A Synopsis of the ecology and status of the Western Pond Turtle (*Clemmys marmorata*) in 1991

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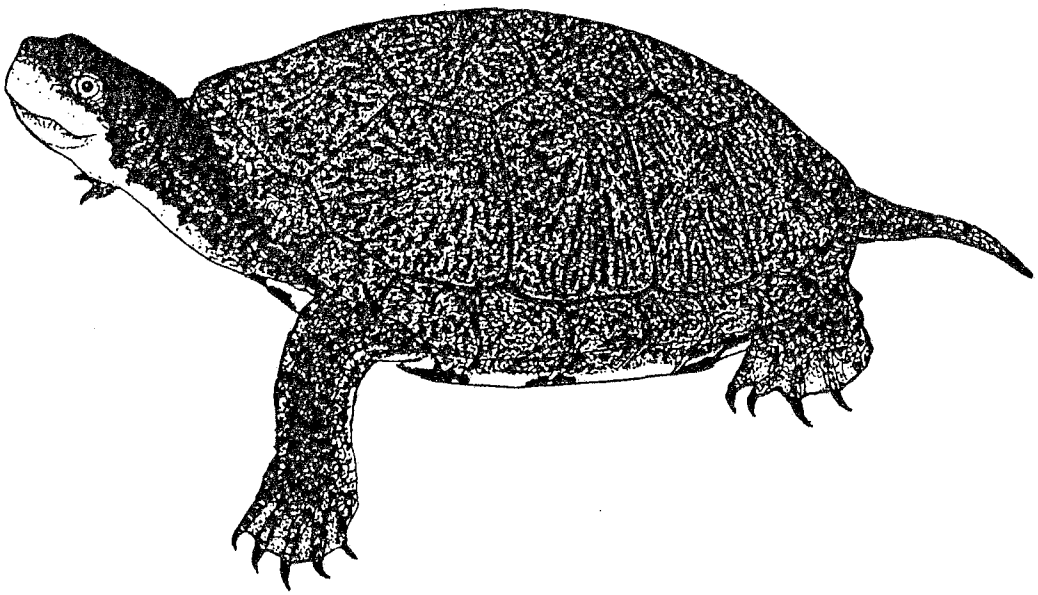

Prepared for the
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IDENTIFICATION: The western pond turtle (Clemmys marmorata) is one of at least four species of freshwater turtles that currently occur or recently occurred on the west coast of North America from the Baja California peninsula northward. The other species include the Sonora mud turtle (Kinosternon sonoriense), the pond slider (Trachemys scripta) and the spiny soft-shelled turtle (Apalone spinifera). None of these species are or were known to exist sympatrically with the western pond turtle. However, the fourth species, the western painted turtle (Chrysemys picta belli) exists sympatrically and syntopically with the western pond turtle in parts of the Willamette and Columbia River drainages, and possibly in the area of Puget Sound. A key to both native and common introduced species is provided in Fig. 1.

The western pond turtle (hereafter WPT or (Clemmys marmorata) can be easily distinguished from the western painted turtle by several characteristics (Fig. 2). Adult WPTs are moderate-sized (110-210 mm straight-line carapace length) with a low to moderately domed shell. The color of the carapace varies from light yellowish-brown to dark brownish-black, often with numerous fine short (2-10 mm) black lines, flecks or vermiculations arranged in a radial or semi-radial pattern from the growth centers of each shield. Carapace color also varies both ontogentically and geographically. Hatchlings and small (less than 2-3 year old) juveniles are usually lighter in color than adults from the same area, but darken with age. Animals from the southern portion of the range (south of the Transverse ranges in California) tend to be lighter in overall coloration (light yellowish-brown to light brown). Animals from the central California coast and interior coast ranges tend to be more variable in color, and northern animals (Klamath River northward) are usually dark brown to blackish. In some areas (such as the central California coast) 1-3% of the females have a terra-cotta/reddish cast to the carapace. In many larger and presumably older males, a significant percentage of the melanin pigment(s) in the carapace are secondarily lost, thus exposing the color of the underlying bone. This produces a "piebald" or mottled color on the carapace, similar to that seen in old male red-eared sliders (Trachemys scripta elegans). The plastron is generally light yellow to cream in color, with varying degrees of brown to black mottling, usually along the shield seams. In many areas, the plastron may be heavily "stained", presumably by the action of tannin or possibly symbiotic bacteria or fungi to a dark reddish-brown color, to the extent that it obscures the degree of natural mottling.

The head and limbs generally have a light brown-yellowish brown ground color, with varying degrees of marking. In hatchlings and first-year animals, the ground color is light yellow-brown, with moderate amounts of dark brown or black flecking or mottling on the sides of the head and neck. A dark brown to black figure is centrally located on the throat, and resembles that seen in map turtles (Graptemys spp.). This figure usually breaks up into a series of small flecks by the end of the first year. In females, the ground color of the head and sides of the neck tends to be slightly lighter

Figure 1: Key to native and common introduced species of freshwater turtles of the west coast.

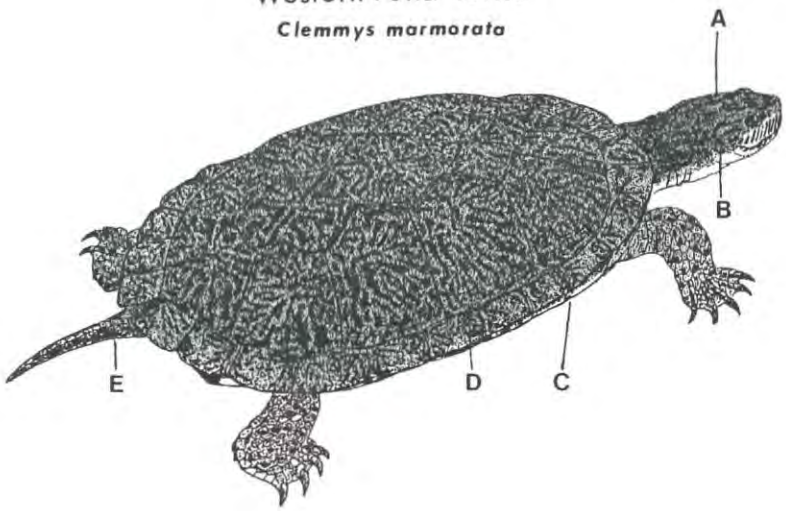
Character	Western Pond Turtle (*Clemmys marmorata*)	Western Painted Turtle (*Chrysemys picta belli*)	Common Snapping Turtle (*Chelydra serpentina*)	Red-eared Slider (*Trachemys scripta elegans*)
	NATIVE	NATIVE *	INTRODUCED	INTRODUCED
A. Head	relatively small, w/fine dark blotches, flecks or lines	relatively small, black w/yellow lines	large, uniform dark color	relatively small, dark green w/small yellow or white lines
B. Neck	brown dorsally & laterally w/ dark flecks or lines, throat light & unmarked or w/ small dark flecks	black w/ several thin yellow lines, throat w/lines	dark dorsally & laterally, w/ numerous tubercles,throat light and unmarked	dark green, with small yellow or white lines, large red "ear" stripe in most animals **
C. Plastron	large, cream to yellowish w/ degrees of dark suffusions	large, bright reddish-orange w/ large complex central figure	very small, cream-yellow	large, yellowish-white w/ large central figure(s)
D. Carapace	brown to black, often with numerous small dark markings	usually dark green or greenish-black w/o dark markings	dark, posterior marginals often serrated	light-green/olive with black and yellow lines
E. Tail	brownish, length moderate to long - 25-35% of carapace length	black w/ yellow or red stripe laterally, length short - 10-15% of carapace length	dark, length very long - 33-50% of carapace length	greenish, w/ white or yellow stripes, very short - 10-15% of carapace length

* western painted turtles are native to the Columbia and Willamette drainages of Oregon and Washington, and other areas of Washington including Puget Sound

** old male red-eared sliders typically lose the red "ear" marking and develop piebald melanism on the carapace, closely resembling old male western pond turtles. Old male red-eared sliders typically have elongated front claws.

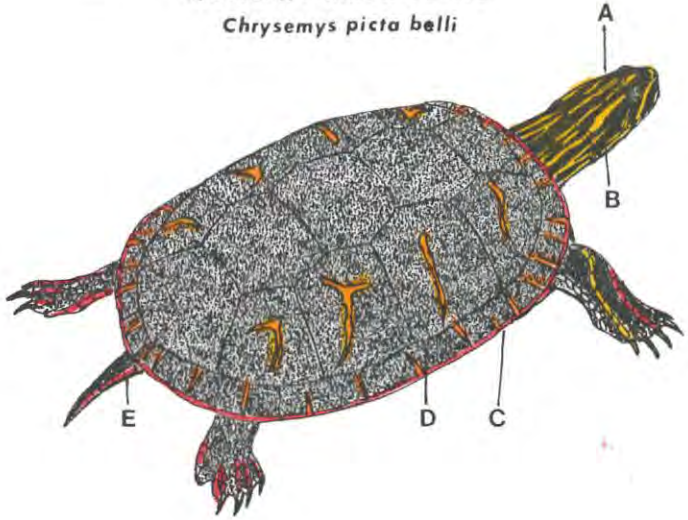
Western Pond Turtle

Clemmys marmorata



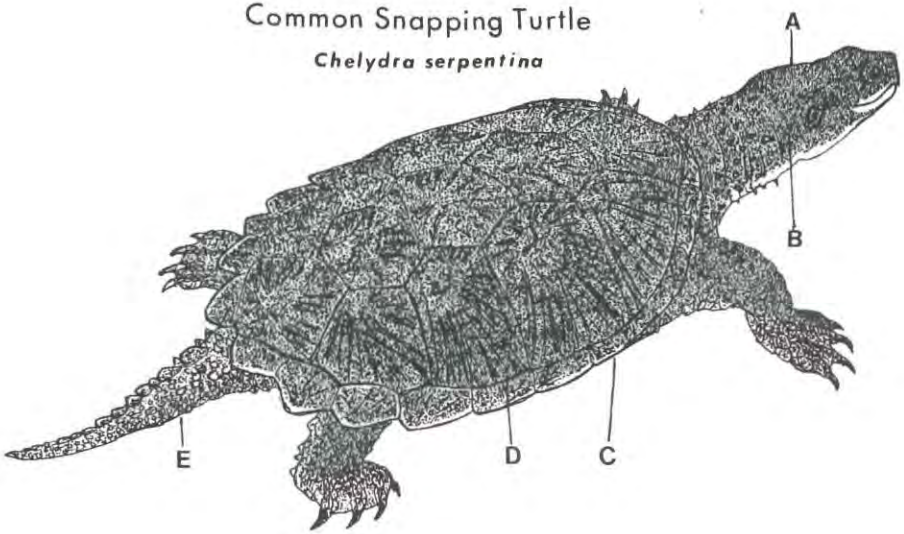
Western Painted Turtle

Chrysemys picta belli



Common Snapping Turtle

Chelydra serpentina



Red-eared Slider

Trachemys scripta elegans

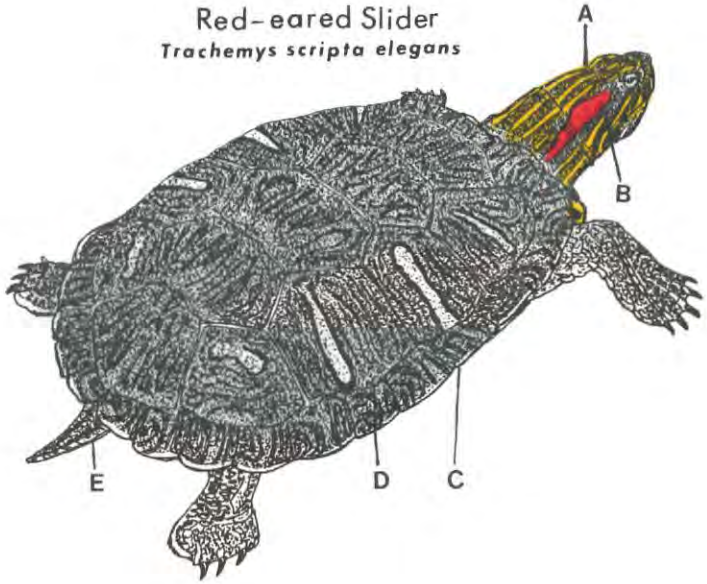
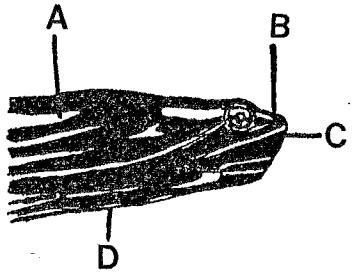
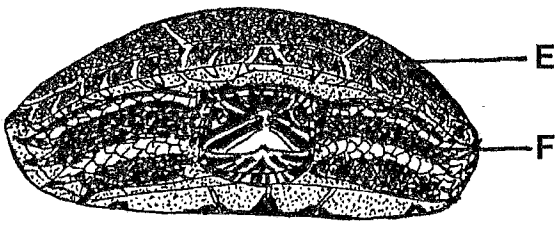


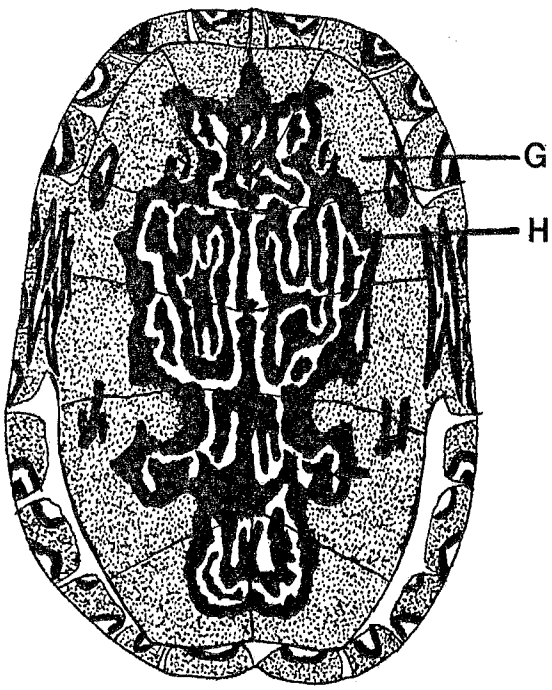
Fig. 2: Key to western pond turtle (*Clemmys marmorata*) and western painted turtle (*Chrysemys picta belli*).

A. Side of neck with yellow stripes	Side of neck plain or mottled
B. Nose very short w/yellow stripes	Nose moderate w/uniform color
C. Maxilla w/ horizontal yellow stripes	Maxilla w/ vertical black or brown lines of flecks
D. Throat dark w/ yellow stripes	Throat light colored, often w/small dark flecks
E. Carapace dark-green to black	Carapace light yellow-brown to dark brown-black
F. Legs dark black w/ yellow and/or red stripes	Legs brown w/ indistinct light yellow stripes
G. Plastron bright red or reddish-orange	Plastron light cream to yellow
H. Plastral marking usually large, map-like and centrally located	Plastral markings suffusion-like, and usually along seams

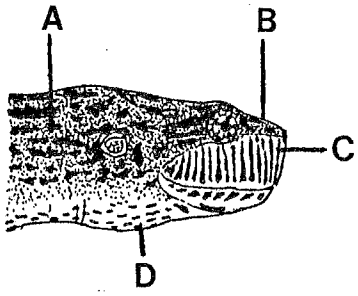
Western Painted Turtle

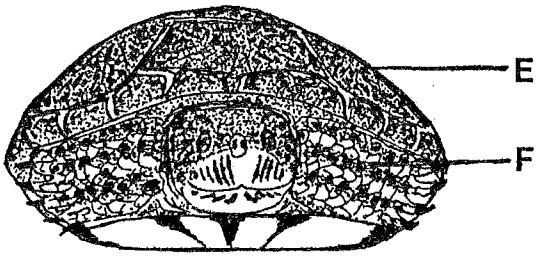


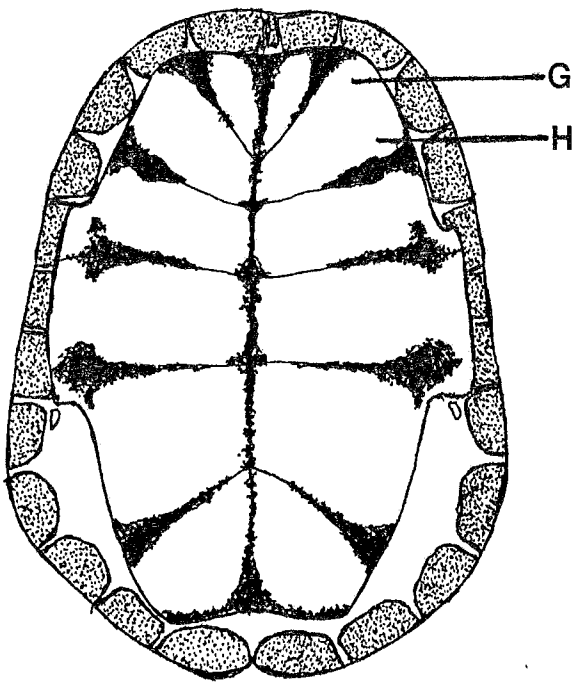




Western Pond Turtle







than in males, and the flecking on these areas and the throat is usually more pronounced (Fig. 3). In males, the amount of flecking on the head and sides of the neck is reduced, and the flecking on the throat is often absent. As with shell color, these characteristics vary ontogentically and geographically. In general, small turtles (less than 110 mm carapace length) are more heavily marked than than larger turtles. Females seem to retain this type of "juvenile" pattern. In the southern part of the range, the color and marking patterns of males also tend to superficially resemble those of females. In the northern portion of the range (San Joaquin valley drainages northward), old males often develop bright white to dull yellow throats with solid dark head and neck coloration. Coloration of the lighter areas of the head and limbs may also be affected by diet; animals from San Diego County (California) whose primary diet is crayfish (Pacifasticus sp.) often develop a reddish-orange suffusion in these areas. A typical WPT is shown in Figure 4. Additional descriptions and illustrations may be found in Ernst and Barbour (1989) and Stebbins (1985).

TAXONOMY: The type specimens of the western pond turtle were collected in 1841 in the vicinity of Puget Sound, and described as Emys marmorata by Baird and Girard (1852). The species is divided into two subspecies based upon the work of Seeliger (1945). The northwestern pond turtle (Clemmys marmorata marmorata) is defined on the basis of mottled head and neck coloration and a relatively high frequency of large inguinal shields in individuals examined. This taxon ranges from approximately the American River northward to the vicinity of Puget Sound (Fig. 5). The southwestern pond turtle (Clemmys marmorata pallida) is defined on the basis of light head and neck coloration with more prominent markings on these areas, and the reduced frequency of occurrence of large inguinal shields. This taxon ranges from the vicinity of Monterey Bay south through the coast ranges to Baja California Norte. The area of the central valley of California from the Transverse ranges north to the American River and west to the eastern edge of the inner coast ranges is defined as a zone of intergradation between the two taxa (Fig. 5).

The original description of these two taxa was based upon an examination of 158 specimens from throughout the range of the species, and represented the majority of animals present in collections at that time. However, the validity of this distinction is questionable for several reasons. First, coloration of the limbs and neck changes with both the nature of preservation of the specimen and with time - both fading and darkening have been observed in specimens, often to the extent of minimizing or obscuring the degree of mottling. Second, the assignment of the size of the inguinal shield into the categories small, moderate and large utilized as a distinguishing characteristic was apparently largely subjective (L. Seeliger, pers. comm.). Third, other evidence (Holland, unpubl. data) indicates that intrapopulation variability in regard to these characters is often significant, and the limited availability of specimens for the initial analysis (Seeliger, 1945) may have biased the conclusions about the distinctiveness of the taxa described.

Figure 3: Key to sexually dimorphic characters in the western pond turtle (Clemmys marmorata).

Character	Female	Male
a. neck	lateral and dorsal surfaces of head and neck usually mottled or ocellate	lateral and dorsal surfaces of head and neck often uniformly colored, especially in older animals
b. nose	nose relatively short	nose relatively long
c. maxilla	maxilla often with fine dark vertical lines or "mustache"	maxilla lightly marked or or unmarked, especially in older animals
d. snout	angle of nose usually vertical or nearly vertical	angle of nose usually 10-15 from vertical
e. throat	often flecked with numerous small dark flecks	usually lightly marked or unmarked
f. vent	usually at or slightly posterior to posterior edge of carapace	usually well posterior to posterior edge of carapace
g. tail	usually relatively long and thin	usually relatively short and thick
h. plastron	area of femoral/anal seam junction usually flat	area of femoral/anal seam junction usually slightly concave
i. shell	shell relatively high/deep in relation to length of carapace	shell relatively low/shallow in relation to length of carapace

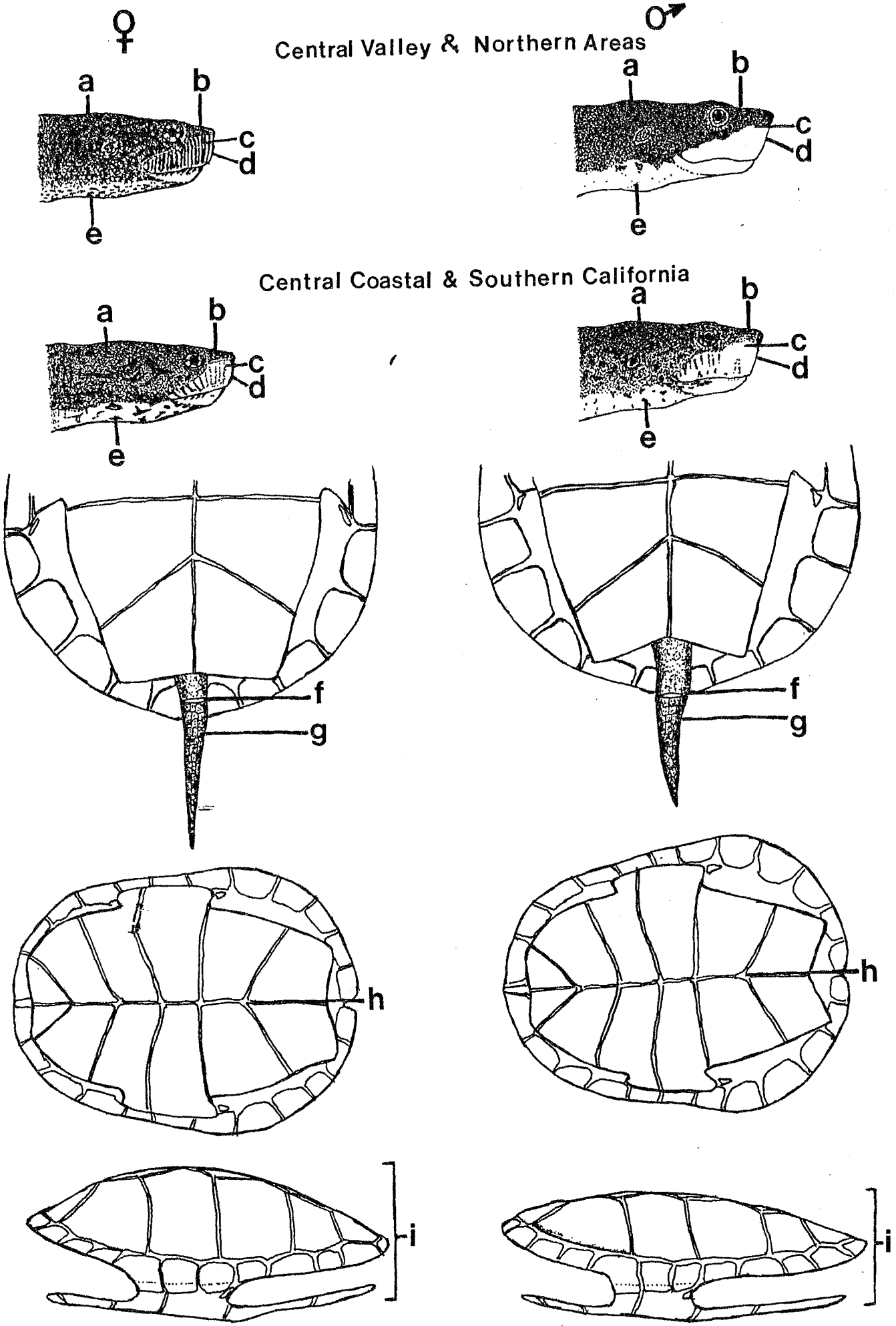


Fig. 3: Key to sexually dimorphic characters in the western pond turtle (Clemmys marmorata).

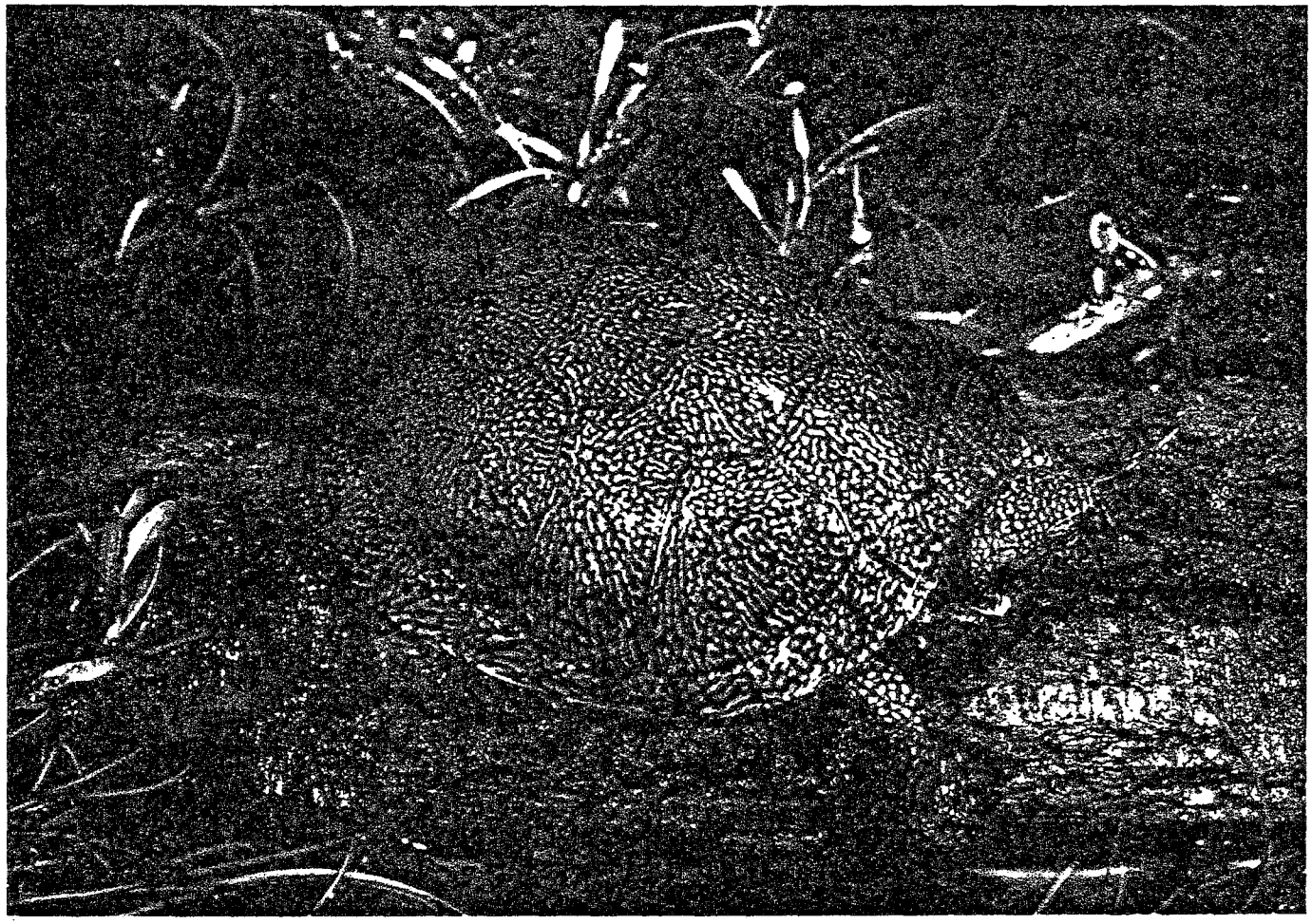
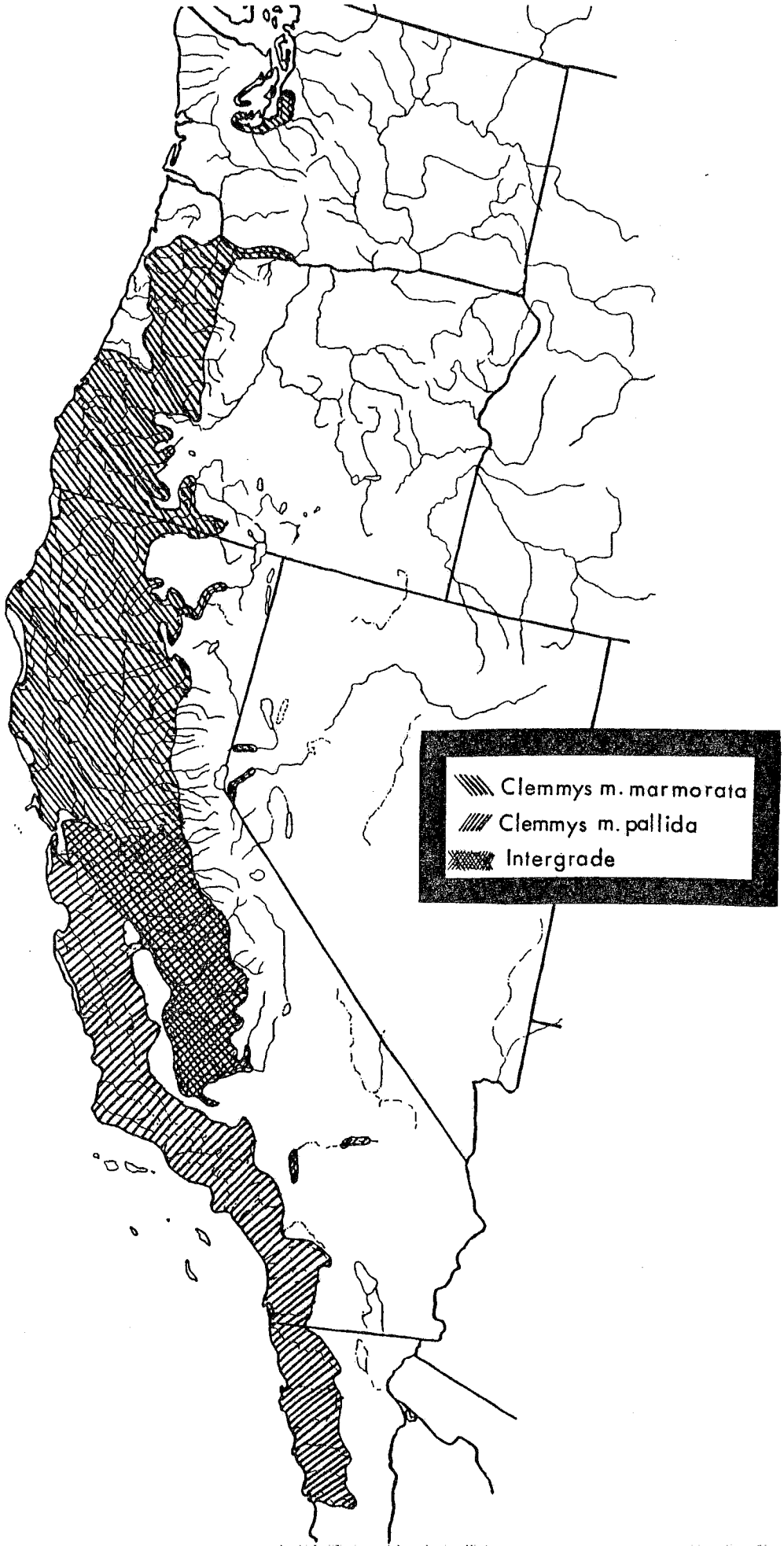


Fig. 4: Southwestern pond turtle (Clemmys marmorata pallida).

Fig. 5: Distribution of the two subspecies of the western pond turtle and the area of intergradation (adapted from Seeliger, 1945).



However, more recent analysis (Holland, unpubl. data) does suggest that more than one relatively cohesive morphologically distinct entity exists with the species currently known as Clemmys marmorata. Using both parametric and non-parametric discriminant analysis with a sample size of 4451 animals from throughout the range of the species, it appears that there are a minimum of two and a maximum of five relatively cohesive groups as defined by morphological characteristics. A more detailed examination of the nature of morphological variation in this species will be submitted for publication in 1992 (Holland, unpubl. data).

SEXUAL DIMORPHISM: Western pond turtles are moderately sexual dimorphic. A list of characteristics is provided in Figure 3. Secondary sexual characteristics generally appear by approximately 110-120 mm carapace length. Males have larger heads, longer noses, shorter, thicker tails and relatively lower shells than females. Additionally, in males the midline of the plastron is usually concave in the area of the femorals and anterior edge of the anals. In the northern subspecies, males tend to lose the flecking on the head and sides of the neck as they increase in size, producing a uniformly dark coloration. The throat is often a white to light yellow color without flecking.

DISTRIBUTION: The total range of the species is shown in Figure 6. Additional maps are shown in Bury (1970), Stebbins (1985) and Iverson (1986), but do not reflect several known disjunctions within the body of the range. The species ranges from the Columbia River southward generally west of the Sierra-Cascade crest to the Sierra San Pedro Martirs in Baja California Norte. Isolated populations are known from several areas, including the vicinity of Puget Sound (Washington), Grant County (Oregon), the Carson and Truckee Rivers (Nevada), and the Mojave River (California). Additional specimens or reliable sightings are known from the vicinity of Grays Harbor (Washington), Drews Creek (Oregon), West Walker River (Nevada), Susanville (California), Lake Tahoe (California) and San Miguel Island (California). The latter is a specimen in the Santa Barbara Museum of Natural History found dead at Simonton Cover in 1978, and probably represents a waif produced by mainland floods. One problem with the status of animals far outside the normal range was first noted by Storer (1930, 1937), namely that turtles are frequently transported considerable distances and are released or escape in novel locations. The species is uncommon or absent along the north and central coast of Oregon, the north coast of California, a thin strip of the central California coast and the arid southwest side of the San Joaquin Valley (Fig. 6). Reports of specimens from Burnaby Lake, British Columbia (Carl, 1960; Froom, 1976; Gregory and Campbell, 1984) probably represent animals that were imported as food items and subsequently escaped (P. Gregory, pers. comm.). A specimen in the California Academy of Sciences Collection allegedly collected in the Snake River (Idaho) and two specimens in the United States National Museum allegedly collected in Sonora (Mexico) probably represent mislabeled specimens from Oregon and California, respectively (Holland, unpubl. data).

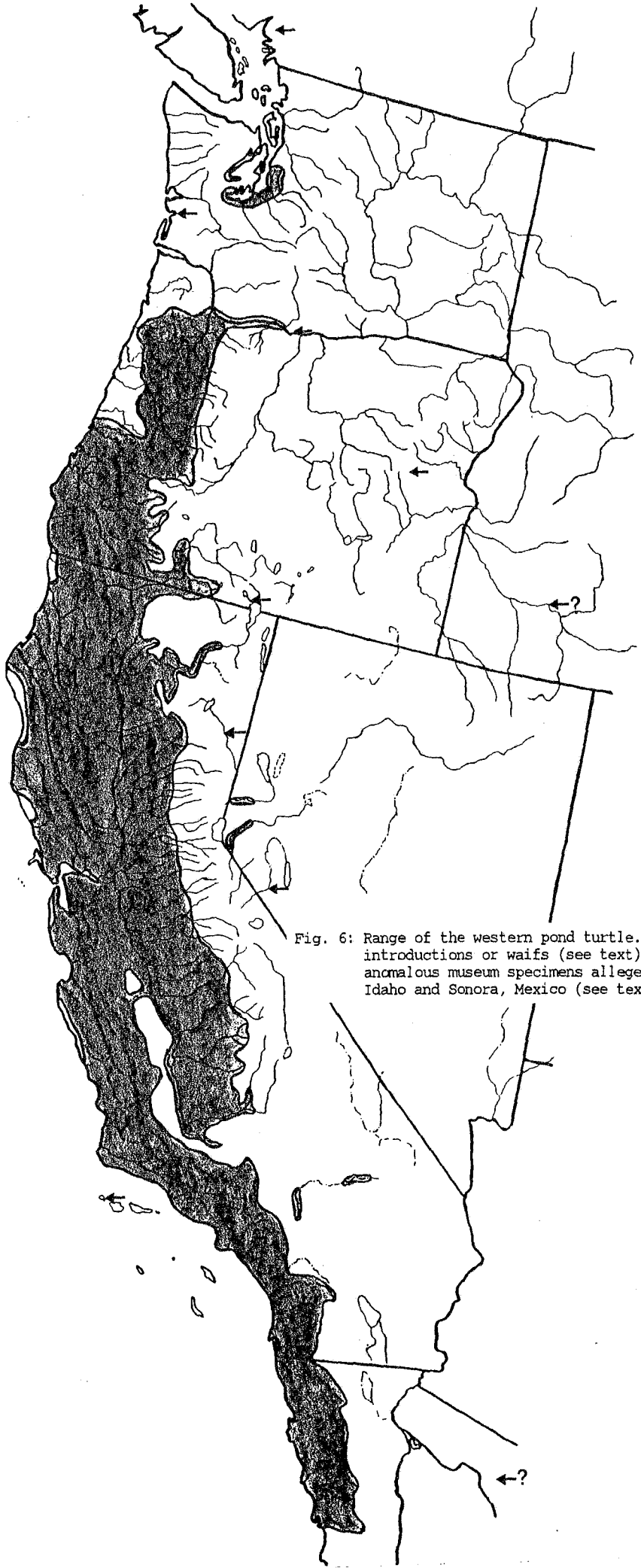


Fig. 6: Range of the western pond turtle. Arrows indicate probable introductions or waifs (see text). Question marks indicate anomalous museum specimens allegedly from the Snake River, Idaho and Sonora, Mexico (see text).

The altitudinal distribution of the species is from sea level to 2041 m, but the majority of populations are found below 1371 m. From the Rogue drainage (Oregon) north, the species is seldom found above 1066 m. In the Carson and Klamath/Lost River systems, some populations are found in habitats approaching 1524 m elevation.

CURRENT RANGE: The geographic extent of the current range of the WPT (Fig. 6) is similar to its range prior to the advent of European man on the west coast. However, the range has been fragmented to varying degrees by human activities, and some populations have been extirpated (see additional discussion under Threats and Current Status). In many areas, only isolated small groups or individuals remain within significant portions of the range.

FOSSIL RECORD: Fossil C. marmorata are known from Pleistocene deposits marginally outside the current range of the species, indicating that the distribution of the species was once more widespread. Subfossil remains from aboriginal middens are known from Puget Sound, Washington (Weasma, 1991), Nevada (Hattori, 1988) and other sites in California.

Fossil species similar to (and possibly synonymous with) Clemmys marmorata include Clemmys owyheensis (Brattstrom and Sturn, 1959) and C. hesperia (Hay, 1908), which have been found outside the current range of C. marmorata. It is likely that the ancestor(s) of WPTs evolved during the Eocene-Miocene eras in the area of what is now Wyoming-Montana, and gradually dispersed west. The immediate ancestor of C. marmorata was probably present in the extensive lake and river systems of the northwest by the Pliocene, and the WPT had probably moved into most of its current range by the early Pleistocene. The primary avenue of dispersal is assumed to be the ancestral course of the Snake and Columbia River systems.

HABITAT: Western pond turtles are habitat generalists, historically occurring in a wide variety of both permanent and intermittent aquatic habitats. This species appears to tolerate brackish conditions well, often coexisting with many species of euryhaline fishes (Cottus, Eucyclogobius) along the central California coast. Several reports (Bogert in Pope, 1939; Stebbins, 1954; Bury, 1963; Holland, 1989) note the presence of the species in brackish or full-strength sea water. WPTs are known from rivers, streams, lakes, ponds, vernal pools and other seasonal and permanent wetlands. In general, turtles occur or occurred along all major river systems on the west coast within their present range. However, they are often restricted to areas near the banks or in quiet backwaters where the current is relatively slow and basking sites and refugia are available. Turtles still exist in small numbers in most large river systems in the central and northern parts of the range (San Joaquin, Sacramento, Klamath, Rogue, Umpqua and Willamette), but have been extirpated in most southern rivers (Los Angeles, San Gabriel, Santa Ana). Typical riverine habitat for

WPTs is shown in Figure 7. Currently, most populations exist in smaller streams, usually in montane areas (Fig. 8). These streams may be either permanent or intermittent, but permanent streams support larger populations. In intermittent streams, turtles persist largely due to the presence of pools that remain after the main stream course dries. Turtle densities in these pools are often very high, with as many as 23 animals occurring in a pool with less than 40 cubic feet of water. The drought of 1987-1991 has directly or indirectly eliminated populations of WPTs in many intermittent streams. In the area where many streams empty onto the valley floor from the Sierra Nevada, long stretches of dry, sandy wash/channel do not currently hold pond turtle populations and constitute a barrier to both upstream and downstream dispersal. Historically, however, the structure and nature of these areas has changed and they formerly held small if disjunct populations. Turtles may be found in very small watercourses; populations are known from streams that average less than less 1 m wide and 0.25 m deep.

Historically, optimal habitat for the WPT was probably the warm, shallow lakes present on the floor of the San Joaquin Valley such as Tulare, Kern, and Buena Vista Lakes. These habitats were highly eutrophic with thick growths of vegetation (Scirpus and Typha) (Preston, 1981) and supported very large populations of turtles (see Density). All of these areas, and the large populations they supported, have long since been eliminated (Fig. 9). Turtles also occurred in sloughs along the valley floor with similar types of vegetative associations.

WPTs have also been noted in small ponds and oxbow lakes along the Willamette River (Oregon), in basaltic sinkhole ponds (Washington), and in vernal/ephemeral pools (California, Oregon and Washington). Use of vernal pools is seasonal, with turtles moving up to several hundred meters from drying pools to adjacent cienagas/small creeks.

Western pond turtles also occur in a variety of watercourses directly or indirectly modified by man, such as reservoirs, canals, excavated farm ponds, mill ponds and sewage treatment plants. Extensive surveys of reservoirs in California and Oregon indicate that viable populations of WPTs are not know to exist in any of these watercourses. Occasional individuals or small groups of animals are observed, usually at the mouths of small feeder creeks or in small, sheltered coves.

Turtles are also occasionally found in canals, particularly when these sites are close to existing natural watercourses with turtle populations. The persistence of turtles in these areas may be closely tied to the amount and nature of vegetation present along the banks, and the relative age of the canal. In many areas of the San Joaquin Valley most vegetation is removed, either chemically or mechanically, from canal banks thus rendering them unsuitable as turtle habitat. In Sacramento Valley canal systems, turtles may occur in modest numbers, particularly when the canal is bordered by undisturbed habitats such as valley grassland or oak savannah. Canals with thick growths of tules, cattails or overhanging brushy

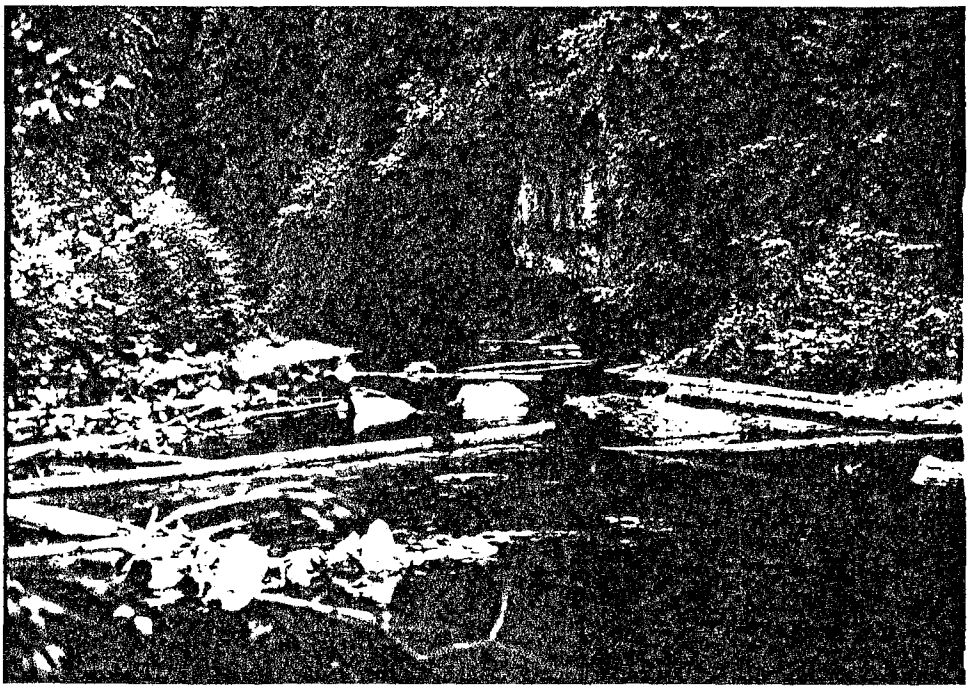


Fig. 7: Typical riverine habitat of the western pond turtle (Site OR 002 U).

