more re-sighting have been reported since then. These data are currently being analyzed and will be presented in a subsequent report. In general, most Resightings of post-breeding terns from the estuary were to the north (Resightings along the Pacific coast as far north as Vancouver, B.C.) and east (Resightings at up-river tern colonies and along the mid-Columbia River). Current Resightings are from along the Pacific Coast of southern California and Mexico. These data suggest that terns may disperse northward along the coast before heading south to over-winter along the Pacific coast of Mexico and Central America.

Monitoring and Evaluation of 2000 Tern Management Plan

Nesting Distribution

In 2000, roughly 94% of Caspian terns breeding in the Columbia River Estuary were on East Sand Island. This represents a dramatic shift in the breeding population from Rice Island to East Sand Island over the past two years (see Figure 4). This move can be attributed to concurrent efforts to attract terns to breed on East Sand Island (i.e., habitat modifications, tern decoys, sound systems that broadcast tern calls) and dissuade terns from nesting on Rice Island (i.e., silt-fencing, planting of winter wheat, eagle decoys, and active harassment of terns attempting to breed in 1999). Research activities (i.e., use of rocket nets to capture terns for marking; see above) may have also contributed to the movement of terns from the Rice Island colony to the East Sand Island colony in 2000. The number of Caspian terns nesting on Rice Island increased in 1998, while total numbers of nesting terns in the Columbia River estuary remained approximately stable during 1999-2000 (see Figure 4), despite reductions in the amount of habitat used by nesting terns in the estuary since 1996 (see Figure 5).

Diet and Smolt Consumption

In 2000, the proportion of juvenile salmonids in the diet of Caspian terns nesting at the East Sand Island colony (47%) was 48% lower than the proportion of juvenile salmonids in the diet of terns nesting at the Rice Island colony (90%; see Figure 2). The proportion of juvenile salmonids in the diet of terns nesting on Rice Island in 2000 was higher than in previous years, whereas the proportion of juvenile salmonids in the diet of terns nesting on East Sand Island in 2000 was the same as last year (Figure 6). As was the case in 1999, fish with marine affinities (i.e., herring, anchovy, smelt, surf perch, sand lance) were more prevalent in the diet of terns nesting on East Sand Island compared to that of terns nesting on Rice Island.

The total consumption of juvenile salmonids by Caspian terns nesting in the Columbia River Estuary in 2000 (7.3 million, 95% c.i. = 5.7 – 9.3 million) represents a reduction in the number smolts consumed by terns compared to 1998 and 1999 (Figures 7 and 8). Smolt consumption by terns in 2000 is markedly less than the hypothetical situation of all terns nesting on Rice Island in 2000 (Figure 7 and Figure 8). Terns nesting in the estuary in 1998 consumed an estimated 12.4 million smolts (95% c.i. = 9.1 – 15.7 million) and in 1999 consumed an estimated 11.7 million smolts (95% c.i. = 9.4 – 14.1 million; Figure 7). We estimate that if all the terns that nested in the estuary in 2000 had nested on Rice Island, they would have consumed 13.3 million smolts (95% c.i. = 10.1 – 17.1 million; Figure 7). The large reduction in the number of juvenile salmonids consumed by terns in 2000, as compared to the previous two years, was primarily due to a reduction in the number of chinook salmon consumed (Figure 9). Conversely, the estimated number of steelhead and coho salmon smolts consumed by terns nesting in the estuary over the last three years has remained relatively constant (Figure 9). Based on these results, we estimate that in 2000 5.1 million fewer smolts were consumed by Caspian terns nesting in the estuary compared to 1998, 4.4 million fewer smolts compared with 1999, and 6.0 million fewer smolts compared to the hypothetical situation where all terns nested on Rice Island in 2000 (Figure 10).

Tern Productivity

Although the productivity of terns nesting at East Sand Island has been higher than the productivity of terns nesting on Rice Island in each of the last two years, East Sand Island terns experienced a large reduction in productivity in 2000, compared to the previous year (Figure 11). We suspect that there were two major causes for the reduction in the productivity at the East Sand Island tern colony in 2000. First, there was a severe rain- and wind-storm in mid-June that caused severe flooding on the colony. As many as 1,000 tern chicks died as a result of that storm. The large size of the East Sand Island tern colony in 2000, as compared to 1999, may also have been a contributing factor for lower productivity. There was no apparent increase in predation on tern eggs and chicks by western/glaucous-winged gulls at the East Sand Island tern colony. Adult-adult and adult-chick aggression, however, was higher on East Sand Island in 2000 as compared to the previous year, likely due to the increased nest density and overall larger size of the colony in 2000, which may have contributed to lower productivity on East Sand Island in 2000.

Summary (1997-2000)

We initiated a field study in 1997 to assess the impacts of Caspian terns on the survival of juvenile salmonids in the Columbia River estuary. Rice Island, a dredged material disposal island, supported an expanding population of 14,000-17,000 nesting Caspian terns until 2000. This breeding colony was the largest of its kind ever recorded in the world, and supported about two-thirds of all the Caspian terns nesting along the Pacific Coast of North America. Diet analysis indicated that Caspian terns nesting on Rice Island

consumed more juvenile salmonids than any other prey type (73% of prey items in 1998). Using bioenergetics modeling, we estimated that in 1998 Caspian terns nesting on Rice Island consumed about 12.4 million juvenile salmonids (95% c.i. = 9.1 – 15.7 million), or approximately 13% (95% c.i. = 9% - 16%) of the estimated 97 million out-migrating smolts that reached the estuary during the 1998 migration year.

Analysis of over 36,000 smolt PIT tags recovered from the Caspian tern breeding colony on Rice Island revealed that steelhead smolts were more vulnerable to tern predation than other species of salmonids, and that over 13.3% of all PIT-tagged steelhead smolts that reached the estuary were consumed by terns nesting on Rice Island in 1998. Hatchery-raised yearling Chinook salmon smolts were more vulnerable to tern predation than their wild counterparts. ESA-listed and unlisted salmonid smolts were consumed in proportion to their availability.

The magnitude of predation on juvenile salmonids by Rice Island terns led to management action in 1999. A pilot study was conducted to determine whether part of the Rice Island tern colony (river mile 21) could be relocated 16 miles closer to the ocean on East Sand Island (river mile 5), where it was hoped terns would consume fewer salmonids. Habitat restoration, social attraction (decoys and audio playback systems), and selective gull removal were used to encourage terns to nest on East Sand Island. About 1,400 pairs of Caspian terns nested at the new colony site on East Sand Island in 1999, where nesting success was good (ca. 1.2 young raised per nesting pair). The terns nesting on East Sand Island foraged more in marine and brackish water habitats than did the terns nesting on Rice Island, and the diet of East Sand Island terns consisted of 46% salmonids, or 40% fewer salmonids than were consumed by terns nesting on Rice Island. Despite the success of the pilot study, an estimated 11.7 million juvenile salmonids (95% c.i. = 9.4 – 14.1 million) were consumed by Caspian terns in the Columbia River estuary in 1999.