Fig. 8: Typical stream habitat of western pond turtle (Site CA 025 SJ)

and juveniles averaged 0.4 ha.

WPTs may move considerable distances both within and among watercourses. Bury (1972a) noted that in a northern California stream system the majority of animals appear to be relatively sedentary. Males tend to move greater average and total distances than either females or juveniles, with distances in excess of 1.5 km being noted. Rathbun et al (in press) recorded movements within a drainage in excess of 2 km for gravid females on the central California coast. Extensive mark and recapture work from 1981-1991 in the same area (Holland, unpubl. data) indicates that the vast majority of turtles marked in a particular drainage, if recaptured, are found in that drainage. Of over 1200 animals marked, less than 10 instances of recapture outside the original drainage were noted. The maximum linear distance between the original capture and recapture points was approximately 2.5 km.

Turtles may engage in overland movments that are not reproductive in nature or in apparent response to flooding (see Activity). In the period and area noted above several turtles, primarily adults of both sexes, have been observed moving overland at distances of up to 0.5 km from the nearest watercourse. Additional animals have found crushed by automobiles on roads adjacent to watercourses. In these instances the maximum distance from water noted was approximately 200 m. Casual observations of overland movements in other areas seem to indicate that the majority of these events occur in early spring and late fall. These probably represent animals moving from and to (respectively) upland overwintering sites. Other movements may also occur in response to drying of the watercourse or other factors that are at this point not well understood.

PREDATION AND MORTALITY: There are numerous known predators on WPTs. Mammalian predators include black bear (Euarctos americanus), coyote (Canis latrans), feral and domestic dogs (Canis familiaris), grey fox (Urocyon cinereoargenteus), raccoon (Procyon lotor), river otter (Lutra canadensis), mink (Mustela vison) and humans. Suspected predators include beaver (Castor canadensis), nutria (Myocastor coypu), bobcat (Felis rufus), spotted skunk (Spilogale putorius),opossum (Didelphis virginianus) and feral pigs (Sus scrofa). Known avian predators are limited to the bald eagle (Halietus leucocephalus) (see references in Clark, 1982). Suspected predators include osprey (Pandion halietus), red-shouldered hawk (Buteo lineatus), great blue heron (Ardea herodias), black-crowned night heron (Nycticorax nycticorax), raven (Corvus corax) and common crow (Corvus brachyrhynchos). Suspected reptilian predators include the giant garter snake (Thamnophis gigas) and the two-striped garter snake (Thamnophis hammondi). Known amphibian predators are limited to the bullfrog (Rana catesbeiana) but the California red-legged frog (Rana aurora draytoni) is a suspected predator. The only known fish predator is the largemouth bass (Micropterus salmoides) but other bass (Micropterus spp. and Morone saxatilis), catfish (Ictalurus spp.) and steelhead/rainbow trout (Oncorhynchus mykiss) are suspected. The only suspected invertebrate predator is the giant water bug (Belastomatidae), which may take hatchlings, and ants (Formicidae) may prey on

eggs and hatchlings.

Under undisturbed conditions, the predators with which WPTs co-evolved probably do not pose a serious threat to the viability and survival of populations. However, in many cases habitat alteration and other factors have altered the actual and potential effects of predation. In this respect, there are two major considerations. Certain types of habitat alteration may foster the establishment and maintenance of increased populations of native predators such as coyotes and raccoons. Raccoons are major predators on the nests of other species of turtles (Christiansen and Gallaway, 1984) as well as on WPTs, taking animals of all sizes as well as eggs and hatchlings. Coyotes are also a major potential threat, particularly to nesting females and nests. There may also be a significant local threat from black bears in the Los Padres National Forest (S. Sweet, pers. comm.). In this area, black bears apparently did not historically occur, possibly because of the former presence of the California grizzly (Ursus arctos). Black bears have been released in this area by the United States Forest Service. These bears prey heavily on WPTs, and have probably been responsible for some localized extirpations or severe reductions in WPT populations (S. Sweet, pers. comm.). Under certain circumstances (see Threats) control of native predators such as raccoons may be adviseable as a short-term management tool for maintenance of WPT populations.

Other native predators may have locally significant effects on turtle populations. Evidence of heavy predation by river otters or mink was noted in a northern California WPT population in 1991. Approximately 35-40% of the adults taken in a two-day sampling period were either recovered dead or missing one or more limbs. Similar samples in the same drainage in 1987-1990 indicated that from 10-20% of the adults in this population were missing one or more limbs, presumably from the same source. Turtles missing limbs tend to have less well-developed body fat reserves than other animals in the same population and are probably more vulnerable to predation. Mark and recapture studies of this population also indicate that turtles with missing limbs are less likely to be recaptured (Holland, unpubl. data). Additionally, such animals may have trouble excavating appropriate overwintering sites and may be subject to an increased probability of mortality.

The second major consideration is the effect of introduced predators. In this respect, there are at least two major species of concern. The most significant is the bullfrog (Rana catesbeiana) (Fig. 21-22). Bullfrogs are known predators on several species of turtles (Carpenter and Morrison, 1972) and specifically Clemmys marmorata (Moyle, 1973; S. Sweet, T. Pappenfuss, pers.comm.; Holland, pers. obs.). The second major species of concern is the largemouth bass (Micropterus salmoides) which has been observed to feed on juvenile WPTs (Holland, pers. obs.). Both species were introduced into the western United States in the latter part of the 19th century (Lampman, 1950), and repeated reintroductions, transplants and range expansion since that time have resulted in the establishment of populations across most of the western U.S. (Moyle,

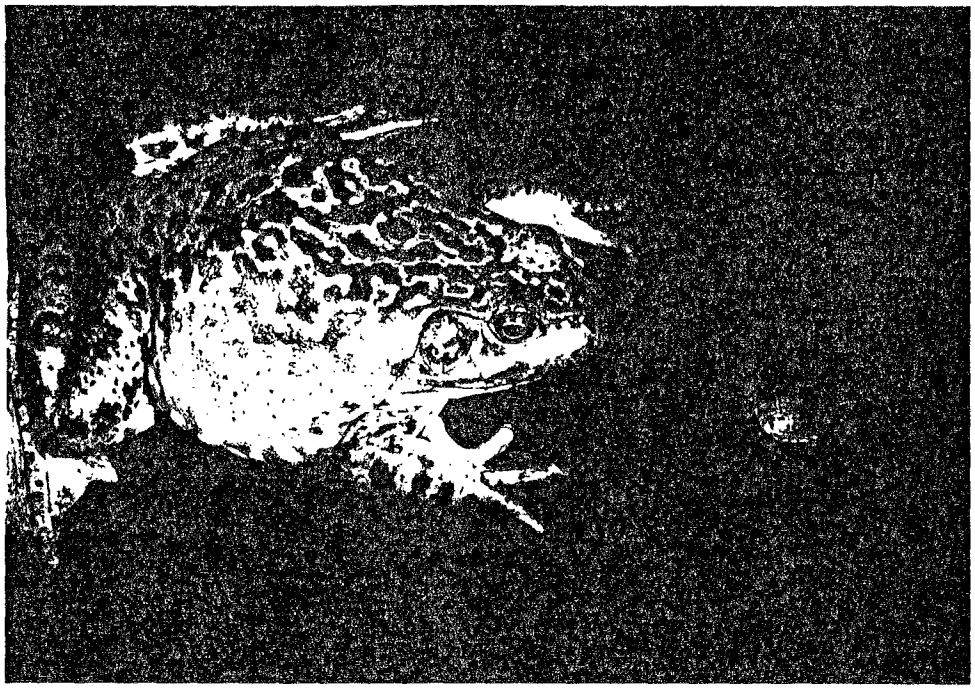
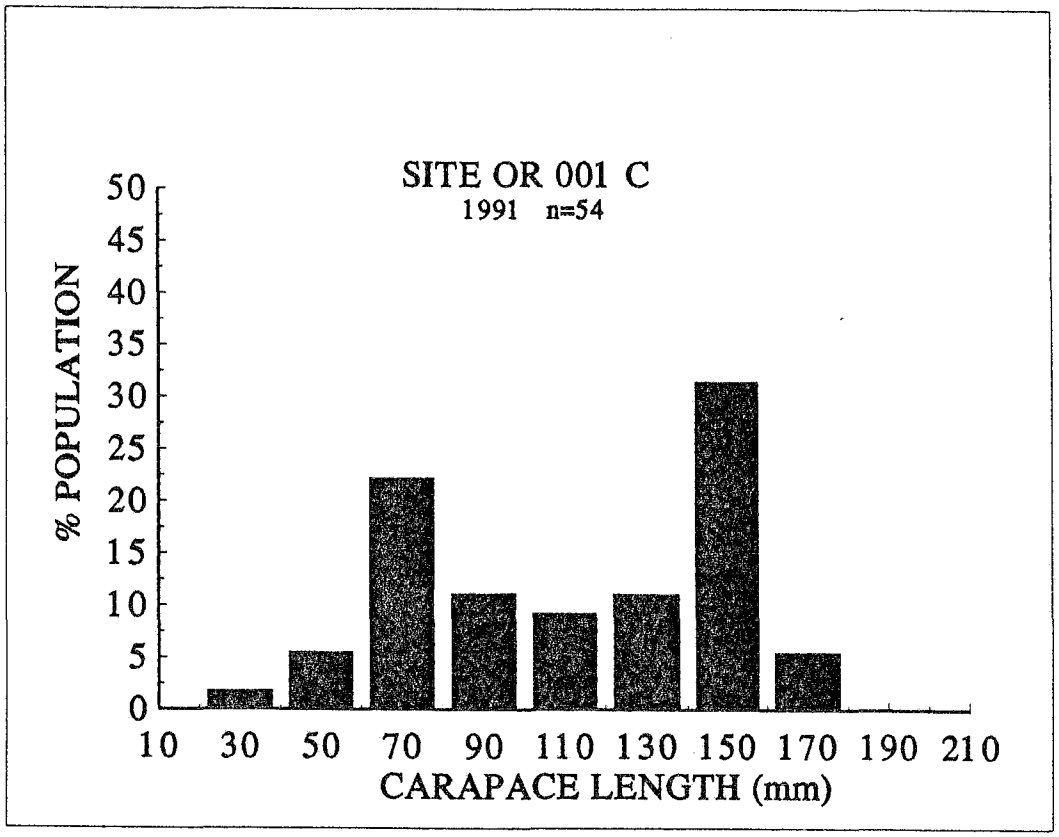


Fig. 21: Adult bullfrog (203 mm SV) w/ hatchling western pond turtle (27 mm carapace length) (Site CA 023 SC).

Fig. 22: Adult bullfrog (189 mm SV) w/ 60 mm western pond turtle.



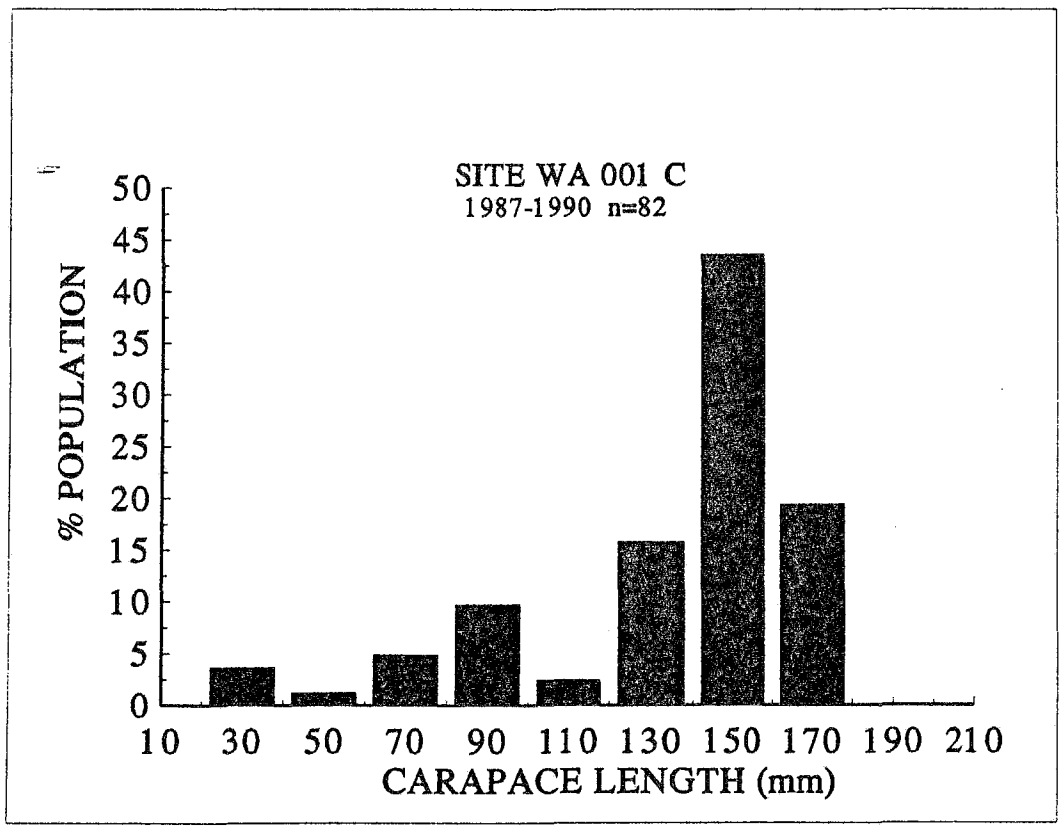


Fig. 23: Comparison of population structure of sites WA 001 C and OR 001 C.

1976; map in Stebbins, 1985). Both species occur in enormous numbers (Cohen and Howard, 1958; Moyle, 1976) in a wide variety of habitats.

Bullfrogs forage primarily in shallow water near the soil-water interface, the microhabitat favored by hatchling and juvenile WPTs. Evidence from a variety of sites and habitats in Washington, Oregon and California (Holland, unpubl. data) indicates a moderate negative correlation between the abundance of bullfrogs and the abundance of small WPTs. This situation is confounded in some instances by habitat alteration or other factors or predators, but in some cases bullfrogs are probably the primary agent responsible for recruitment decline or failure in some populations. Given the current status of bullfrogs and their obvious invasive tendencies, populations of WPTs in many areas that are not currently at risk or at risk from other threats (see Threats and Current Status) may soon face this threat. For example, bullfrogs seem to be in the process of invading the Sespe drainage (S. Sweet, pers. comm) in southern California, which holds some of the largest remaining turtle populations in this area.

Largemouth bass may also pose a significant threat to the viability of WPT populations in some areas. WPTs evolved in isolation from gape-and-suck predators such as bass. Evidence from a population along the central California coast indicates that where bass and bullfrogs are present, the WPT population(s) appears to be moderately to severely adult biased in relation to populations a short distance away that lack these predators (see Threats). Most areas where bullfrogs are present also hold bass and it is difficult to disentangle the actual and potential effects of the two species. Observations of two structurally similar habitats about 10 km apart along the Columbia River is of interest in this regard. A WPT population on the Washington side of the river occurs in a series of small ponds/lakes, some of which hold only bullfrogs and catfish, some of which hold bass, sunfish, catfish and bullfrogs. A population of WPTs on the Oregon side occurs in a habitat that contains bass, sunfish and catfish but lacks bullfrogs. The structure of the two populations is shown in Fig. 23. The Washington population is moderately adult-biased; until intensive surveys were conducted in 1990 no hatchlings were observed. The Oregon population was surveyed in 1991 and animals of all size and age classes were noted. The most obvious differences between the two populations are (1) the presence of bullfrogs in the Washington population and (2) the presence of a thick fringe of emergent vegetation (cattails) in the Oregon habitat. This vegetation fringe may serve to shelter hatchling WPTs from possible predation by bass; additionally the presence of large populations of alternate prey (sunfish, catfish) may also minimize the effect of bass predation. Large catfish may also act as predators on WPTs (L. Botra, pers. comm.)

Predation by humans may be a major factor in the decline of many WPT populations. Predation may be deliberate or incidental. Deliberate predation involves collection for food, commercial or scientific purposes, or wanton shooting. Harvest for commercial purposes probably began in the mid-1800's; historic records exist (Preston, 1981) of a commercial turtle fishery in Tulare Lake in the

late 1800's. Lockington (1879) noted that the trade in turtles and California red-legged frogs (Rana aurora draytoni) in the San Francisco market was so extensive that by this period trappers and hunters were working at least as far south as the Visalia area (central California) to supply the demand for the market trade. The scope of this trade was substantial; Smith (1895) noted that an average of 18,000 turtles a year were sold in the markets in San Francisco. Additional markets probably also existed in the vicinity of Seattle and Portland. The commercial trade in turtles continued until at least the late 1920's in interior central California (Storer, 1930) and also along the central California coast (H. Warren, pers. comm.). This situation was probably reponsible for significant declines in some turtle populations, and exacerbated other factors involved in declines. Current accounts (H. DeLisle, S. Sweet; pers. comm.) exist of collection of substantial numbers (20-100+) of turtles for food from streams in southern California. Additional reports (J. Applearth, T. DeLorenzo; pers. comm.) note collection for food from Oregon. In many of these cases, turtle populations may be effectively extirpated or at best severely reduced by skilled collectors. This is particularly true in the small, shallow streams present in many montane areas in southern California. Collection for the pet trade has also been a major problem in some areas; Bury (1982) noted the removal of over 500 animals from one lake in southern California. Collection for pets by individuals may also pose a significant threat; at one Nature Conservancy Reserve in southern California approximately 10 turtles in the last three years have been "recovered" from visitors as they were leaving the area (G. Bell, pers. comm.). As the total population of WPTs at this site numbers only 60-70 animals, loss of any member of the population may have major consequences. Although turtles have been collected for scientific purposes in the past (Noble and Noble; 1940; Holland, pers. obs.) there is no current activity of this type and it probably does not pose a serious threat to turtle populations. Deliberate shooting of turtles has been noted in many areas (D. Chesemore, S. Sweet, pers. comm.; Holland, pers. obs.) and may be responsible for the localized extirpation of some populations (Zimmerman, 1986).

Incidental collection may be a serious problem in some areas. Surveys conducted from 1981-1991 indicate that significant numbers of WPTs are taken accidentally by fishermen. Turtles have been taken on floating and bottom-set baits, trolled baits and bass plugs. Approximately 3.6% of the turtles captured in an 8-week period at a single site in Oregon had ingested fish hooks. Approximately 6% of the animals captured at a site in the southern Sierra Nevada either had obvious trauma due to the removal of hooks, had hooks in place, or were found dead with a hook embedded in the esophagus or stomach wall. Numerous additional isolated records (Mader, 1988; Holland, pers. obs.) (Fig. 24) indicate that this situation is widespread and more frequent than previously thought (Holland, 1989). Most turtles captured by fishermen are usually released by cutting the line. The majority of turtles that have ingested hooks probably starve to death. An animal initially captured, marked and weighed in Oregon was recaptured two weeks later and found to have ingested a hook since the initial capture. The weight of the animal had declined

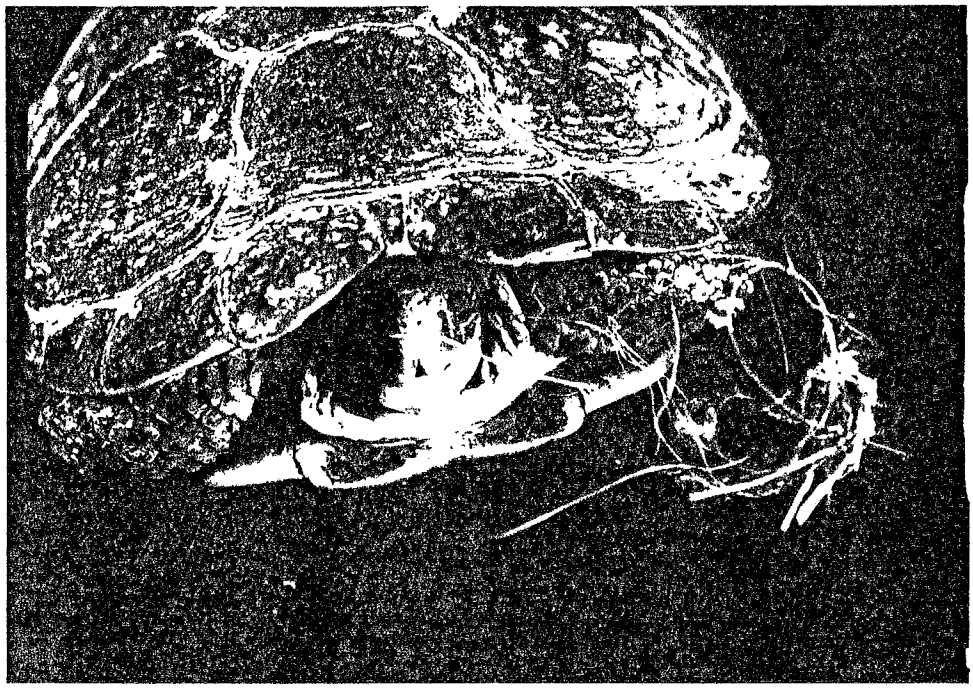


Fig. 24: Adult male western pond turtle w/fish hook in esophagus (Site NV 001 C).

Fig. 25: Road-killed post-partum female western pond turtle (Site OR 008 U).

approximately 10% in the time period between the initial and second capture. Other turtles with hooks also tend to be below normal weight when captured/recovered (T. DeLorenzo, pers. comm.). Conversations (1981-1991) with 40+ fishermen over the majority of the range of the WPT indicate that a significant percentage misidentify or have misidentified WPTs as snapping turtles (Chelydra serpentina) and killed them in the belief that the turtles take fish as prey. Incidental observations indicate that some persons will shoot WPTs for the same reason, or to eliminate presumed (incorrectly) predation on waterfowl. WPTs have been taken in modest numbers in fyke nets along the Sacramento River (C. Brown, pers. comm.). It is also likely that turtles are trapped and drowned in illegal gill nets (Holland, pers. obs.).

Substantial mortality occurs in some areas through crushing by automobiles. Roads that parallel watercourses seem to produce higher rates of mortality and major trauma than roads that intersect watercourses, with turtles being hit by traffic while moving to and from overwintering sites. Loss of breeding females while moving to and from nesting sites may also be a critical problem in some areas (Fig. 25). Hatchlings moving to water may also be subject to heavy losses by vehicular traffic.

PARASITES & COMMENSALS: Little work has been done on parasitism in WPTs. The only ectoparasites noted in an examination of 5000+ animals (Holland, unpubl. data) were leeches (presumably Placobodella). Leeches were present on about 7-10% of all animals examined from a series of sites in northern California, and a similar percentage was noted from a lake in central Oregon. Occasional turtles from the southern Sierra Nevada have been noted with leeches, but only one animal from the central coast of California has been observed to be carrying this parasite. Interestingly, this animal had 47 leeches, most of which were concentrated in the inguinal pockets. Bury (1986) noted substantial numbers of nematodes in the guts of animals from northern California, and casual examination of animals dissected for tissue samples noted the presence of lung worms in at least one specimen from central Oregon.

WPTs occasionally carry significant amounts of algae or fungi on the shell. Animals from central and southern California have been observed with a grey fungus-like growth covering up to 75% of the carapace and 100% of the plastron, and also covering extensive areas of the limbs and neck. This growth may be up to 6-8 mm thick in some areas, and feels slick to the touch. In 1987, approximately 80% of all animals captured in one central California watercourse were carrying the fungus. In the 1988, the percentage had dropped to approximately 25%, and only occasional animals have been noted with this condition from 1989-1991. All animals noted with this growth occurred in highly eutrophied watercourses (including sewage treatment plants), typically in areas that were heavily grazed. Green algae may be present on the shells of turtles in a variety of areas, but is most common in animals from slow-moving, eutrophied streams or lakes. The amount of algal growth appears to vary seasonally, with maximum amounts noted in late summer/early fall. Larger

animals tend to have more extensive growths than smaller turtles.

THREATS: Given the wide geographic range and variety of habitats in which WPTs occur, it is perhaps not too suprising that the species faces a variety of threats, some of which have been noted above. What follows is a brief description of some of the major threats. All population structure data noted below was collected directly by the author with the exception of some sites in the Willamette drainage, in which the author was assisted by various persons (Holland, 1991c).

Habitat Alteration: The first form of habitat alteration affecting WPTs probably began with the introduction of grazing by the first European settlers (Burcham, 1957). Livestock grazing had and has a significant impact on riparian and aquatic habitats through increasing erosion, siltation and direct and indirect alteration of the habitat (Mosconi and Hutto, 1982; Kauffman and Krueger, 1984; Marlow and Pogacnik, 1985; Taylor, 1986). Other observations (Platts, 1981; M. Hayes, M. Jennings, pers. comm.; Holland, pers. obs.) indicate that cattle trample streambanks and cause the collapse of undercut areas utilized by turtles as refugia. Additionally, cattle trample and eat emergent vegetation (see sources above; Fig. 26) that serve both as foraging sites for turtles of all age size/classes and as critical microhabitat for hatchlings and first-year animals. An incidental source of mortality is crushing of turtles by cattle foraging or drinking in watercourses (Holland, pers. obs.).

Other agricultural practices responsible for the decline of WPT populations involve the widespread conversion of aquatic habitats to farmland. Extensive "reclamation" of "swamp and overflow lands" (Elliot, 1883a; Brown, 1940, Harding, 1960) began in the late 1870's-early 1880's in the southern San Joaquin Valley. The history of this type of situation has been well-documented by Preston (1981) for the Tulare Lake basin. These practices on marsh and other aquatic habitats on the floor of the San Joaquin and Sacramento Valley have had a major impact on populations of turtles and numerous other native vertebrates, effectively extirpating populations in many areas (see Current Status). Alteration of habitats for agricultural purposes may not only directly eliminate turtle populations in those habitats, but also affect turtles in adjacent areas through the associated processes. These include alteration of the timing, pattern and nature of water flow patterns in existing watercourses, direct alteration of the watercourse (sloughs, creeks, streams) through straightening, channelization or removal or control of emergent vegetation. Even in areas where turtles still persist in watercourses alteration of adjacent habitats utilized as nesting areas may effectively eliminate or severely restrict recruitment in these populations (Fig. 27). Turtles will persist in areas long after effective recruitment has ceased due to the (potential) long life span of the species. Assessment of population structure and size in areas with extensive agricultural development (see Current Status) indicates that in many of these areas turtle populations are extremely small and/or heavily adult biased. The effects of other activities associated with agricultural uses of a

Fig. 26: Cattle in hatchling western pond turtle habitat (Site CA 021 CC).

Fig. 27: Typical agricultural infringement on riparian habitat in the San Joaquin Valley, California (Site CA 016 SJ).

given area, such as use of biocides, increasing salinity of water sources and contamination by heavy metals (e.g. selenium) are effectively unknown in relation to WPTs, but may be significant.

Alteration of habitats by activities associated with water control projects have also had a significant effect on WPT populations. Construction of dams, canals and water diversion/storage facilities has changed the pattern and timing of water flow throughout the western United States. As noted above (see Habitat) and detailed below (see Current Status), WPTs have been noted in in reservoirs, but in all cases consisted of small groups of adults. In no case of which I am personally aware has a viable population of WPTs been found in any reservoir of any significant size (> 2-3 ha). Dams and reservoirs affect WPT populations in several ways.

1. Construction of the dam directly eliminates turtle habitat and may force dispersal of turtles into adjacent and possibly less suitable or unsuitable habitats. Some direct mortality may occur through construction activities.

2. Completion of the dam and flooding of upstream areas also directly eliminates turtle habitat; not only aquatic habitat but also adjacent upland nesting areas. The effects of vehicular traffic and construction activities may directly eliminate nesting areas or affect the probability of nesting success through soil compaction.

3. The aquatic habitat created behind dams in the reservoir is largely unsuitable for WPTs due to a alteration of the invertebrate prey base, elimination of basking sites (removal of logs, rocks, emergent vegetation) and alteration of refugia. For operational and safety reasons, the preferred basking sites (floating logs, snags) are often removed in many reservoirs.

4. Reservoirs are often utilized for recreational activities (boating, swimming, fishing, etc.), high levels of which tend to discourage or preclude turtle activity in a given area.

5. Reservoirs are often used as sites of introduction for exotic species of fishes (bass, sunfish, catfish) which if not direct predators on WPTs may compete with them for the available prey base.

6. Reservoirs create habitat suitable for the establishment and spread of exotic species, such as those noted above and including the bullfrog, even if these species are not deliberately introduced. This in turn may facilitate the effective movement of these species into adjacent undisturbed habitats or drainages.

7. The nature and timing of water releases from dams in many cases is the direct opposite of historical patterns of water flow in a given system (i.e. high winter flow prior to the dam, high summer flow after construction). This alteration of the pattern may affect the downstream habitat by elimination or alteration of

basking sites, refugia, foraging areas and particularly hatchling microhabitat. The thermal environment of a given drainage may be dramatically altered by releases from the reservoir. Drainages that for hundreds of thousands of years were characterized by low summer flows and moderate to high water temperatures may now have high flows and low water temperatures. The probable effects of this shift in flow pattern are to change the composition of the invertebrate prey base, change the energetic "cost" of foraging for WPTs and possibly decrease growth rates. The practice of periodic exponential increases in water flow during certain times of the year may have major negative effects on WPT populations. Observations along the Trinity River (northern California) in 1991 following an approximate 1000% increase in water flow for a period of one week in late May-early June indicated that the available hatchling microhabitat along several miles of the river below the dam had been effectively scoured by this action. A similar situation was noted along Piru Creek (southern California) (S. Sweet, pers. comm.). As hatchlings typically emerge from the nest and move to the watercourse in spring and occur only in limited areas of suitable microhabitat (see Hatchlings), abnormally high spring-summer flows may severely alter patterns of recruitment in a population(s) subject to this condition.

8. Construction of reservoirs and the alteration of upstream and downstream habitat may pose significant problems for normal turtle movements within a drainage. As previously noted (see Density, Home Range and Movement), turtles may move considerable distances within a watercourse, either in relation to nesting (Rathbun et al, in press) or other activities (Bury, 1972).

9. Reservoirs effectively fragment populations of turtles continuously distributed within a given drainage, thus decreasing total population size. Reduced populations are thus more likely to be negatively affected by other factors (see above and Current Status) and the probably of localized extirpation is increased. Furthermore, the difficulty of recolonization of areas where populations have been eliminated is increased by the presence of the reservoir and associated activities and conditions.

Many of the above noted situations also apply to canals and other water diversion or storage structures. For example, extensive development of canal systems in the San Joaquin Valley has led to dramatic alterations in the nature of water flow in natural watercourses in this area. Many of the major rivers (Kern, Tule, Kings, Kaweah) which formerly emptied into the large lakes on the valley floor (Kern, Buena Vista, Goose, Summit & Tulare) have had significant percentages of their water flow diverted for agricultural, industrial and urban use. This has resulted in the total elimination of WPT habitat along significant portions of these watercourses. In many areas stretches of the river miles in length remain dry or have very low water flows for several months of the year (Fig. 28). These areas, which formerly held populations of WPTs are now unsuitable as habitat and pose major barriers to potential movement(s) of animals within these drainages. Canals used to move water in the place of

existing natural watercourses divert water from existing or former WPT habitat and do not generally hold populations of WPTs. This situation is more extreme in the southern part of the San Joaquin Valley where management of water movement includes elimination or control of emergent vegetation (see Habitat), thus making the area even less suitable as WPT habitat.

Alteration of habitats for other purposes has also had a significant effect on WPT populations. Urbanization and associated activities in many areas have eliminated WPT populations. In the Los Angeles basin, for example, channelization and cementing of watercourses (Fig. 29) has led to the extirpation of many WPT poulations (Brattstrom, 1988; Brattstrom and Messer, 1988; Holland, unpubl. data). Elimination of populations and alteration of habitats in this and adjacent areas makes extremely unlikely the possibility that these areas will be recolonized naturally, or that the habitats would support viable populations if such an event occurred. The spread of urban "development" into WPT habitat, even where such situations are "low density" in concept, may have significant effects. Alteration of nesting sites, increased levels of predation and incidental or deliberate collection may impact populations. In particular, development of "lakeside" or "streamside" urban areas may have a major negative impact on WPT populations through these factors.

Some alteration of aquatic habitats began with the advent of hydraulic mining in the 1850's in California. These activities resulted in widespread localized flooding and heavy siltation in numerous rivers and streams, particularly in the northern and central Sierra Nevada. Flooding, particularly aseasonal flooding, often results in mortality or adverse downstream dispersal of turtles (Holland, pers. obs.). Siltation fills in pools and similar areas utilized by turtles, and eliminates or restricts refugia thus increasing the probability that turtles will be subject to predation. Siltation also tends to decrease or eliminate outright the invertebrate prey base in many of these systems, with deleterious results. Although hydraulic mining has been essentially eliminated, other in-stream and streamside mining activities have adverse effects on turtle populations. Sand and gravel operations may directly impact turtles through elimination or modification of aquatic habitats and riparian vegetation, through alteration of the pattern and timing of water flow, through impacts on nesting areas, through creation of habitat conditions that favor introduced predators (particularly bullfrogs and bass), through disruption of normal behavioral patterns or forced displacement, or by increased siltation as noted above and long-term habitat alteration. In-stream mining activities such as suction dredging may also have deleterious effects on turtle populations through direct mortality, alteration of refugia, alteration of the substrate and impacts on the invertebrate prey base, and disruption of normal behavioral patterns.

Alteration of basking sites within the aquatic habitat may also significantly affect WPT populations. Removal of logs, snags, brush piles and/or aquatic vegetation to facilitate boating, fishing or other activities not only changes the thermoregulatory behavior of

Fig. 28: Typical current condition of river channels in the San Joaquin Valley, California.

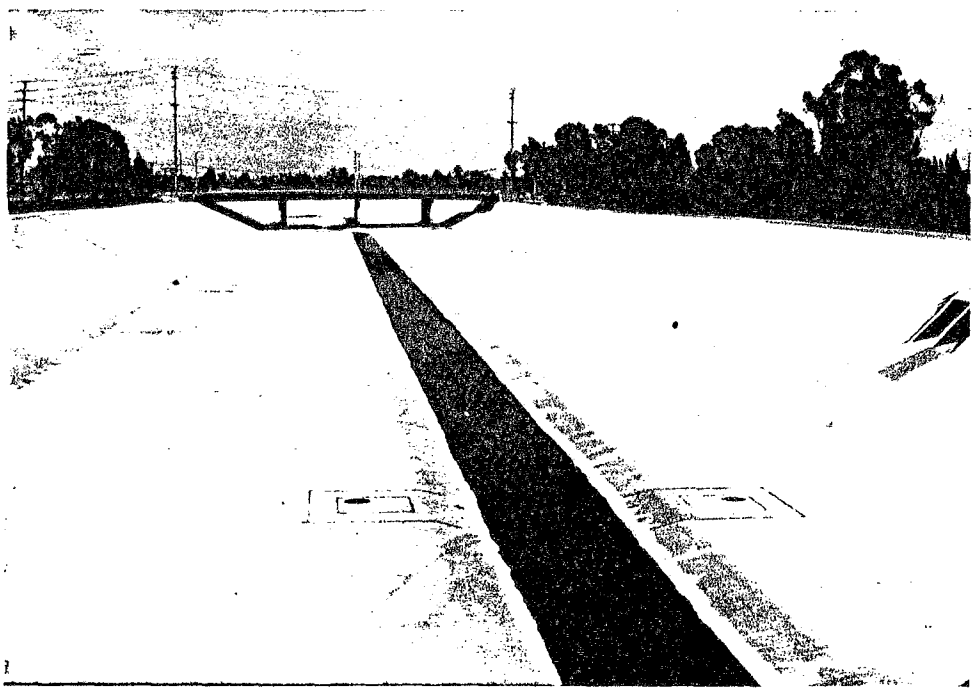


Fig. 29: Type locality of southwestern pond turtle (Clemmys marmorata pallida), Coyote Creek, Orange County, California.

turtles, but also eliminates foraging sites and refugia. This type of activity has been implicated as a major factor in the decline of WPTs in some lakes in Oregon (Holland, 1991c).

Another form of habitat alteration that may have a locally signifcant impact on WPT populations are certain cultivation practices in habitats adjacent to the watercourses in which turtles occur. In particular, the practice of irrigating pasture lands in these areas may lead to substantial if not total loss of recruitment through destruction of eggs in the nest. Existing evidence (Feldman, 1982; Holland, 1991c; J. Congdon, F. Slavens, pers. comm.; pers. obs.) indicates that WPT eggs are intolerant of even moderate amounts of soil moisture during incubation. If exposed to such conditions up to 100% (Feldman, 1982) may break or fail to develop (see Reproduction). In some areas this may be a major source of recruitment declines; observations along the Klamath and Lost Rivers (Oregon) indicate that irrigated pastures often extend to within 10-20 m of the edge of these watercourses, and extend for several hundred meters on either side. Given the known distances of oviposition sites in WPTs (Fig. 17) and the extent of these cultivated areas, it may be likely that females are effectively forced to oviposit in unsuitable habitats. Effectively similar situations may also occur in other types of cultivated areas, where females may successfully nest in fields but nests are destroyed due to plowing or other similar activities. Observations in central and northern California indicate that even where the riparian corridor may be relatively intact, cultivation closely infringes upon the adjacent habitats typically used for nesting (Fig. 27).

Population Fragmentation: Western pond turtles were historically continuously distributed throughout the majority of many major drainages within their range, such as the Willamette, the Rogue, the Klamath and the San Joaquin/Sacramento system. Natural fragmentation of populations through changes in topography or climate have been a part of the evolution of this species throughout the Pleistocene. However, these changes have been relatively gradual and conditions that followed allowed recovery and re-expansion of turtle populations. Currently, WPT populations are moderately to severely fragmented in the majority of their range, a situation that has essentially occurred within the last 110-120 years. Concurrent with this population fragmentation has been a significant decrease in total population size for the species. The consequences of this type of situation are well known to biologists in both a theoretical and applied sense; among them are increased susceptibility to extirpation or extinction, decreased resistance to perturbations (both natural and man-made), decreased gene flow and genetic variability and potential alteration of community structure and dynamics. In the portion of the range south of the Santa Clara River (California), the minimum mean straight-line distance between known viable WPT populations is approximately 33.6 km. If the population(s) in the Santa Clara drainage are included, the average increases to approximately 50 km. In actuality, potential dispersal distances among populations are much greater if routed through likely avenues of movement, such as watersheds or drainages. Given the nature and extent of habitat alteration in the

southern part of the range, if any of the isolated populations in this area were to be extirpated the possibility that they would be re-established by immigration from other areas is vanishingly small. In other areas such as Kern County (California) where turtles were historically found in most of the watercourses, their distribution has become progressively more restricted, with some major discontinuities occurring in the last 20-25 years (Fig. 30). Similar situations have occurred and are occurring along a number of major river systems in California such as the Salinas, the San Joaquin and the Sacramento.

Predation: As previously noted, native predators (such as black bears, coyotes, river otters, mink and raccoons) have been observed to take adult pond turtles. The relative and total effect(s) of these predators may vary from area to area and in relation to other parameters. For example, the introduction of black bears into areas of the Los Padres National Forest where they were previously scarce or absent may have dramatic effects on WPT populations. Adult WPTs can survive extensive trauma and loss of the significant portions of the shell produced by attempted predation by coyotes, mink, raccoons and river otters (Holland, unpubl. data). However, it is apparent that predation by black bears usually results in the death of the turtle. In this respect, turtles in some areas (such as Los Padres) are particularly vulnerable, as they 1) are on the average much smaller than turtles in areas with larger stream systems (Holland, unpubl. data) and 2) occur in habitats that make them considerably more vulnerable to predation. Observations of WPT populations in this area (S. Sweet, pers. comm.) indicate that during the drought of 1987-1991, drying of watercourses forced movement of turtles within stream systems and resulted in heavy predation by both bears and coyotes. At least one population was effectively extirpated by predation in this period (S. Sweet, pers. comm.). Furthermore, certain types of human activity may actually favor the establishment of certain predators in a given area or may alter normal foraging patterns or ranges. The establishment or increase of raccoon populations in urban areas adjacent to WPT habitats may increase predation on nests or possibly juveniles and adults. This phenomenon has been documented for sea turtles (Ehrhart, 1979). Predation on turtle nests is known to increase near ecological edges (Temple, 1987), a common result of human-induced habitat alteration.

Introduced predators may also have a significant effect on the structure of WPT populations, primarily through alteration of recruitment patterns and survivorship (see Predation and Mortality). In many cases, there are possible multiple causes for declines in recruitment confounding the effect(s) of introduced predators. The presence of adjacent or similar sites in a given area which lack one or more of the postulated confounding factors allows for examination of the role of introduced predators on population structure in WPTs.

There are two species of primary concern in this respect, bull-frogs and bass. The structure of two WPT populations along opposite sides of the Columbia River is shown in Fig. 23. Population WA 001 C occurs in a series of 5 small ponds, two of which contain bullfrogs,

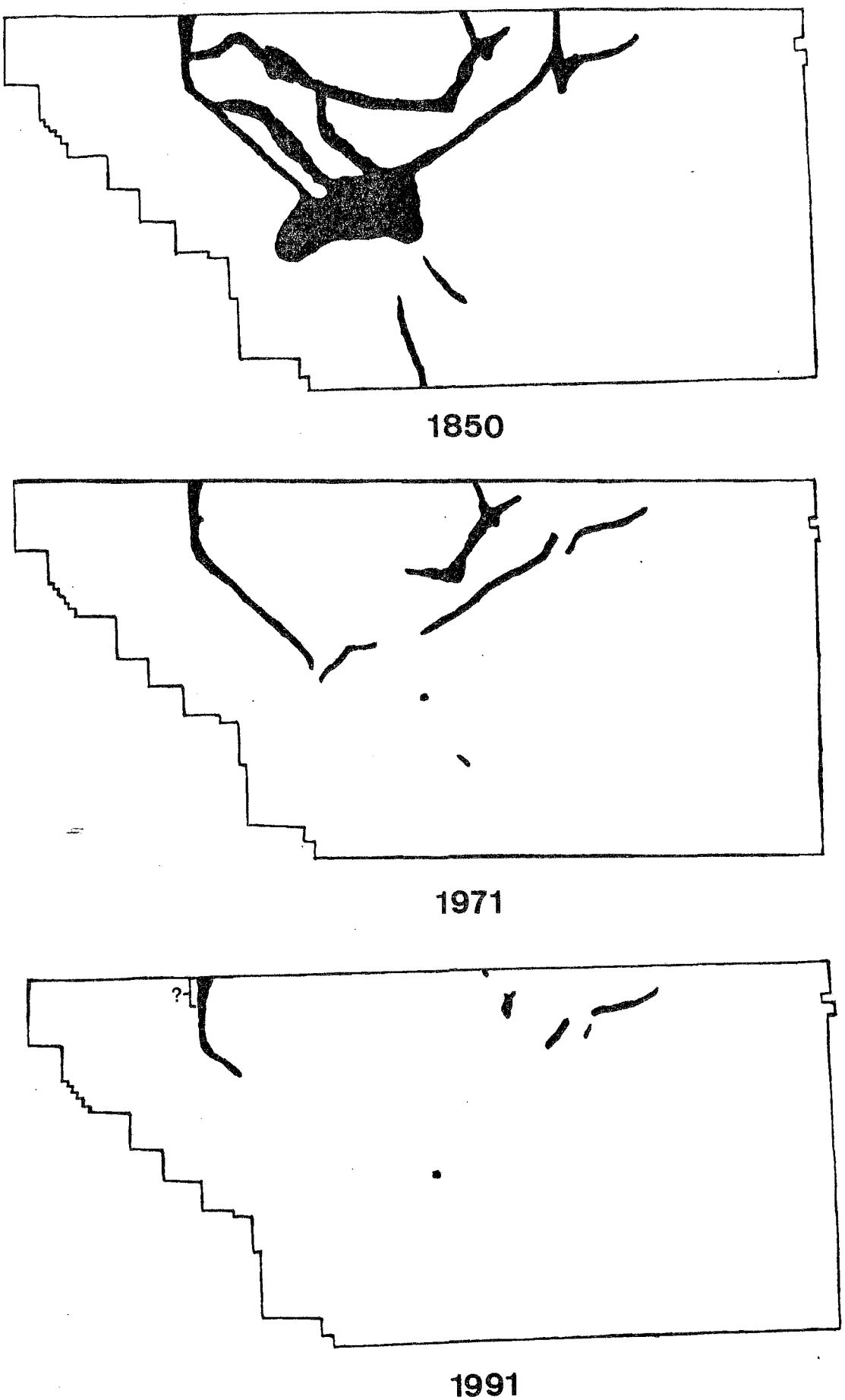
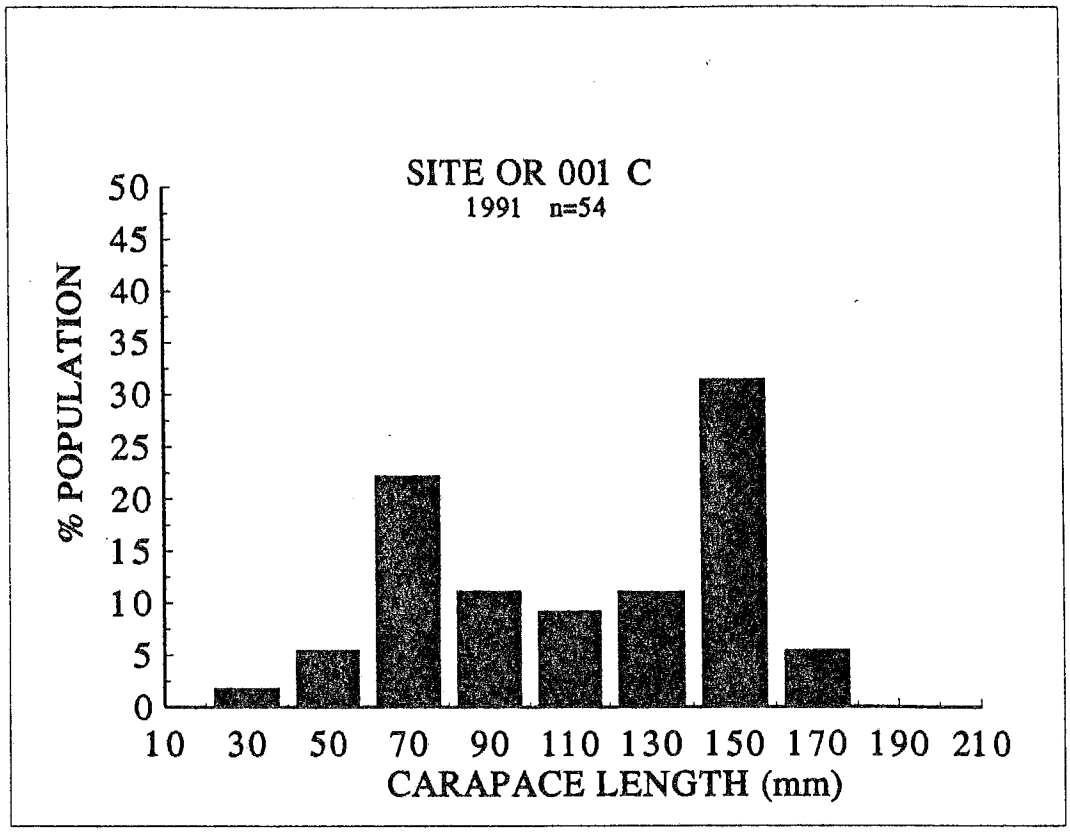


Fig. 30: Fragmentation of western pond turtle distribution in Kern County, California 1850-1991.



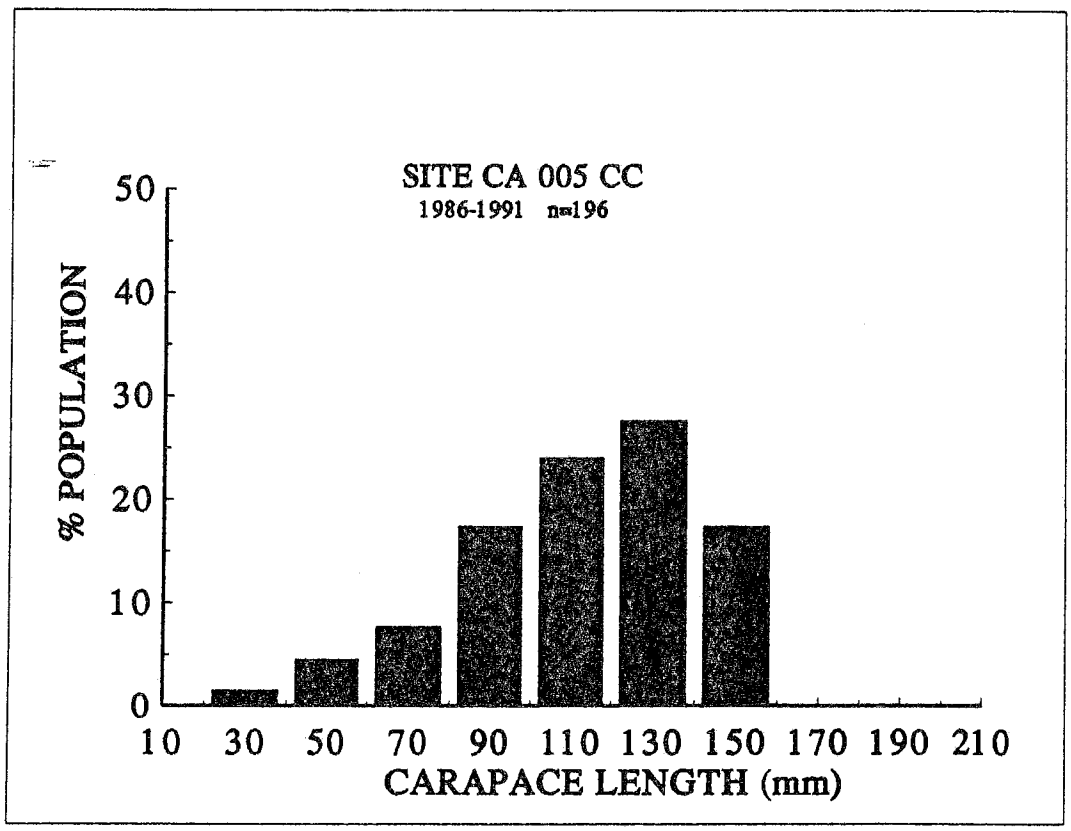
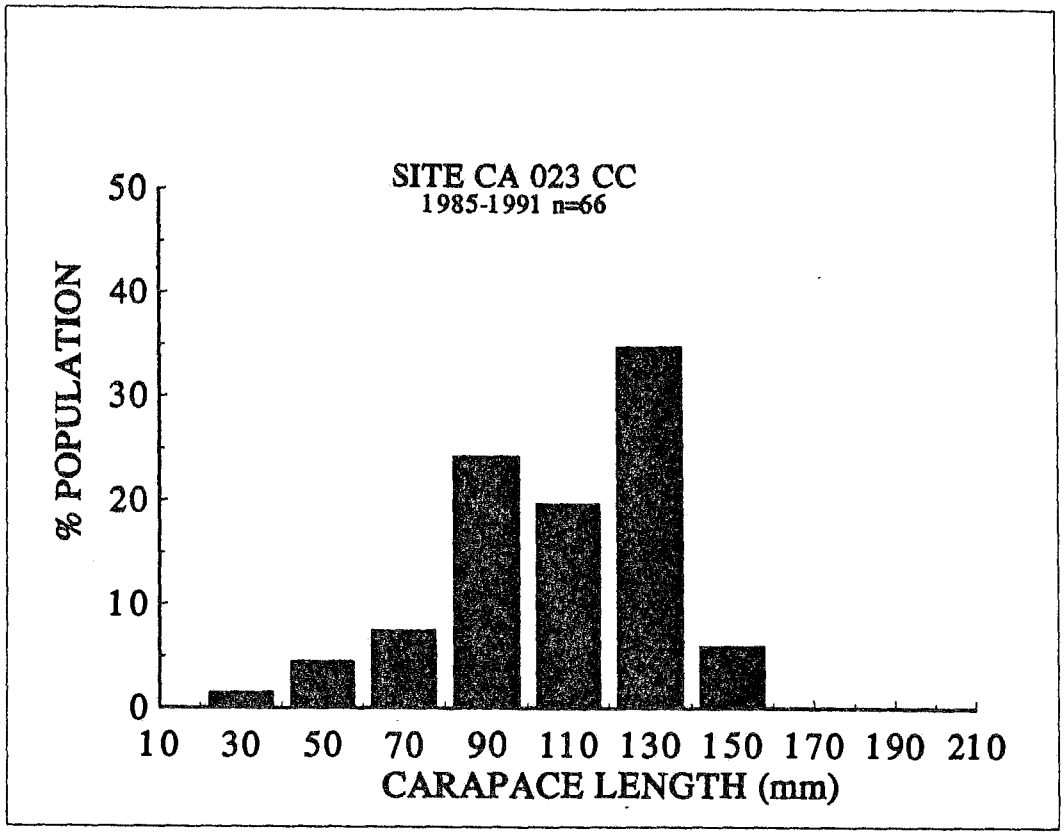


Fig. 31: Comparison of population structure of sites OR 001 C and CA 005 CC.

two of which contain bullfrogs and catfish, and one of which contains bullfrogs, bass, sunfish and catfish. One of the two ponds that contained bullfrogs alone was apparently first invaded in 1990. This pond, interestingly, contained the highest percentage of small animals noted in the 1990 survey (23%), as opposed to 14%, 14%, 0% and 0% in the other ponds. The overall structure of the population in this system indicates a deficiency in recruitment as reflected in the low percentage of animals in the 50-70 mm size class and the 110-130 mm size class. A more detailed assessment of the status and structure of this population is provided in Holland (1991a). The population on the Oregon side (OR 001 C) of the Columbia occurs in a single pond, but probably moves seasonally into adjacent ephemeral pools. This pond contains bass, catfish (black bullhead) and two species of sunfish, but no bullfrogs are present. The structure of this population resembles that of other populations in areas of California where the habitat is relatively undisturbed and no introduced predators or competitors are present (see Fig. 31). The significant numbers of small animals in this population may be due to a number of factors. The presence of a thick fringe of emergent vegetation around approximately 90% of the perimeter of the pond may serve as an important refugium for small turtles, shielding them from predation by bass. The presence of numerous other prey species may also minimize predation on small turtles.

In other areas, similar comparisons can be made. The structure of two California central coastal populations (CA 023 CC and CA 024 CC) are shown in Fig. 32. These two small watercourses are separated by approximately 2 km. Site 024 has large populations of bullfrogs and bass, while site 023 lacks both species. The population at site 024 is moderately adult-biased with relatively few (8.5%) animals in the <4 year age group. For site 023 the equivalent figure is 13.54%. Despite the fact that there is considerably more habitat present at site 024, the overall turtle density is much lower. Populations CA 021 CC and CA 022 CC are located 6.2 and 3.0 km from site CA 023 CC, respectively. The structure of these populations is shown in Fig. 33. Both sites are grazed, but bullfrogs are present at site 021 but absent at site 022. Neither site has any introduced fish. Site 021 is heavily adult biased (88.7%) and the last small animal (<70 mm) was noted at this site in 1986. Animals in the <4 y age group constitute only 7.1% of the population. At site 022, approximately 56.3% of the population are adults, and the <4 age group comprises 29.4% of the population. A tributary of site 021, site CA 020 CC (Fig. 34) which lacks bullfrogs has a population structure that more closely resembles site 022. At site 020, 66.6% of the population are adults, and 23.8% of the population are in the <4 y age group.

Two populations (CA 001 PS and CA 002 PS) occurring approximately 20 km apart in the upper Pajaro-Salinas drainage also provide an interesting contrast. The population at site 001 exists in a small pond that lacks bullfrogs and bass, and has the highest density on record for any WPT population (3700 animals/ha). The population at site 002 occurs in a moderate-sized (0.5-0.7 ha) impoundment that had (until 1990) a substantial population of largemouth bass. The



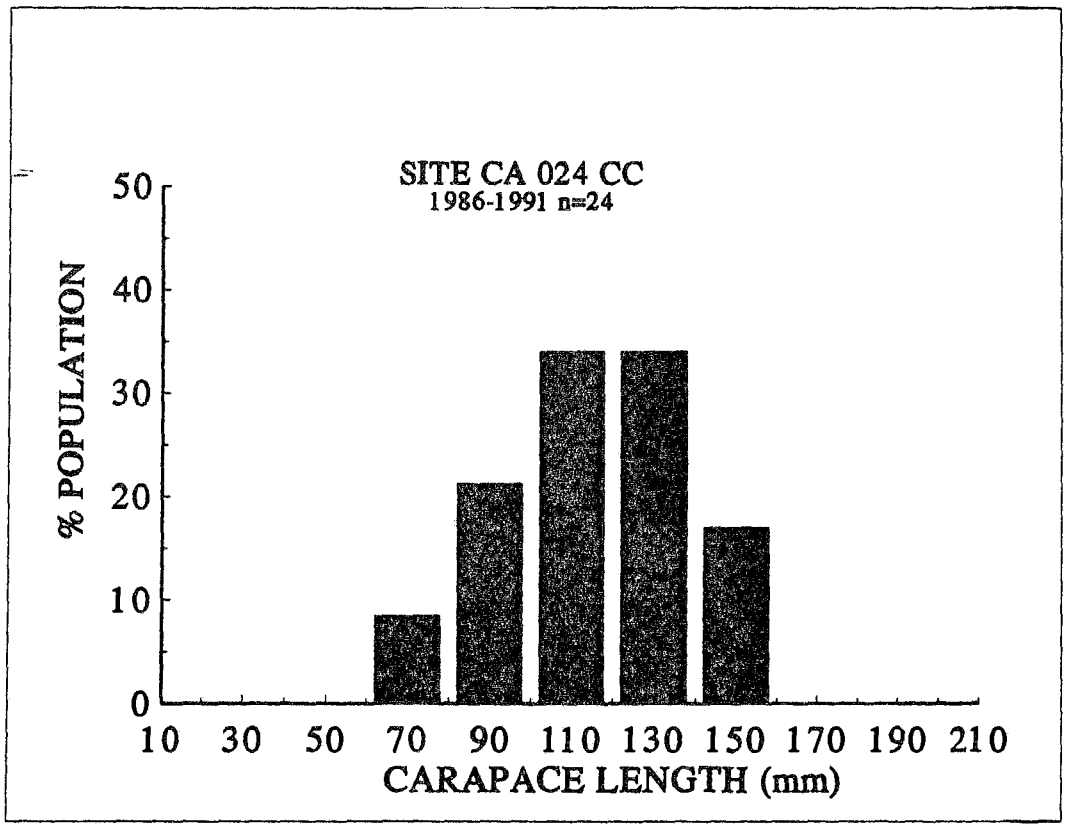
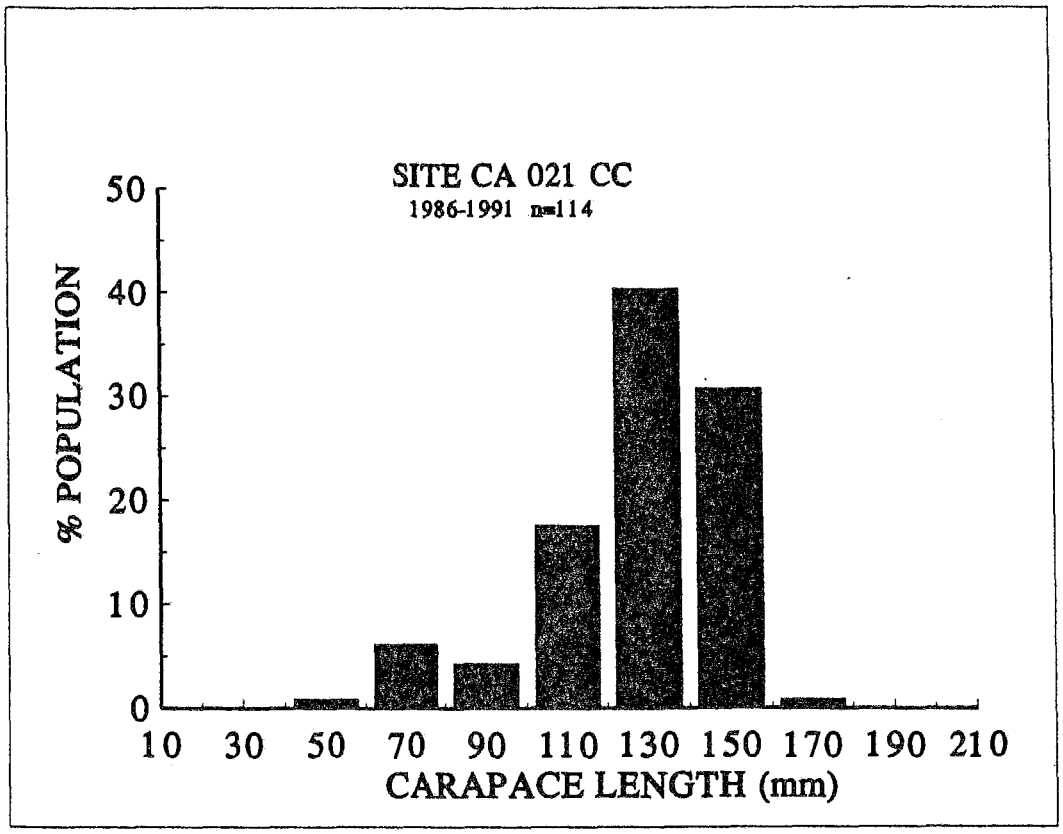


Fig. 32: Comparison of population structure of sites CA 023 CC and Ca 024 CC.



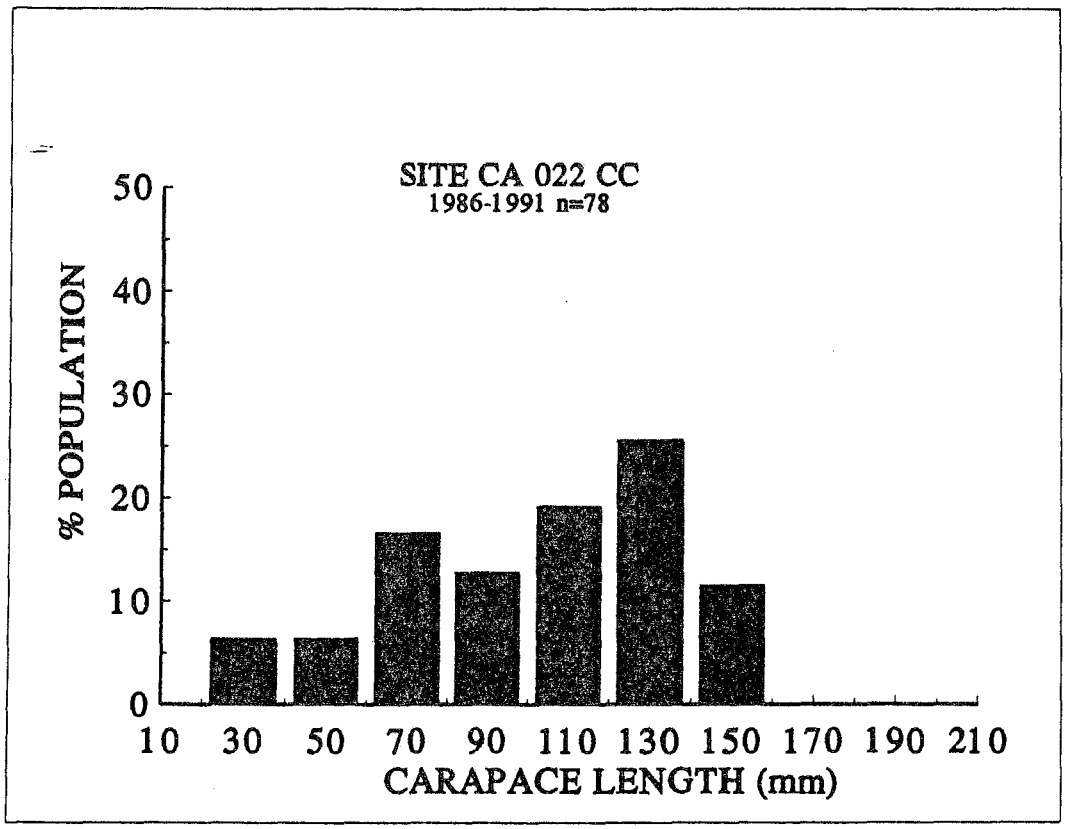
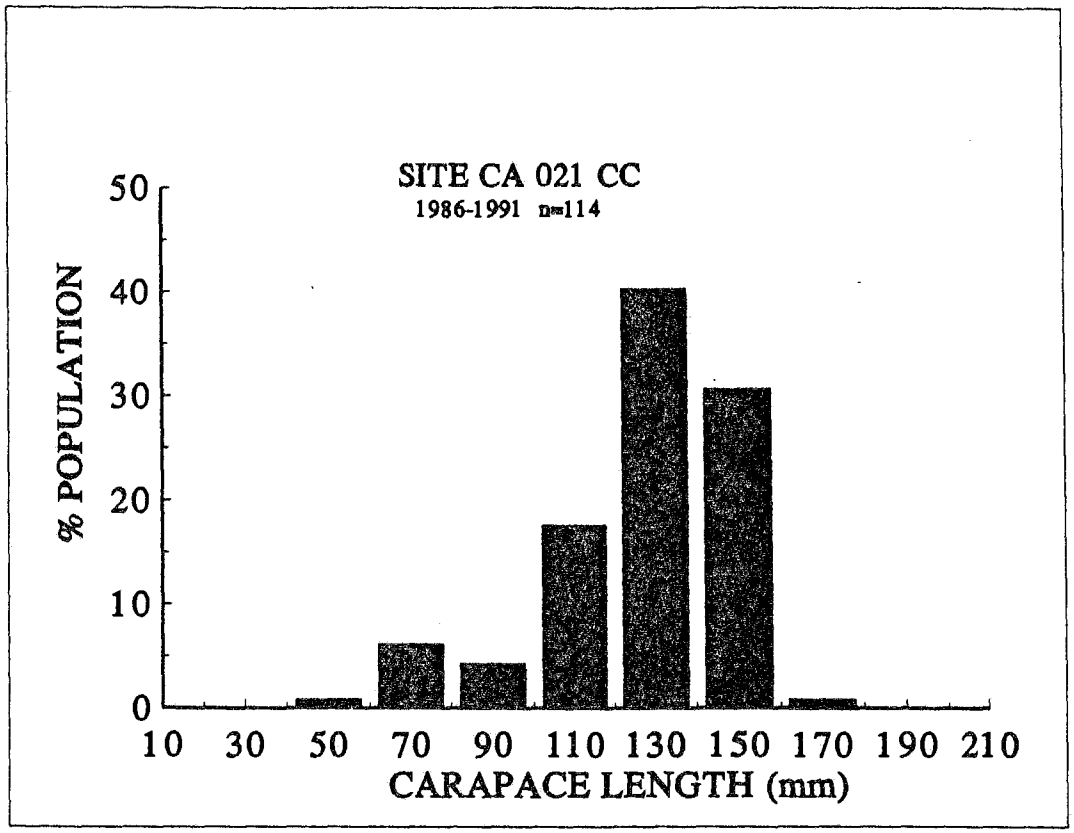


Fig. 33: Comparison of population structure of sites CA 021 CC and CA 022 CC.



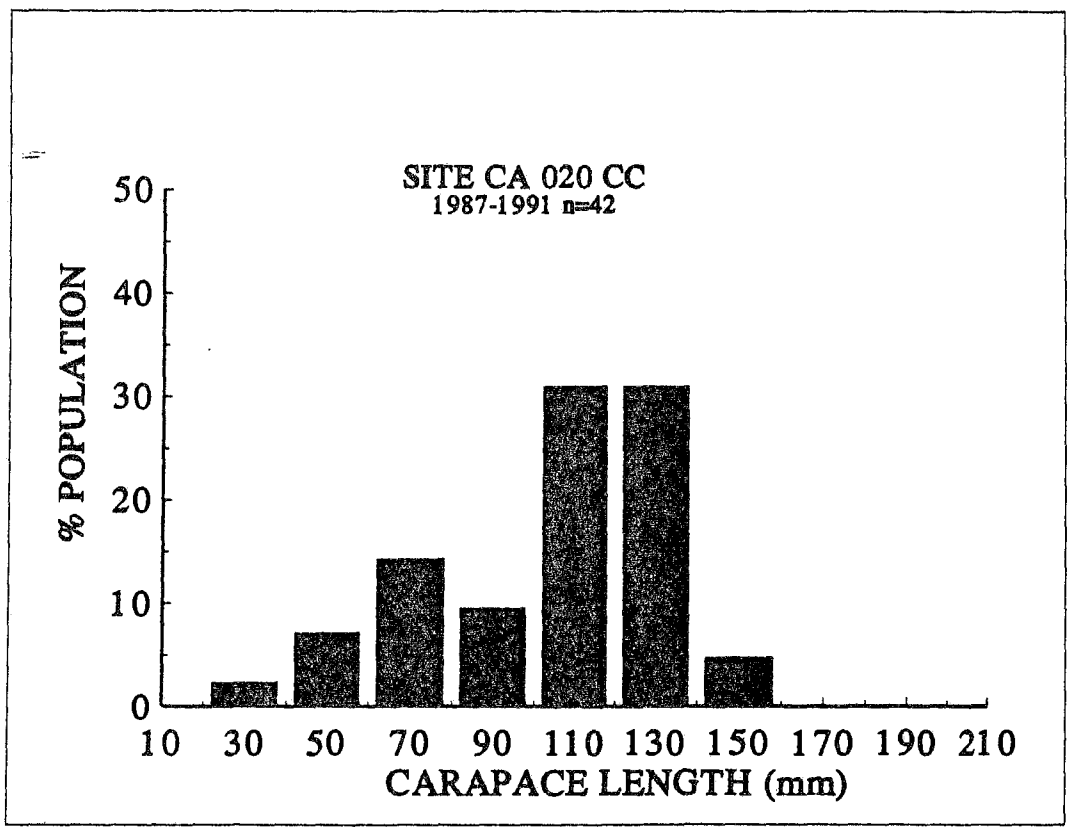


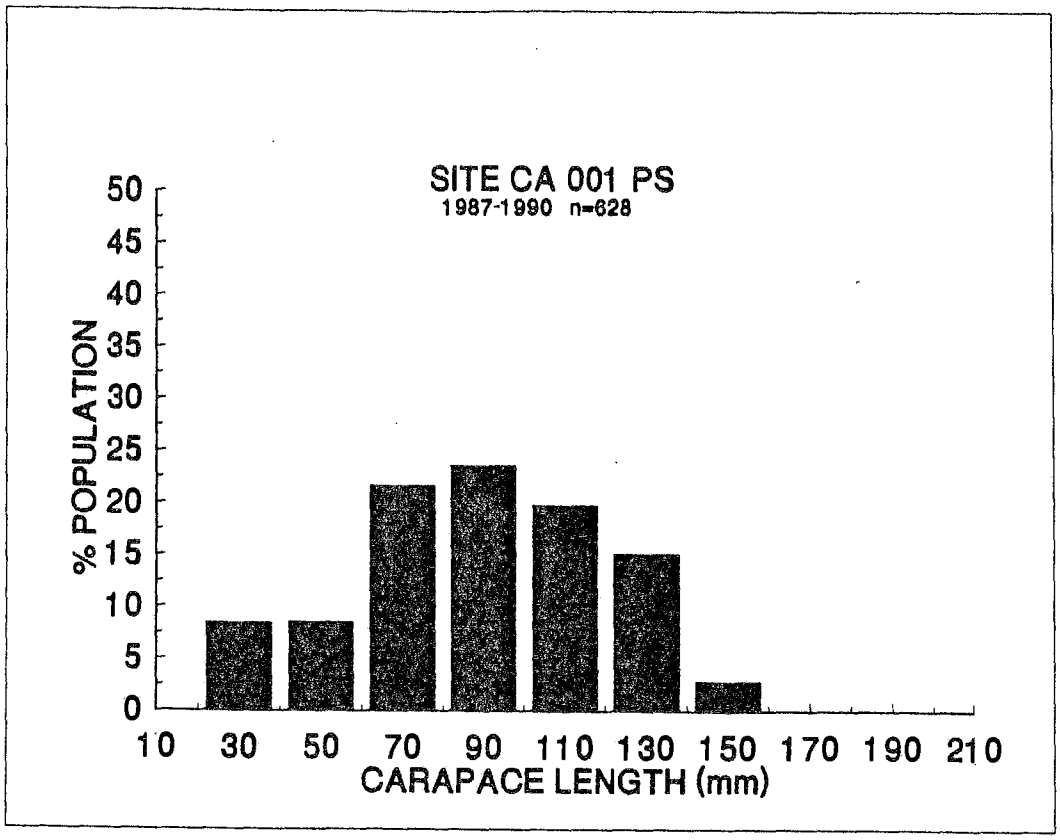
Fig. 34: Comparison of population structure of sites CA 020 CC and CA 021 CC.

population at site 001 consisted of 37.94% adults and 62.06% juveniles. Approximately 38.5% of the population was in the <4 y age group. The population at site 002 consisted of 73.1% adults and 26.9% juveniles. Approximately 10% of the population was in the <4 y age group. Two small animals were initially observed in 1987 and a single juvenile was noted in 1989. This population was apparently extirpated by the drought in 1990. The size distribution of the two populations is shown in Fig. 35.

In a comparison of two other populations in the Pajaro-Salinas drainage similar patterns are observed (Fig. 36). These two sites are approximately 10 km apart. Site CA 007 PS had large numbers of bullfrogs and sunfish, but no bass. Site 008 PS had moderate numbers of sunfish, but no bullfrogs or bass. Neither site was grazed, and the surrounding habitat was relatively undisturbed. Adults constituted 68.4% of the site 007 population, and no animals <4 y were captured or observed. Site 008 was comprised of 55% adults, and 22.9% of the population were in <4 y age group.

A comparison of two populations in the Sierra Nevada shows similar patterns (Fig. 37). The two sites are in the same major drainage system but located 25 km apart. Site CA 025 SJ is a stream environment with no introduced fishes. Significant numbers of bullfrogs were not noted in this system until 1991. Sites 026-029 SJ are a series of pond environments along a river. All sites have bullfrogs in large numbers, and bass are present at one site. Access between sites is relatively easy for turtles, and they are treated as a single location in this analysis. The population at site 025 had 73.1% adults, and 18.6% of the animals were in the <4 y age group. At sites 026-029, 94.6% of the population were adults, and no animals <4 y were captured or observed in the period from 1986-1991.

Other exotic species may also prey on WPTs. Of particular interest in this regard are striped bass (Morone saxatilis), white bass (Morone chrysops), the larger species of catfish (Ictalurus sp.), and possibly crayfish (Cambarus, Procambarus and Pacifasticus). Unlike the exotic species noted above, direct evidence of predation on WPTs by these species is not well-established. However, given the wide distribution and catholic feeding habits of these species, it is probable that they prey on WPTs to some degree. Of particular concern in this respect are the larger exotic species of crayfish, which reach densities in excess of 3/square meter in some streams (pers. obs.). Hatchling WPTs may be particularly vulnerable to crayfish predation due to their small size (23-31 mm) and microhabitat preferences. An additional concern (see Introduced non-predaceous species) is that all of these taxa may compete with WPTs in many areas for the existing prey base. The potential effect(s) of wild pigs (Sus scrofa) may be locally significant, given the feeding habits of the species. Observations of pig activity in WPT habitat in central and southern California indicate that pigs may heavily alter or in some cases eliminate areas of emergent vegetation utilized by hatchling and first-year WPTs. It is also likely that predation on nests occurs.



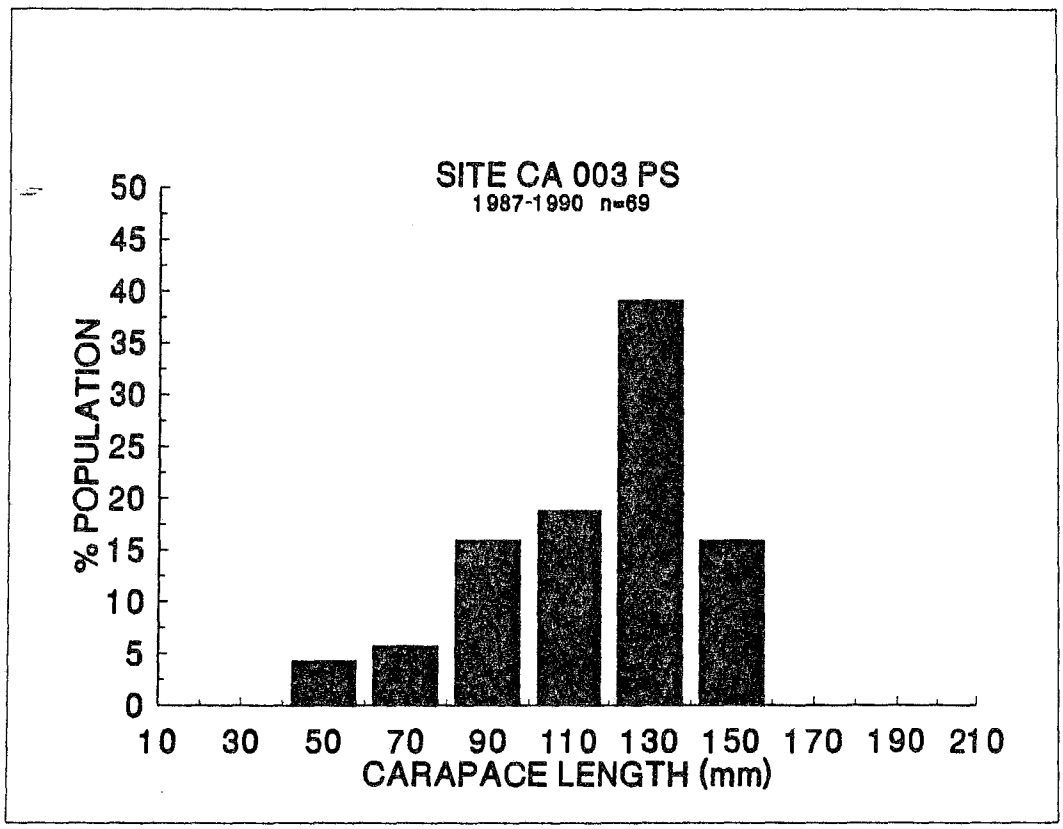
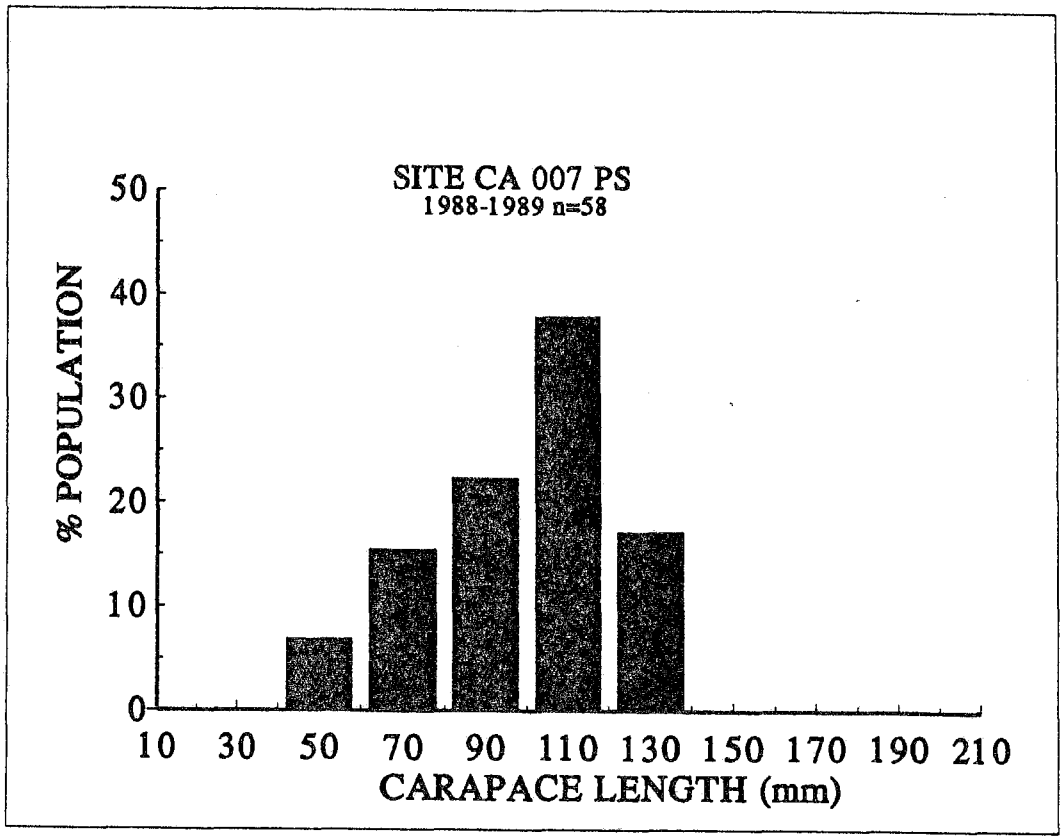


Fig. 35: Comparison of population structure of sites CA 001 PS and CA 003 PS.



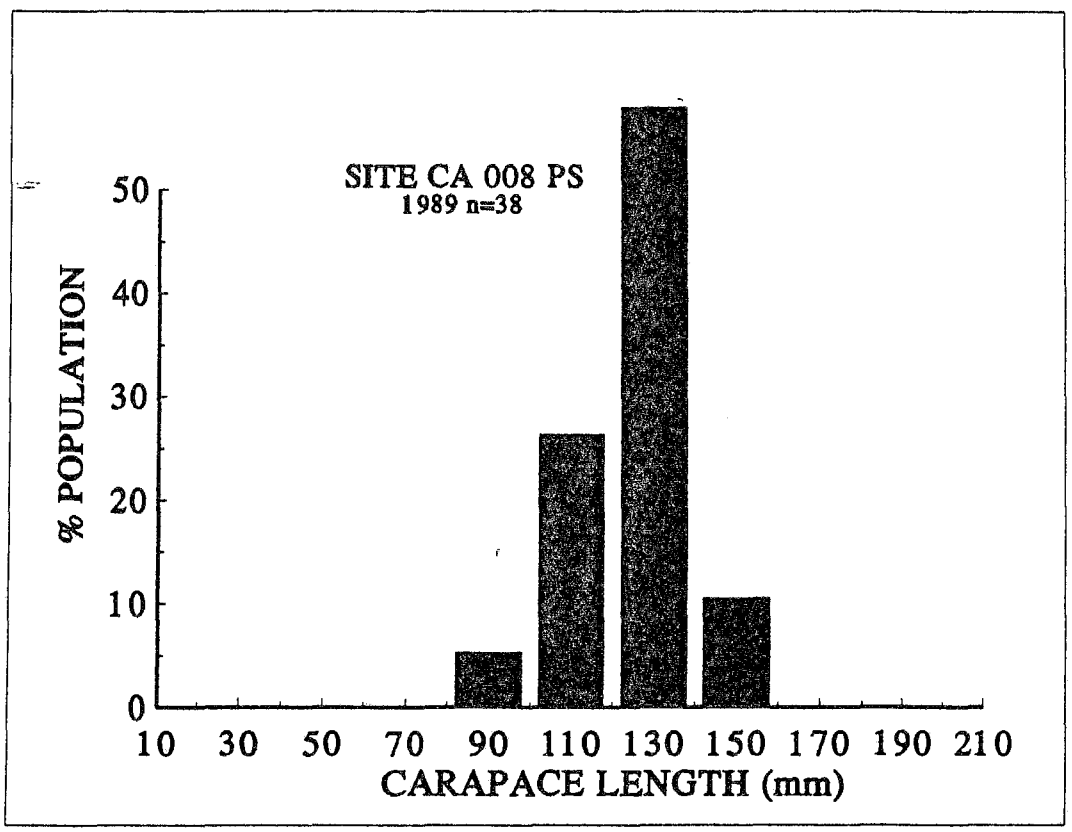
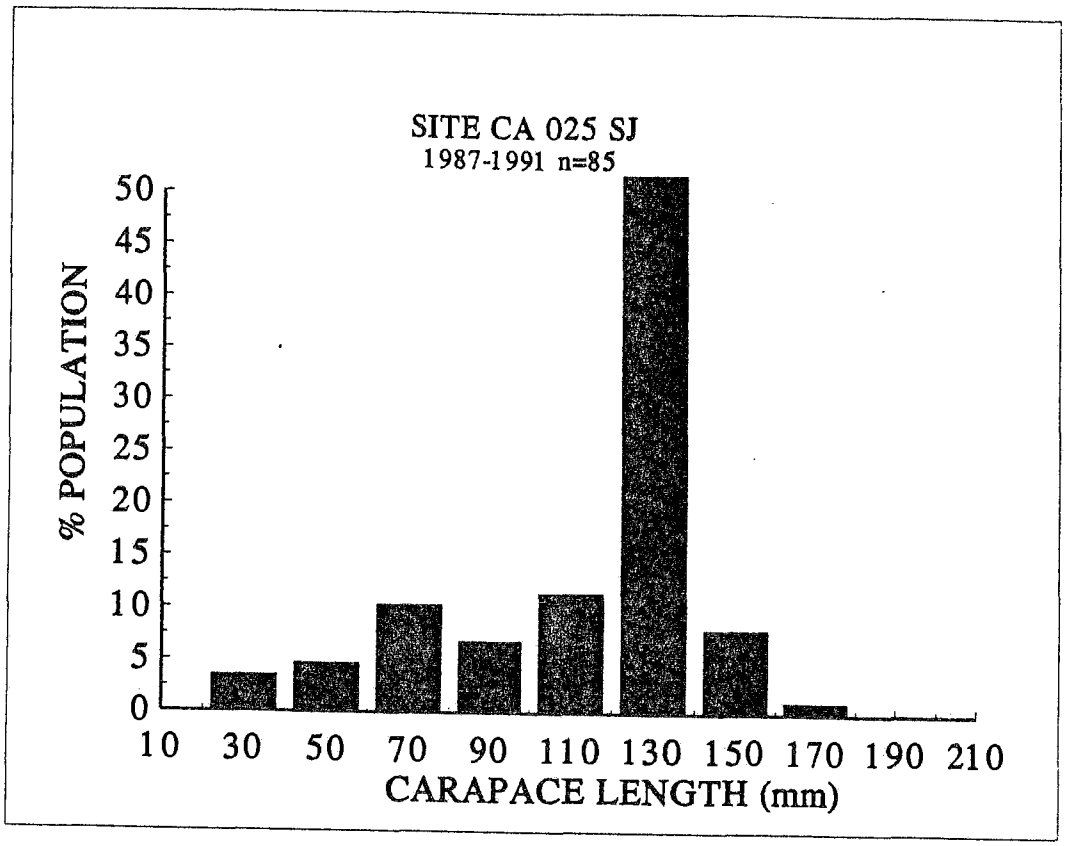


Fig. 36: Comparison of population structure of sites CA 007 PS and CA 008 PS.



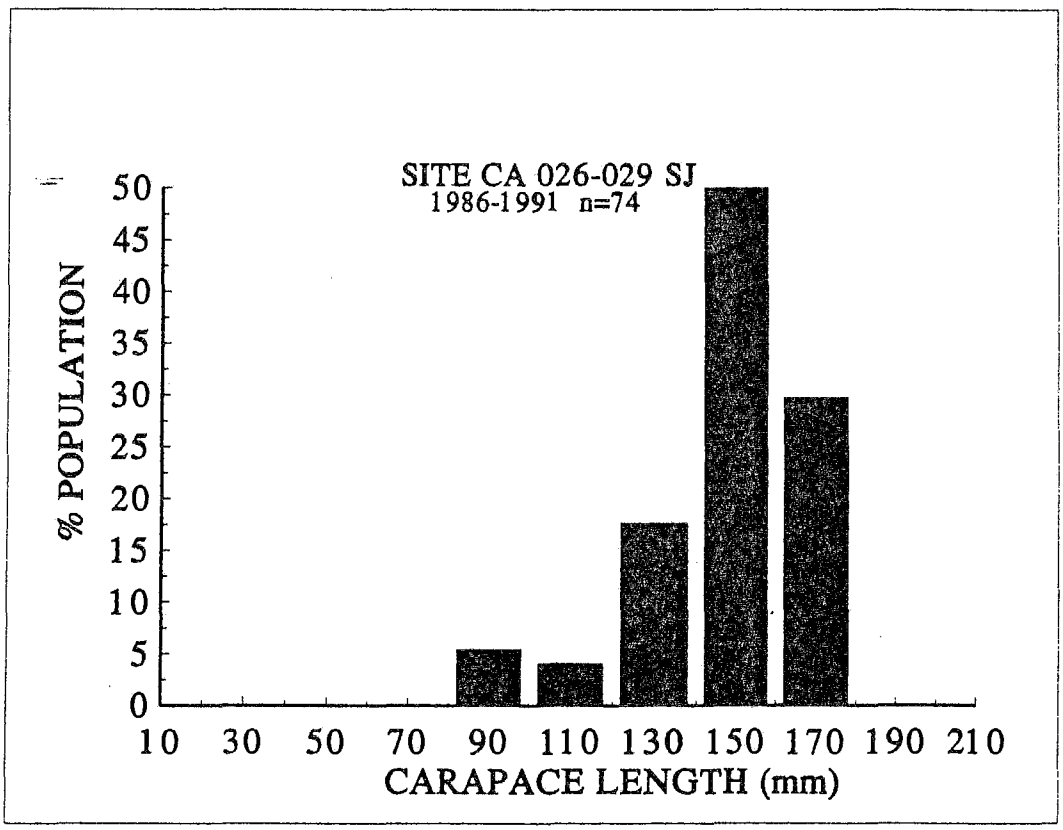


Fig. 37: Comparison of population structure of sites CA 025 SJ and CA 026-029 SJ.