The management plan in 2000 sought to prevent all nesting by Caspian terns on Rice Island and to attract all the terns that formerly nested at Rice Island to 4 acres of tern nesting habitat on East Sand Island. However, a court-ordered temporary restraining order precluded the elimination of all tern nesting on Rice Island. Nevertheless, 94% of the terns nesting in the estuary chose the colony site on East Sand Island. Tern nesting success at the East Sand Island colony was only about half the nesting success recorded at the East Sand Island colony in 1999, but was nearly four times higher than that at the Rice Island colony in 2000. Juvenile salmonids comprised 47% of the diet of terns nesting at East Sand Island, compared to 90% of the diet of terns nesting at Rice Island. The relocation of nearly all the nesting terns from Rice Island to East Sand Island resulted in a sharp drop in consumption of juvenile salmonids. Total consumption of juvenile salmonids by Caspian terns nesting in the Columbia River estuary in 2000 was estimated at 7.3 million (95% c.i. = 6.1 – 8.6 million). This represents a reduction in smolt consumption by terns of about 4.4 million (38%) compared to the 1999 consumption estimate. To achieve further reductions in the annual consumption of juvenile salmonids by Caspian terns in the Columbia River estuary, regional fish and wildlife managers are considering the restoration of tern colonies outside the estuary and the relocation of a portion of the East Sand Island colony to these alternative sites.

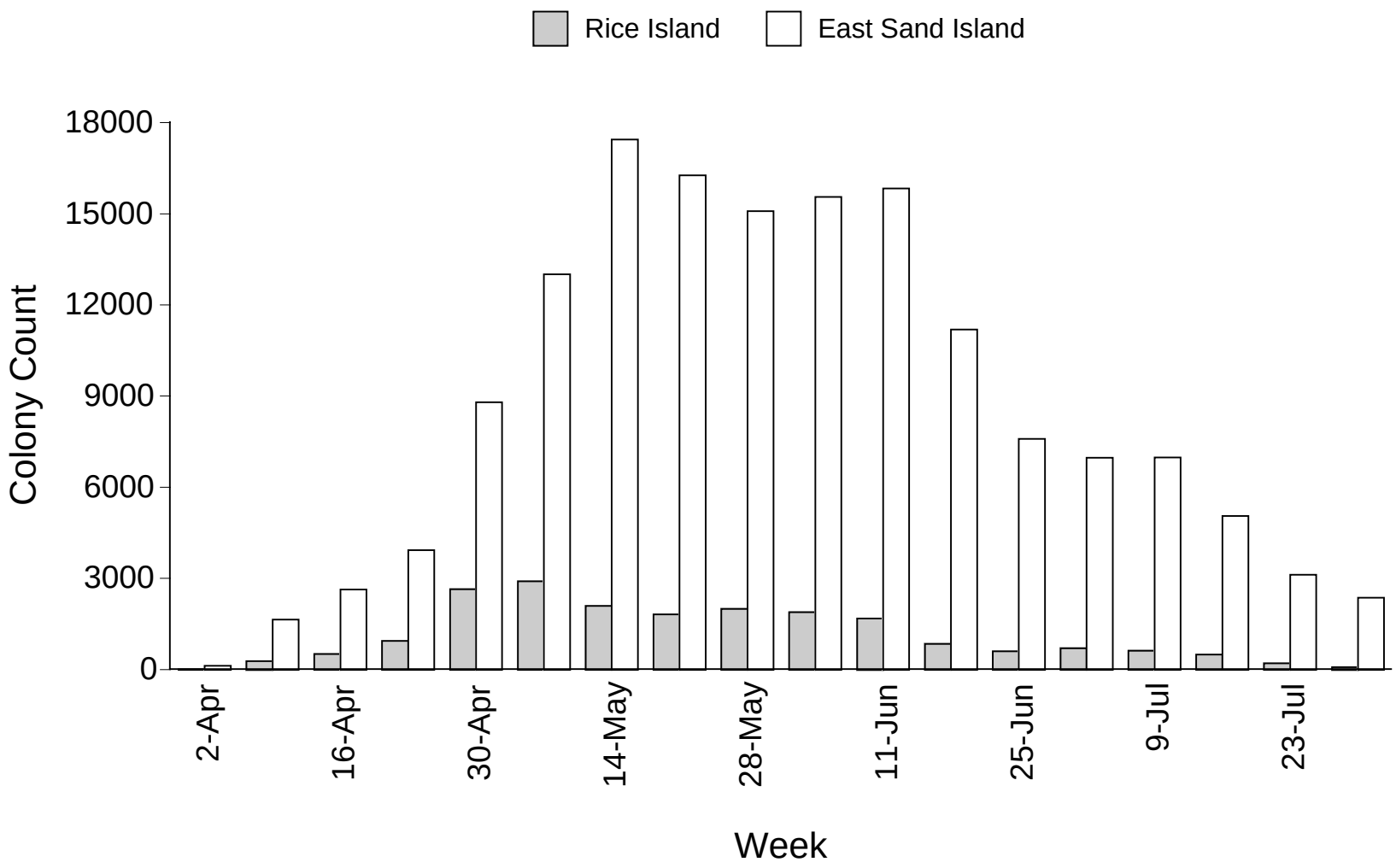


Figure 1. Caspian tern colony counts on Rice and East Sand islands, 2000.

Figure 2. Caspian tern diet composition on Rice and East Sand islands, 2000.