Drought: A substantial portion of the west coast, and in particular southern and central California, have been suffering from the effects of an extended drought, beginning in 1986-87 and continuing through at least late 1991. This situation has had a major effect on WPT populations in many areas, but most significantly in southern and central California. Ongoing surveys of several WPT populations from 1987-1991 revealed a generally consistent pattern. Turtles in small to moderate-sized watercourses were moderately abundant until 1988 or even 1989. Progressive drying of the habitat resulted in - 1) concentration of large numbers of turtles in the few remaining pools 2) major increases in the distance between pools - up to 2 km + in some systems 3) exhaustion of the available prey base 4) increased exposure to predation and 5) an general increase in stress suffered by the turtle population. The result(s) of these conditions were major decreases in or outright extirpation of WPT populations in many areas. The number of turtle carcasses recovered in 1989-1990 was approximately 400% greater than recovered in 1987-88 in surveys of the same areas. Most of the intact (w/soft parts) carcasses showed no obvious signs of predation as a cause of death, but the majority had no visible body fat reserves and obvious signs of decrease in muscle mass upon dissection. These conditions are consistent with death induced by starvation. A summary of selected sites surveyed during the drought is provided in Table 3. A brief discussion of particular cases follows.

Site CA 008 PS (Fig. 38) was first sampled on 03 July 1988, and 46 turtles were captured in 3.0 h of search time. There was flowing water in an estimated 95% of the watercourse at that time, and abundant populations of native fishes and sunfish were present. The same area was sampled on 30 May 1989. Sixteen turtles were captured in 1.5 h of search time. There was flowing or standing water present in an estimated 50-60% of the length of the watercourse at that time, and fishes were still abundant. The area was sampled again on 01 September 1990. No turtles were observed or captured. There was no flowing water anywhere in the 3 km of watercourse surveyed, and the only standing water was a pool less than .8 square meters and less than 2 cm deep. Damp areas and the bottoms of former pools were excavated in the search for estivating turtles, but none were observed. The area was rechecked on 21 September 1991. There were no turtles observed or captured, and the bed of the watercourse was completely dry. There was no indication of the presence of standing water at any time in the past several months. It is likely that the turtles in this system have been effectively extirpated, due to the lack of downstream refugia and the very limited nature of the habitat some distance upstream.

Site CA 031 CC was first sampled in 1987 (Fig. 38). The area is a small rocky stream and there was flowing or standing water present along an estimated 80-85% of the area surveyed on 11 July 1987. Eighty-four turtles were captured in 4.5 h of search time. There were numerous native fishes (*Gila*) and introduced fishes (*Lepomis cyanellus* and *L. macrochirus*) present. The area was sampled again on 03 August 1988 and thirty-seven turtles were taken in 1 h of search time. There was little flowing water, but standing water was present in an esti-

TABLE 3: SELECTED SITES SURVEYED IN SOUTHERN AND CENTRAL CALIFORNIA

LOCALITY	YEARS SURVEYED	ESTIMATED % DECLINE 1987-1991
CA 009 SC	1987-1991	90+
CA 023 SC	1987-1991	66
CA 001 PS	1987-1990	85+
CA 003 PS	1987-1990	100
CA 031 CC	1987-1991	65+
CA 008 PS	1988-1991	100
CA 018 SJ	1987-1991	90+
CA 025 SJ	1987-1991	80+

Fig. 38: 5-year average capture success rate for Clemmys marmorata at selected sites in southern and central California

LOCALITY	X NUMBER OF TURTLES/HOUR & % INCREASE/DECREASE				
	1987	1988	1989	1990	1991
CA 009 SC	*	13 (-)	8 (-38)	9 (+12)	0 (-100)
CA 023 SC	16 (-)	32 (+100)	20 (-36)	59 (+280)	10 (-83)
CA 031 CC	19 (-)	37 (+100)	18 (-50)	60 (+333)	16 (-74)
CA 001 PS	82 (-)	165 (+100)	109 (-29)	34 (-68)	*
CA 008 PS	*	31 (-)	11 (-62)	0 (-100)	0 (-100)
CA 018 SJ	*	19 (-)	8 (-65)	2 (-75)	0 (-100)
CA 025 SJ	15 (-)	18 (+23)	18 (-1)	11 (-40)	4 (-63)

* = Site not surveyed

mated 35-40% of the stream channel. Fish were still moderately abundant, but beginning to be concentrated in the deeper pools. The area was surveyed again on 03 and 04 July 1989. Twenty-six turtles were taken in 1.5 h of search. There was standing water in less than 5% of the creek bed. Fishes were still present, but in reduced numbers and only in pools. The site was sampled again on 08 August 1990. Ninety-two turtles were captured in 1.5 h of search. Standing water in the creek was reduced to three small pools, with a total surface area of less than 30 square meters. There were no living fish observed in any of the pools, and there was also a suprising absence of any macroscopic invertebrates. Notonectids, an almost ubiquitous inhabitant of these types of stream systems, were not observed, although some turtles did defecate out remnants of these arthropods. Notonectids are capable of producing a powerful sting and are generally avoided by turtles; only one example was found in over 500 stomach flushings of WPTs on the central California coast (Holland, 1985a) despite the fact that they were a common species in the area. Evidence of feeding on notonectids is probably reflective of an overall increase in stress and lack of other suitable prey items. Two turtles carcasses in an early stage of decay were recovered at this time, and several of the turtles captured were effectively moribund. All turtles captured were noticeably lighter than the average for animals of their size, and no visible evidence of fat reserves in the inguinal or axillary pockets was noted. Four of the turtles died in the 2 h prior to processing, a situation that had not previously occurred in processing 3500+ animals. Several turtles exhibited exuviation of lamina, previously only noted in starved captive animals. Several animals were also observed to display "crumbling" of the shell when handled; it was apparent that the connective tissue between sutures had been severely weakened. When returned to the water, some animals were able to make only feeble swimming movements. This site was sampled again on 04 September 1991. Thirty-two turtles were taken in 2.0 h of search time. Only nine of these were recaptures from previous years. There were no animals taken that correspond to the 1, 2, or 3-year old age classes, nor were any animals seen in this age group. Water was present in approximately 5-7% of the stream channel, and fishes and inveretebrates were present in moderate numbers. It is likely that this population has suffered an approximate 60-65% decline. Given the small average body size and limited fecundity of animals in this and similar areas, it will probably take decades for the population to recover. Similar if not greater declines have also been noted in two garter snake species in this area (S. Sweet, pers. comm.).

Site CA 001 PS is a rather unique pond environment in the Pajaro-Salinas drainage in south-central California. This site contained the highest recorded density of turtles anywhere in north America (Holland, unpubl. data) - an estimated 3700 animals/ha of water surface. The inital sampling of this site was made on 03 July 1987 and 164 turtles were taken in 2.0 h. Large numbers of turtles were still visible in the pond after the capture effort ceased. The site was sampled again on 04 August 1988 and 165 turtles were taken in 1 h of sampling. As previously, large numbers of turtles were observed in the pond after capture efforts had ceased. The area was sampled again on 29 June 1989 and 218 turtles were captured. An exact count

revealed that at least 44 turtles remained in the pond after the termination of capture efforts. The pond remained relatively constant in size from 1987-1989, decreasing by approximately 10%. The pond was sampled again on 18 July 1990 and 34 turtles were taken. This probably represented all turtles in the pond; no turtles were observed after termination of capture efforts and extensive probing of the bottom. Surveys of the surrounding habitat revealed no carcasses. The size of the pond had decreased by approximately 30-40%. The concentration of salts in the water in 1990 produced a layer of deposits several mm thick and weighing several grams on the shells of turtles in this population. No sampling effort was made at this site in 1991, but a casual survey (S. Sweet, pers. comm.) revealed the presence of at least 5-6 turtles. Mark and recapture estimates and direct counts indicate a total population size at this site of approximately 300+ animals from 1987-1989. By 1990 the population had declined approximately 88%, and may have suffered further declines in 1991 (Fig. 38). It is unlikely that turtles merely emigrated to another watercourse; all adjacent watercourses were dry and the nearest was approximately 8 km away.

Site CA 023 SC was also affected by the drought. This site is a stream habitat in montane coastal southern California. The site was first sampled on 19 June and again on 21 June 1987. Fifty-five turtles were taken in 2.5 h of survey on 19 June and 40 turtles taken in the same time period on 21 June. There was flowing or standing water in approximately 60-70% of the stream bed at that time. The area was sampled again on 26 July 1988. Sixty-eight turtles were taken in 2.0 h of search time. Although there was little flowing water, standing water was present in approximately 20% of the stream bed. On 27 June 1989 the area was sampled again and 32 turtles were taken in 1.5 h of search time. There was standing water in less than 10% of the stream bed at the time of the survey. The area was sampled again on 03 August 1990. Fifty-nine turtles were taken in 1.0 h of search time. All animals were concentrated in a single pool approximately 20 m x 4 m x 0.8 m which was the only standing water in 3.2 km of stream bed. All animals were emaciated, well below normal weight and several were moribund. Observations from 1-2 weeks later at this site (S. Buck, pers. comm.) indicated that several turtle carcasses were observed in and around the pool. This area was sampled again on 22 May 1991. Twenty turtles were taken in 2.0 h of search time. None of these animals were less than 70 mm carapace length. There was flowing water in 100% of the streamcourse at this time, due in large part to the effects of "Miracle March" when unseasonal heavy rains occurred in the area. The result of this occurrence was an exponential rise in flow rates in all watercourses in the area. Surface water flow in Site 023 ran to the Pacific Ocean for the first time in several years. Unfortunately, the flows were essentially scouring in nature and may have eliminated a significant percentage of the turtle population in this system, as the turtles are typically becoming active at the approximate time of the flooding. The overall decrease in the turtle population in this system approximated 66% (Fig. 38).

Evidence of the impact of the drought was also noted in the Sierra

Nevada. Site CA 025 SJ is a moderate-sized rocky stream in the southern Sierra Nevada and was first sampled on 02 June 1987, and 19 turtles were taken in 1.25 h of search time. There was standing or flowing water in 100% of the stream bed at this time. The site was sampled again on 09 July 1988 and 28 turtles were taken in 1.5 h of survey. There were small stretches of flowing water, and there was standing water in approximately 30-40% of the stream bed. The area was sampled again on 06 June 1989 and 37 turtles were taken in 2.0 h of survey. There was no flowing water at this time, and standing water occurred primarily in small pools in approximately 8-10% of the stream bed. The area was again sampled on 23 July 1990. Twenty-two turtles were taken in 2.0 h of search time. Standing water was reduced to three small pools totalling less than 100 square meters. All animals noted were emaciated, but not to the degree noted in other areas. The area was sampled again on 13 September 1991 (Fig. 38). Twelve turtles were taken in 3.0 h of search time. All were mature adults, although one small (40+ mm) animal was observed but not captured. The lack of small animals may not be due entirely to the drought; moderate numbers of large bullfrogs were noted here for the first time in 1991. There was standing or flowing water in approximately 25-30% of the area surveyed. This population is estimated to have declined 75-80% since 1987.

A similar situation was noted at another system in the Sierra Nevada. Site CA 018 SJ is a moderate-sized rocky creek draining into a large reservoir, and was initially sampled on 14 July 1988. Twenty-four turtles were taken in 2.0 h of survey. There was standing or flowing water in 100% of the creek. Native fishes (Ptychocheilus lucius), introduced fishes (Lepomis cyanellus, Micropterus dolomieui, Ictalurus punctatus) and bullfrogs were abundant. The area was sampled on 07 June 1989, and 20 turtles were taken in 2.5 h of search time. There were small stretches of flowing water present, but only about 35-40% of the creek held water. The site was sampled again on 31 August 1990 and 4 turtles were taken in 2.0 h of search time. Two additional animals were observed but not captured. One small animal had swallowed a fish hook. Standing water was present only in a series of isolated pools several hundred meters apart, and covered approximately 5% of the stream course. The area was sampled again on 28 September 1991 and no turtles were taken or observed. There was standing water in approximately 15% of the stream bed at this time. Although a few turtles may remain at this locality, there is little doubt that the population has suffered a significant decline. Based upon mark and recapture and visual survey estimates, the population in 1988 probably numbered from 50-70 animals. Assuming that 5-6 animals remained in 1991, this population has suffered an approximate 90% decline (Fig. 38).

Intermittent observations of other stream courses in the Coast ranges, Transverse ranges and Sierra Nevada indicate that this general pattern of decline is widespread. Some effects of drought on turtle populations have been previously noted. Others may be equally important. One consistent situation appears to be a decrease in the relative frequency of juveniles in the population(s). Although this has been noted in areas where no bullfrogs are present (such as some

areas of the central coast) (see previous discussion), bullfrogs undoubtedly exacerbate many problems produced by the drought. The possible mechanisms for this decline may involve 1) interference with normal reproductive activity through lack of adequate body fat reserves to support development of eggs and embryos 2) alteration of nest site characteristics, possibly through compaction of the soil 3) failure of spring rains to soften the vegetative /soil "plug" in the neck of the nest, which would allow escape of hatchlings 4) elimination of hatchling microhabitat by lowering of water levels and/or 5) increased susceptibility to predation by lowering of water levels. Definitive evidence is lacking to identify any one of these factors as primary, but observations during 1986-1991 indicated a significant decrease in hatchling microhabitat in many areas.

Additional long-term effects of the drought may be very serious. Fragmentation of populations and reductions in population size of the magnitudes observed will require decades to recover in some cases. In other cases, recovery may not be possible without human intervention. Several cases of reduction below the presumed critical minimum population size have been observed; it may be largely a matter of chance whether these populations are able to recover. Although some areas gained a temporary respite due to "Miracle March", persistence of the drought for a sixth or seventh year will probably doom many marginally viable populations. The drought has also favored the spread of exotic species (especially bullfrogs) through alteration of thermal environments into areas where they previously did not occur or occurred in low numbers. Increased water diversion efforts and long-term planning for construction of additional dams and reservoirs (such as Los Banos Grandes) facilitated by the drought will probably significantly reduce already diminished/ impacted turtle populations.

Commercial Exploitation: Commercial exploitation of WPTs as a food resource has existed since at least the 1870's, when Lockington (1879) noted the commercial harvest of turtles and red-legged frogs for the San Francisco market. Commercial harvest at that time had already depleted populations in San Francisco and adjacent areas, and hunters were moving far afield to areas such as the southern part of the San Joaquin Valley to supply the demand. Extensive harvests occurred on Tulare Lake in the 1870's-1880's; the thirty-two foot schooner Water Witch was used to support seining efforts from 1878-1882. Elliot (1883a) and Brown (1940) noted that as many as eighty to ninety turtles might be taken in a 100-200 yard haul of the seine. Available data (Elliot, 1883a) indicated that at least one operation collected at least 2160 turtles (180 dozen) in one season. Other information (M. Jennings, pers. comm.) indicates that the total harvest figures were enormously higher than this. True (1884) noted that in the eighteen-eighties the species was "still almost constantly for sale in the markets of San Francisco". Smith (1895) noted that approximately "1500 dozen" WPTs (18,000) were offered for sale in San Francisco markets, presumably during one year in the 1890's. This practice continued at least through the 1920's. Incidental records published by the California Department of Fish and Game from 1911-1928 noted that moderate numbers of "terrapins" were

harvested from many regions of the state during this period, with the reported maximum being 2160 during October-December 1919. Maintenance of harvest figures for "terrapins" was not required (M. Jennings, pers. comm.); as such the reported catch may be considerably lower than the actual catch. Storer (1930) noted that the commercial harvest continued in the Whitesbridge slough area (Fresno County) until at least the 1920's, with prices from $3-$6/dozen. The trade was fairly widespread; H. Warren (pers. comm.) noted that turtles were collected along the central coast of California in the 1920's and 30's by draining ponds and vernal pools. These turtles were then held in washtubs until a shipment could be sent to market. Although commercial traffic in WPTs is prohibited in all states where the species occurs, collection for food still exists (H. DeLisle, S. Sweet; pers. comm.), with numbers from 20-100+ being noted in a single instance.

As with any species, the amount of commercial harvest WPT populations can or could withstand depends on several factors, among them the initial size, structure and dynamics of the population, the nature and timing of the harvest and the presence and degree of other threats. In all these respects, WPTs are and were a species that was ill-suited to comercial harvest. The lengthy time to maturity, relatively low fecundity and survivorship, and adult-biased distribution in most populations would render them very susceptible to overharvest. Coupled with the nature and size of the harvest and other factors, such as the introduction of exotic predaceous fishes into many areas (Elliot, 1883a; Brown, 1940) and ongoing widespread habitat alteration (Harding, 1960; Preston 1981), the decline of WPT populations had begun by the 1870's at the latest. The continued commercial harvest no doubt effectively eliminated or severely decreased turtle populations in many areas. As such, commercial harvest of the species was an important factor in initiating declines in this species and continued to impact populations until at least the 1920s-30s. The extent of the current illegal commercial harvest is unknown; however in some areas (see above) it may be sufficiently large to jeopardize the viability of populations. For example, removal of 100+ animals from any stream in southern California would probably result in the eventual extirpation of that population.

Illegal Collection and other factors: A commercial market exists for WPTs. Casual examination of three animal dealers price lists in 1991 indicated that one dealer in Florida was offering six adult WPTs for $125 each. Conversations with the dealer as to the origin of these turtles by three different parties produced three different explanations, indicating that they were probably illegally collected. It is highly likely that poaching of WPTs already occurs on some steady but indeterminate level, and that as legal protection of the species increase the level of poaching will increase. Of particular concern in relation to this is the impending CITES listing of two of the eastern relatives of the WPT, the wood turtle (Clemmys inscuplta) and the bog turtle (*Clemmys muhlenburghi*). The listing of these two species may shift illegal collecting pressure to WPTs and to spotted turtles (*Clemmys guttata*). Although California has had a ban on the sale and/or exhibit of native reptiles and amphibians since at least

the early 1980's, occasional WPTs were noted for sale in pet stores in various locations in the state through at least 1985. Bury (1982) notes that during the 1970's, several hundred WPTs were removed from a single watercourse in southern California and sold in pet stores.

Another potential concern deals with the consequences of Federal listing under the Endangered Species Act. Unsolicited conversations with several persons while conducting field surveys in 1989-1991 produced numerous statements to the effect that if the turtle was listed, any seen on "their property" or even on adjacent federal or state lands would be shot forthwith. The number of animals found with bullet wounds, especially on public lands, indicates that this is not an idle threat, and may be a potentially serious problem. As previously noted (see Predation and Mortality) two teenagers with .22 caliber rifles killed a substantial portion of one population of WPTs under study in southern California (S. Sweet, pers. comm.). A similar situation has been noted in other areas (Milner, 1986).

One bizarre situation affecting a WPT population was noted in summer 1990 (L. Wold, pers. comm.). A helicopter used to extinguish "hot spots" in a fire in the Sierra National Forest was "dipping" with a bucket out of a pothole in a stream which contained large numbers of WPTs. Turtles were concentrated in this pool due to dry-down of the stream during the drought. Release of the contents of the bucket dropped the turtles onto the burning or smoldering remnants of the fire and resulted in mortality. The exact number of animals lost in this manner was not determined, but is thought to be substantial.

Pollution/Biocontaminants: A single study exists on the effect of biocontaminants on WPTs. Bury (1972b) observed mortality in WPTs in a stream in northern California due to a spill of diesel fuel. Although hard data is lacking, the presence of biocontaminants may play a significant role in regulation of populations through disease (see Disease). The long-life span and feeding habits of the species may well result in the accumulation of many non-metabolizable compounds such as heavy metals, PCBs and some biocides. In this respect, populations in certain areas, particularly the San Joaquin, Klamath and Willamette Valleys, should be closely monitored. Preliminary arrangements have been made with the U.S. Environmental Protection Agency to initiate a limited survey of blood contaminants, but a more extensive program is needed.

The massive herbicide spill in the upper Sacramento drainage in summer 1991 may have affected WPT populations therein, but hard data is lacking. No direct mortality has been noted (J. Brode, pers. comm.) but turtles may have merely left the watercourse when concentrations of the contaminant became intolerable. As most streams in the immediate area are not suitable as long-term turtle habitat, it is likely that the majority of animals displaced will either fall prey to predators or die of starvation. The effective sterilization of this section of the river will probably preclude successful re-establishment and maintenance of the WPT population therein for a number of years until succession re-establishes a suitable prey base.

Pollution of watercourses may directly or indirectly affect turtle populations therein. Direct effects would include mortality and forced displacement. Indirect effects would include contamination or alteration/elimination of the prey base, interference with normal behavioral, foraging or other activities, and/or a decrease in overall fitness through disease or other factors. Although hard evidence is lacking, the disappearance of WPTs from some river systems in the Willamette drainage (such as the Tualatin and the Clackamas) may be linked to extensive pollution of these watercourses during the late 1950's-1960's.

Oil or other chemical spills into fresh-water environments also have the potential to affect WPT populations. At least two major spills occurred in the immediate vicinity of drainages containing WPT populations in 1991 (pers. obs.). Many turtle habitats are bisected by major traffic arteries such as U.S. Hwy. 1. Given the amount and nature of traffic on these systems, it is inevitable that a spill will occur which will threaten some of these populations. In southern California, only a single population is currently probably safe from this threat. Given the nature and cost of clean-up efforts ansd the long-term effects of such spills, it is likely that any such event might lead to the effective extirpation of a population of WPTs in a watercourse so affected.

Disease: The role of disease in regulation of wild reptile populations is poorly known. Existing information indicates that it may be a significant source of mortality in turtle populations (K. Dodd, pers. comm.). This situation has recently been observed in a population of western pond turtles in Washington, one of only two in the state. During an intensive study of the structure and reproductive ecology of this population (Holland, 1991a), dead and moribund turtles were observed beginning in June 1990. By late June it was obvious that a significant portion of the population displayed symptoms similar to those exhibited by desert tortoises (*Gopherus agassizi*) afflicted with URD (Upper Respiratory Disease) syndrome. An intensive effort was initiated to capture, remove from the wild and treat as many turtles as possible. This effort was conducted co-operatively by the Washington Department of Wildlife, the Woodland Park Zoo and the Center for Wildlife Conservation. In spite of extraordinary efforts by zoo and consulting veterinarians, over 50% of the animals captured and treated died. A total of 38 known cases of mortality were documented in 1990-early 1991, and at least two additional treated animals died or were killed by predators after re-release in summer 1991. This minimum estimate of known mortality represented approximately 42-47% of the population estimated to be present at the beginning of 1990 (approximately 85-95 animals; see Holland, 1991b for further details).

The agent and mechanism responsible for this epidemic are not known with certainty. The agent is at this point assumed to be a mycoplasm or virus, and possibly facilitates secondary bacterial activity with a significant probability of mortality. There may be more tham one factor responsible for inducing the activity of the

primary agent. Possible causes include 1) the presence of biocontaminants, particularly heavy metals or organochloride pesticides, which are known to compromise immune systems 2) environmental stress produced by biotic or abiotic factors 3) transmission of the agent to WPTs by WPTs or exotic species of turtles introduced into the system (at least two successful and one unsuccessful events of this nature were noted during the study) acting as vectors and/or 4) other factors. What is known is that the disease/condition is highly contagious and produces an extremely high rate of mortality. If the primary or secondary vector for this agent was an introduced turtle it emphasizes the potential danger of 1) release/escape of exotic species into western pond turtle habitat and/or 2) translocation/reintroduction of WPTs from outside areas, particularly if these turtles have been exposed to or held with exotic species.

The only potentially beneficial aspects of the epidemic in Washington were that 1) it occurred in a population that was both isolated from other populations and under study and 2) that it focused attention on disease as a possible mechanism of decline in WPT populations. There is no guarantee that this disease is restricted to the Washington locality; at least one other turtle from the Willamette drainage in Oregon when X-rayed in 1990 showed lesions on the lung similar to those observed in the Washington turtles (T. DeLorenzo, pers. comm.). Given the nature of the disease and the limited (essentially incidental) nature of monitoring of turtle populations, the occurrence of this situation within a drainage system where turtles are contiguously distributed is potentially catastrophic. Over $60,000 was spent by the agencies previously noted in the Washington epidemic to treat less than 40 turtles; cost of treatment for hundreds or thousands of animals would probably be prohibitive.

Off-Road Vehicles (ORVs): Off-Road Vehicle activity poses a significant localized threat to WPT populations. This threat may occur through direct or indirect impacts. Direct impacts include 1) crushing 2) shooting 3) deliberate or incidental collection and 4) destruction of nest sites. Indirect impacts include the overall effects of high levels of human and vehicular activity such as 1) interference with normal basking or foraging patterns 2) restriction or alteration of intrastream or overland movements and 3) interference with nesting movements. Long-term impacts typically associated with ORV activity such as increased erosion, compaction of soil and removal of vegetation, siltation of watercourses and alteration or elimination of refugia may also have serious consequences. WPT populations occur in many designated ORV areas in California such as Afton Canyon (San Bernardino County), Frank Raines (Stanislaus County), Clear Creek (San Benito County), and Hungry Valley (Los Angeles County), as well as in areas where extensive ORV use is allowed (such as National Forests). These populations tend to be small, disjunct and occur in very limited habitats. The nature of these populations, coupled with the very low probability of maintenance or re-establishment by immigration, renders them highly susceptible to extirpation. Additionally, ORV activity within National Forests (in particular Los Padres National Forest) poses a threat to WPT populations therein as well as other sensitive species including the Arroyo

Toad (Bufo microscaphus), the two-striped garter snake (Thamnophis hammondi), the California red-legged frog (Rana aurora draytoni) and the foothill yellow-legged frog (Rana boylei).

Roads/Traffic: Causal observations over the last ten years have shown that WPTs are often killed by traffic while crossing roads. Surveys in Oregon in 1991 (Holland, 1991c) noted 4 road-killed turtles in a six-week period. Three of these were gravid or post-partum females. During a study of this species on the central California coast from 1981-1985, (Holland, 1985a), approximately ten road-killed turtles were observed. Of these, only a single animal was a juvenile amd 6 were mature females. At least two of these animals were gravid at the time of death. Most of the live turtles recovered from roads have been gravid females (pers. obs.). In part, the heavily biased sex-ratio (Holland, 1985a) noted in many populations in this area may be exacerbated by traffic-induced mortality in females. In this area, a major roadway directly intersects almost all turtle habitats. In the only other long-term study of a population of this species Bury (1972a) notes a sex ratio that approximates 1:1. Interestingly, the majority of this site is located well away from roads. Other observations (Holland 1985a) note that turtles presumably "flushed" from hibernation sites by heavy winter rains may also move onto roads and be crushed, occasionally in significant numbers.

Roads appear to have a significant deleterious impact on WPT populations in several ways. First, as noted above, direct mortality results from crushing. Second, the presence of a road increases access to WPT habitat and facilitates deliberate or incidental collection, such as through creation of fishing access. Third, road construction may eliminate or modify nesting areas (see Reproduction and Nesting), which may have major consequences for the short and long-term viability of the population, particularly if female WPTs exhibit nest-site philopatry. Fourth, similar effects may occur through elimination or alteration of terrestrial overwintering sites. Fifth, runoff from roads, either surfaced or unsurfaced may alter the biotic environment of adjacent watercourses to the detriment of turtle populations. Unfortunately, roads, like watercourses, tend to follow the path of least resistance. This maximizes exposure of WPT populations to the factors noted above. Construction of new roads in areas where WPTs occur should be avoided whenever possible, and where not possible designed to minimize the problems noted above.

An interesting and potentially serious problem in relation to the effect(s) of traffic on WPT populations was first noted in Oregon in 1991. M. Dahlgreen (pers. comm.) noted the presence of WPT carcasses between railroad tracks adjacent to a creek which contains a small population of WPTs. There were no obvious signs of physical injury or predation. It is possible that the tracks acted as an effective "drift fence", with spaces under the rails and between the ties restricting both ingress and egress. It is possible that turtles engaged in overland movements might be able

to move into the area between the tracks and then be unable to find a way out. This site was visited in August 1991. Observations indicate that the size and shape of the tracks would probably preclude escape over the track. If movements of turtles to and from nesting or hibernation sites are stereotyped, then the presence of railroad tracks in a given area may be a significant source of mortality.

Other forms of traffic that may have a sigificant impact on WPT populations include boating activity. The WPT is normally an extremely wary species, and will usually depart basking sites as soon as a disturbance is detected. Observations in Oregon in 1991 (Holland, 1991c) indicate that high levels of boat/raft traffic in areas such as the Rogue River may potentially alter thermoregulatory patterns and behavior, and possibly the distribution of certain types of microhabitat, particularly that utilized by hatchlings and juveniles. Turtles that become acclimated to the presence of boat or vehicular traffic may run an increased risk of mortality through shooting. Incidental observations during a study in Washington in 1990 (Holland, 1991a) indicate that flight distances of turtles in watercourses in view of low-moderate levels of vehicular traffic often are significantly less than turtles in undisturbed areas.

Although not traffic per se, there is some evidence that farm vehicles may impact turtle populations. Observations in the Klamath Valley indicate that turtles are frequently crushed by harvesting/reaping machinery in the fields and pastures adjacent to the Klamath and Lost Rivers. The timing of these events suggests that the majority of thee animals may be nesting females. Additionally, nests may be destroyed by collapse of the nest chamber or by plowing.

Translocation/Relocation: In recent years, there have been at least minimal attempts to mitigate for impacts to WPT populations caused by construction activities in turtle habitat(s). A popular strategy appears to be to temporarily "relocate" turtles from disturbed areas/construction sites to adjacent areas assumed to be suitable habitat, and then return the animals at some point in the future when the habitat is assumed to be "recovered" to a point capable of supporting the reintroduced population(s). At least three projects of this nature were initiated in southern California between 1985 and 1991 (L. Hunt, M. Jennings, K. Mosier; pers. comm.). For a variety of reasons this may not be an adviseable strategy as mitigation for damage to turtle habitats or impacts on populations. Existing projects are not conducted in a manner that allows for rigorous determination of pre- and post-site characteristics relevant to maintenance of turtle populations. Among the information necessary to evaluate the effectiveness and advisability of these efforts are 1) determination of pre- and post-construction prey base composition 2) determination of the effects of translocation on nesting behavior and nest site location 3) determination of relative rates of survival among translocated and "control" animals 4) determination of time frames involved in recovery of habitat and potential losses of recruitment and 5) examination of potential homing behavior. As increasing alteration of WPT habitat occurs throughout the range of the species, the temptation to engage in "quick and dirty" projects such as relocation/transloca-

tion that allegedly mitigate for negative impacts should be deferred until the effectiveness of these efforts can be rigorously assessed.

Introduced turtles: Several species of exotic aquatic turtles have been recorded within the range of the western pond turtle. For example, in California (Jennings, 1987) the following taxa have been noted in a variety of sites: Western painted turtle (Chrysemys picta), red-eared slider (Trachemys scripta elegans), common snapping turtle (Chelydra serpentina) and spiny soft-shelled turtle (Apalone spinifera). Other species also noted include alligator snapping turtle (Macroclemys temmincki), stinkpot (Sternotherus odoratus), diamondback terrapin (Malaclemys terrapin), and the Mississippi map turtle (Graptemys kohni). Records from Oregon (T. Delorenzo, pers. comm.) indicate that red-eared sliders and snapping turtles are commonly found in Portland and adjacent areas. Surveys throughout the state (Holland, 1991c) noted red-eared sliders in all major drainages except the Rogue. Milner (1986) notes the occurrence of red-eared sliders in the Puget Sound area. The majority if not all of these animals represent turtles imported for the pet or food trade, which were subsequently released or escaped. In addition to being highly destructive of turtle populations in the areas where these species are "harvested", their accidental or deliberate release into WPT habitats may pose a significant threat, particularly to WPTs and possibly western painted turtles as well. Turtles in the pet trade are often maintained under extremely crowded and unsanitary conditions, creating optimum opportunities for the establishment and spread of infectious disease(s). Due to the nature of turtle physiology and the general ignorance of people buying turtles as pets, sick or diseased turtles may not show obvious symptoms for some time after purchase. The relatively low initial cost of purchase (red-eared sliders were selling for as low as $9.95 in Oregon in the summer of 1991) and high cost of veterinary care may preclude treatment of sick turtles. Alternately, turtles bought as pets for children may be treated as "disposable" and released into the nearest watercourse. The potential for transmission of disease(s) to WPT populations through this avenue should not be underestimated (see Disease); if incidental observations (Holland, unpubl. data) are any reliable indication of the scope of this problem then a minimum of several dozen exotic turtles a year escape or are released into WPT habitat. Given that WPTs essentially evolved in isolation from most other turtle species throughout the majority of their range, it is likely that WPTs have evolved little resistance to pathogens present in multi-species turtle communities. The introduction of a novel pathogen might well have disastrous consequences for WPT populations.

Interestingly, there are existing regulatory mechanisms which if enforced would significantly restrict if not eliminate the trade in exotic turtles (Code of Federal Regulations, Public Health Service, sections 71.52 and 1240.62). Strict enforcement of provisions of the Lacey Act would also severely limit the interstate shipment of illegally taken native turtles.

Introduced non-predaceous species: Western pond turtles coexist with a wide variety of exotic species in the aquatic habitats within their

range. A number of these species may pose threats to WPT populations in several ways. The species of primary concern in this respect are carp (Cyprinus carpio and Carassius auratus), sunfish (Lepomis spp. and Pomoxis spp.) and crayfish (Cambarus, Procambarus and Pacifasticus). Carp modify the aquatic habitat by consuming both emergent and floating vegetation. Observations in Oregon and California during 1987-1991 indicate that carp may have a significant impact on WPT hatchling microhabitat, cropping or even eliminating vegetation in shallow-water areas. The description of an oxbow lake in Oregon (Wilhemi, 1964) prior to the advent of carp in this system noted abundant emergent and floating vegetation. Surveys of this lake in 1987 and 1991 noted essentially no emergent vegetation, and cropping of some shoreline terrestrial vegetation within the reach of the fish. By removing vegetation carp not only eliminate microhabitat required for hatchlings, they may also affect the prey base utilized by turtles. Furthermore, increases in turbidity produced by the foraging activities of carp may affect foraging success by turtles, who depend primarily on vision to locate prey items.

Sunfish occur in large numbers in habitats occupied by WPTs. Seining of one pond (OR 001 C) in 1991 produced over 300 kg (total) of two species of sunfish. The occurrence of these exotics in these numbers may pose a threat to turtle populations, particularly in systems that did not historically hold fishes that may have served as competitors (e.g. some streams in southern California, vernal pool habitats). The concern is that exotic fishes may depress recruitment or survivorship in certain habitats through modification or depletion of the invertebrate prey base. Although hard data is lacking to support this contention in respect to turtles, it should remain a matter of concern. Under drought conditions, exotic fishes and turtles may be concentrated in a few restricted microenvironments and competition for the available prey base may ensue. This may stress turtles, particularly small animals, to the point where it affects the probability of overwinter survival. Interestingly, several areas that lack fishes (either native or introduced) also hold the densest known WPT populations, ranging from 1500-3700 turtles/ha.

Crayfish of several genera have been introduced into a wide area of the west coast. These animals occur in tremendous densities and numbers in some areas, and may function as either predators (see Predation) or competitors for WPTs. The scavenging feeding habits of crayfish are in some ways similar to those of WPTs, and the two may under a variety of circumstances compete for both the invertebrate prey base and available carrion. Predation on introduced crayfish by WPTs is known from at least two sites in California. However, it is apparent that turtles do not play a significant role in regulating crayfish populations in at least one of these sites.

Fire: Fires threaten WPT populations in at least three ways. First, unseasonal fires may kill overwintering animals, either hatchlings in the nest or other turtles. In particular, chaparral fires in southern and central California in areas where the normal fire cycle has been suppressed often effectively sterilize the soil several cm deep due

to the buildup of combustible materials and the intensity of the fire that will eventually occur. The Sespe Creek fire in fall 1991 probably killed any hibernating turtles or hatchlings in the majority of the area burned (S. Sweet, pers. comm.). Second, although some erosional loss is normal in such situations, exceptional runoff may produce rapid siltation of the watercourse and alteration of the prey base, elimination or alteration of refugia and/or increased susceptibility to predation, thus decreasing the suitability of the area as turtle habitat. Third, the occurrence of fires in urban and some rural areas serves as an excuse to engage in extensive and immediate "flood control" efforts, which usually results in channelization of the watercourses in the area and dramatic alteration or elimination of WPT habitat. This situation occurred in the Santa Barbara fire of 1990 and will likely reoccur in other areas. Additionally, the loss of turtles through fire-fighting activities (see illegal collection and other factors) although hopefully an isolated incident, may be locally significant.

CURRENT STATUS: The western pond turtle is in a general state of decline in an estimated 75-80% of its range. Some of the reasons for this situation have been noted above. Historically, the species probably occurred in most watercourses and aquatic habitats below 1371 m in the majority of the range from the Klamath River drainage south, and in many locations below 1066 m in the Rogue and Umpqua River drainages. Most known sites in the Columbia and Willamette River drainages are below 700 m, and all known Puget Sound locations are below 500 m. Museum specimens and/or reliable sight records exist for several hundred localities (Appendix A, Figs. 39-40), and the majority of these localities may still hold pond turtles. In assessing the historical and current status of the WPT, there are several important points to consider.

1. Current and recent surveys (pers. obs.) indicate that large areas of presumably suitable habitat exist that should hold pond turtles but do not. For example, extensive visual and diving surveys in watercourses conducted by the author in 1986-1991 indicated that turtle populations are remarkably scarce in many areas (see below for specifics); several hours of searching were often necessary to find even small groups of animals along major river systems such as the Willamette, the San Joaquin, the Salinas and the Sacramento. As such, and given a lack of a detailed accounting of the actual area occupied historically by WPTs, all estimates of percentage loss of habitats and decreases in population size should be considered <u>minimum</u> values.

2. Turtles, due to their large size and ungainly shape may be deliberately under-represented in museum collections due to difficulties involved in preservation, transportation and storage. Additionally, examination of a number of museum collections (see Appendix A) indicates that the majority of all WPTs in these collections were collected after 1930, when many populations had already undergone serious declines or were already extirpated. For example, no specimens exist from Tulare Lake, and yet turtles were commercially harvested in tremendous numbers

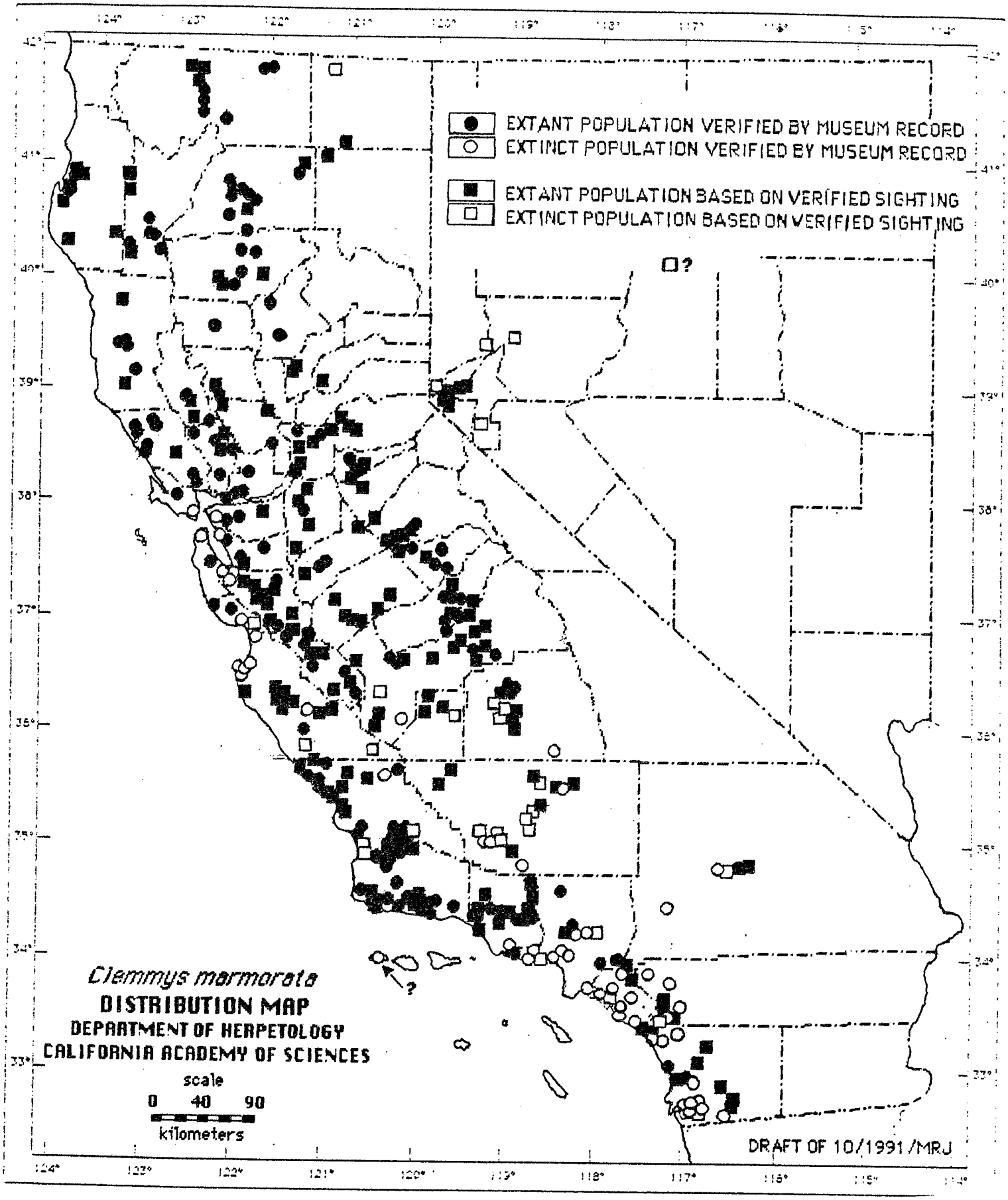


Fig. 39: Known localities for the western pond turtle in California and Nevada based on museum and verified sight records. Extant populations are where at least one animal has been sighted in the last 5 years. Map template prepared by M.R. Jennings and locality status by D.C. Holland. Any errors are the sole responsibility of D.C. Holland.

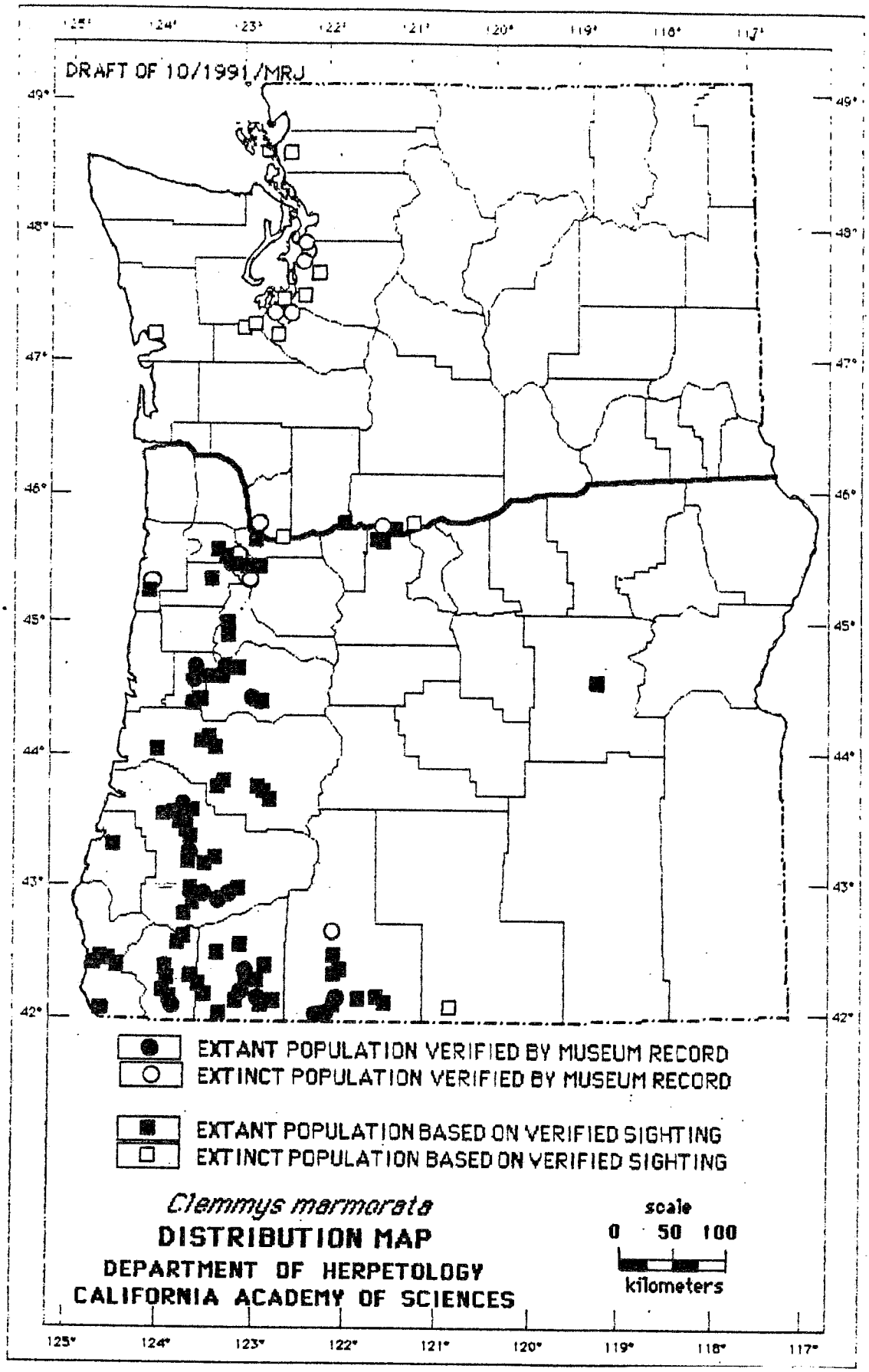


Fig. 40: Known localities for the western pond turtle in Oregon and Washington based on museum and verified sight records. Extant populations are where at least one animal has been sighted in the last 5 years. Map template by M.R. Jennings and locality status by D.C. Holland. Any errors are the sole responsibility of D.C. Holland.

from this site in the 1870's-1880's.