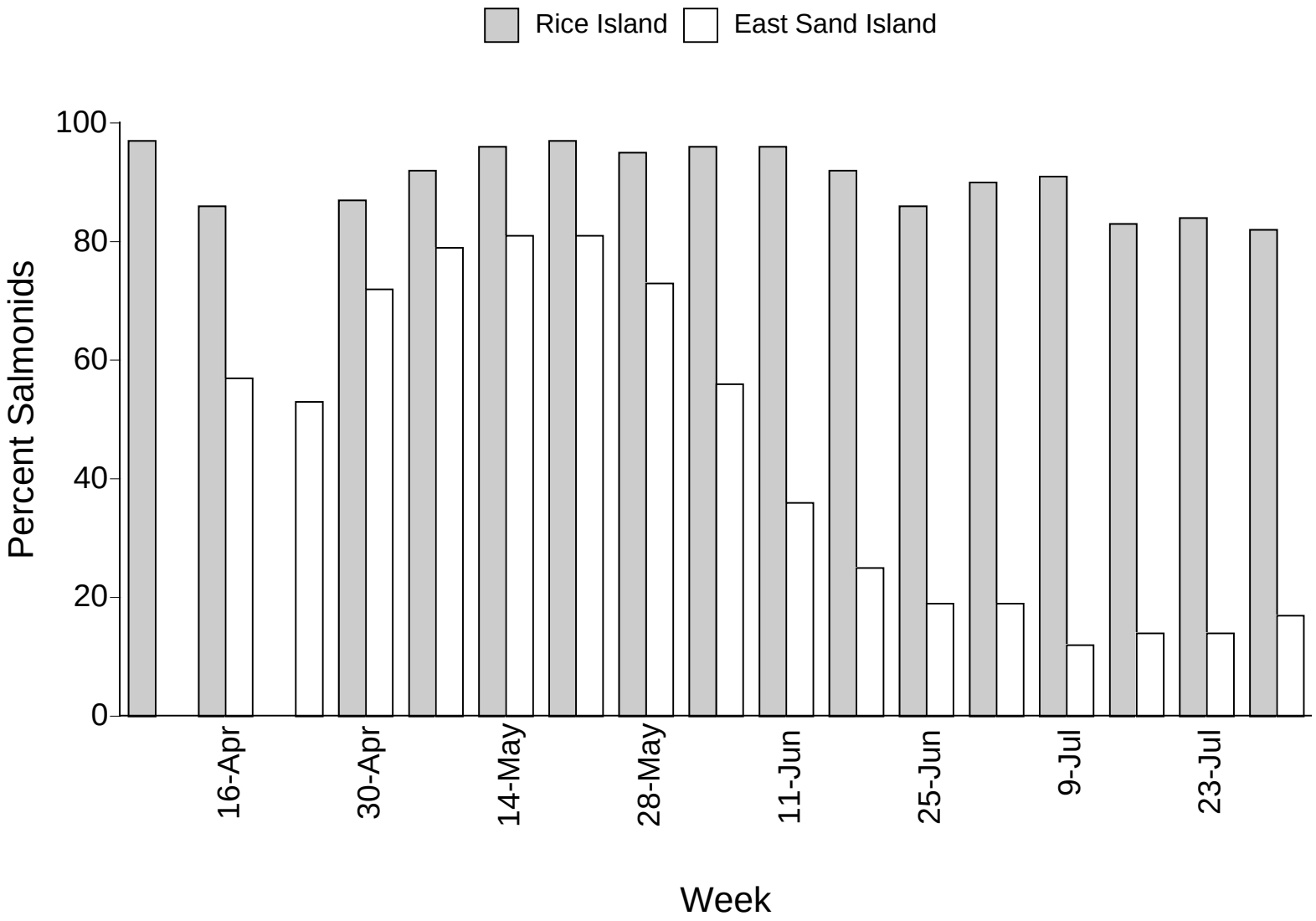


Figure 3. Caspian tern diet composition on Rice and East Sand islands, 2000.

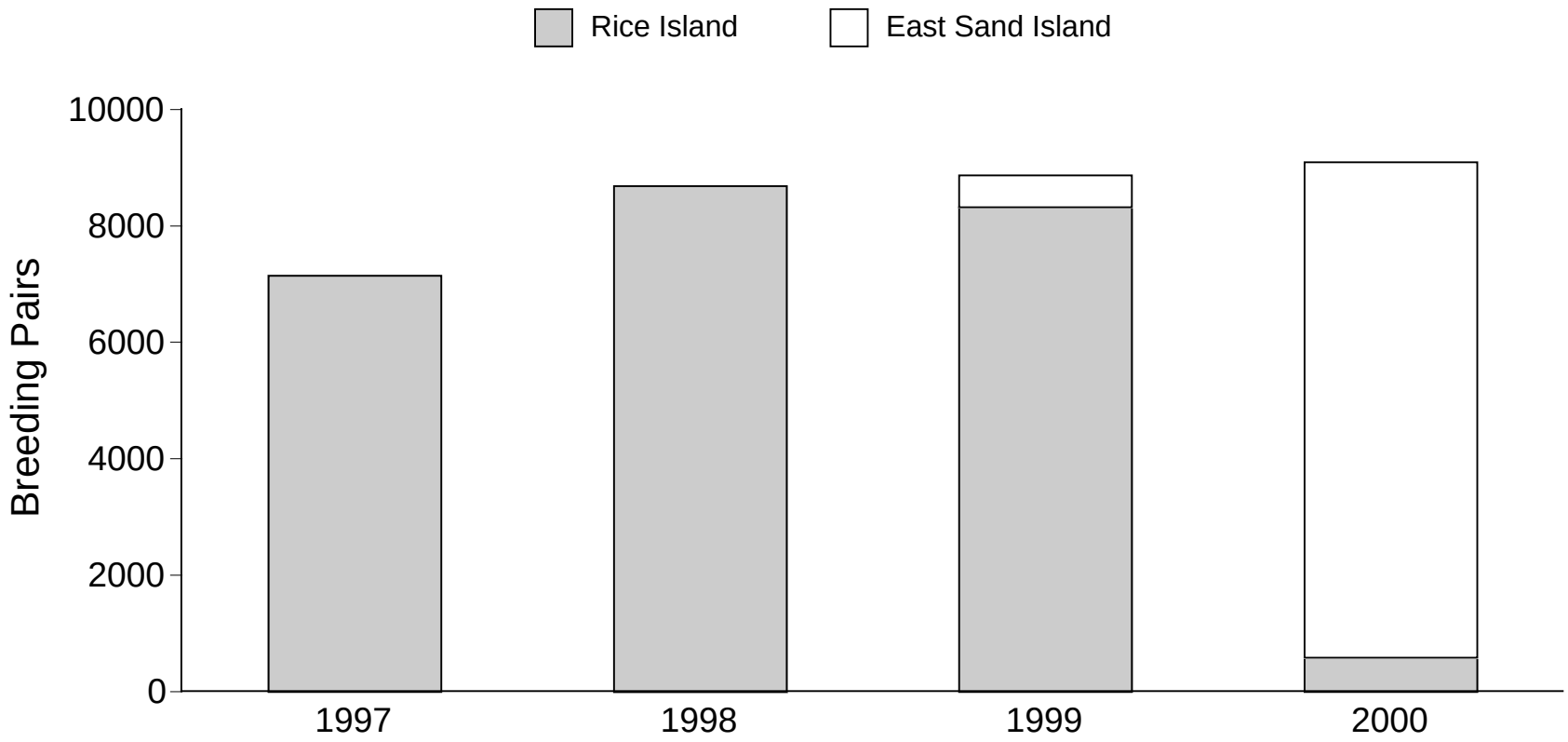


Figure 4. Caspian tern colony size in the Columbia River Estuary, 1997 - 2000.