3. As noted both above and below, many of the localities which still hold turtles may not in fact represent viable populations; but are rather groups of old individuals in which no effective recruitment occurs or even single animals that persist in an area for many years. Given the long life of this species and its ability to persist in degraded habitats, turtles may be present in some numbers in an area for 25-30 years after the population has been effectively extirpated due to declines in or failure of recruitment.

4. The evaluation of the current status of the WPT is based primarily upon the author's research from 1976 to the present. From 1976-1986 the total number of surveys made on this species exceeded 150. Although the majority of these surveys (100+) were made at only 4 sites, over 40 additional sites were surveyed. From 1986 to the present I have conducted over 700 surveys on 250+ sites throughout the range of the species. As such, assessment of numbers, population structure and relative status of these populations does not suffer from the potential problem of inter-observer variability. Approximately 80% of these surveys included sampling efforts by diving; the survey technique most likely to accurately reflect the actual structure and status of a population.

Localized Extirpation: Western pond turtles have been completely or effectively extirpated from an estimated 7-10% of their original range (Fig. 41). Complete extirpation is defined as the complete lack of any recent sitings of undoubtedly native turtles in a given area. By this criterion, turtles are absent from the Puget Sound area (Milner, 1986); the greater metropolitan areas of San Diego and Los Angeles, and the majority of the Columbia River. Effective extirpation means that recent surveys indicate that there are no viable populations of turtles known within a given area. Viability by the criterion of Brattstrom and Messer (1988) means that at least thirty turtles were observed at a given site. Preliminary analysis of life-history data and survivorship (Holland, unpubl. data) indicates that this number is a realistic estimate only if several unlikley assumptions are satisfied. A preliminary estimate of the minimum viable population size for WPT populations in southern and central California under undisturbed conditions is 40+ animals, with at least 20 of these being reproductively active adults. Given variation in time to maturity and other factors, this is a minimally conservative estimate; the actual number may be much higher. By this criterion, conservatively no known viable populations of the WPT exist in coastal northern Baja California, the western and possibly all of the Mojave River, numerous areas adjacent to the greater San Diego, Los Angeles and San Francisco metropolitan areas, the southern end of the San Joaquin Valley from at least the San Joaquin River south, the Truckee and Carson Rivers in Nevada, the general area of Tule Lake National Wildlife Refuge, and probably most of the drainage area of the Willamette River (see specifics below). There is no doubt that turtles still exist in at least some of the areas noted above; however extensive surveys indicate that these

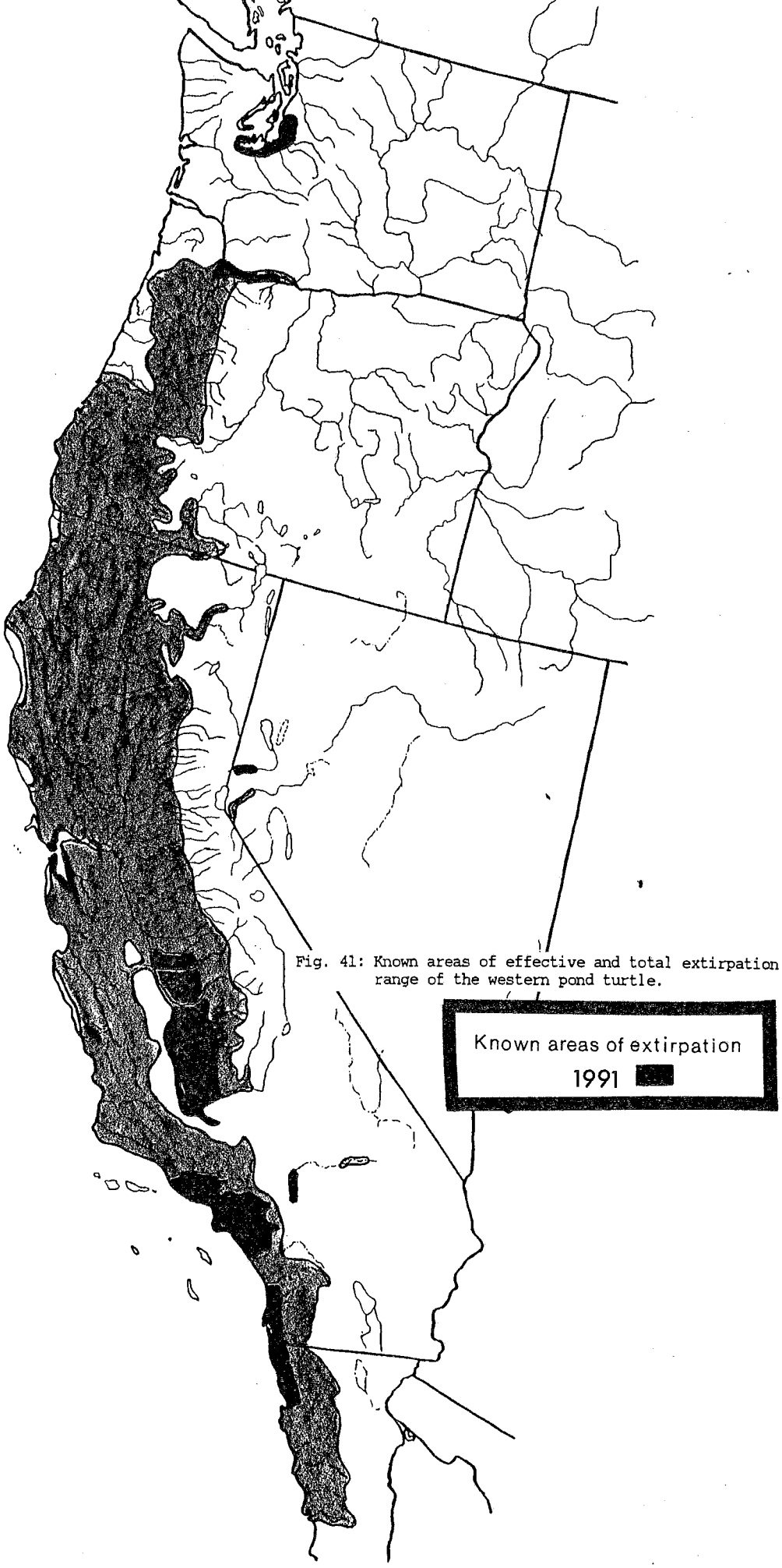


Fig. 41: Known areas of effective and total extirpation within the range of the western pond turtle.

occurrences do not constitute viable populations. The effective area of extirpation may actually be more extensive than noted above; it is only these areas in which it is reasonably well documented. A specific area-by-area analysis follows.

Canada: No known populations of this species exist today in Canada, and it is likely that previous records represent accidental releases (see range).

Baja California Norte: Turtles were historically known from at least 11 localities in this state. Surveys conducted by the author in 1987 and 1988 indicated that WPTs were no longer present in at least 6 of these localities. All of the latter localities were suffering from various degrees of habitat modification and exotic species (primarily sunfish, catfish and crayfish) were present in most of the watercourses surveyed. A single moderate-sized population (estimated at 50-70 animals) was noted in a remote montane locality and a smaller (est. 30-40 animals) population was noted at another site. These were the only two areas in which turtles were observed; over 20 sites were checked. The extreme isolation and small size of the existing populations, coupled with patterns of land use and the effects of the drought (see above) make it likely that should any of the existing populations be extirpated, they will not become re-established without human intervention.

Nevada: The status of the WPT in Nevada is an interesting situation. The possibility exists that the species was introduced into the state as a food item in the late 1880's (Cary, 1887). This possibility was noted by LaRivers (1942), but disputed by Banta (1963), based upon a variety of evidence including a note on the presence of turtles in the "valley of the Carson" by Cooper (1860). Subfossil remains of this species radiocarbon-dated at 3700 y BP have been recovered from aboriginal midden sites at Falcon Hill, Winnemucca Lake (Hattori, 1988), which is well outside the current range of the species in the state. However, it is possible that these artifacts (which have been reworked into adornments) represent items carried across a trans-Sierran trade route. Examination of the fragmentary remains (Holland, unpubl. data) did not yield enough data for comparison with the existing morphometric data base using discriminant analysis, however data from 20 live specimens collected during 1987-1988 indicated that they were not morphologically distinguishable from animals in the Sacramento-San Joaquin drainage, the most likely source of origin for animals imported as food (see Commercial Exploitation, Predation). As such, the status of the species may not be exactly ascertained without alternate methods of analysis, some of which are planned.

There were no specimens of WPTs from Nevada in any major museum (including the University of Nevada at Reno) as of 1988. The Nevada Department of Wildlife keeps a file on all turtle sitings. All localities in this file and all specific literature records were checked in surveys during 1987. Of the 6 localities specified in La Rivers (1942), turtles were found at only 1 site. Additional searches revealed the presence of turtles at 5 other sites, all

along the Carson River. A single specimen was observed by NDW personnel at a site on the West Walker River. This site was checked and the original collector and the NDW personnel interviewed. Surveys at the site of capture and along adjacent and other areas of the river leave little doubt that this specimen was introduced from elsewhere. A single reliable sight record also exists for the Truckee River drainage. This site was also checked and the reporting parties interviewed in 1987. This turtle was/is a large male and probably represents one of the last if not the last animal in this area. Extensive surveys along the Truckee indicated that although suitable habitat was present in at least two or three areas, no turtles were noted. The report of a turtle in a flume east of the Lahontan Dam on the Lahontan River proved to be a large river cooter (Psuedemys concinna).

Several areas along the Carson River were checked in both 1987 and 1988. Turtles were observed at 6 localities. The total number of turtles captured in these surveys was 20, and the size distribution is shown in Fig. 42. Of all turtles captured, approximately 90% were adults, and single animal (5%) was in the <4 y age group. Of approximately 20 turtles observed but not captured, none were less than 130 mm carapace length and the majority (70%) were over 150 mm. The first turtle I captured in Nevada had swallowed a fish hook set on a trot line (Fig. 24). The WPT population in Nevada is confined to a single river system and is present in very low densities - an estimated 30+ h of visual and snorkeling surveys resulted in the sighting of only 40 turtles in a two-year period. The total population probably does not number over 200-300 animals and is apparently suffering from major declines or outright failures in recruitment. The area(s) in which the majority of the turtles were observed (3 sites) are heavily altered by agriculture, and the remaining sites are poor-quality habitat and impacted to various degrees by mining operations and heavy recreational use of the river. Additionally, exotic species (bullfrogs, bass and carp) were present at all but one site surveyed, which interestingly contained both small animals noted.

Washington: The type locality of the WPT is Ft. Steilacoom, Puget Sound (Baird and Girard, 1852). The status of the WPT in Washington has been recently reviewed by Holland (1991b). The species formerly occurred along the Columbia River from the vicinity of Vancouver east to the area of Dallesport, and in the immediate area of south and east Puget Sound. Extensive surveys by Milner (1986) in the Puget Sound area did not reveal the presence of any pond turtles, although occasional individuals have "turned up" over the last several years. These individuals are most likely escaped pets or animals deliberately released in certain areas (R. Milner, pers. comm.). The presence of one or possibly two animals on Whidbey Island is the result of a deliberate introduction (F. Slavens, pers. comm.), although this may have been within the historic range of the species (Weasma, 1991). WPTs were probably patchily distributed along the Columbia to the current eastern edge of the range, although in the Pleistocene the species was found at least as far east as White Bluff (Brattstrom and Sturn, 1959). Although museum specimens are lacking, there is little doubt that suitable habitat existed along the Columbia to

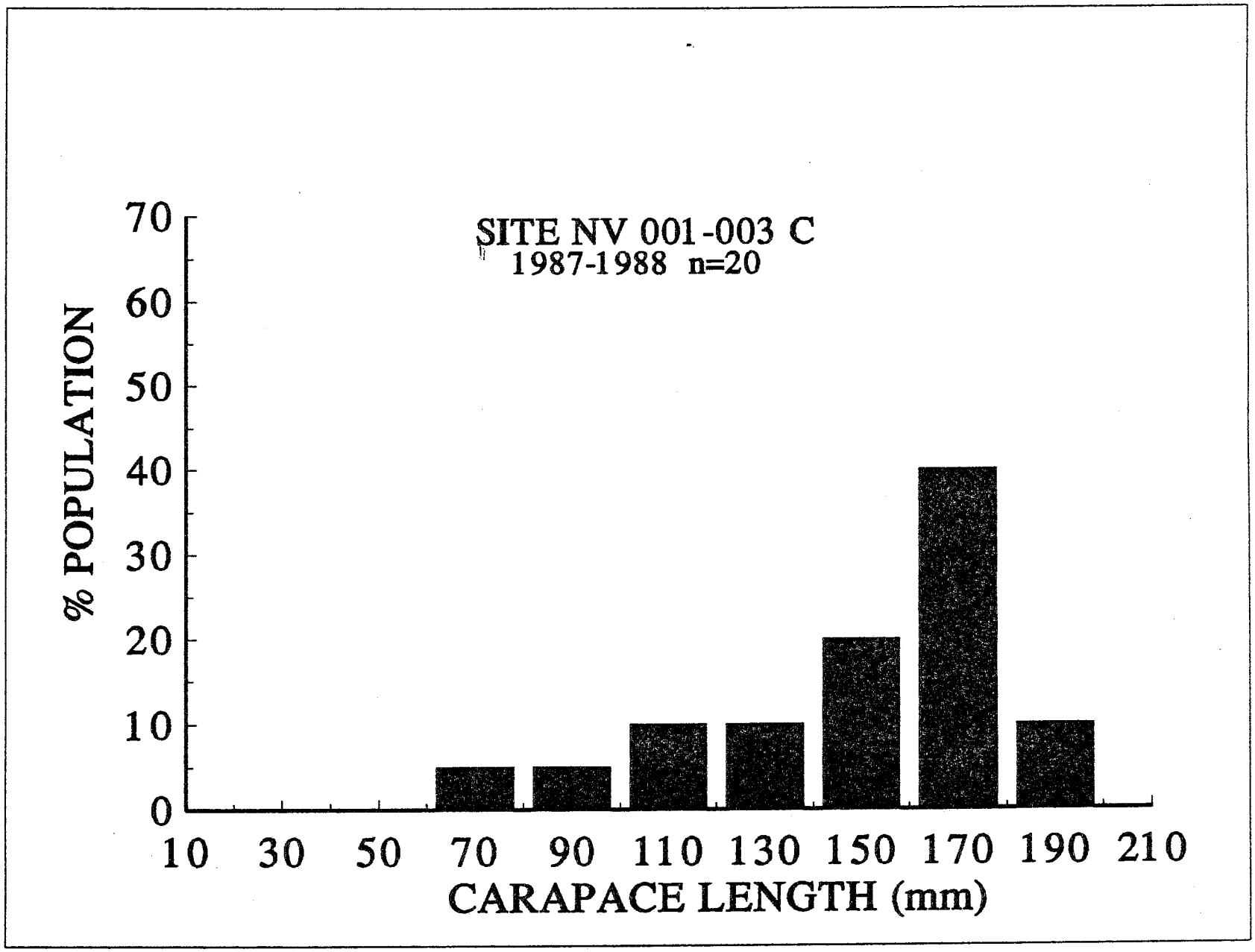


Fig. 42: Structure of population at site NV 001 C.

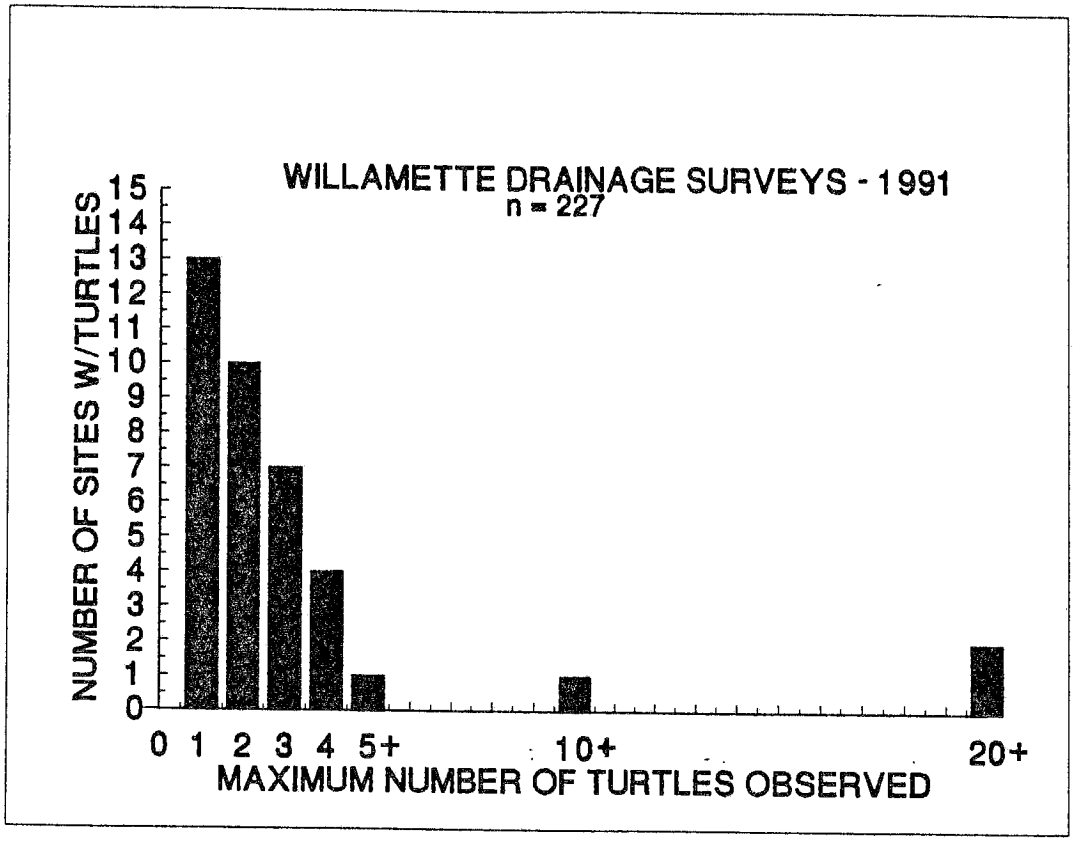
maintain populations. Most if not all of this habitat was destroyed by construction of dams and impoundements, not only eliminating existing habitat(s) but effectively precluding immigration inhto habitats adjacent to the river. At present, two populations of WPTs are known to exist in Washington, both along the Columbia River (Holland, 1991b). Extensive surveys by the author in 1987-1990 and by the Washington Department of Wildlife in 1991 failed to reveal the presence of any additional populations. Records of isolated individuals are known from at least two other localities along the Columbia, but probably represent deliberate introductions.

The total number of WPTs in Washington as of late fall 1991 may be as high as 100-110 animals (Holland, 1991b) but may be significantly lower. These occur at only two sites, one in which the total number of animals is known to number approximately 75-80 animals (WA 001 C). The second site (WA 002 C) has not been extensively surveyed, but may hold 25-30+ animals, although no more than 12 were noted in surveys in 1990. A possibility exists that a few isolated individuals survive in the Puget Sound area, but it is unlikely that any viable populations remain (Milner, 1986; Holland, 1991b). However, this needs to be verified by further surveys.

The status of WPTs along the Columbia drainage is difficult to assess exactly due to a lack of historical comparative data. However, if it is assumed that turtles were distributed at relatively low densities (30/km) along the 100 km of potential habitat, then WPT populations in this have declined in excess of 99%. The situation is probably even more severe in the Puget Sound area, where the species has been effectively extirpated.

Oregon: The distribution and status of the WPT in Oregon was surveyed from 1987-1991 (Holland, 1991c). In general, it appears that populations have been extirpated or severely reduced in many areas, and relatively few moderate-large viable populations exist. In 1991, extensive efforts were made to survey the status of the species statewide. Coupled with other information (see references in Holland, 1991c) and intermittent surveys from 1987-1989, a brief assessment of the status of the species is noted below on a drainage-by-drainage basis.

Willamette River and associated drainages: Approximately 144 sites in the Willamette drainage were surveyed in 1991. A significant percentage of the sites were resurveyed, some up to 4 times. The distribution of sites was approximately 69 in the upper valley (Salem northward) and 75 in the lower valley (Salem southward). A summary of the results is shown in Fig. 43. Exactly 26.3% of all sites surveyed held WPTs. The upper valley survey noted WPTs in 13% of all sites, and in the 37% of the sites in lower valley. The maximum number of turtles observed was 27 at one very isolated and small site in the southern end of the drainage. Sixty-two percent of all sites surveyed contained only one or two turtles. Only three sites were noted that held more than 10 turtles (7.8%) and all were in the southern portion of the valley. Exactly 103 surveys were conducted in the upper part of the valley, and the average number of turtles



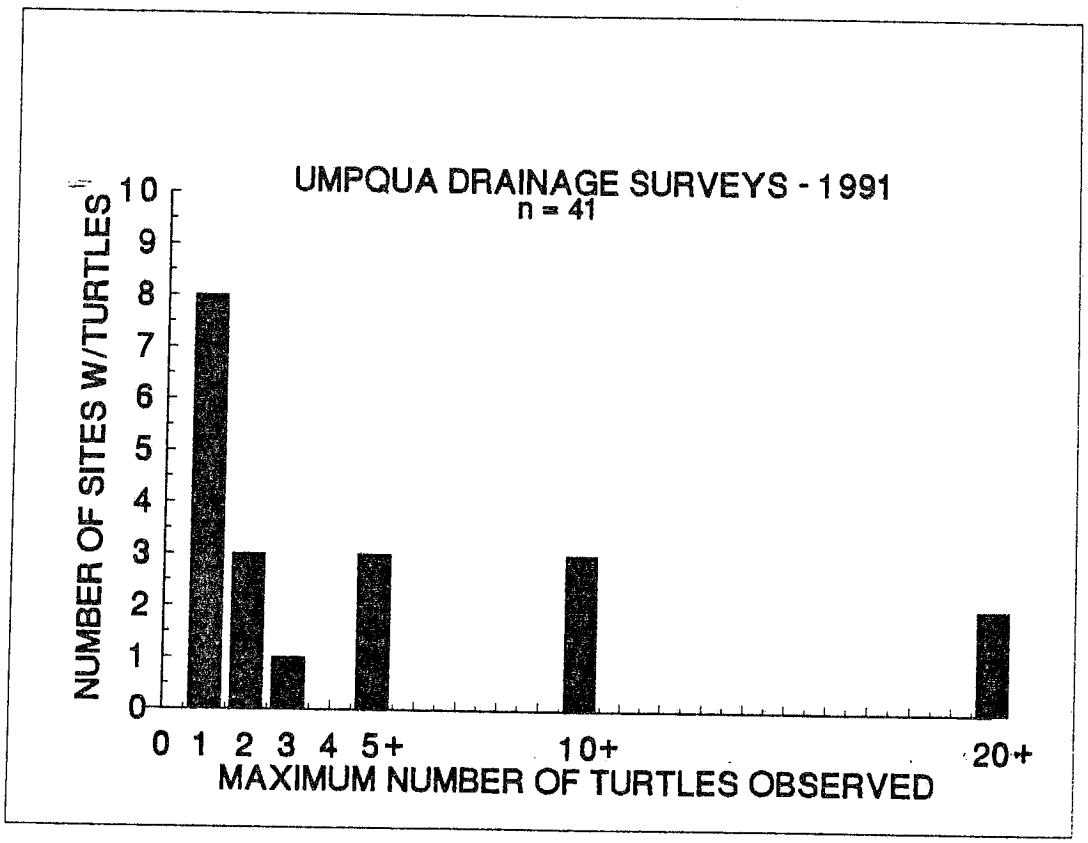


Fig. 43: Summary of 1991 survey results for Willamette and Umpqua drainages, Oregon.

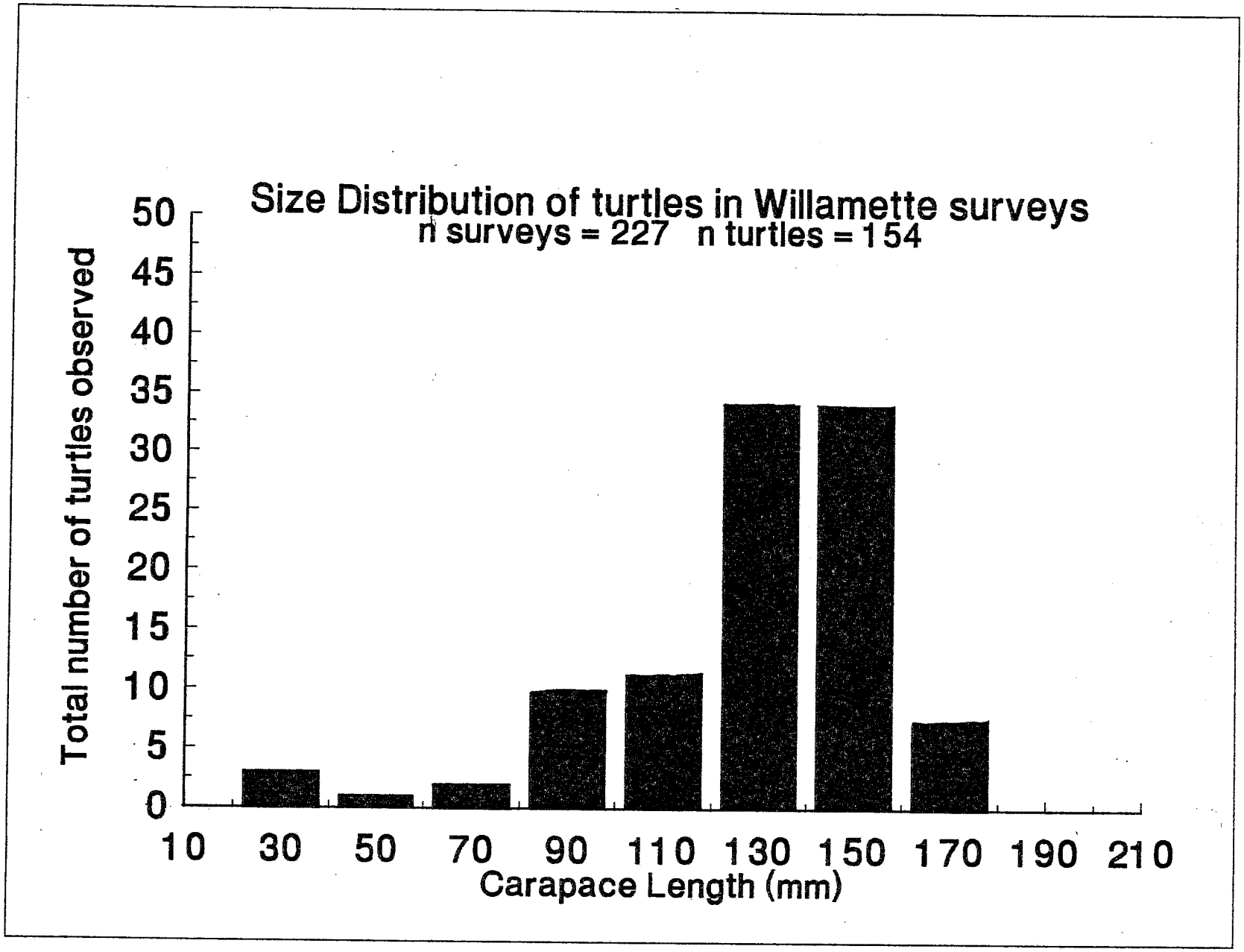


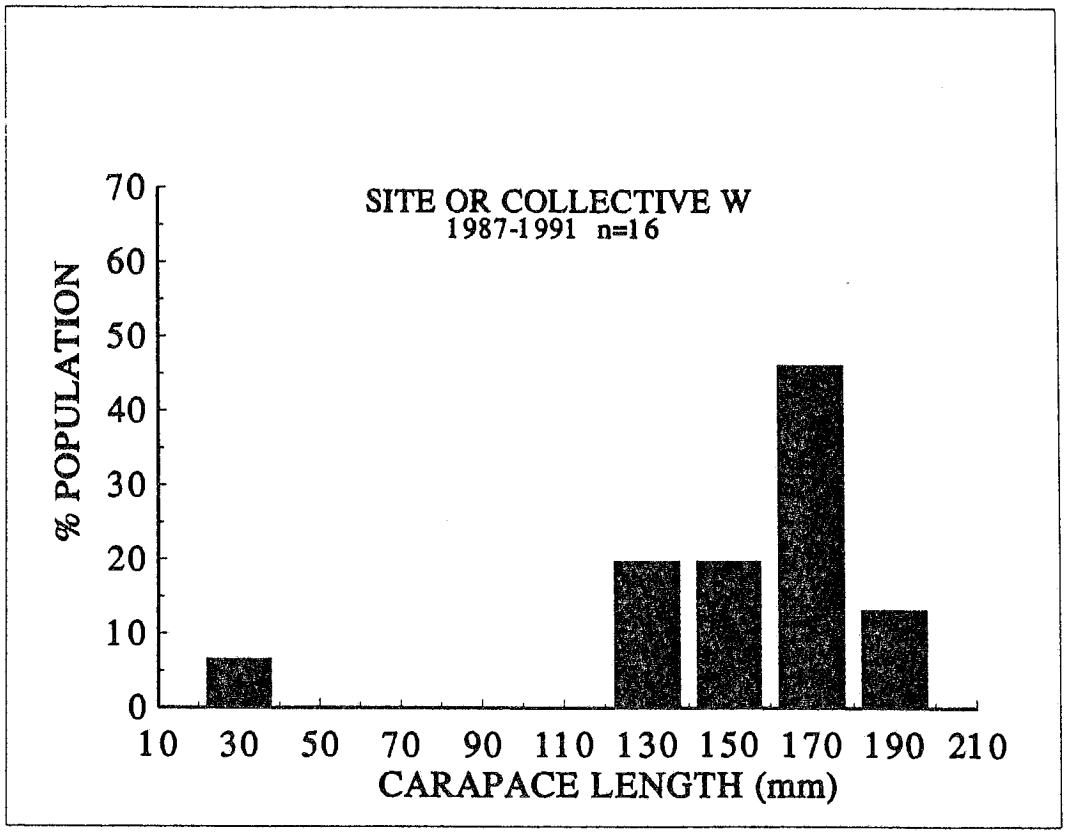
Fig. 44: Size distribution of all turtles observed in surveys of the Willamette drainage, 1991.

observed/survey was 0.223. There were a total of 124 surveys in the lower valley and the average number of turtles observed/survey was 1.05. The estimated size distribution(s) of the two sample areas are shown in Fig. 44. In the upper Willamette, 92.3% (n=13) of the animals whose size was noted were adults. In the lower Willamette, 84.7% (n=111) of the animals were adults. Sampling efforts from 1987-1991 in the Willamette drainage from Benton County northward yielded only 16 turtles, despite intensive efforts to locate and sample populations. A single juvenile was collected in a protected area in 1991. A comparison of one of the three presumably viable WPT populations in the southern Willamette with the 1987-1991 size distribution noted above is provided in Fig. 45.

Western pond turtles populations have undergone dramatic declines in the Willamette Valley in the last 25 years. Wilhemi (1964) estimated a population of 180 WPTs occurred in an oxbow lake near Salem in 1964, along with 75 western painted turtles. This site was surveyed in 1987 and only three large adult WPTs and seven western painted turtles were observed. The site was resurveyed in 1991 and a single WPT and one painted turtle were observed. The mean carapace length of 28 males in this system in 1964 was 174 mm, and 13 females averaged 169 mm. Two "small" (Nussbaum et al, 1983) individuals (105 and 140 mm) were captured in this study. Current comparisons with the detailed descriptions of the site (Wilhelmi, 1964) and conversations with the property owner indicate that this site has been severely degraded in the last 20-25 years. However, this lake is typical of the majority of the remaining aquatic habitats in this portion of the Willamette Valley. Other information on a WPT study from 1976-1978 in lake near Corvallis (Nussbaum et al., 1983) estimated the population at approximately 75 animals. This site was surveyed in 1987-1989 and a maximum of 13 animals were noted. The site was resurveyed twice in 1991 and a maximum of 4 animals were observed. Of interest is the note that the mean carapace length of males (n=38) at this site was 163 mm (range 146-176) and for females (n=26) was 161 mm (range 143-175) in 1976-1978. A single animal approximately 123 mm carapace length was captured in this study.

This evidence confirms the patterns noted in the 1991 survey; the few existing populations are very small, extremely adult-biased and declining. That the problems previously discussed with recruitment declines or failures are not a recent phenomenon is apparent in both studies; the Salem population consisted of 97.7% adult turtles in 1964, and the Corvallis population consisted of 98.5-100% adults in 1976-1978. The apparently high proportion of adults in these systems cannot be attributed to the survey methodology alone (baited live traps were used in both cases); evidence from similar trapping efforts in Oregon in 1991 and elsewhere in 1989-1990 indicate that a significant percentage of the animals captured are less than 100 mm. Based upon extrapolation from survey results (Holland, 1991c) and an assessment of the quality and quantity of the current habitat, it is probable that WPT populations have declined in excess of 99% from historical levels in this drainage.

Umpqua drainage: Approximately 29 sites were surveyed in the Umpqua



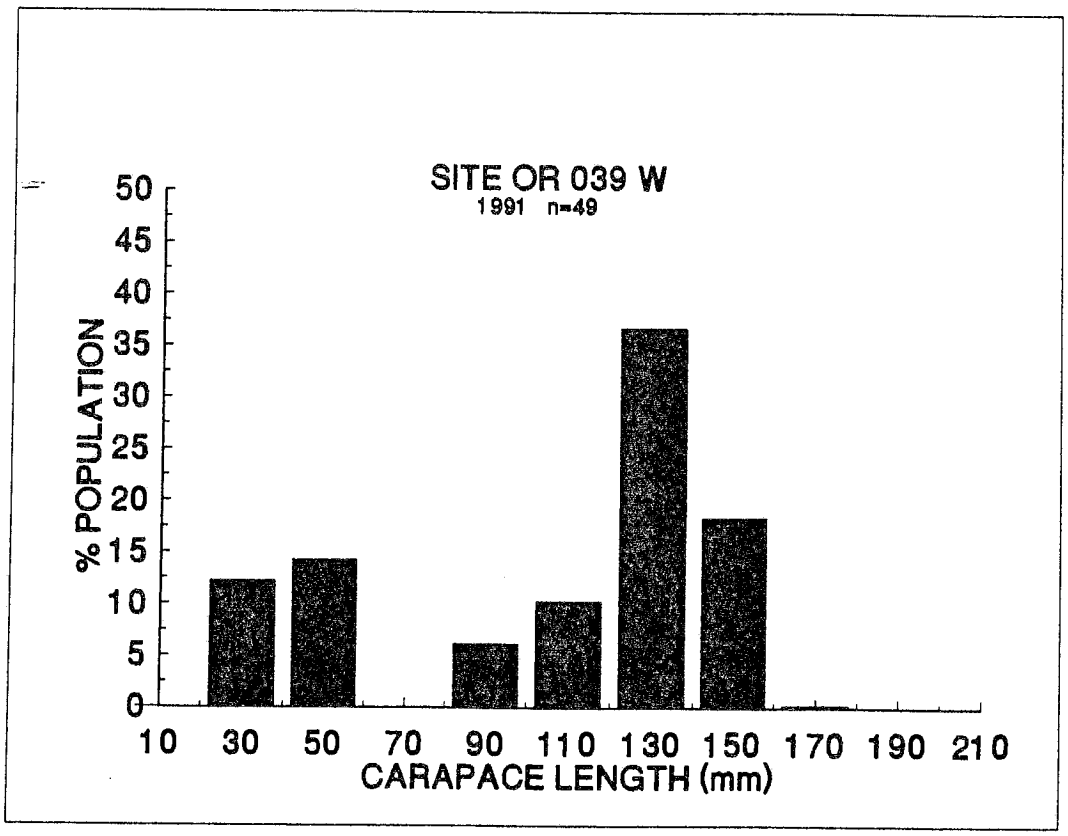
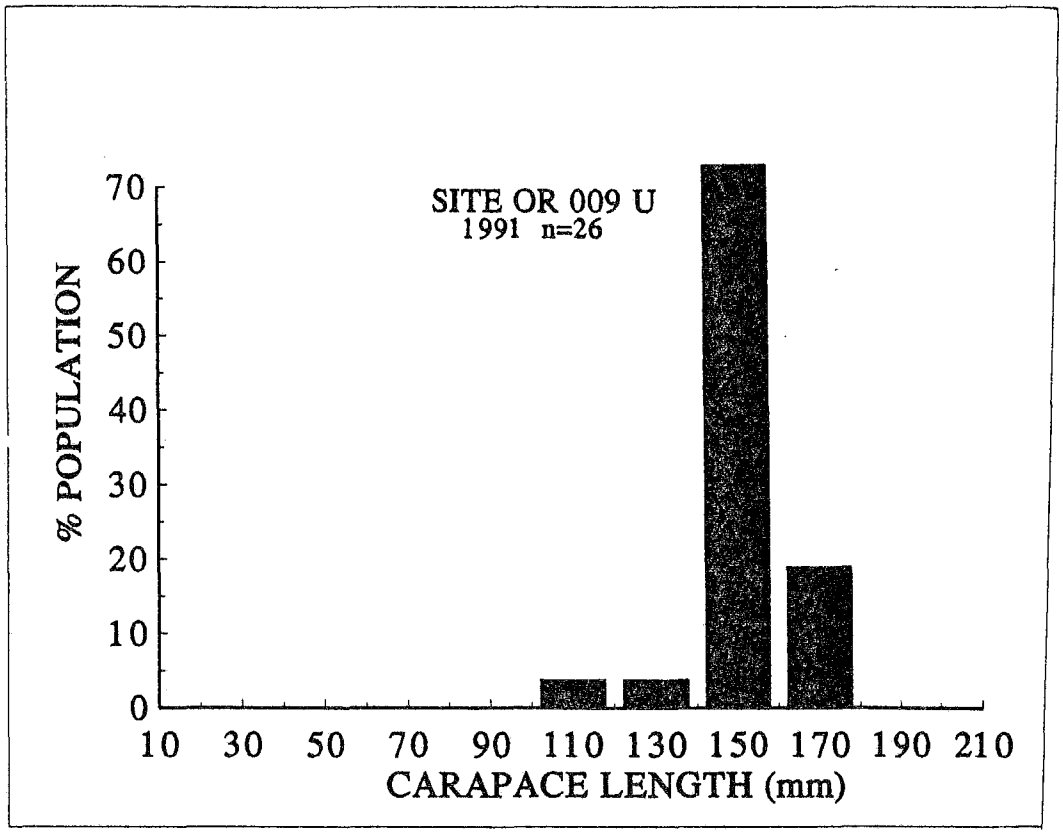


Fig. 45: Comparison of population structure of sites OR Collective W and OR 039 W.

drainage in 1991 (Holland, 1991c). Turtles were observed in 18 (62%) of all sites (Fig. 43). The maximum number of turtles noted at any one site was 55, and a total of 232 turtles were observed in 41 surveys (mean = 5.6 turtles/survey). Two sites accounted for over 50% of the sightings. Of the sites with turtles, 41% (n=10) had only one or two animals and 8.33% (n=2) had more than 20 animals. One of the latter sites was a public park used as a "dumping ground" for WPTs picked up elsewhere in the drainage, as well as for other species such as red-eared sliders (Trachemys scripta elegans). This resulted in an unusually high concentration of turtles at this site, a situation not observed elsewhere in this portion of the drainage. The majority of animals in this site (87%) were adults. The size distribution of two populations in the lower part of the drainage is presented in Fig. 46. Adults comprised 100% of the sample (n=24,n=26) at both sites. Site OR 001 U was surveyed from 1987-1989 and again in 1991. This site contains the largest known population of turtles in the Umpqua drainage, estimated to number between 80-100 animals. A size distibution of the population is shown in Fig. 47. In this population, 54.7% of the animals captured were adults, and 16% of the animals were in the <4 y age group. This site is somewhat unique in that it lacks exotic predators and significant disturbance of adjacent habitats. During surveys in in the Umpqua drainage in 1991, bullfrogs were noted in the majority of sites in relatively low numbers, but some sites harbored concentrations of thousands to tens of thousands. Smallmouth bass were also noted in some lower areas in the drainage. In general, it appears that populations from at least Myrtle Creek downstream in the drainage are relatively small, heavily adult biased, and existing in areas where there is light to moderate disturbance of adjacent upland habitats typically used for nesting. Populations from the vicinity of at least Tiller upstream appear to be relatively stable, however this may change as forest management practices change.

Rogue River: Approximately 30 sites were surveyed in this area in 1991 (Holland, 1991c). Turtles were observed in 7 (23%) of all sites. The maximum number of turtles noted at any one site was 22, and a total of 58 turtles were observed in 32 surveys (mean = 1.81 turtles/survey). Of the sites with turtles, 28.5% (n=2) had only one or two animals, and only a single site had more than 10 animals. The distribution of the maximum number of turtles observed at each site is shown in Fig. 48. The size distribution of 38 animals captured at Site OR 010 R is shown in Fig. 49. Adults comprised 84.3% of the two samples collected at this site. In relation to search time, animals in the Rogue drainage are marginally more abundant than in the Willamette drainage, but considerably less abundant than in the Umpqua or Klamath drainages. Although comparisons with similar habitats in other areas (such as northern California) are tenuous, it appears that WPTs are generally less abundant in the Rogue drainage than elsewhere. Given the nature of some habitats in the Rogue drainage, it is curious that turtles are not more common. Observations on the main channel of the Rogue indicate that it is probably not optimal turtle habitat due to the strength of the current and the average water temperatures. Furthermore, the Rogue is heavily utilized for recreational purposes (see Roads/Traffic) and this may have a significant negative impact on WPT populations in this drainage. Despite intensive searches in this



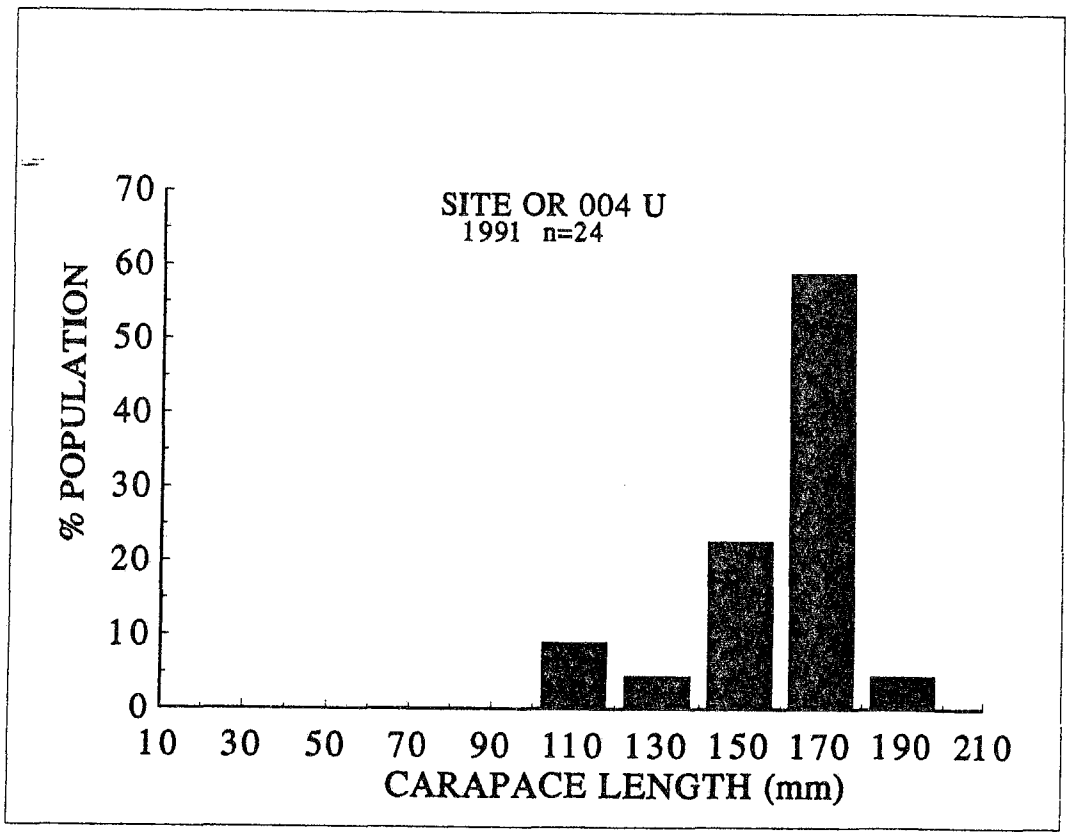
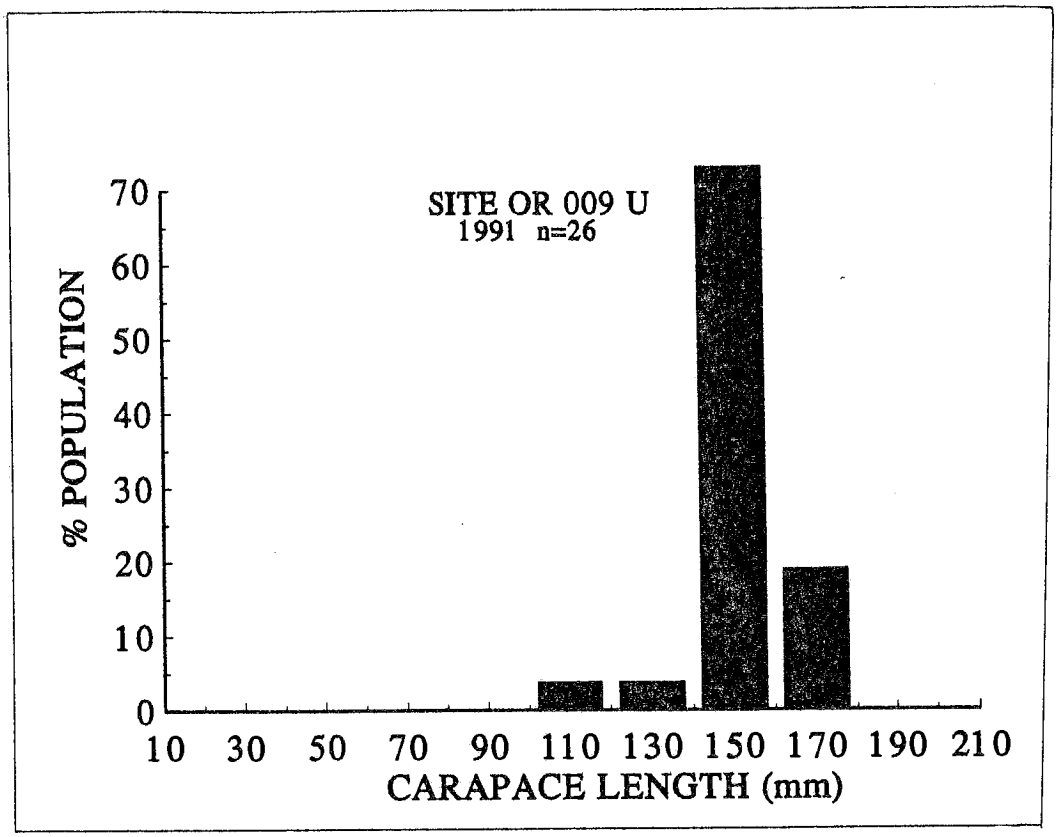


Fig. 46: Comparison of population structure of sites OR 009 U and OR 004 U.



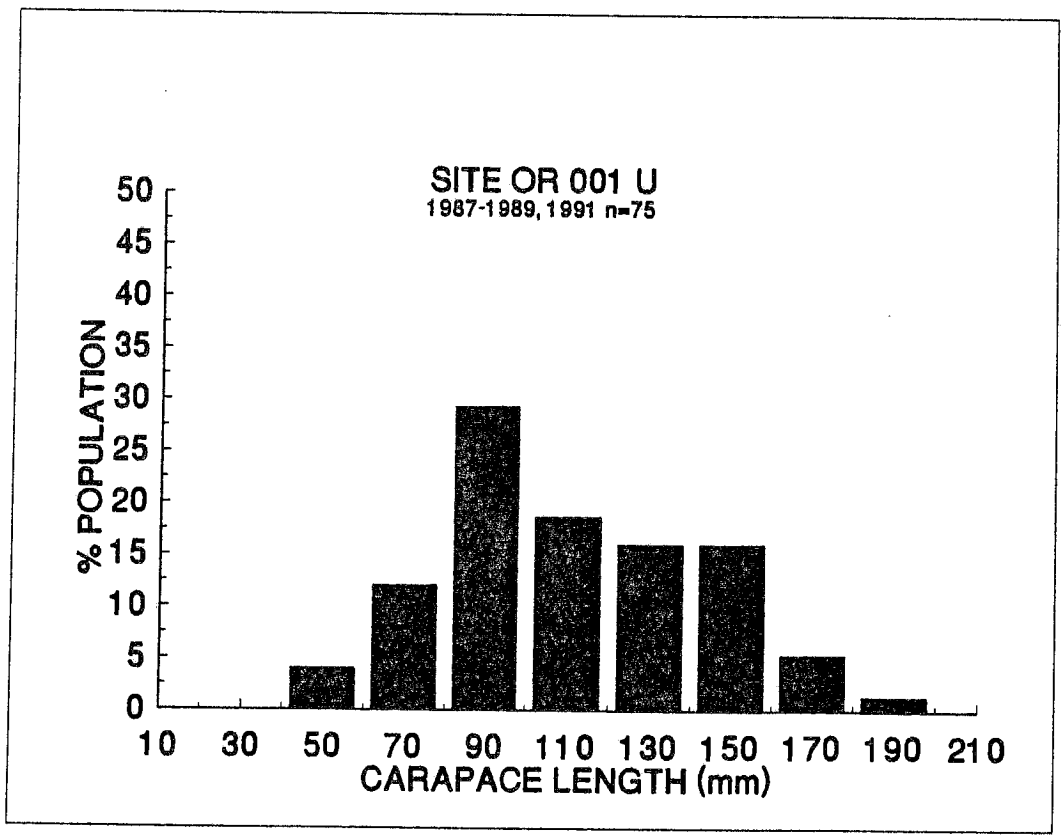
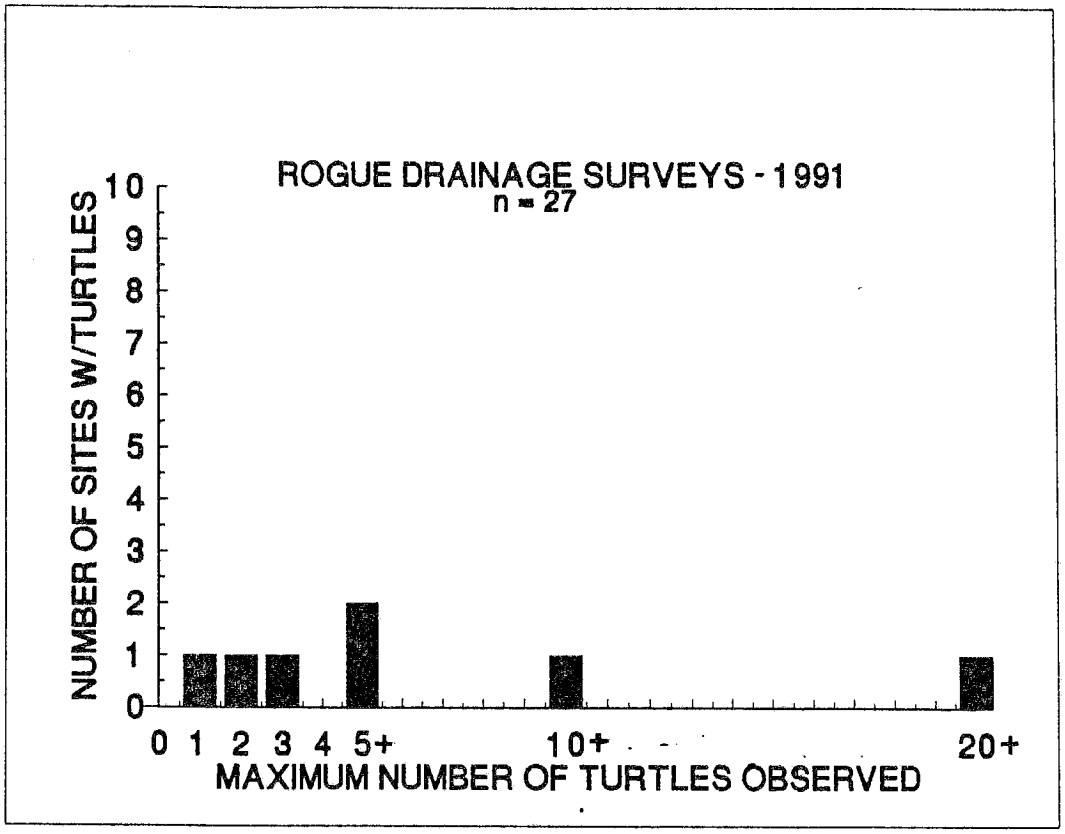


Fig. 47: Comparison of population structure of sites OR 009 U and OR 001 U.



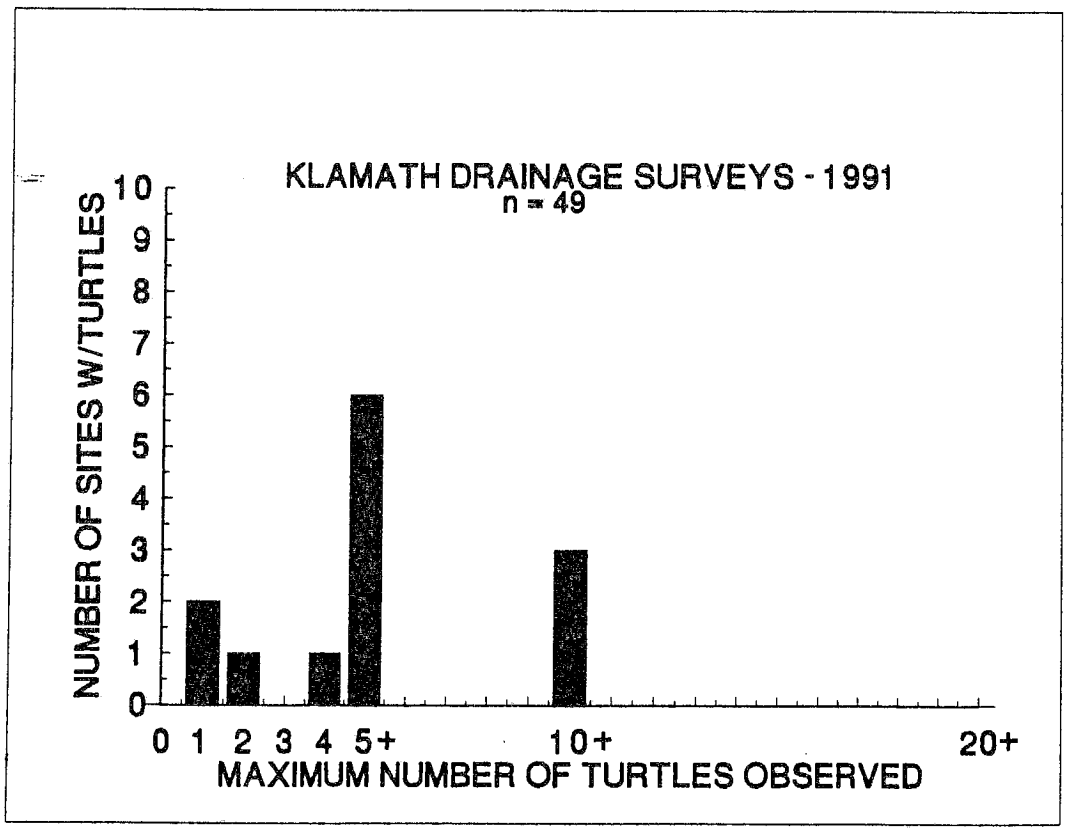


Fig. 48: Summary of 1991 survey results for the Rogue and Klamath drainages, Oregon.

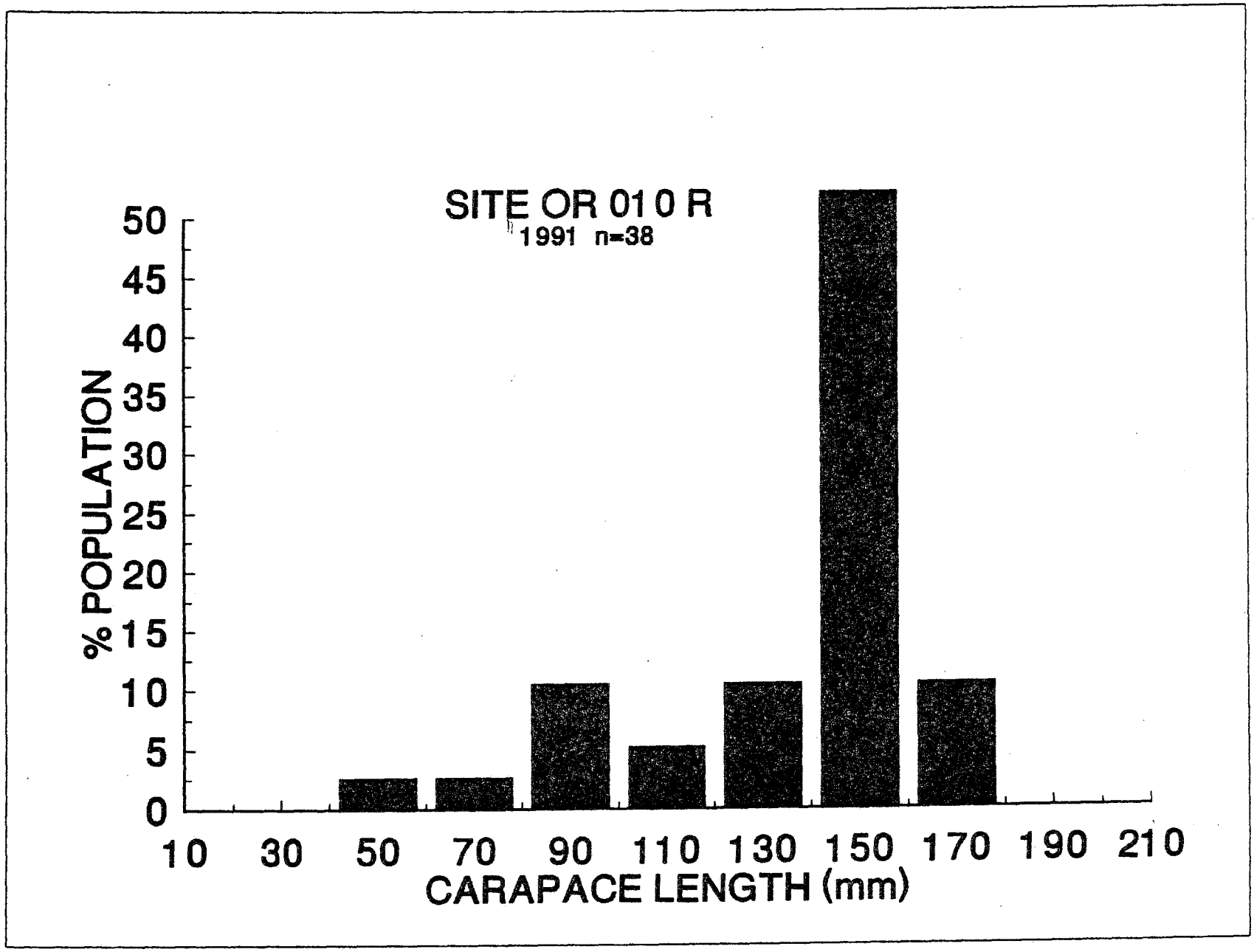


Fig. 49: Structure of population at Site OR 010 R.

area, only a single moderate-sized population was observed. This population (OR 010 R) exists in an apparently undisturbed habitat with no predaceous fishes, and only two bullfrogs were noted in the surveys. However, conversations with residents of the area indicate that bullfrogs were common in this system several years ago and declined significantly during the last few years. The status of WPTs in the Rogue system appears to be that relatively few populations of moderate size exist, and that they are heavily adult-biased. Small populations or isolated individuals may occur in a number of areas, but the total distribution within this system appears to patchy and densities are very low.

Klamath/Lost River drainages: Approximately 39 sites were surveyed in this area in 1991 (Holland, 1991c). Turtles were observed in 13 (33%) of all sites. The maximum number of turtles noted at any one site was 14, and a total of 151 turtles were observed in 49 surveys (mean = 3.08 turtles/survey). Of the sites with turtles, 23% (n=3) had only one or two animals, and 23% (n=3) had more than 10 animals. The distribution of the maximum number of turtles noted at each site is shown in Fig. 48. The size distribution of 71 animals captured is shown in Fig. 50. Adults comprised 95.8% of all animals captured and approximately 89.4% of all animals observed (n=135). In relation to search time, turtles are relatively more abundant than in the Willamette drainages. However, absolute densities compared to other areas (see Fig. 20) are probably much lower. Along the Klamath/Lost River drainage, turtles appear to aggregate in favorable habitats, with very low densities in areas between these presumably favorable patches. Based upon surveys conducted in 1991 (Holland, 1991c), it appears that WPTs currently inhabit at least 100 km of the Klamath/Lost River drainage in Oregon. The population probably numbers in excess of 1200 animals. However, the patterns noted in the Willamette and other drainages are obviously present here. The vast majority of animals in this system are old, large adults - 75.6% of the animals captured were in excess of 170 mm. The mean, median and modal sizes of this population are significantly larger than any one of more than 100+ populations assessed to date (Holland, unpubl. data). The reasons for this decline may be multiple, including destruction of nesting habitat (see Habitat Alteration); alteration of historic water flow patterns, the presence of introduced predators and possibly historical commercial exploitation. Although some extensive areas of apparently suitable habitat occur on Upper Klamath Lake, turtles were scarce or absent in most surveys in this area. Removal of basking logs and driftwood on the southern end of the lake is thought to have been a major factor in the decreased frequency of observations of turtles in this area (R. Opp, pers. comm.).

Coastal and other drainages: WPTs are known from several small and medium-sized drainages on the Oregon coast and at least two interior drainages. One population in the John Day drainage in Grant County probably represents introduced animals (Nussbaum et al, 1983) and its current status is unknown. The other record was a single animal observed in the Goose Lake drainage in 1990. A brief survey of this area in 1991 (Holland, 1991c) indicated that although some suitable habitat may exist in the area, no turtles were observed and it is

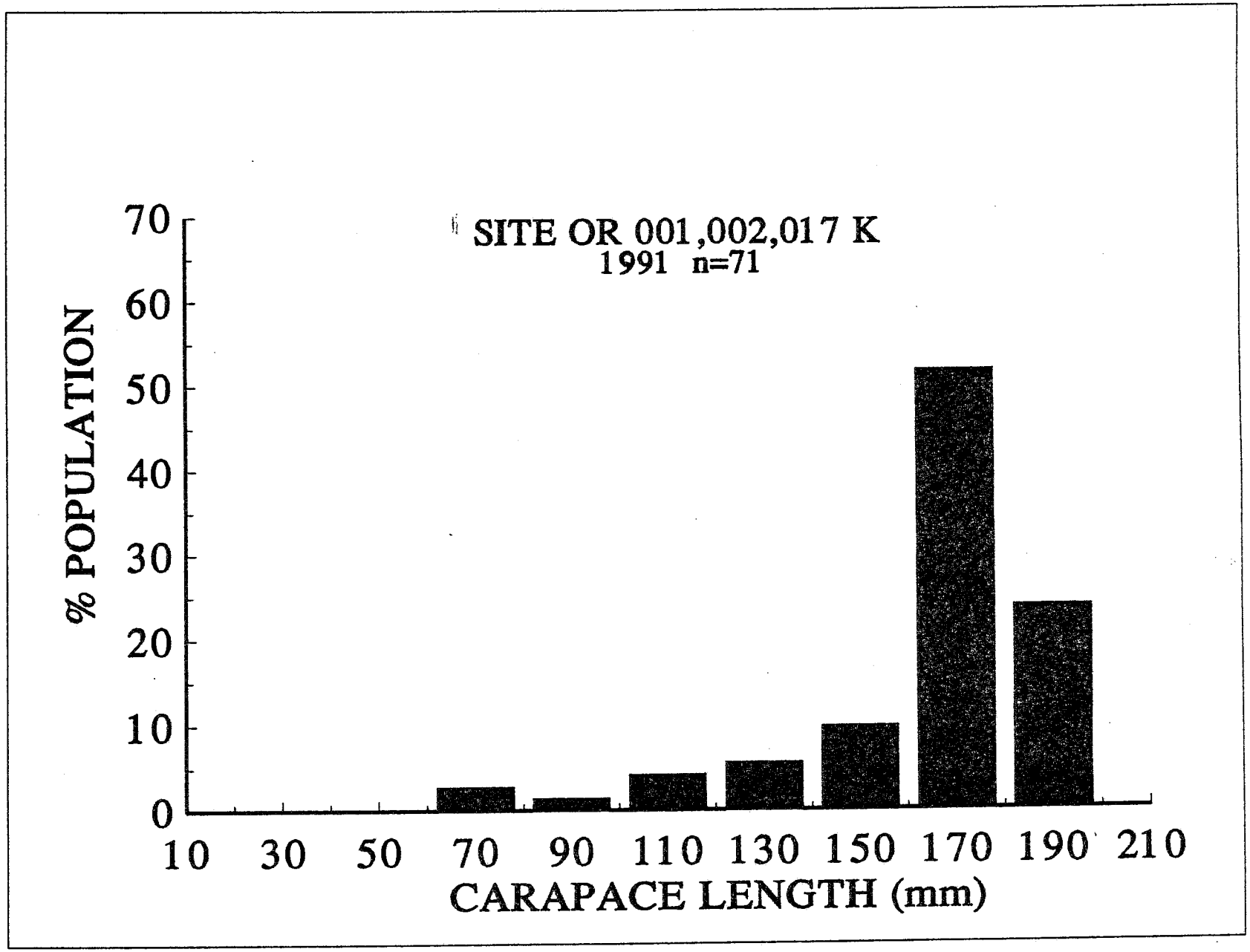
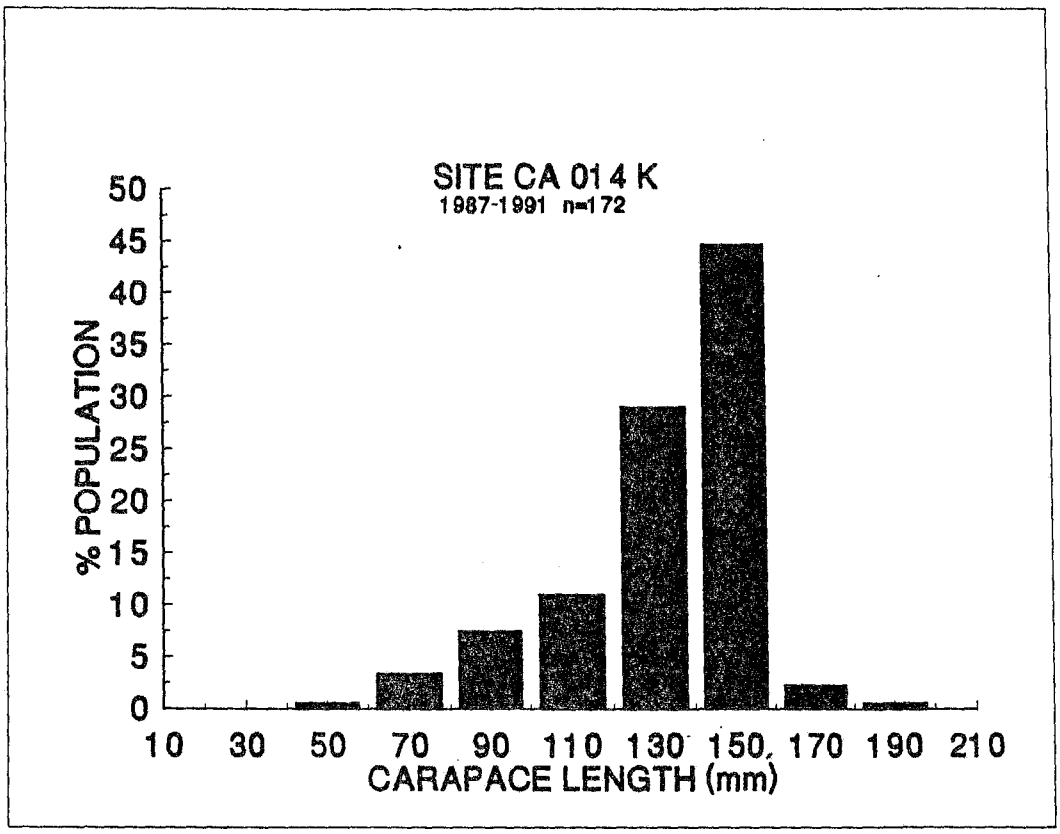


Fig. 50: Structure of population at site OR 001,002,017 K.

likely that this animal represents a deliberate or accidental introduction. On the coast, turtles are known from the Nestucca, Coos, Coquille, Sixes, New and Chetco river systems (Holland, 1991c). Brief surveys of some of these systems in 1991 did not reveal the presence of turtles at the 12+ sites surveyed, but existing accounts are reliable indicators that the animals are present. It is also obvious from the nature of material accompanying these accounts that the distribution of animals in these systems is extremely patchy and existing populations are likely to be only small to moderate in size.

California: Populations of WPTs in California have been surveyed by the author from 1981-1991. Long-term data (10 years) exists for the structure of at least 4 populations on the central coast, and shorter-term data (1987-1991) for at least 26 other populations throughout the state. In general, WPTs seem to be in a state of decline in the majority of their range in California. The status of populations in the state runs the gamut from large and apparently stable to completely extirpated. The majority of populations, however, appear to be small to moderate and threatened by a variety of factors. A drainage-specific assessment of the status of populaions follows. The partitioning of drainage basins generally follows Moyle (1976).

Klamath/North Coast: Western pond turtles are widely distributed within the drainage area of the Klamath River, its tributaries and in some north coast drainages (e.g. Eel, Russian and Mad Rivers). Within this system, turtles are found primarily in lowland areas. WPTs occur in watercourses of all sizes, but are most abundant in small to medium-sized shallow, warm streams. Several sites within the Klamath drainage were surveyed from 1987-1991. Site CA 014 K is located on a moderate-sized stream draining into a major tributary of the Klamath. Turtles are apparently continuously distributed along this watercourse and the total population probably numbers in excess of several thousand animals. This is the largest remaining population of WPTs known, and is rather unique in several respects. Surveys of other streams and river systems in this area (R. Wilson, pers. comm.; Holland, unpubl. data) indicate that the density of turtles/kilometer of watercourse is much lower, perhaps by as much as an order of magnitude. The size distribution of turtles captured at site CA 014 K from 1987-1991 consisted of 88.5% adults, with only 3.98% of the animals in the <4 y age group. Although the aquatic habitat appears to be relatively intact, extensive development of the adjacent upland habitats likely to be used as nesting areas has occurred. Additionally, bullfrogs were first observed in this area in 1989. Another site (CA 012 K) within the same stream system was surveyed concurrently. The size distribution (Fig. 51) is considerably different - 70.3% of the population are adults, and 9.4% of the animals captured were in the <4 y age group. The latter site is essentially undisturbed throughout the area surveyed (about 4 km of stream), and no exotic fishes or bullfrogs have been noted at this site. The size/age structure from another population in the Klamath drainage surveyed by the US Forest Service in 1991 (R. Wilson, unpubl. data) is shown in Fig. 52. In this population, 83.2% of the animals captured in 1991 were adults, and 8.4% of the animals were in the <4 y age group. This sample was



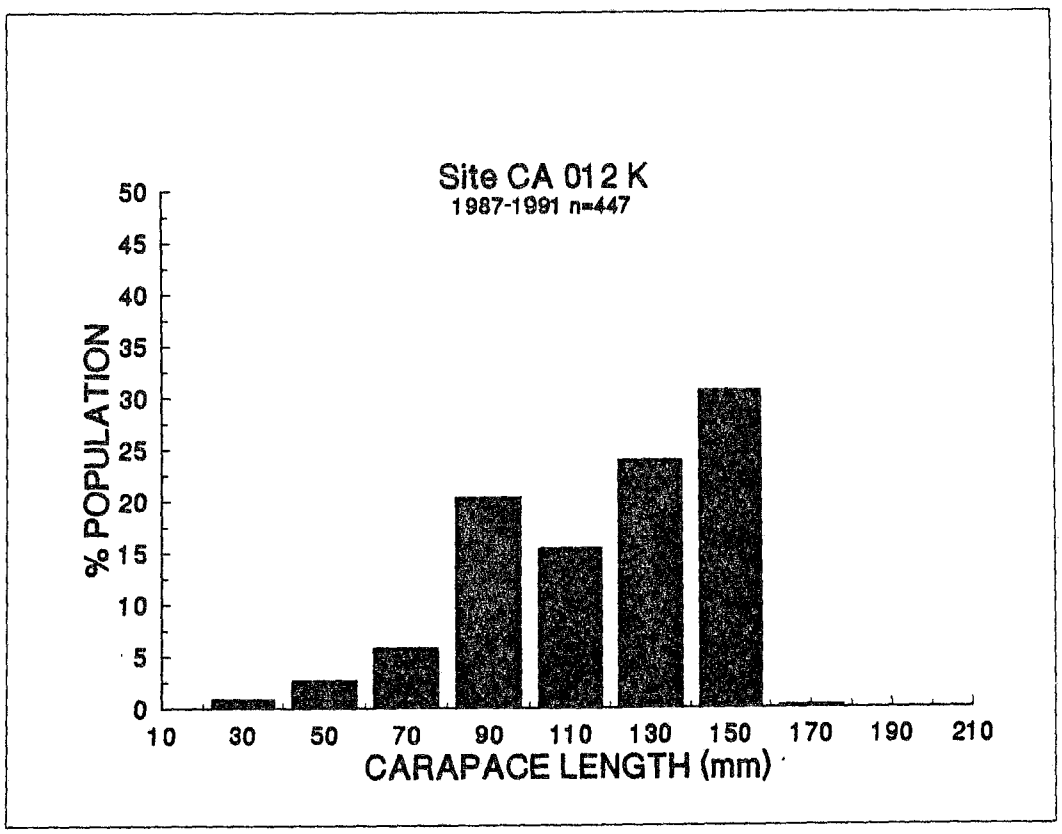
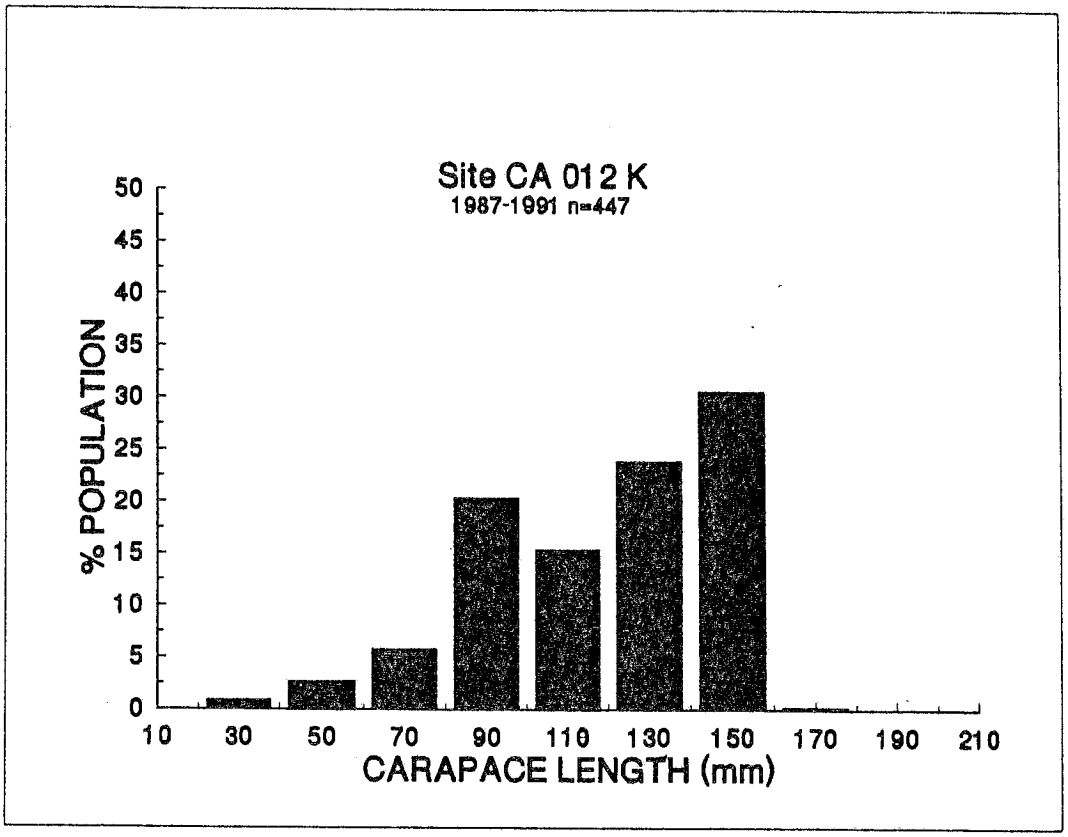


Fig. 51: Comparison of population structure of sites CA 012 K and CA 014 K.



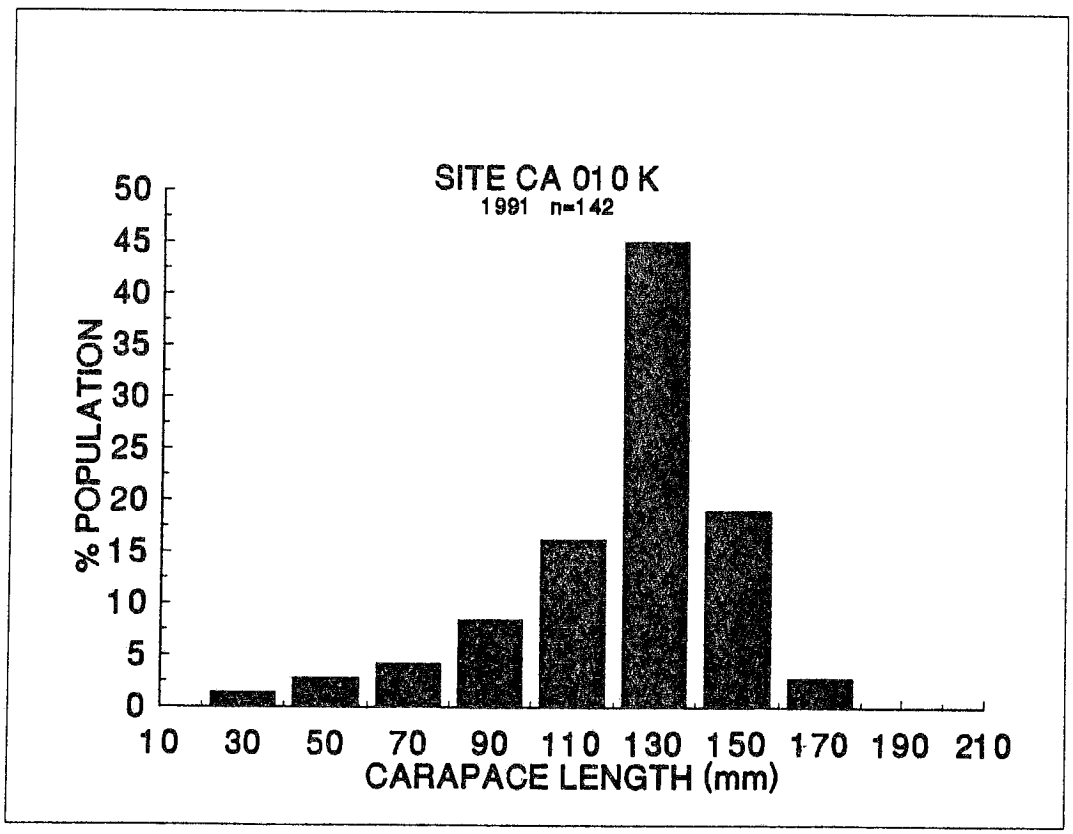


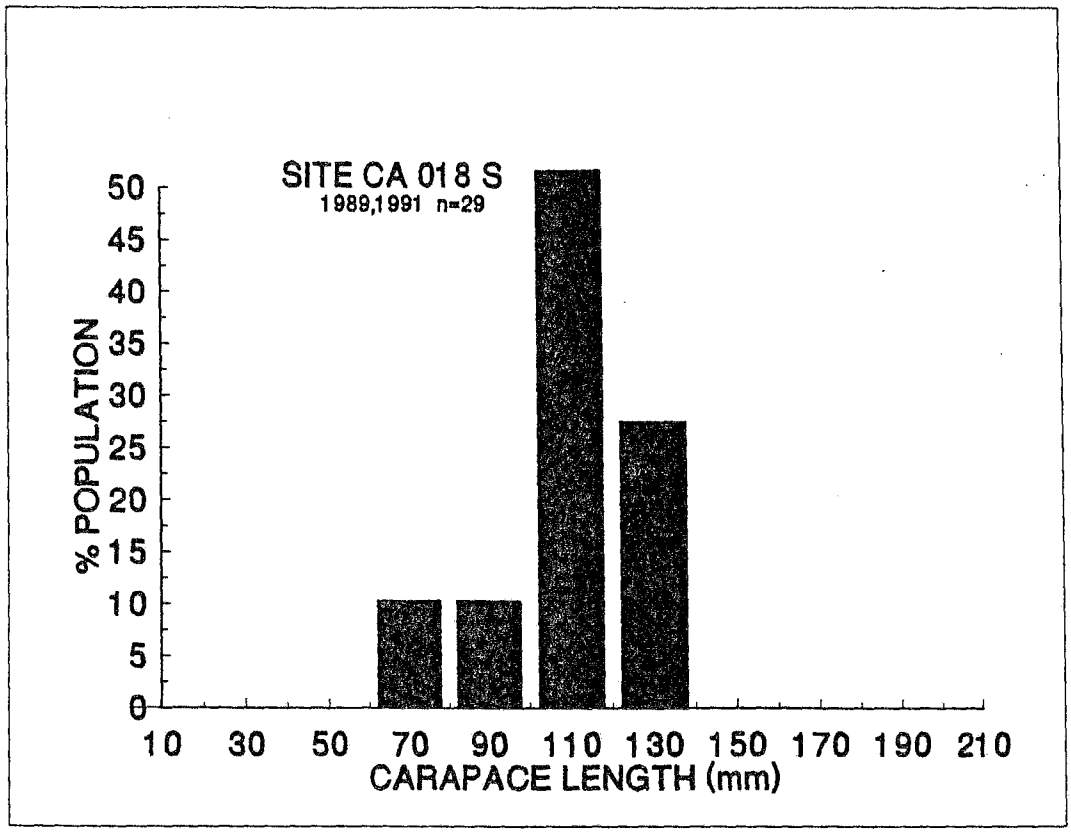
Fig. 52: Comparison of population structure of sites CA 010 K and CA 012 K.

collected over a stretch of several miles in one watercourse, and the degree of habitat disturbance varied significantly within the survey area. It appeared that turtles were most abundant (est. 47-50/km river) in the least-disturbed section of river (R. Wilson, pers. comm.).

Several surveys of the portion of the Klamath River downstream from the Oregon border indicate that the patterns observed there (moderate-sized populations composed primarily of very old adults) appear to occur in California as well. In a sample of 13 animals captured in 1988-1989, 92.3% were in excess of 170 mm (the remaining animal was 168 mm). Visual surveys of 25-30 other animals revealed no animals <150 mm.

At least some populations within a portion of the Klamath drainage appear to be relatively large and stable, without evidence of recruitment declines. These populations occur within a relatively small (<10%) portion of the drainage. There are indications that some of the problems previously noted in other areas are beginning to appear in this system. The invasion and establishment of bullfrogs and exotic fishes is a very real possibility in the area in which sites CA 012-014 K occur; should such a situation occur it may well have a strong negative impact not only on WPT populations but also on one of the few remaining large foothill yellow-legged frog (Rana boylei) populations, another USFWS Category 2 species. Furthermore, dams and reservoirs within this drainage have eliminated substantial areas of WPT habitat, and current water management practices may impact remaining populations (see Threats: Habitat Alteration).

Sacramento: The area drained by the Sacramento River and its tributaries formerly constituted a major portion of the range of the WPT. Extensive marsh and backwater areas along the valley floor and the lower reaches of both Sierran and North coast range streams covered at least 445,000 ha (Harding, 1960). These areas, and several hundred miles of river- and streamcourse held relatively large populations of WPTs, probably numbering in excess of several million animals (see San Joaquin for estimation methodology). Extensive alteration of riparian and marsh habitats, as well as construction of dams have probably eliminated or severely reduced many populations in this area. Surveys in in 1987-1991 and other information (J. Brode, M. Jennings, pers. comm.) indicate that small to moderate-sized populations of turtles exist in some areas along and immediately adjacent to the main channel of the Sacramento, and that turtles may be found in small numbers along some tributaries. However, in relation to the total amount of habitat present, turtle numbers are relatively low. Surveys were conducted on a limited number of upland sites within this system due to the difficulty of finding sizeable populations in lowland areas. Site CA 018 S was surveyed in 1989 and again in 1991. The collective size distribution is shown in Fig. 53. Of 29 animals collected in this system, 79.3% were adults and 10.3 % were in the <4 y age group. Bullfrogs and possibly bass were present at this site, although few sunfish were noted. Another site (CA 001 S) was also surveyed in 1989, and 26 turtles were captured. This site lacked bullfrogs and bass, and the size distribution is shown in Fig. 54. This population



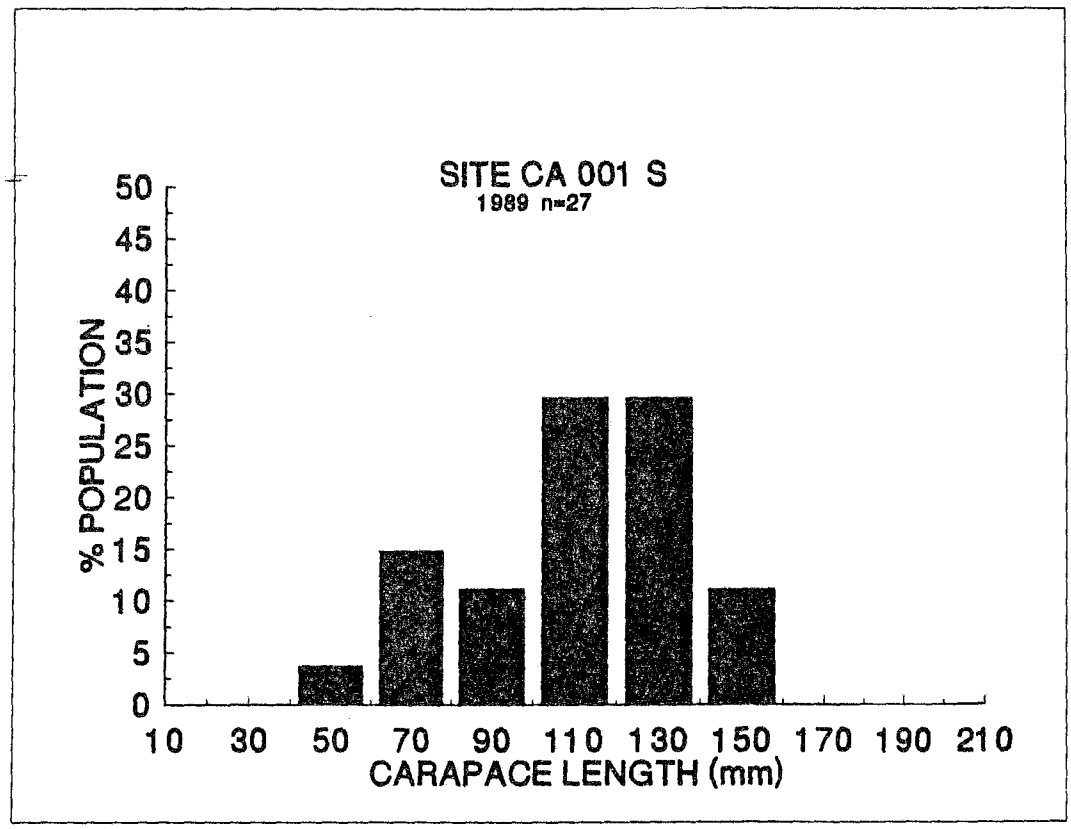
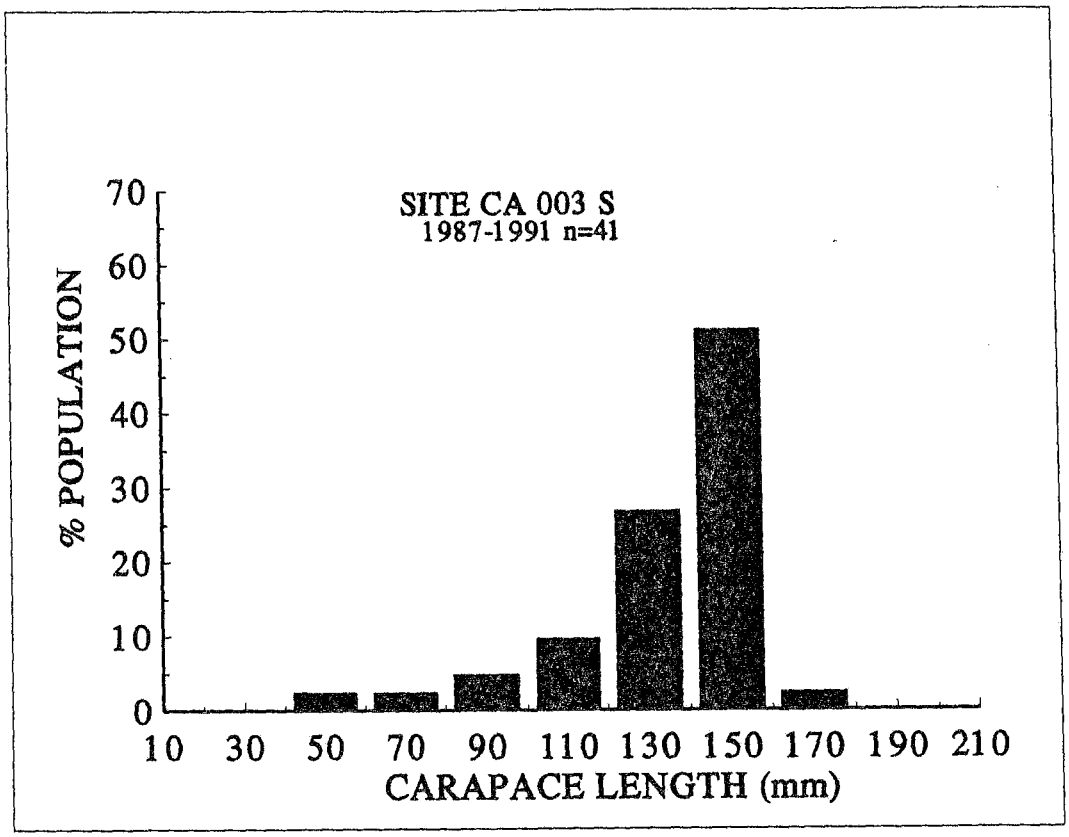


Fig. 53: Comparison of population structure of sites CA 018 S and CA 001 S.