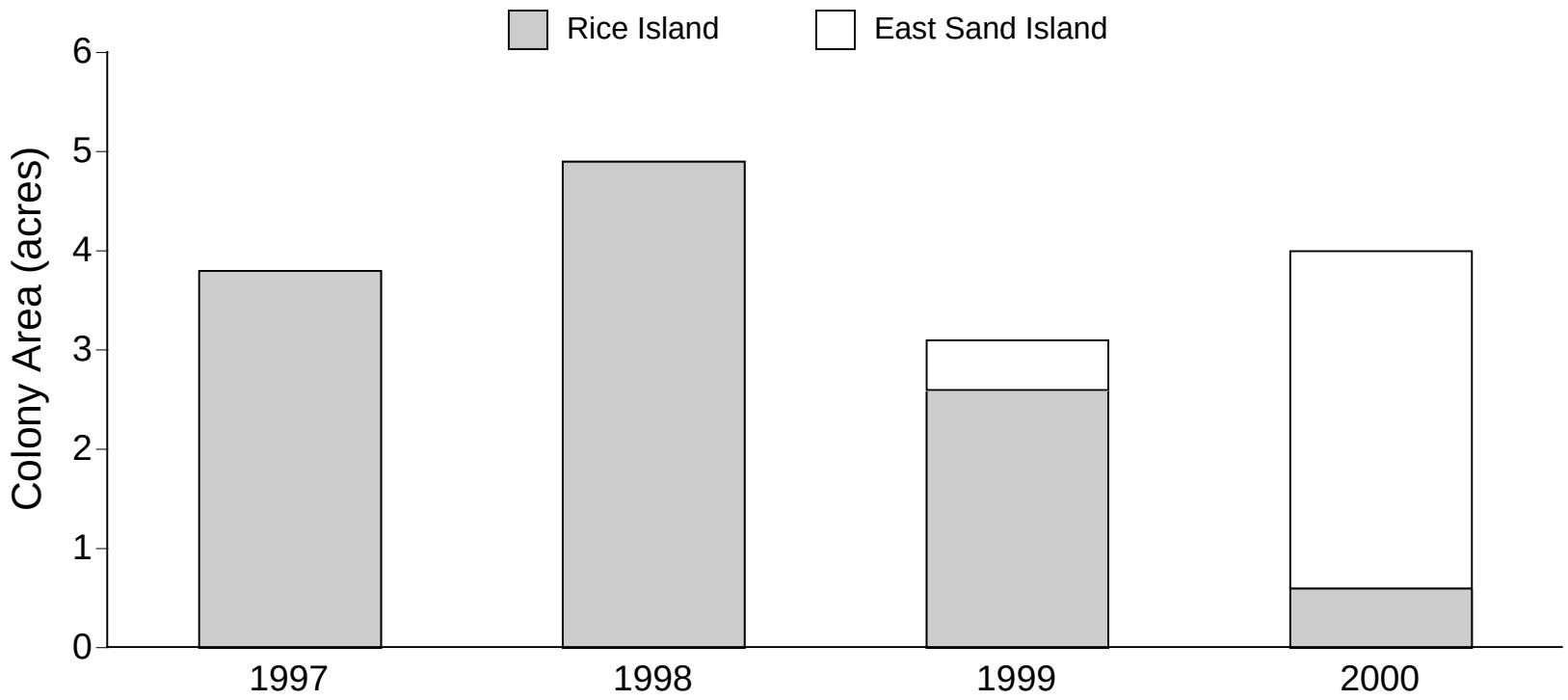


Figure 5. Caspian tern colony area in the Columbia River Estuary, 1997 - 2000.

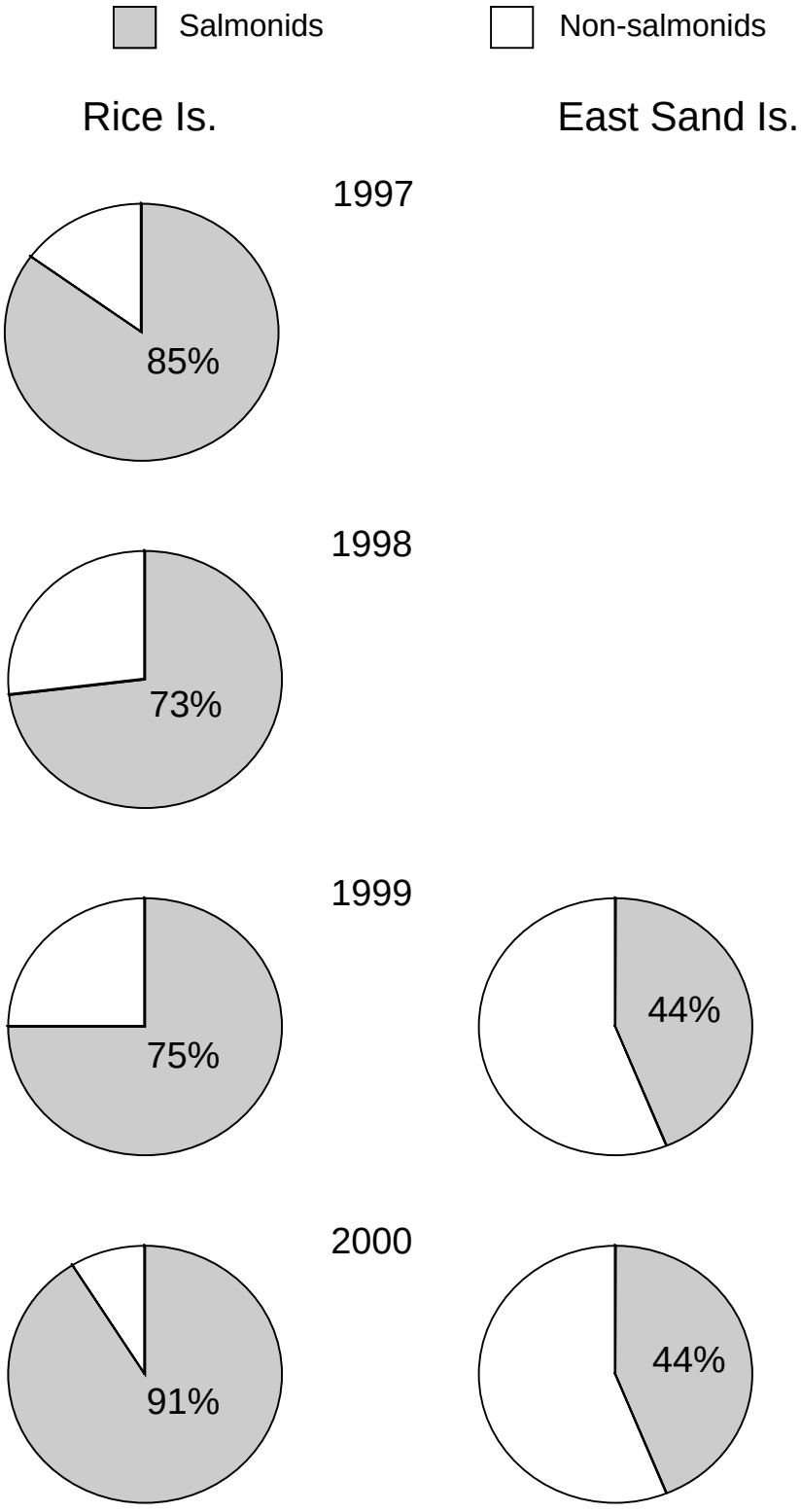


Figure 6. Caspian tern diet composition in the Columbia River Estuary, 1997 - 2000.

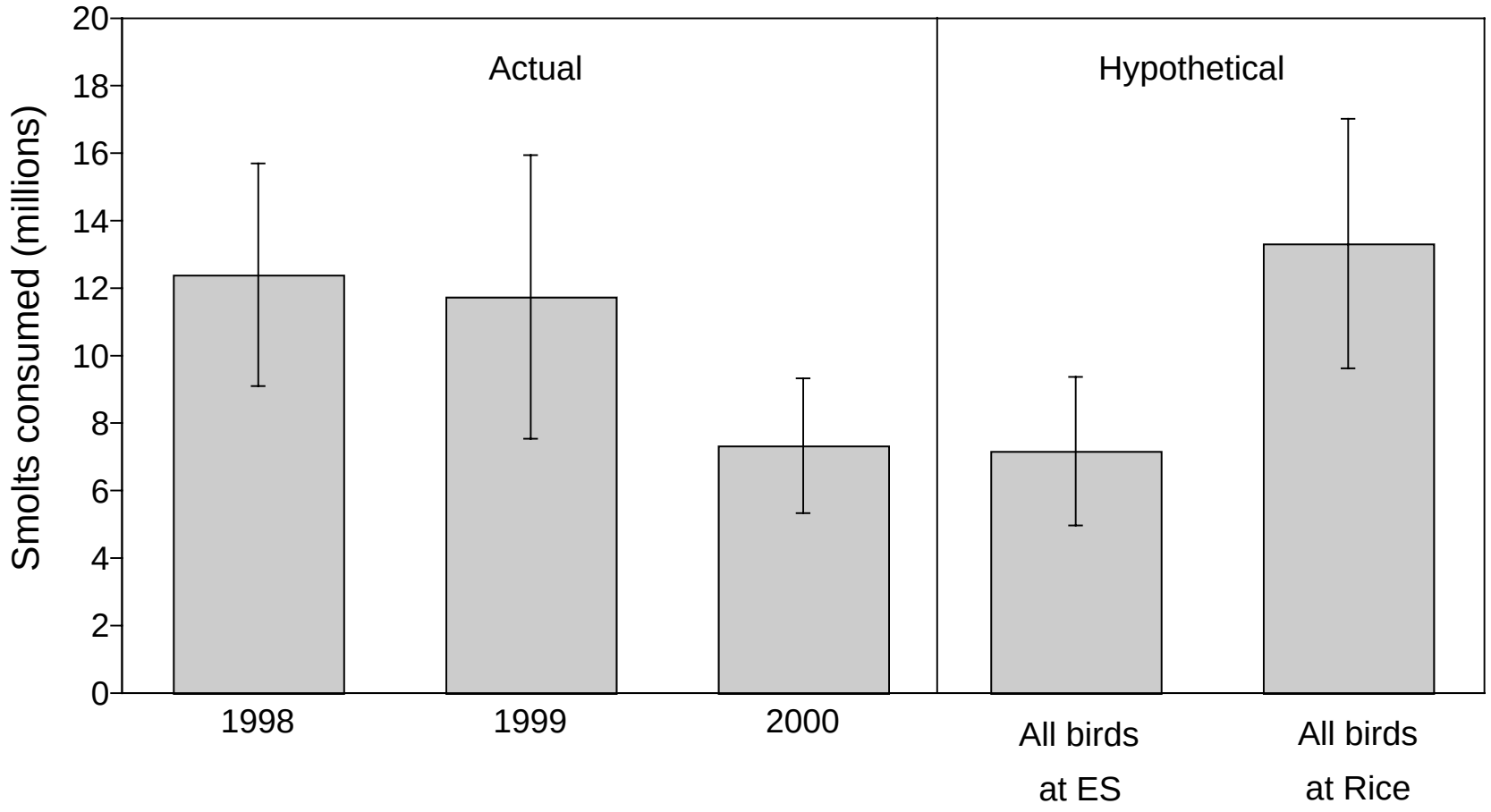


Figure 7. Caspian tern smolt consumption in the Columbia River Estuary, 1998 - 2000.