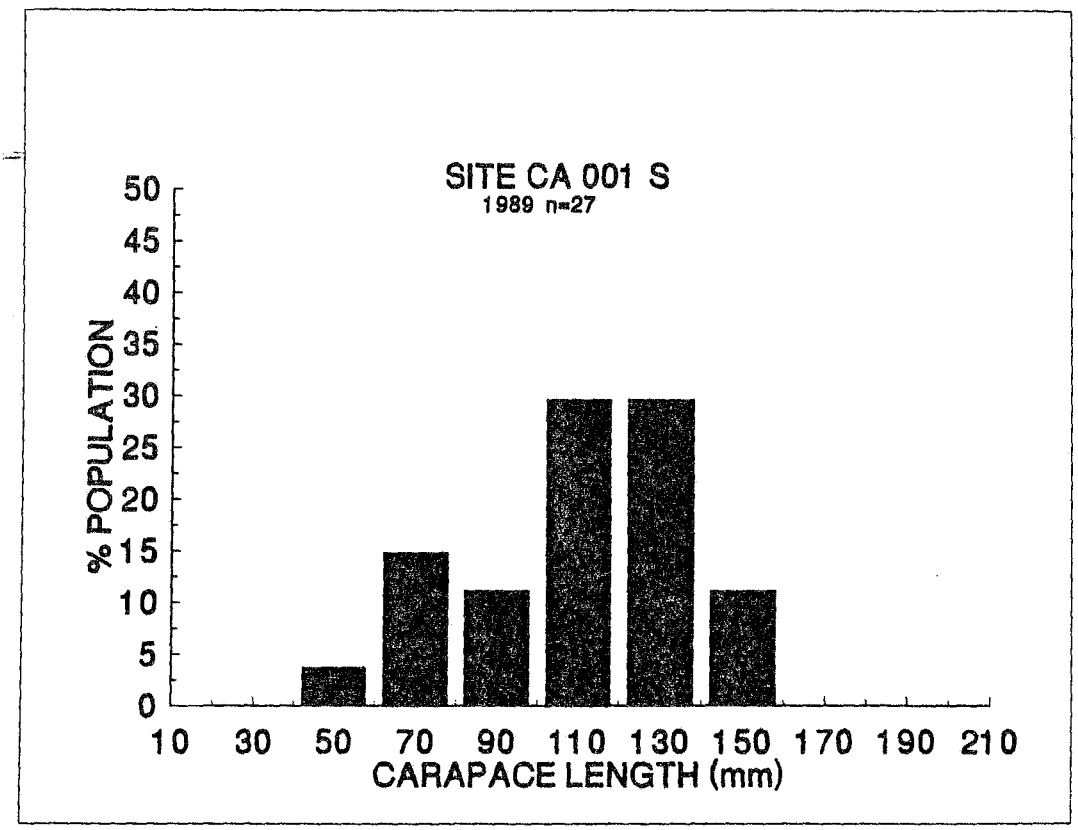


Fig. 54: Comparison of population structure of sites CA 003 S and CA 001 S.

consisted of 73% adults, and 17.2% of the animals were in the <4 y age group. A third site surveyed in 1987 and 1991 (Site CA 003 S) and 42 turtles were captured. This site has bullfrogs in moderate numbers and is paralled by a major highway for most of its length. Adults comprised 90.5% of this population, and 2 animals (4.74%) were in the <4 y age group (Fig. 54).

Clear Lake: The Clear Lake drainage supports the highest percentage of endemic fishes of any system in California (Moyle, 1976), as well as WPTs. The historic condition of the lake, with abundant emergent vegetation, a large prey base and nesting areas probably supported a significant population of turtles. Turtles were formerly abundant enough in this system to support a commercial harvest in the 1910's-1920's (R. Tremper, pers. comm.). The current state of the lake does lend lend itself to the maintenance of large turtle populations, although small groups of animals still exist in some areas. The lake now contains numerous introduced species of fishes (Moyle, 1976) as well as bullfrogs, and extensive development of shoreline areas has occurred. There is also a significant amount of boat traffic on the lake. Existing turtle populations were surveyed in 1988-1989, and were concentrated in the state parks along the south shore of the lake. Of approximately 30 animals observed in one survey, none were less than 130 mm, and the majority were over 160 mm. Given the presence of abundant introduced predators in this system and the degree of development of the surrounding habitat, the lack of small animals in this system is consistent with similar patterns observed elsewhere. Although the total population of WPTs in this system may be moderate in size, it is probable that it will continue to decline due to a lack of recruitment.

San Joaquin: The area drained by the San Joaquin River and its tributaries formerly constituted the stronghold of the WPT. Estimates of the extent of swamp and overflow lands by the State Engineers Office in the 1880's (Harding, 1960) indicate that approximately 242,000 ha were so classified. Examination of both maps and historical accounts (Elliot, 1883a, 1883b; Brown, 1940; Preston, 1981) of the floor of the southern San Joaquin Valley indicate that aquatic habitats were both abundant and widespread, with the warm, shallow lakes (Kern, Buena Vista, Summit, Goose and Tulare) providing optimal habitat for WPTs. Given certain assumptions about the extent of the habitat and densities within those habitats, a rough estimate of total population size for some areas can be made. Examination of maps in Elliot (1883a, 1883b) and Preston (1981) indicate that as of the early 1880's there existed approximately 50,000 ha of swamp and overflow lands in the area of the lower Kern River channels and Kern, Buena Vista and Tulare Lakes. Additionally, extensive marsh areas occurred along the lowland drainages of the Tule, Kaweah and Kings Rivers, as well as in numerous small to moderate sized watercourses such as Goose Lake Slough and Poso Creek. Assuming that these areas covered an additional 5,000 ha the total lowland habitat available for WPTs was approximately 55,000 ha. If approximately 50% of this area was utilized by turtles then the total habitat area becomes 27,500 ha. Turtles were also distributed along river- and streamcourses in upland areas, although presumably not in the numbers

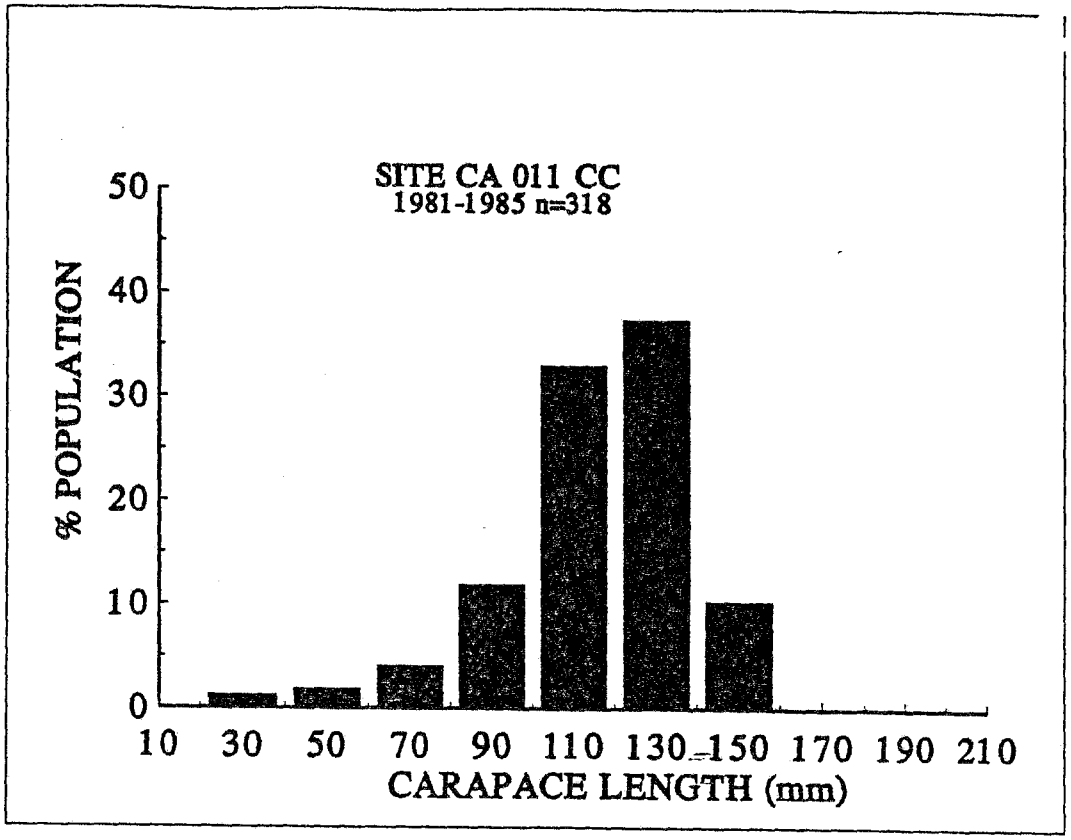
present in lowland habitats. Based upon minimal density estimates of 120 animals/ha for lowland marsh habitats and 200 turtles/mile of river/streamcourse, the total population size for the San Joaquin Valley from Tulare Lake south was in at least 3,350,000 turtles. Similar density estimates for lowland river courses such as the San Joaquin, Fresno, Chowchilla, Merced and Tuolumne rivers and adjacent marsh areas indicate that the total population size for the San Joaquin Valley south of the Stanislaus River may have been minimally between 10,000,000 and 14,000,000 turtles. The total habitat area and density estimates are conservative; Wertschull et al (1984) estimated that there was approximately 105,000 ha of freshwater marsh habitat historically present on the southern valley floor, and known current turtle densities (see Density; Fig. 20) for similar habitats are as much as 1200% higher than the figure used in this estimate. Extensive surveys of the southern San Joaquin Valley floor and the associated upland drainages from 1981-1991 indicate that existing WPT populations in this area are small, highly disjunct and heavily adult-biased. The few remaining populations have undergone progressive reductions in size and have become increasingly fragmented over the last 20 y (Fig. 30). Repeated surveys of at least 10 sites in this area from 1986-1991 indicate that the total population of WPTs in the Kern, Tule, Kaweah and Kings drainages probably does not exceed 1000 animals. This is a conservative estimate; the actual number may be less than 500 animals. Based upon the most conservative estimate, WPT populalations have suffered a decline in excess of 99.95% in the southern San Joaquin Valley. From the Kings River north the situation is not as well surveyed or understood. Small, heavily adult-biased populalations exist along the San Joaquin, Merced, Tuolumne and Stanislaus Rivers and in some small foothill drainages. The total number of turtles remaining is not easily estimable, but may number over 1000 animals. In comparison to estimated historic levels however, WPT populations have still declined in excess of 99.9% in this area. Only four sites of ten surveyed from the San Joaquin drainage north to the Tuolumne had small to moderate populations of WPTs and were free from bullfrogs and bass. One of these sites, however, was located in an ORV park.

Pajaro-Salinas: This area was initially surveyed from 1981-1985, and extensively surveyed from 1987-1991. Turtles were found in approximately 14 sites in this time period. Historically, turtles were probably distributed throughout the drainage from the headwaters to the vicinity of Elkhorn slough. However, the current distribution within this system is highly fragmented due to the drying or dewatering of long stretches of the Salinas and San Benito Rivers, and extensive habitat alteration within this area. In these systems, turtles may occasionally be found in adjacent farm ponds, gravel pits or sloughs which still hold water. Within this drainage bass and bullfrogs were widely but patchily distributed and were noted in 9 of the 15 sites surveyed. The majority of WPT populations surveyed (80%) were small (probably less than 25-30 animals). Of these populations (n=12) all but two were heavily-adult biased. One of the 3 known presumably viable populations one (CA 007 PS) was extirpated by the drought in 1990-1991, and another (CA 001 PS) was reduced by an estimated 88% (see Threats:Drought; Table 3). Although other presum-

ably viable populations may exist in this drainage, as of 1991 only a single population of approximately 150-200+ animals was known from this system. Most of the viable populations noted in 1988-89 were concentrated in the headwaters of the system; the total habitat occupied was less than 8 km of watercourse.

Central Coast: This area is defined as extending from the Santa Maria River northward to the vicinity of the Little Sur River. This area was surveyed intermittently from 1976-1980, and extensively from 1981-1991. Approximately 44 sites were surveyed in this time period, and turtles were observed in 36 of these. The typical habitat for WPTs in this area are the small arroyos/creeks that drain into the Pacific Ocean from the coast ranges. The central coast area is one of two areas that retain some moderate - large populations of WPTs. However, many of the sites noted above contain only small populations and turtles have been extirpated in at least 7 of the sites surveyed. At least two other sites (CA 021 CC and CA 024 CC) (Figs. 32-33) consist primarily of old adults. At least one population (CA 011 CC) surveyed from 1981-1991 has shown a noticeable shift in the size/age composition towards older adults (Fig. 55). Other populations in this area seem to be relatively stable (Fig. 56). The median population size in a series of 26 coastal arroyos was approximately 30-35 animals (Holland, unpubl. data), and the total population size for these drainages probably does not exceed 1500-1800 animals. Bullfrogs were noted in 7 of the systems surveyed and bass in 5. The majority of the 26 arroyos (n=14) are also grazed to varying degrees. Habitat alteration has probably eliminated or severely reduced turtle populations in many of the drainages in metropolitan areas such as San Luis Obispo, and impacted other populations in smaller cities and rural areas to varying degrees. The current situation on the central coast is a microcosm of the status of the WPT, providing both an important historical record and current and future opportunities for assessing the relative impact(s) of development. Some large turtle populations with evidence of adequate recruitment exist in this area in relatively undisturbed habitat (Fig. 56). Other populations are beginning to exhibit signs of declines in recruitment, while a few are already composed primarily of old adults. Still others have been extirpated within the last 20 y. Existing turtle populations face a variety of threats, including ongoing and planned water diversion projects, highway and road construction, urban expansion, population fragmentation and and potential expansion of the range of bullfrogs and bass.

Mojave River: Turtles were historically known from three stretches of the Mojave River totalling about 30-35 km in length. At present, turtles are known from only two locations within this system. Sites CA 001 M and CA 005 M were surveyed in 1989. Thirteen animals were observed at the former site , twelve adults and one subadult. Eleven turtles were captured, and 10 (90.9 %) were adults. One 98 mm subadult was taken. The total amount of habitat at this site consisted of four artificial ponds less than 1 ha in extent, and there was no suitable hatchling/first year microhabitat present at the time of the survey. The animals observed probably represented the majority of the turtles present. There were no bullfrogs or bass noted at this



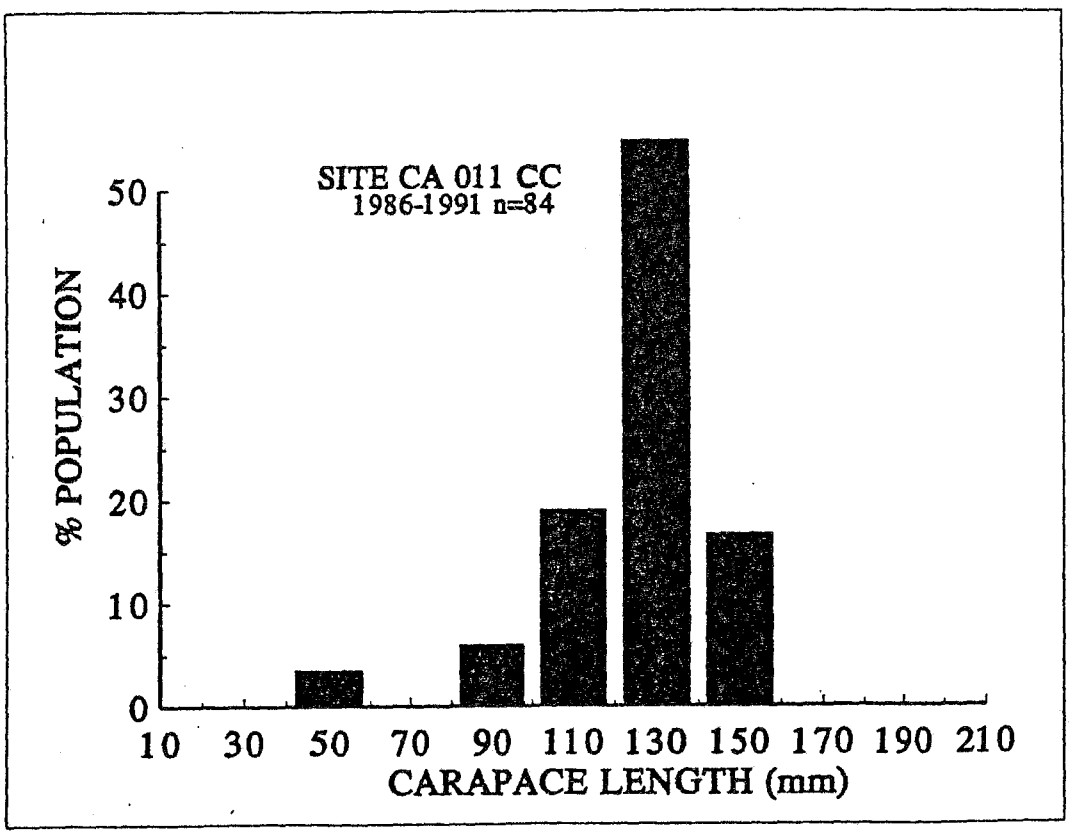
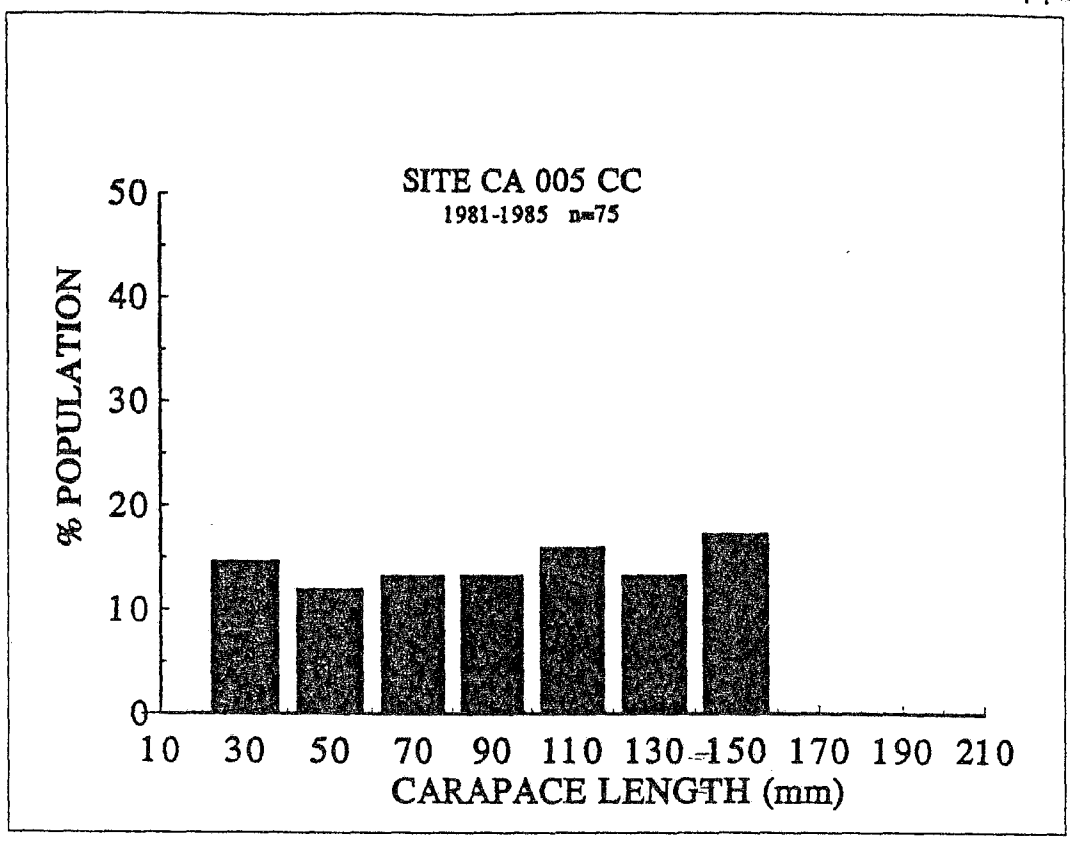


Fig. 55: Comparison of population structure at site CA 011 CC from 1981-1985 and 1986-1991.



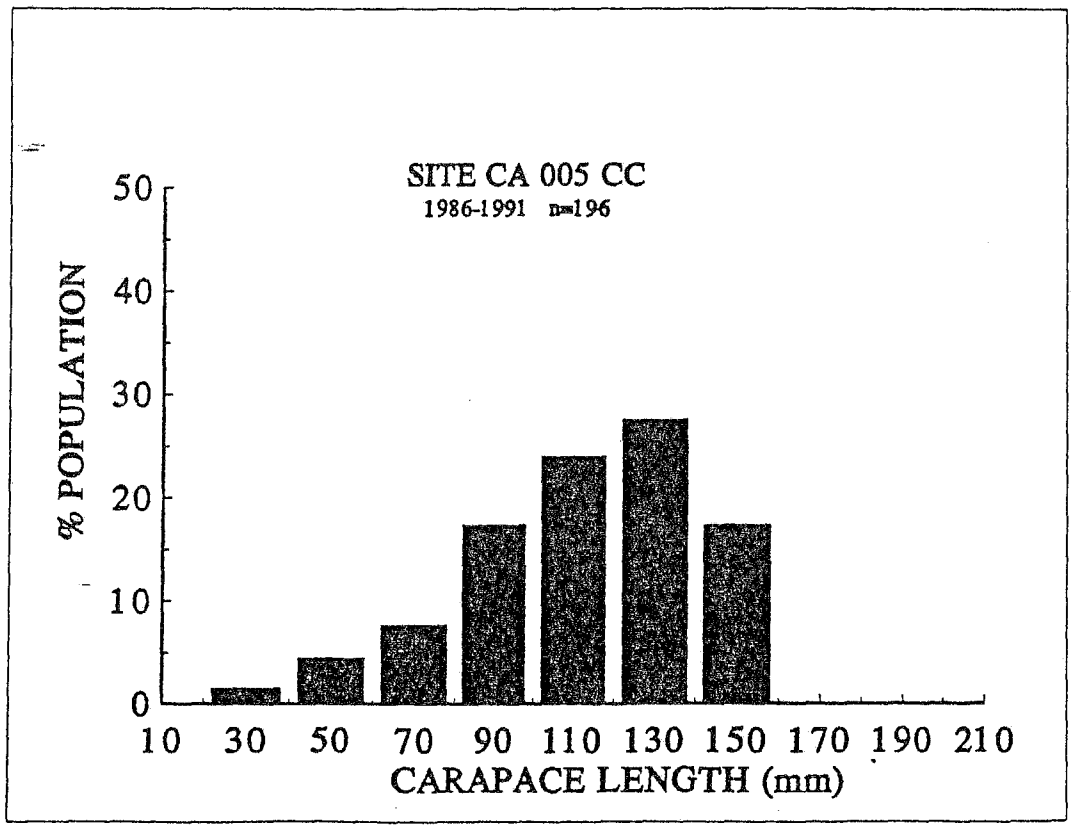


Fig. 56: Comparison of population structure at site CA 005 CC and CA 005 CC.

site, but they are present elsewhere in this drainage. Site CA 005 M was surveyed in the same time period. No turtles were observed in 4 h of search time. The available habitat at this site consists of about 2-2.5 km of rivercourse that is heavily impacted by ORV use. At the time of the survey it was estimated that there were only three small pools totaling less than 800 square meters that were suitable as turtle habitat. Other data (J. Buskirk, pers. comm.) indicate that a few turtles were present at this site in 1990. It is doubtful that more than 10-12 animals remain at this site. Brief surveys of other artificial ponds in this area indicate that they may support a few turtles, but it is unlikely that any substantial populations exist. The status of the WPT in the Mojave River is somewhat similar to that of the Carson River (Nevada); the extant meta-population probably does not number more than 100 animals and the probability of natural re-establishment in the event of extirpation is effectively zero. The size, isolation and fragmentation of the two known populations in the Mojave renders the possibility of extirpation due to chance alone high.

South Coast: This area contains all drainages south of the Santa Maria River. Turtles were historically distributed in probably all watercourses in this area, both permanent and intermittent. Extensive surveys in this area by Brattstrom and Messer (1988), S. Sweet (pers. comm.) and the author indicate that the following pattern seems to hold. In interior Santa Barbara and Ventura counties there exist a small number of moderate to large populations of WPTs, primarily on lands administered by the United States Forest Service. Small and fragmented populations exist at a number of sites in the same area and to a lesser extent along the direct coastal drainages. Surveys conducted along the Santa Ynez River in 1988-1991 indicate that a moderate - large population exists at one site, but is heavily adult biased. Smaller populations (10-20 animals) composed primarily of large adults also exist at at least two other sites within this system. Bullfrogs and bass are found in large numbers at least to the vicinity of Gibraltar reservoir, and existing water diversion efforts have had a significant impact on WPT populations in the upper portions of this drainage. In general, most turtle populations in most of Santa Barbara and Ventura counties appear to be small to moderate in size, lightly to moderately fragmented, and subject to a variety of threats. Furthermore, many of these populations suffered significant declines during the drought (S. Sweet, pers. comm., pers. obs.). Continued development of urban areas, water diversion and management practices, ORV use and the expansion of the range of introduced predators pose significant threats to remaining populations. While there may be as many as 20+ viable populations in this area, the nature and degree of threats will probably reduce this number significantly in the next few years. South of the Santa Clara River the situation is considerably different. Brattstrom and Messer (1988) surveyed directly or by consulting informed sources 255 sites in Ventura, Orange, Los Angeles, Riverside, San Bernardino and San Diego counties. Turtles were noted in only 53 (20.8%) of these sites. Of 218 sites south of Ventura County only 28 (12.8%) held turtles. Of all 218 sites, only 5 (2.2%) held viable populations. As defined by Brattstrom and Messer a viable population consists of 30 or

more turtles. As previously noted (see Threats), viable population size depends on many factors. Some preliminary analysis (Holland, unpubl. data) indicates that in southern and central California, minimum viable population size under undisturbed conditions is probably closer to 50 animals. Surveys in this area by the author in 1987-1991 found two additional viable populations, and a few others may exist in eastern San Diego county. One of these populations was reduced by an estimated 66% by drought and floods in March 1991 (see Drought). Surveys in 1988 of the some of the sites noted by Brattstrom and Messer indicated that at least one of the populations they note as viable may no longer be so. The best available current information indicates that as of 1991 a maximum of 7 known viable populations existed south of the Santa Clara River, and that one or possibly two populations existed within that drainage. Extensive surveys by the author in 1987-1991 failed to reveal any additional viable populations, and most watercourses checked were either heavily altered and/or contained large populations of bullfrogs, bass or both. The survey of Brattstrom and Messer also noted 4 "moderate" sized (defined as >5 and <30) in this area, and 19 "small" (1-5 animals) populations. Surveys by the author located 3 unlisted small populations and one unlisted moderate population. Turtle populations in southern California face all the threats previously described (see threats). Without intensive management, it is likely that a number of marginal/"moderate" and small populations will disappear in the next few years and that existing viable populations will undergo further declines. The total population size south of the Santa Clara River probably does not exceed 1000 animals, and may be significantly less than that. Given the nature and degree of threats and alteration of the surrounding habitats, if populations in this area are extirpated it is extremely unlikely that they will become re-established through natural means. Based upon the current estimated population size, the former and current extent of the habitat, it can be assumed that WPT populations have declined from 95-99%+ in the series of drainages in this area.

A summary of the status of WPT populations is shown in Fig. 57 Basically, all areas and populations classified as "Category 1" would roughly correspond to the classification "Endangered" under the provisions of the Endangered Species Act. The areas and populations classified as Category 2 would correspond to the classification "Threatened". Category 3 means that most populations in these areas are currently assessed as being relatively stable. However (see Summary/Conclusions) these populations face many of the same threats and could easily become Category 2 populations.

EXISTING LEGAL STATUS: The WPT is accorded varying degrees of legal protection within its range. A brief summary is provided below.

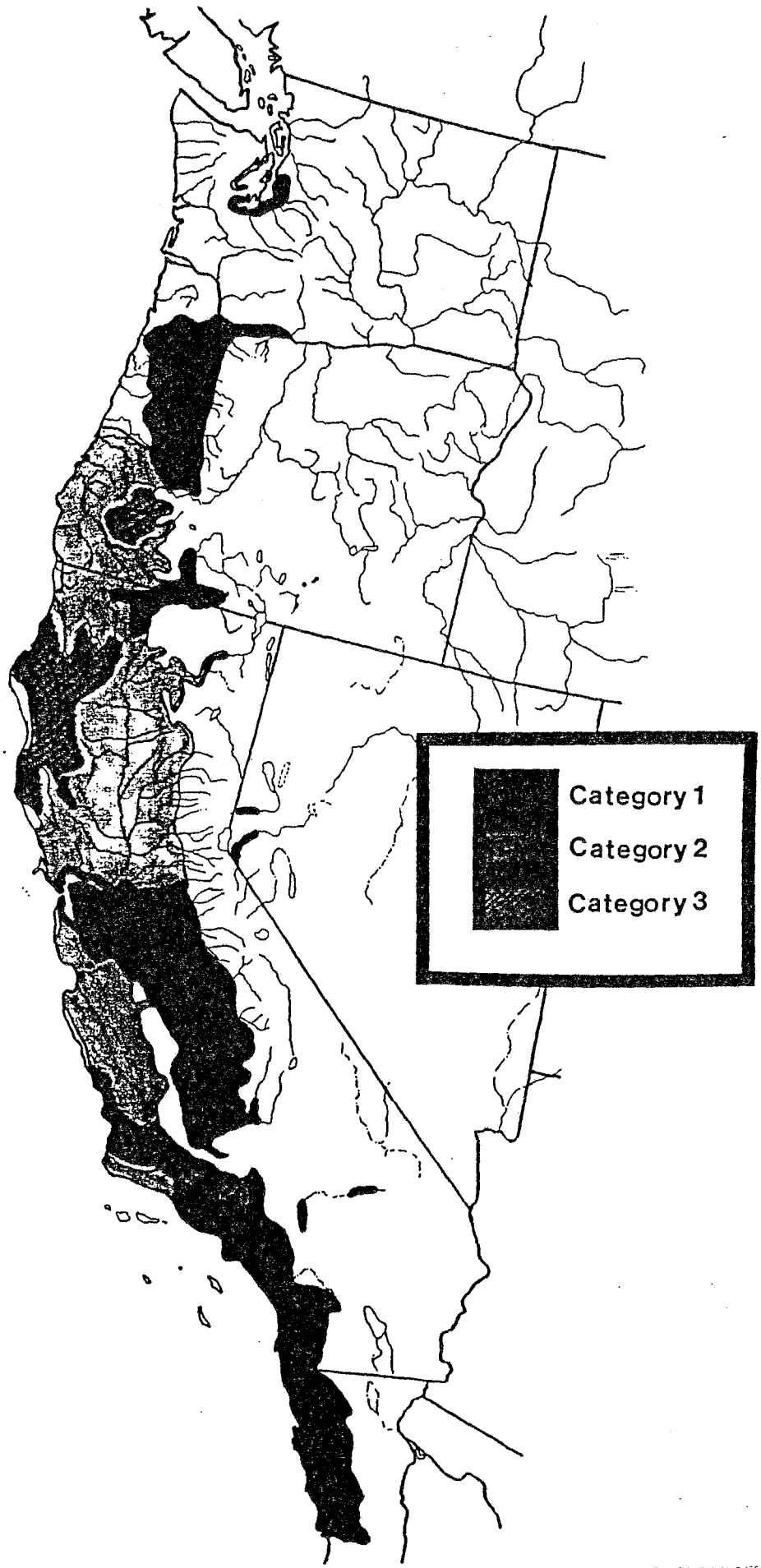
Federal: The northwestern pond turtle (Clemmys marmorata marmorata) is currently listed as a Category 2 species by the United States Fish and Wildlife Service (Federal Register, 21 November, 1991). The southwestern pond turtle (Clemmys marmorata pallida) is listed as a Category 1 species. Category 2 lisitng means that although there is not sufficient information to formally propose the taxon

Fig. 57: Status of western pond turtle populations in 1991.

CATEGORY 1:
- total number of populations low to very low
- almost all populations with evidence of low recruitment or recruitment failure
- evidence of historical decline or reduction
- populations moderately to severely fragmented
- habitat disturbance moderate to severe

CATEGORY 2:
- total number of populations low to moderately low
- most populations with evidence of low recruitment or recruitment failure
- evidence of historical decline or reduction
- populations moderately fragmented
- habitat disturbance moderate

CATEGORY 3:
- total number of populations moderate
- some populations with evidence of low recruitment or recruitment failure
- limited data on historical decline or reduction
- populations lightly to moderately fragmented
- habitat disturbance low to moderate


Category 1
Category 2
Category 3

for listing, there is reasonable cause for concern about its status and further information is needed to proceed with listing. Category 1 indicates that sufficient information exists within the files of the USFWS to warrant the initiation of review for listing. The western pond turtle as a species was formally proposed for listing to the USFWS in December 1991. For a summary of proposed categories of status, see Conclusions.

Baja California Norte: The WPT is nominally protected in Mexico by the actions of Fauna Silvestre, which requires the issuance of a scientific collecting permit prior to any work on or collection of the species. The exact legal status of the species is not known to the author.

Washington: The WPT is currently listed as a threatened species by the Washington Department of Wildlife, and is in the process of being upgraded to Endangered.

Oregon: The WPT is currently listed as a Sensitive Species, subcategory "critical" by the Oregon Department of Fish and Wildlife under Oregon's Sensitive Species Rule OAR 635-100-040. As defined by this law, the "critical" classification applies to those species "for which listing as threatened or endangered is pending; or those for which listing as threatened or endangered may be appropriate if immediate conservation actions are not taken."

Nevada: The WPT is not formally protected under existing state Threatened or Endangered species law, but a scientific collecting permit is required for capture.

California: Legal take of two WPT with a valid fishing license is allowed under provisions of Title 14, California Code of Regulations Section 40.15. The state also lists both subspecies as Species of Special Concern and take of more than the number allowed under a fishing license requires a scientific collecting permit.

SUMMARY/CONCLUSIONS: The western pond turtle evolved in essential isolation from other turtle species, and in a relatively unique environment. The conditions under which this species evolved have fostered the development of many aspects of its natural history which are not easily altered - they have been perfectly adequate for approximately 2 million years . The lack of many types of predators and/or competitors, the nature of the habitats in which it occurs and the basic resiliency of the turtle <u>bauplan</u> in this species allowed the development of enormous population sizes and the occupation of a wide geographic range. The WPT is an animal that is well adapted to the environments in which it historically existed. Unfortunately, these environments are changing rapidly and the characteristics which allowed it to thrive under those conditions now work against the species. Species which lack the ability to adapt to changes in the environment, in essence to evolve, eventually become extinct. There are many factors which control the

balance between a continual process of adapation or extinction, but two of the most important are the nature of changes and the time involved. The long life span, low fecundity and low survivorship of hatchlings and juveniles in the WPT have allowed the maintenance of the species in the face of changing environments. Since the Wisconsonian glaciation, the range, habitats and total population size of the species have undergone significant changes, both positive and negative. However, these changes have taken place over thousands of years. Changes in the environment at least as radical in nature as occurred during the Pleistocene have occurred during the last 100-120 years within the range of the WPT. The western pond turtle is a species that evolved to deal with disturbance on evolutionary/ geological time scales, and has persisted despite radical changes in its environment. The nature and speed of current changes in the environment pose a major threat to the continued existance of this species.

The western pond turtle is in a state of general decline throughout an estimated 75-80% of its range. Localized extirpations have occurred in the area of Puget Sound, the Columbia River, the metropolitan areas of Portland, San Francisco, Los Angeles and San Diego, and the majority of the area south of the Santa Clara River in California. Major reductions (estimated at 95-99%+) in population size have occurred in the Willamette Valley, the San Joaquin Valley, the South Coast drainages of California, and possibly a number of other areas. The factors responsible for these declines include habitat alteration, population fragmentation, predation, drought, disease, commercial expolitation, off-road vehicle use, traffic and roadways, incidental take, illegal collecting and other factors. Faced with the continuance of most of these factors and the strong possibility of future threats, the continued existance of viable WPT populations in many areas cannot be assured under existing regulatory mechanisms and management programs. Given the state of habitat alteration and the number and degree of threats, it is unlikely that viable WPT populations could be maintained in some areas without prohibitively expensive management efforts. In other areas, considerable potential exists to recover and successfully manage populations that are currently non-viable or marginally viable. Given the significant lack of information concerning certain aspects of the natural history of this species that are directly relevant to management considerations, protection and study of the few remaining viable populations are of paramount importance. The mere presence of WPTs in an area, even in moderate numbers, does not necessarily indicate the presence of a viable population. Due to the long life span of the species, isolated individuals may persist in an area for 30-50 years after the population has been effectively extirpated.

Existing regulatory mechanisms, particularly on the state level, emphasize protection against illegal take. Classification as State Sensitive, Species of Special Concern, etc. serve primarily as information-gathering devices to assist in decisions concerning potential listing as Threatened or Endangered. Relatively little to no protection in a real sense is conferred by these actions as they do not address the primary source of most problems with many Threatened and

Endangered species, namely protection of habitats and mitigation of other factors responsible for declines. As such, while protection of a taxon against illegal take is important, it may be only one step in a program designed to prevent further declines in or the outright extinction of a species. In December 1991 this report was submitted along with a formal petition to the United States Fish and Wildlife Service Region 1 office to list the western pond turtle as Endangered in some portions of its range and Threatened in the remainder. Specific recommendations follow.

Washington: Endangered for the entire state.

Oregon: Endangered for the Columbia, Willamette and Klamath drainages. Threatened for remainder of range,

Nevada: Endangered for the entire state.

California: Endangered for the Klamath River to confluence with Scott River, all Clear Lake drainages, San Joaquin Valley from Mokelumne River south to Tejon Pass, Mojave River, south coast drainages from the Santa Clara River drainage (inclusive) south. Threatened for remainder of range.

Baja California Norte: Endangered for the entire state.

ONGOING RESEARCH: Several research projects were initiated in 1991 on WPTs. H. Welsh, R. Wilson and A. Lind of the Redwood Sciences Lab (United States Forest Service) have initiated a three-year survey of habitat utilization, population structure and fecundity, and movement in a population in the Trinity River drainage. D. Reese (Univ. of California-Berkeley) is conducting long-term research on movement patterns among pond systems in northern California, as well as investigating the use of DNA fingerprinting to examine historical aspects of microgeographic dispersal. L. Gray (Univ. of Washington) is involved in modeling various aspects of life history parameters to assist in the development of management strategies and a recovery plan for the state of Washington. The US Fish & Wildlife Service (San Simeon Field Station) is involved in a co-operative effort to census and track movements in a WPT population on the central coast of California. At least three undergraduate theses have been completed at the Claremont Colleges involving various aspects of movement, habitat utilization and "head-starting" of hatchlings in a semi-wild population. The Washington Department of Wildlife is involved in an extensive program to manage and recover populations of WPTs in the state, which includes a captive-breeding and head-start effort. Initial results from the head-start program run by F. Slavens (Woodland Park Zoo) are very encouraging, with as much as 4 years growth being produced in a one-year period in animals allowed to hatch in the wild.

The author's work on assessment of morphological variability and phylogeographic history of the species will be completed in

1992. At present, I am continuing to monitor the status and structure of approximately 45+ populations throughout the range of the species. Some data on aspects of the natural history of the species collected during 1987-1991 will be submitted for publication in 1992; the first deals with the reproductive ecology of the species. Surveys of the status and certain aspects of the reproductive ecology of the species in Washington were completed in early 1991 (Holland, 1991a, 1991b), and the results of the 1991 surveys of status and distribution in Oregon (Holland, 1991c) will be available in early 1992. The author is continuing a collaborative effort with R. Bury (USFWS) to monitor long-term changes in population structure and movement in a northern California population. A significant portion of my research has dealt with determination of movement patterns and variability in interpopulation survivorship. To this end, I have marked over 4500 turtles throughout the range of the species. The US Forest Service, US Fish and Wildlife Service, R. Bury, D. Reese and myself are all utilizing a common marking system (Fig. 58). Recovery of any marked turtles is of considerable interest to us and we would appreciate being informed of any such events. A report form is included with Fig. 58.

Several extensive research and management efforts are in varying stages of planning and/or implementation. The general goal of most of these efforts is to provide effective management-oriented information to allow various governmental agencies to comply with provisions of the Endangered Species Act should this species become listed. Collaborative efforts between the US Fish and Wildlife Service, US Forest Service, Bureau of Land Management, Bureau of Reclamation, Army Corps of Engineers, United States Marine Corps, United States Navy, United States Army, Bonneville Power Administration, Washington Department of Wildlife, Oregon Department of Fish and Wildlife, Oregon State Parks Department, the Columbia Gorge Commission, California Department of Fish and Game, California State Parks Department, The Nature Conservancy and various individuals to facilitate and implement research efforts on this species are already underway or in some stage of planning. I would welcome additional interest(s) in this process, and can be contacted for further details through my forwarding address, given below:

Dan C. Holland
2310 Alturas
Bakersfield, California
93305
(805) 325-3476

GENERAL MANAGEMENT SUGGESTIONS: Given the information noted above, it may seem suprising that the management recommendations/considerations listed below are somewhat vague. This was purposely done for two reasons - 1) the existing state of knowledge on this species allows only general recommendations to be made at this point and 2) existing information indicates that there is tremendous geographic variability in some critical aspects of the life history of this species - what may apply in Washington might not work in southern

PLEASE RETURN TO:

YOUR NAME _____

ADDRESS _____

_____

_____

Dan C. Holland
2310 Alturas
Bakersfield, CA
93305
(805) 325-3476

or

R. Bruce Bury
US Fish & Wildlife
Service - NERC
4512 McMurray Ave.
Ft. Collins, CO
80526-3400

DATE FOUND _____ TIME _____

LOCATION (Please be as specific as possible) _____

_____

_____

_____ COUNTY _____ STATE ____

ESTIMATED DISTANCE TO NEAREST WATER _____

NOTES _____

_____

_____

On the figure to the right (Below), please note any notches/marks on the shields around the edge of the shell. Notches are typically triangular.