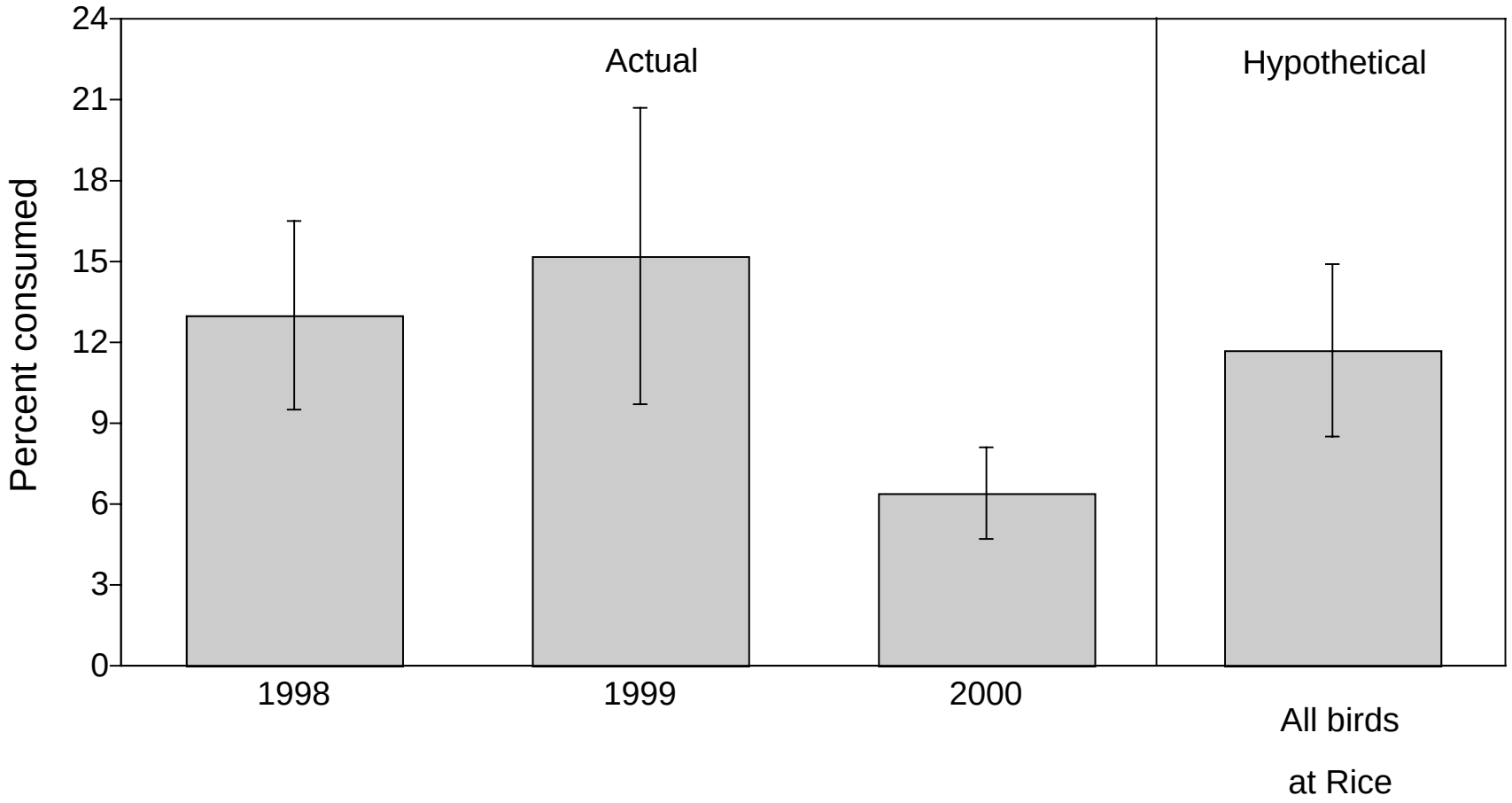


Figure 8. Percent of smolts reaching the Columbia River Estuary consumed by Caspian terns, 1998 - 2000.

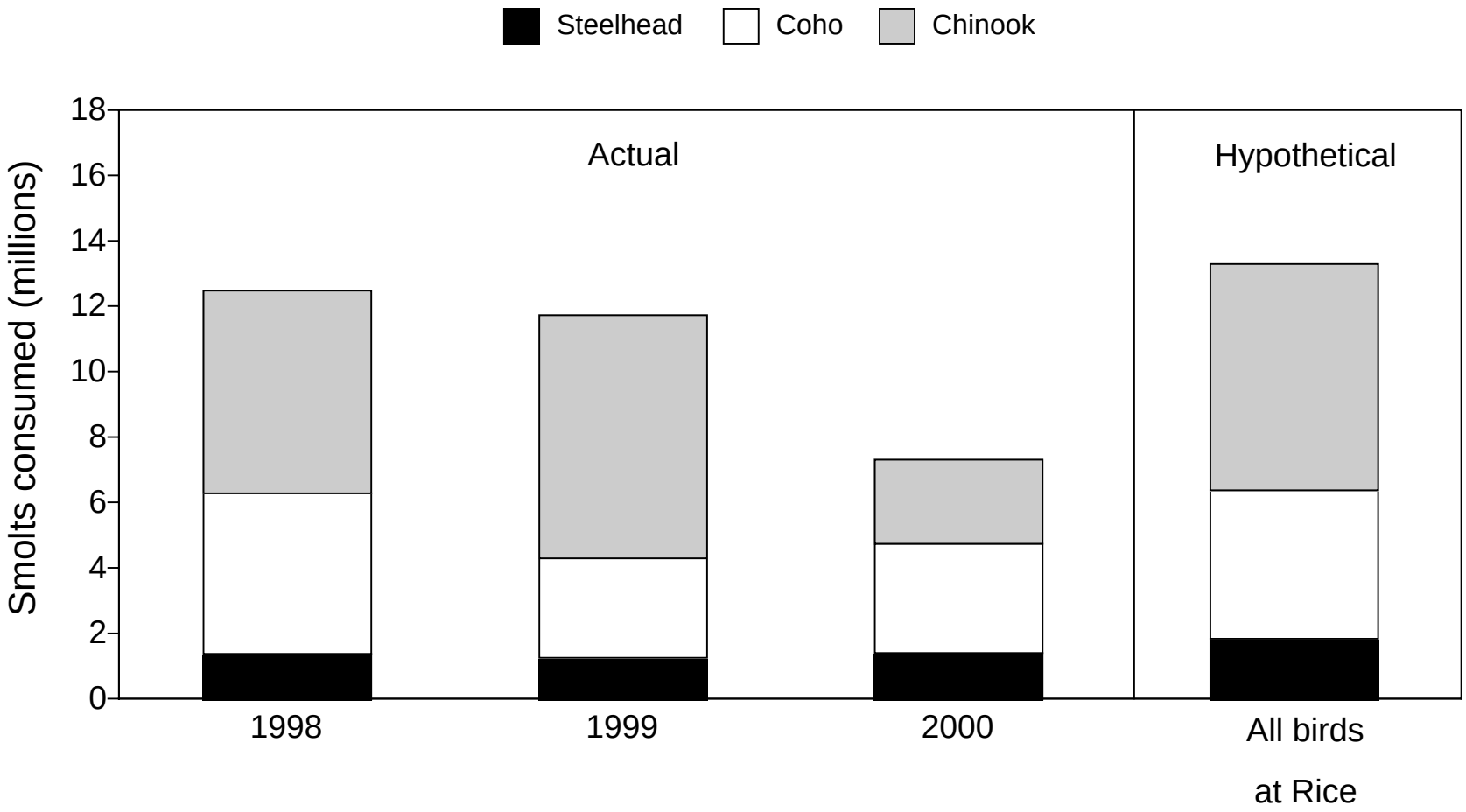


Figure 9. Caspian tern smolt consumption in the Columbia River Estuary, 1998 - 2000.

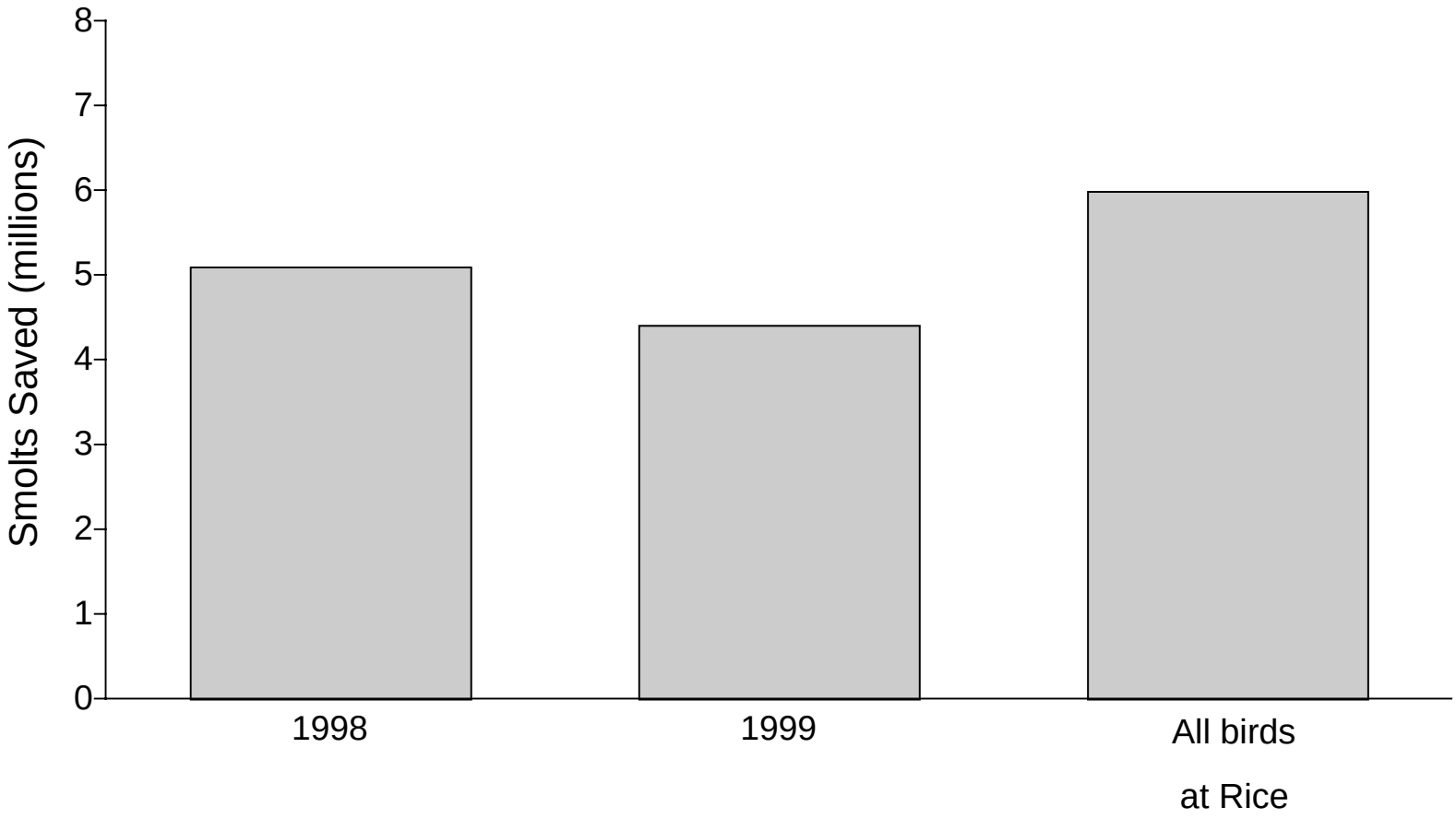
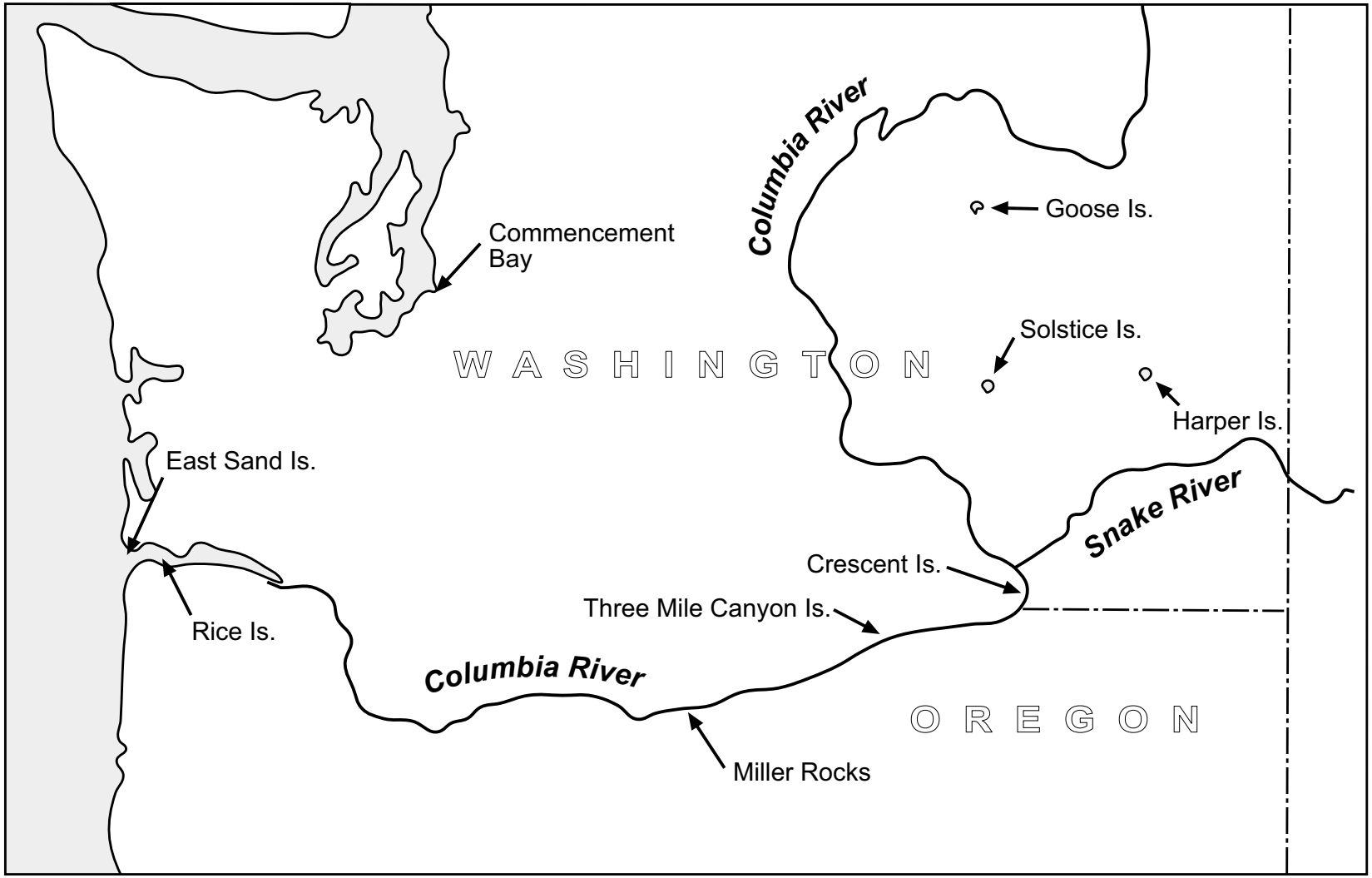
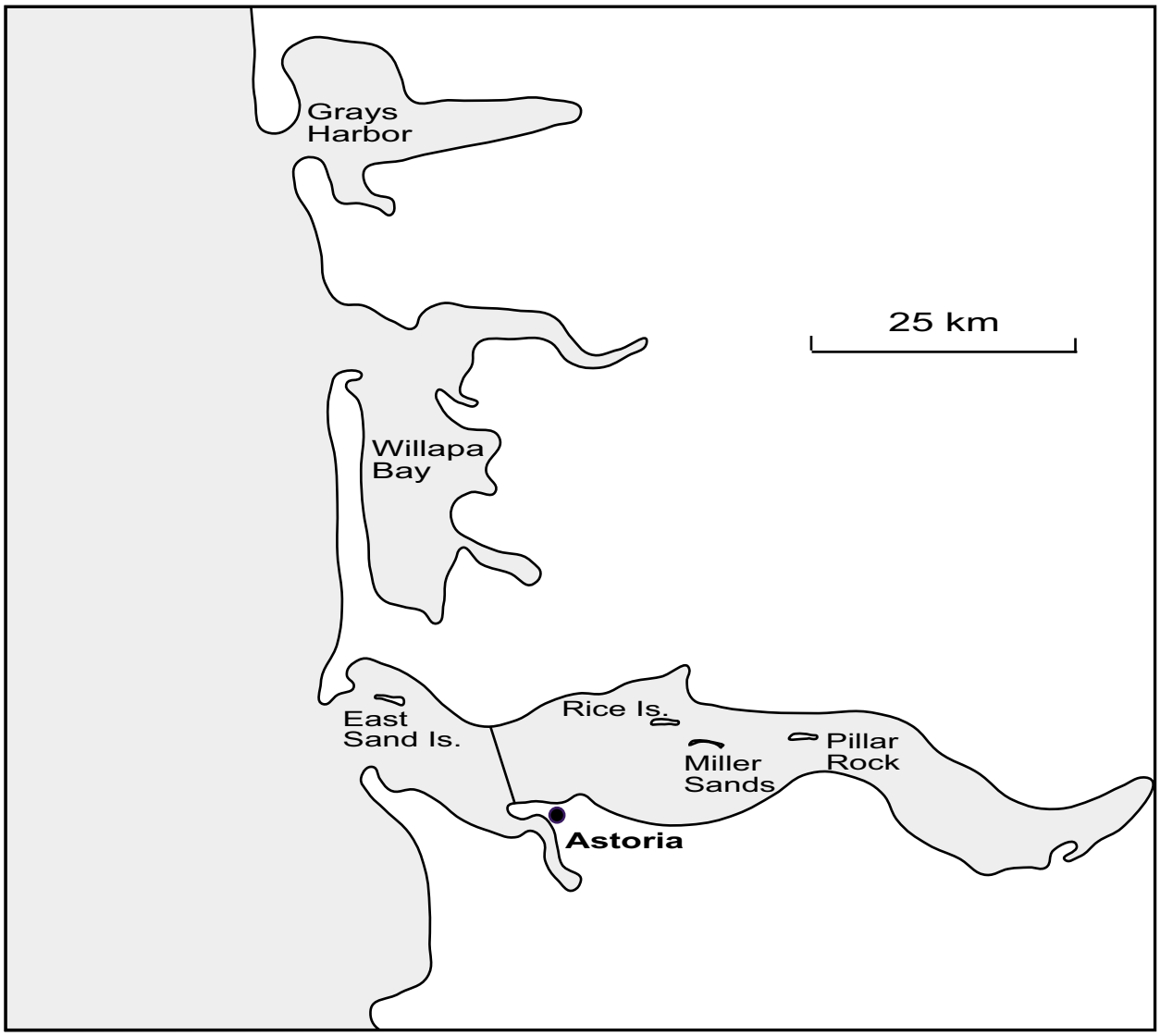


Figure 10. Reduction in the number of smolts consumed in 2000 compared to 1998, 1999, and the hypothetical scenario of all terns nesting on Rice Island in 2000.



Map 1. Caspian tern colony locations on the lower Columbia River and eastern Washington, 2000.



Map 2. Columbia River estuary and coastal Washington study area, 2000.

Table 1. PIT Tag Recoveries on the Solstice Island Caspian Tern Colony in 2000.

Release Site	Basin	Chinook	Coho	Sockeye	Steelhead	Total Salmonids
Big Canyon Creek	Snake	1	0	0	0	1
N. Fork Clearwater River	Snake	1	0	0	0	1
Mid-Columbia River	Mid-Columbia	0	0	0	527	527
Dworshak NFH	Snake	0	0	0	2	2
Grande Ronde River	Snake	0	0	0	1	1
Ice Harbor Dam Tailrace	Snake	1	0	0	0	1
Imnaha Trap	Snake	0	0	0	1	1
Jack Creek	Mid-Columbia	0	1	0	0	1
Knox Bridge	Snake	1	0	0	0	1
Leavenworth NFH	Mid-Columbia	14	54	0	0	68
Lower Granite Dam	Snake	1	0	0	3	4
Okanogan River	Mid-Columbia	3	0	0	0	3
Priest Rapids Hatchery	Mid-Columbia	1	0	0	0	1
Red Fish Lake Creek	Snake	0	0	1	0	1
Rock Island Dam	Mid-Columbia	60	0	0	93	153
Rocky Reach Dam	Mid-Columbia	67	0	2	29	98
Salmon Trap	Snake	0	0	0	1	1
Snake River Trap	Snake	0	0	0	1	1
Wells Hatchery	Mid-Columbia	3	0	0	0	3
Wells Dam Tailrace	Mid-Columbia	0	0	0	691	691
Winthrop NFH	Mid-Columbia	12	66	0	0	78
Yakima River	Mid-Columbia	0	2	0	0	2
Total	-	**165**	**121**	**3**	**1349**	**1640**
Percent	**-**	**10%**	**7%**	**<1%**	**82%**	**-**