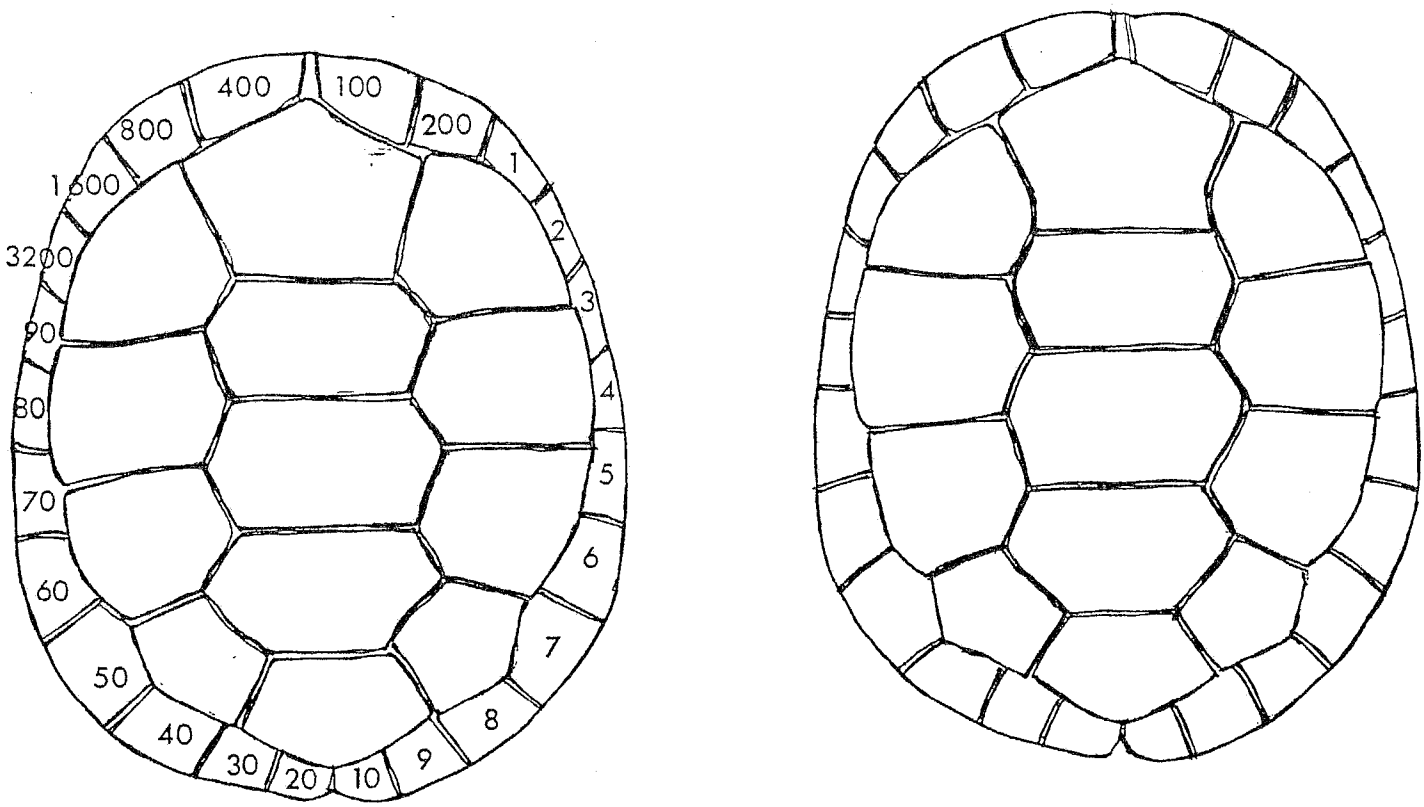


Fig. 58: Marking system and report form

California. Effective management of WPTs will not necessarily be easy, cheap or produce immediate results. Due to certain aspects of the natural history of this species, planning efforts should be considered in long-term time frames - 20-50 year plans are not inappropriate. Although there are many aspects of the species' ecology that may prove difficult to encompass or mitigate for in conventional management efforts, others may partially compensate for the inevitable mistakes that will be made during both currrent and future research and management efforts. The long life-span and broad habitat tolerances displayed by this species may "buy" valuable time while effective mitigation and recovery plans are developed.

Habitat Management, Manipulation and/or Creation: The preferred strategy should usually be to protect and manage habitats in which WPT populations already exist. Maintenance and/or restoration of habitats will usually prove less costly and more effective in the long run than de novo creation of habitat. Habitat protection and management for WPTs will involve considerably more than protection of the immediate aquatic environment as turtles move overland between watercourses and deposit eggs a considerable distance away from the watercourse (Fig. 17). The size of adequate buffers may vary significantly between areas, however as a preliminary recommendation Rathbun et al (in press) suggest a strip 0.5 km (1640 feet) on either side of the watercourse to protect nest sites and potential overland movement corridors.

Maintenance and management of habitats may limit or preclude certain types of activities. The effects of grazing need further study, but it is obvious that in many systems, particularly small watercourses, cattle trample and eat emergent aquatic vegetation and destroy or severely limit the distribution of hatchling microhabitat. For a more extensive discussion of this problem see Threats: Habitat Alteration. Some incidental mortality may occur through crushing of nests. Low-level grazing may be possible in some areas if watering sites (cattle tanks) are located well away from the watercourse and cattle are excluded from riparian areas and nest sites are protected. Human activities such as fishing, boating and vehicular traffic may conflict with management efforts (see Predation, Threats). In particular, disturbance of nesting females should be avoided (Holland, 1991a; see oviposition). This may mean that access to an area or certain types of activities may have to restricted at certain times of the year. The most sensitive period in this respect would be April-July.

The use of fire as a management tool may be important in maintaining WPT populations, either through suppression (short-term) or prescribed burning (long-term). Suppression of fire may be important as a short-term management tool to prevent or minimize loss of nests, nesting females or overwintering turtles (see Threats:Fire) in impacted/depleted populations. However, long-term maintenance of open upland areas for nesting may be critical to the continued viability of WPT populations and may depend on periodic burning. In many areas, these types of habitats are dependent upon fire to prevent or minimize encroachment from shrubby vegetation and trees.

Controlled burning of early-mid successional stages in these types of habitats may improve nesting habitat, but the dynamics of this situation need more study. Prescribed burning as a management tool should take place only when more data is available in this regard.

Similar caveats apply to habitat manipulation (often expressed as "enhancement") or creation. Creation and management of WPT habitat involves far more than simply digging a hole, adding water and throwing in a few logs. Although efforts aimed at creating or enhancing habitat will no doubt proceed without the considerations noted below, all such efforts should ideally be approached cautiously and conducted in such a matter that rigorous analysis can demonstrate the relative efficacy of various approaches and the importance of certain variables. Furthermore, design of created habitats should take into account the concerns noted in numerous areas above; some of these are that 1) creation of the aquatic habitat alone does not guarantee population viability/stability unless (minimally) nesting and overwintering areas are suitable and secure 2) movement among sites may be a part of the historical repertoire of a population, and turtles may not "remain" in a created site 3) creation of new habitats also offers opportunities for the invasion and establishment of exotic species - bullfrogs are notorious in this respect 4) translocation/reintroduction of turtles, especially into created habitats, is fraught with potential problems (see Threats: Translocation/Reintroduction) and 5) it may take several years for succession to establish an adequate prey base in these areas to allow successful maintenance of a turtle population.

Bearing these factors in mind, some general recommendations can be made concerning created habitats. First, the aquatic habitat should be at least moderately heterogenous in structure. Ponds/lakes should have shallow areas to allow emergent vegetation to develop, and deep areas to provide refugia. In particular, some deep areas (>1.5-2 m) will probably be necessary to prevent eventual choking of the pond through growth of certain emergents, specifically cattails and tules. Shallow areas, particularly with growths of small emergents such as reeds and sedges are important microhabitat for hatchlings. Second, sheltered areas where turtles can bask or forage with minimal probability of disturbance should be included in the design wherever feasible. These might include backwater areas, side channels or sheltered coves. Third, most slopes of the pond/lake banks should be low to moderate - probably not more than 15-20 degrees in most areas. However, in some areas slopes might be graded to allow for development of a narrow emergent vegetation fringe adjacent to deep-water areas. Fourth, placement of the site should be planned to minimize visual disturbance from human or vehicular activity. However, other considerations (such as relative locations of potential nesting or overwintering areas) may constrain this factor. Fifth, emergent vegetation should be encouraged to develop, possibly through plantings. The most important groups in this respect are cattails, tules, reeds and sedges. Only species native to the area should be used. Some floating vegetation (Ruppia, Polygonum, Nuphar, Sagittaria) may be established by introduction. Planting of trees along the banks is also important, with the proviso

that only native species be used. Typical species to utilize would include willows, alders, cottonwoods, ash or other species typical of riparian areas at or near the site. Sixth, basking sites should be provided wherever possible, however this should be considered in light of the potential problems noted in Threats, specifically that provision or enhancement of basking sites may make turtles more vulnerable to wanton shooting. Baskings sites should be of varying sizes and types. In many areas, logs appear to be preferred, perhaps due to the nature of heating and cooling of these sites. Ideally, logs should be of native hardwoods or deciduous softwoods. Hardwoods have the advantage of taking longer to decay and it appears that they develop a different algal/arthropod epifauna than do conifers. Branches should be left intact wherever possible. A variety of sizes should be available to turtles, with trunk/branch diameters from 20-25 cm and less. Other basking sites may also be provided. Rocks may be submerged in appropriate areas and should be of a shape that allows turtles to easily climb onto them once the majority of the rock is submerged. Where rocks are not available broken cement pilings or rubble might be used. If the previous two materials are not available, large planks might be utilized. In some areas these should probably be anchored to prevent wind drift from moving the basking site. Placement of basking sites should generally be in near-shore areas, and adjacent to deep-water areas where possible. It is important to note that turtles may not always require "enhancement" of basking sites if sufficient naturally occurring areas/sites exist (such as on emergent vegetation). Seventh, it is important to include in the design and implementation of the habitat creation effort monitoring and evaluation procedures. Given the amount of time, money and effort involved in such a project, examination of the effectiveness of the measures taken is not only economically wise, but also prevents repetition of errors. Eighth, as previously noted, under no circumstances should exotic species be introduced into these habitats, and immediate efforts should be made to eliminate them if they become established.

Habitat "enhancement" or and/or restoration may be important management strategies for the reasons noted above, namely that it is easier to maintain or possibly restore existing habitat than to create new habitats. The two are not necessarily the same - enhancement should presuambly increase the "quality" of the habitat and restoration should presumably return to habitat to some semblance of its former state. As with the general caution noted above, it is proper to note that the current state of our knowledge about the habitat requirements of this species allows only generalizations that are only weakly supported by existing data as to what factors to consider in regard to "enhancement" or "restoration". Perhaps the easiest factor to consider are basking sites. Increasing the number or presumed quality of basking sites has one demonstrated effect - it makes turtles easier to observe. The possibility that it may enhance or increase the viability or stability of the turtle population cannot be denied, but by the same token has yet to be rigorously demonstrated. Nevertheless, enhancement of basking sites should probably follow the same guidelines noted above.

Creation or management of nesting sites is also a possible enhancement strategy. However, this must be considered in light of several factors - 1) possible nest-site philopatry may limit or preclude females from using "enhanced" or managed sites 2) the micro-characteristics of existing nest sites are not well known, and thus duplication or modification of other areas to hopefully reproduce the nature of these sites may not be currently feasible 3) the use of fire as a nest-site management tool should be approached with caution (see above) 4) nest site management/enhancement alone may not be enough to affect population viability if other factors such as predation and hatchling microhabitat quality are not managed concurrently. As above, attempts to create or manipulate nesting areas should be designed with monitoring and assessment in mind. Creation of nesting areas, particularly in created habitats, may involve recontouring of terraces or other areas, soil modification, and/or vegetation management. Slopes in potential nesting areas should probably be less than 15 degrees where possible, placed so as to maximize exposure to incident solar radiation, and face south or southwest where possible. Dominant vegetation should be graminaceous or other herbaceous elements, possibly with some small shrubs. Soils should be well drained, and exposure to water during the developmental period (May-August) minimized (see Reproduction for further details).

In some areas, modification of the watercourse may be a useful management tool. In certain types of shallow-water ponds or lakes, particularly those that dry down in late summer-early autumn, excavation of deep-water (>1.5 m) areas may prove beneficial to turtle populations. This process may be used to maintain some open-water areas to prevent encroachment and covering of the pond by aggressive emergent vegetation such as tules and cattails, and to provide a refugium for turtles as the pond/lake dries down. Additionally, some existing ponds/lakes that currently lack a vegetation fringe due to steep banks might be modified by careful filling of certain areas to create shallows and encourage the growth of emergents. The timing and nature of any watercourse modification should be planned to minimize disturbance or disruption of normal turtle activity patterns, and should only be undertaken after the dynamics and status of the particular population are better understood.

Predation: As previously noted, predators may have a significant effect on the viability of WPT populations through alteration of patterns of recruitment. In this respect there are two categories of predators - native and introduced. The most significant native predator from a management standpoint is probably the raccoon, which are known predators on both turtles and their nests. The majority of WPT nests destroyed by predation are probably victims of raccoons. Under undisturbed conditions, raccoons probably do not pose a significant threat to the viability of WPT populations. However, many turtle populations exist in or near altered habitats. The alteration of these habitats may support larger numbers of raccoons than would be the case in an undisturbed situation, which may in turn increase the significance of raccoon predation. In terms

of management, protection of nests by use of exclosures (see Holland, 1991a) may eliminate or reduce nest predation. Exclosures should be made of moderate - heavy gauge steel or aluminum mesh and at least 35 cm on a side, and secured around the nest by heavy stakes. The mesh size should be large enough to allow free passage of air and sunlight but not so large that hatchling turtles can force a head or limb through. This effectively restricts mesh size to 1/4" or less. Nests so covered should be monitored on a daily basis from 70-110 days after egg deposition to determine if hatchlings are emerging. Shade should be provided should hatchlings emerge from the nest - two 2" dia x 6" long plastic pipes cut in half lengthwise should be generally adequate. A diagram of a nest exclosure is provided in Fig. 59. Once hatchlings enter the water, they remain very vulnerable to raccoons. In cases where management goals include recovery of depleted populations, some degree of raccoon control may be necessary.

Perhaps far more significant are the effects of introduced predators and/or competitors. In this respect perhaps the most serious problem are bullfrogs. Given the feeding habits of the frog, large populations may not only affect WPT populations but those of many other vertebrates as well, particularly snakes, native amphibians, waterfowl and other marsh-nesting birds, and possibly small mammals. Elimination of bullfrogs from a given area is possible only under restrictive circumstances. In the vast majority of cases, cost-effective management may dictate only periodic control efforts. It is very important that once control efforts are initiated they be continued on a regular and frequent basis; the enormous fecundity of even a single pair of adult frogs will allow quick recovery of most populations if control efforts are interrupted. It may be possible to significantly increase WPT hatchling/juvenile survivorship through consistent bullfrog control efforts, even if bullfrogs cannot be eliminated from an area. Control of bullfrogs can take several forms. Direct elimination of adults by shooting or gigging is preferable; experienced hunters can kill several dozen animals in one night. Calling males can be easily located at night with the use of a headlamp; the frequent presence of satellite males allows the opportunity to eliminate several frogs in a short period of time. <u>All</u> bullfrogs observed, regardless of size, should be eliminated. If shooting is the control method chosen, .22 caliber guns are preferred as shooting with .177 caliber pellet guns will often not kill the frog. If deposition of lead in the environment is a concern, gigging may be preferable although it is slightly less efficient. Removal of larvae (tadpoles) is considerably more difficult. In most areas the larvae require 1 year + to metamorphose, and it may be possible to eliminate entire cohorts by selective dewatering of given areas during the late fall or winter. Use of rotenone or other biocides is not in general recommended due to the unknown nature of their effects on WPTs, and their known deleterious effects on the invertebrate prey base. Removal of egg masses is also an important management tool. The egg masses of bullfrogs are usually laid in warm, shallow water, often in areas of emergent or floating vegetation. The masses are easily detected and large - a single one will easily fill a 20 liter bucket. These masses can be removed through use of a fine-mesh dip net or sifting screen. It is important to census likely oviposition

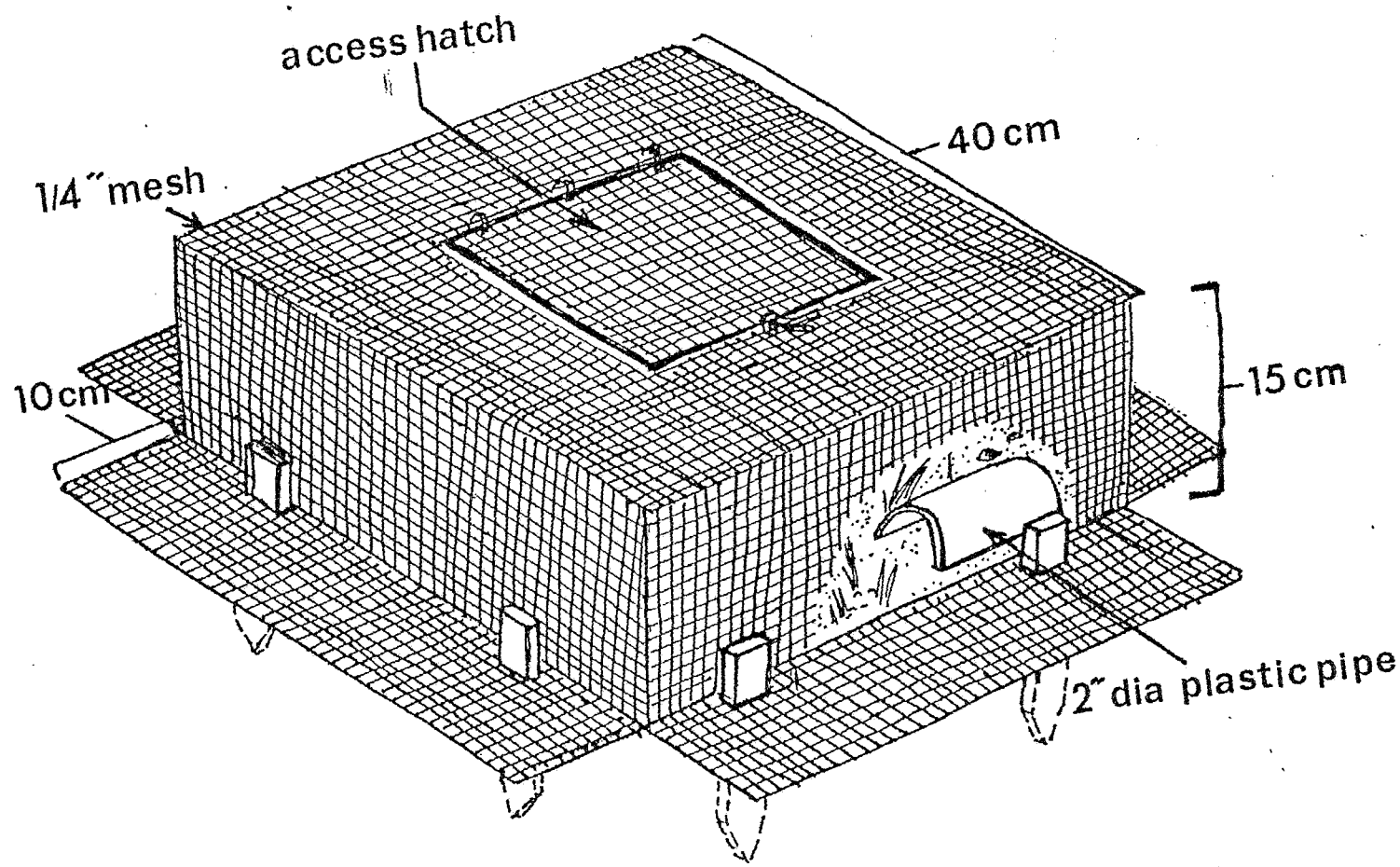


Fig. 59: Nest exclosure.

sites on a daily or bi-daily basis as masses quickly become indistinct due to the growth of green algae. A final consideration in bullfrog control efforts is that every effort must be made to eliminate only bullfrogs; native ranids co-occur with bullfrogs in a number of areas. Native ranids are in a general state of decline and control efforts on exotic species should not excerbate this problem.

Bass are a potentially significant problem in many areas. It is clear that viable populations of turtles coexist with bass in a very few sites, however there are considerably more sites where this situation does not exist. The situations in which coexistance occurs are not known to be stable, and may change to the detriment of the turtle population. As such, removal of all exotic fishes (bass, sunfish, catfish and carp) is a generally desireable goal for management of WPT populations. As above, the use of biocides is not generally recommended for the same reasons. Seining (where practical) may remove significant percentages of the introduced fishes. However, as with bullfrog control, this effort will have to occur on a continuing basis to maintain its effectiveness. The use of gill nets is not recommended due to the possibility of drowning turtles.

Predator control may be among the least costly and most effective of management efforts for WPTs. Strict enforcement of existing state laws regarding the introduction and/or transplantation of exotic species (such as bullfrogs, bass, etc.) would be an important first step. Under no circumstances should the deliberate introduction of exotic species into areas where WPTs occur be allowed. As noted above, the situation where complete elimination of introduced predators is possible will probably be rare. However, it may be possible to significantly improve WPT survivorship and population viability through continuous predator control even if elimination is not feasible.

Translocation/Reintroduction: The policy of translocation of WPTs as a mitigation strategy needs extensive further study, and is not recommended in the absence of certain information (see Threats). Similar caveats apply to reintroductions. Given the occurrence of turtles in "created" or artificial habitats it is obvious that the species can and does invade and occupy these types of areas. However, evidence of the long-term maintenance of viable populations in these situations is scarce. As such, all reintroduction and/or translocation schemes should be approached with caution and with a thorough understanding of the dynamics of a particular situation.

Captive Breeding/Headstarting: Captive breeding efforts are already underway as part of an overall management and recovery plan for the WPT in Washington. In general, captive breeding is not recommended except as a last-ditch effort to salvage populations where all else has failed. Under certain rare circumstances (such as occur in Washington) captive breeding may be the preferred method of re-establishment of extirpated WPT populations. Head-starting may be a valuable tool in the same context, but should only be considered in conjunction with other efforts such as habitat protection and

predator control. The existing captive breeding and head-start program is operated by Frank Slavens at the Woodland Park Zoo in Seattle, and he should be contacted for additional information regarding these types of efforts.

SURVEYS & SURVEY METHODS: There are several methods for surveying WPT populations, which vary in both their accuracy and ease of application. A brief discussion of some aspects of the survey process follows.

Data Collection Forms - Depending upon the goals of the project, a variety of different types of data may be collected. For general survey work conducted in Oregon in 1991, I utilized the form shown in Appendix B. At a minimum, most survey forms should include the following information:

Identity of surveyor - Name of person(s) conducting survey

Date and exact time of survey - date expressed as 06 Apr 1991, etc. and time in military time - i.e. 1330-1450.

Exact location of survey - this should contain a description of the location of the site accurate enough that future survey efforts will have no problems locating it. Appropriate references should include mileage from major crossroads, or other stable reference points. DO NOT use references such as "6 km west of Anywhereburg" except as a precursor to a more detailed description. Township, Section and Range descriptions or UTM coordinates are utilized by many resource agencies and might be included if readily available. As a useful general reference, we utilized the DeLorme Atlas Series, noting approximate survey site locations by reference to the page number, the horizontal letters and vertical numbers on each page, e.g. p. 59 C 7. As atlases are available for California (2), Oregon and Washington, they cover the majority of the range of the species. Alternately, USGS topographic maps could be utilized as both a general and specific reference source.

Watersource Type - this should be clearly indentified as a natural watercourse (i.e. river, stream, lake), a man-made watercourse (reservoir, stock pond, etc.) or a human-altered watercourse (channelized streamcourse, excavated pond, etc.)

Dimensions at survey site - estimated dimensions of watercourse in meters, minimally length and width.

Introduced species - numbers of exotic fishes and bullfrogs observed and/or heard.

Total number of turtles - this should be a count of all WPTs (and other species) observed. Note numbers of other species separately. For the purposes of identification, an illustrated key to the two native species on the west coast and two common exotics is provided in Fig. 1.

Size and sex of WPTs - With some practice, it is possible to identify the sex of WPTs at a considerable distance, even if only the head or shell is visible (see Fig. 3). Estimating the size of turtles takes some practice. A useful technique is to cut out turtle figures of a known carapace length and place them at typical survey distances (50-100 m) and estimate lengths until you become comfortable with the practice and can accurately classify animals to +/- 20 mm carapace length. A series of pre-measured figures are provided for your use in Appendix C. These should be photocopied, cut out and the size written on the back. Conventionally, we record estimated carapace lengths of all animals observed where possible in 20 mm increments, i.e. 30-50, 50-70, 70-90, 90-110, 110-130, 130-150, 150-170, 170-190 and 190-210. If it is not possible to determine the approximate size of the animal, it should be classified as either an adult (>110 mm) or juvenile (<110 mm).

Notes: There should be at least 2-3 lines on the form for notes from the surveyor. These could include behavioral observations, habitat descriptions (if not a standardized part of the form), or other information.

Survey Methodology: Western pond turtles are an extremely wary species and any survey efforts should be conducted with this in mind. The species has excellent vision and hearing, and will see see a potential observer before the observer sees them. The typical response to disturbance is flight/escape behavior. If this occurs the observer may be able to see turtles re-emerge onto basking sites if they take care to conceal themselves and restrict movement. For a more detailed description of escape behavior see Holland (1985a). Some general considerations on survey methods follows.

Observers: Ideally, any personnel involved in any type of survey work on WPTs should have considerable familiarity with the species. Practically, this is unlikely. At the time of writing (Dec 1991) there are approximately 2 dozen people known to the author that can accurately survey WPT populations. Given the number, nature and distribution of ongoing or planned WPT research projects this number will increase in the next few years. Inexperienced observers may not accurately assess the relative or total abundance of the species either at a given site or in total. As such, for persons or agencies planning survey efforts it would be wise to contact your state wildlife agency for recommendations in this matter.

Clothing, movement and behavior: Surveyors should dress so as to blend with the surroundings - avoid bright colored clothing. In certain cases it appears that high contrast between the skin and clothing (i.e. light-colored skin, dark clothing) should be avoided. Long sleeves and pants are often a good idea given the amount of poison oak, nettles, blackberries and other itchy-scratchy plants that occur in WPT habitat. WPTs have color vision and will more rapidly respond to "flashes" of color or contrast than to dull-colored clothing. Surveyors should move slowly and take advantage of existing cover where possible to screen your movements from the turtles. Avoid loud noises, and if it is necessary to talk do so

in a subdued voice. Turtles will often initiate escape behavior on the basis of auditory stimuli alone.

Binoculars and Spotting Scopes: The use of binoculars and spotting scopes is recommended. A good pair of 7 x 35 or 8 x 40 binoculars are adequate for most survey work. Wide-field binoculars are less suitable than those with a narrow field of view. Spotting scopes offer some advantages over binoculars, the most obvious being the increased level of magnification possible.

Timing of Surveys: There are two important temporal considerations when surveying for WPTs. First, it appears that there are "peaks" of activity that occur within the diurnal regime of WPTs. Second, there are peaks of apparent abundance that also occur in relation to the time of year. Daily activity may begin in some areas as soon as the sun rises, but most typically turtles begin to engage in emergent basking by 0900-1000 h, with the maximum # turtles being observed at a given site typically being noted by about 1000 -1100 (Holland, 1985a; Bernard, 1991). This may vary with the time of year - in the late summer months emergent basking may peak by 1000 or may not occur at all (see Thermoregulation). In some areas such as the central coast of California there may be a smaller peak at approximately 1500-1630 h. As such, most surveys should be initiated by at least 0900 and terminated by 1700-1800 unless a more complete picture of daily activity periods is desired. Seasonal variation is a very important consideration in surveys. The percentage of turtles in a population likely to be consistently observed appears to peak in late spring-early summer. There may be considerable geographic variation in this regard; surveys in Washington (F. Slavens, K. Slavens, pers. comm.) indicate an apparent peak in observable numbers of turtles occurring in late April-early May. Along the central coast of California, the peak occurs in late May-June. In most areas visual surveys conducted during August-September will note turtles in areas where they are moderately abundant but may miss them in areas of low abundance. This will also vary with the weather preceeding a given survey (see below). Thus, surveys should generally concentrate on the seasonal period when turtles are most likely to readily observable in numbers proportional to their true abundance (see below), typically late April-early May to July-early August.

It is important to insert a note of caution at this point. Visual surveys alone only rarely observe the majority of members of a population - the rule of thumb based upon a large number of concurrent visual and mark and recapture surveys is that the maximum number of animals observed is <u>usually</u> only about 20% of a given population. Repeated surveys, especially in conjunction with mark- and recapture efforts, may be necessary to accurately assess the size and structure of a given population. Visual surveys also have the disadvantage of being biased towards the larger members of the population for two reasons - 1) larger turtles are easier to see and 2) smaller turtles often utilize different microhabitats in which typical visual surveys are less effective. As such, depending upon the goals of the project, visual surveys alone may not be adequate to answer some of the questions posed.

Temperature/Weather: WPTs are active at a wide range of air and water temperatures. The level and type of activity may often be dependent upon the the differential between the two. In general, most activity takes place when water temperatures are between 16 and 28 degrees Celsius, and air temperatures between 14 and 34 degrees Celsius. Turtles may be active at water temperatures as low as 8 degrees and as high as 39 degrees Celsius. Turtles have been noted moving overland during the winter months at air temperatures as low as 5 degrees Celsius, and during the summer months at temperatures as high as 36 degrees. In situations where air temperatures are actually or effectively (due to wind) lower than water temperatures, turtles may be active but may not engage in emergent basking. In situations where water temperatures are consistently in excess of 28-30 degrees emergent basking may also be very rare. A useful "trick" to observe animals that are aquatic basking in floating vegetation is to "pop" the water surface by cupping the hand and striking the water surface so as to make a "popping" noise. Turtles will often respond to this by elevating the head and neck out of the water to locate the source of the sound, and can thus be censused. Turtle activity may decline dramatically during changes in weather, particularly during the spring when cold fronts following a period of warm weather may effectively eliminate emergent basking for extended periods of time. Turtles may also move overland during periods when weather fronts move through an area, particularly when rain occurs (see oviposition).

Trapping, Mark and Recapture and other survey methods: An important consideration prior to the initiation of any studies involving WPTs is the matter of legality. WPTs are protected by state law in all areas in which they occur. Any efforts which involve handling or even potential disturbance of animals require scientific collecting permits from the appropriate state wildlife agency. Failure to obtain proper permits may have severe consequences for the potential surveyor and/or associated parties. Should the species become listed under the provisions of the Endangered Species Act Federal permits will also become necessary. Given the number of parties involved in ongoing and planned research, it would be wise to contact the appropriate state wildlife agency to prior to the initiation of any research to avoid potential complications in regard to disturbance or interference with ongoing studies. Alternately, I will act as a temporary "clearing house" in this respect until a more formal procedure can be developed. Correspondence can be sent to me at the address previously noted.

Each survey method has both advantages and disadvantages. The advantages of trapping are that 1) it is relatively "low-cost" in terms of time and effort 2) it can be conducted with a minimum of training and 3) it potentially allows multiple sites to be surveyed within a short period of time. The disadvantages are 1) trapping results tend to be heavily adult-biased, as small animals either will not enter the traps or can easily escape 2) traps are initially difficult to set 3) animals quickly become "trap-shy" 4) the possibility of mortality is greater with this method than any other and 5)

non-"target" species may be taken. Mark and recapture efforts have the advantages of 1) accurate assessment of population size and structure 2) collection of important ancillary data on reproductive status, growth, survivorship and habitat utilization patterns and 3) allowing some level of comparison with other such studies. The disadvantages are that 1) it is relatively "expensive" in terms of time and effort 2) it requires specialized training and 3) it limits the number of sites that can be surveyed within a given time period. The advantages of visual surveys are that 1) they are relatively "cheap" in terms of time and effort and 2) they allow multiple surveys to be conducted within limited time periods. The disadvantages are that 1) properly conducted visual surveys require some specialized training and/or knowledge 2) survey results are often heavily dependent upon variation in local topography, observer skill, weather and other factors and 3) a large number of surveys may be necessary to accurately assess size and structure of a population.

The preferred method of population estimation survey combines various aspects of all three of these methods. Ideally, inital surveys should be conducted through snorkeling or skin-diving for turtles and the turtles captured should be weighed, measured, marked and released at the exact site of capture. As with other techniques, diving requires a considerable amount of skill and knowledge of the habits of the species to be effective as a survey method. At minimum, the captured animal should be sexed, weighed to the nearest gram and the straight-line carapace length measured to the nearest mm (Fig. 60). Additional linear measurements can be taken at the discretion of the surveyor. Notes should be taken on the presence of scars, missing limbs or or shell/shield abnormalities. Assessment of the reproductive status of females is valuable information but requires some training (see below). Animals can be marked by making shallow (4-5 mm) notches in the marginal shields with a small-medium fine-toothed triangular file. This produces a permanent mark that is known in some cases to last for at least 23 years. Small animals (<60 mm) can be marked by cutting small notches out of the appropriate shields with a pair of iridectomy or other small scissors. As previously noted (see above and Fig. 58), an existing marking system is already in extensive use. As I have marked large numbers of turtles in over 100 localities throughout their range, please contact me before any marking efforts are initiated. The use of two marking systems and efforts at a site has the potential to create enormous problems.

Turtles may be marked to assist in follow-up visual surveys. The preferred method is to use white fingernail polish and paint a large two-digit number on both sides of the carapace. The size of the number should vary with the size of the turtle, but should normally occupy a significant percentage of the 2nd and 3rd costals (see Fig. 60). The nail polish, if allowed to dry well (20-30 min) before replacing the animal in the water, will last 4-8 weeks under normal circumstances. I <u>do not</u> recommend marking any animal under 90 mm carapace length or gravid females as the potential increased exposure to predation almost always outweigh the benefits of the data collected. Turtles marked with this system are often

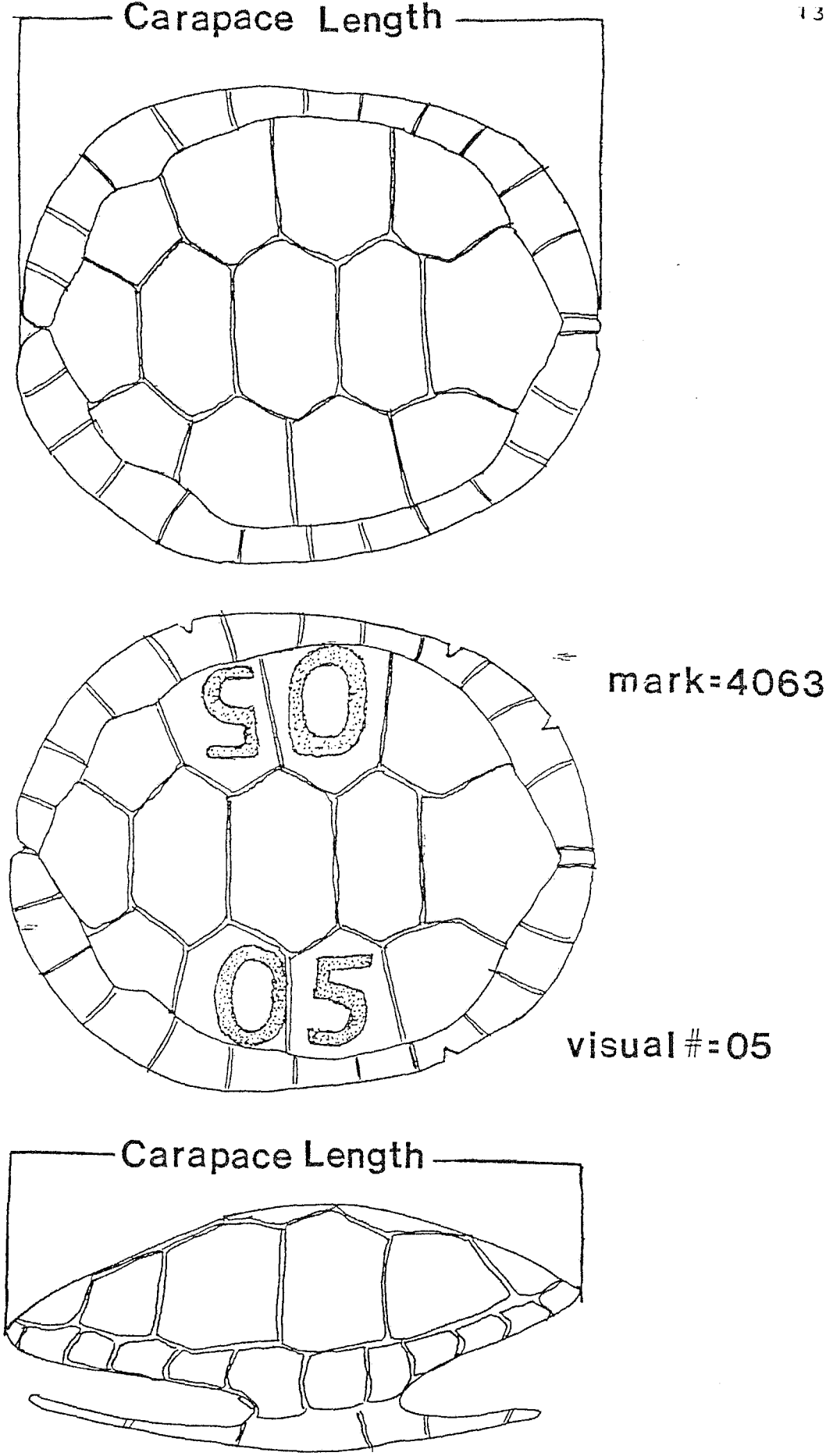


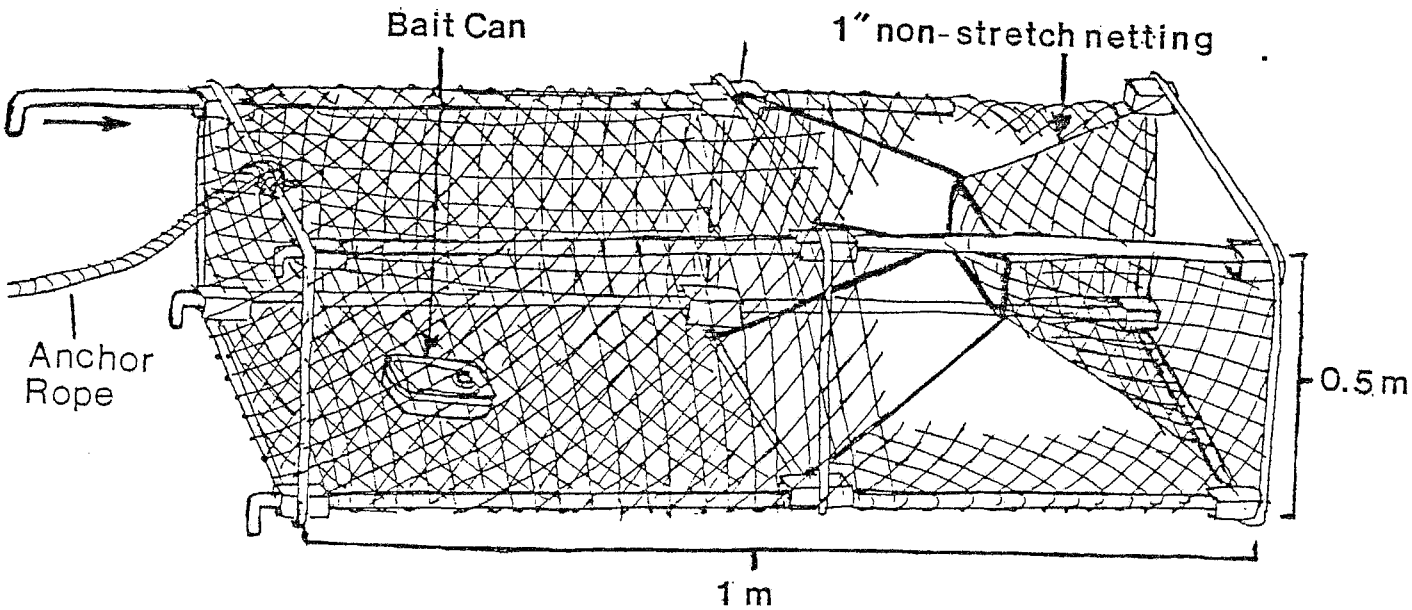
Fig. 60: Measurement and marking system.

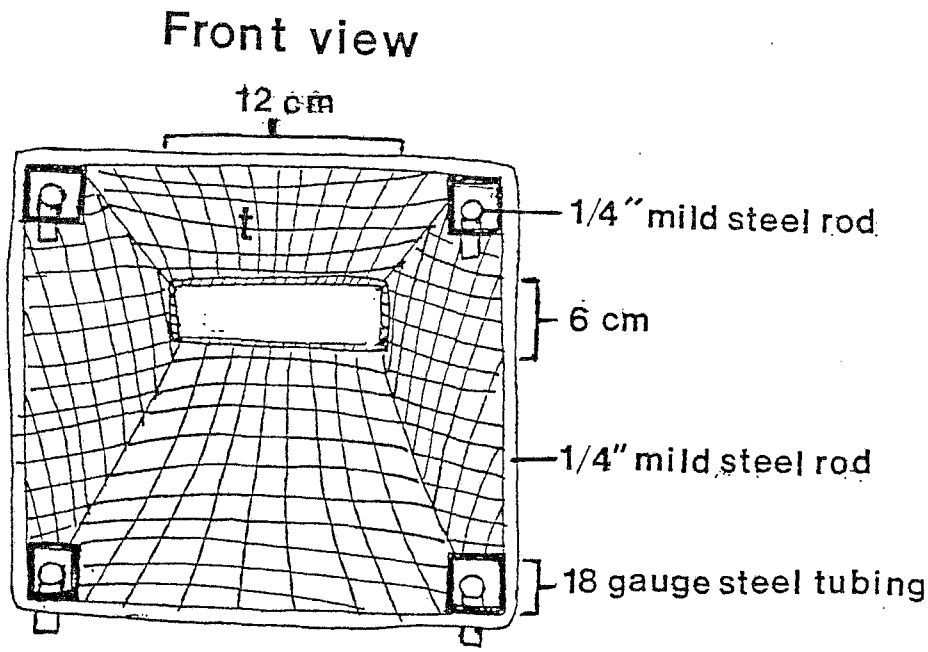
identifiable at distances in excess of 100 m with 7 x 35 binoculars.

Continuation of the survey can be conducted through repeated hand-sampling (by diving), visual surveys and/or trapping. A typical trap is shown in Fig. 61. The dimensions on this trap are not fixed, and could be increased (particularly in length) to suit the needs of a particular survey. This trap is collapsible - removal of the 4 support rods allows the trap to telescope to a height of approximately 10-12 cm. Cost per trap averages about $7-10 for materials, and construction time with practice requires 1.5-2 h. The metal framework of the trap can be made of either mild steel or aluminum; however steel is easier to weld in most cases. Netting should be secured relatively tightly to the frame - loose areas allow possible entanglement of turtles and risk of drowning. The netting should be ONLY 1" NON-STRETCH netting - cotton will work but deteriorates more rapidly than nylon. Stretch netting may entangle and drown turtles. Traps can be baited with fresh fish, but I have generally found canned sardines or herring ("fish steaks") in oil to be more effective. All bait, whether canned or fresh, should be tied to the bottom of the trap. The funnel/neck of the trap should always be placed "up" (toward the surface of the water). Placement of the trap may be critical to success - ideally traps should be placed in shallow water near foraging areas and on or near basking sites. Traps should be placed so that at least 4-5 cm of the netting on one end will protrude above the surface to allow breathing space for turtles. Traps should be placed and firmly secured so as to preclude any possibility of the trap slipping into deeper water, thus possibly drowning turtles. The time it takes for turtles to enter traps seems to vary widely - I have captured turtles within 20 min of placement and on other occasions it may take several days for the turtles to enter the trap. In general, traps should be placed in the water early in the morning (prior to 0700), checked at least every 2-3 h and removed just before dark.

Although WPTs are a remarkably tough species, handling should be limited to minimize stress. Data collection and marking should be done as quickly and efficiently as possible, and the animal returned to the exact site of capture. Survey tools usually include a clipboard for data forms, a 20 l plastic bucket to temporarily hold turtles, a pair of 200-300 mm calipers, several small-medium triangular files (they dull quickly) and a 1 kg scale with a minimum accuracy of 10 g.

Fig. 61 - Collapsible turtle trap





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23 December 1991

Dear Colleague,

Enclosed you should find (1) a copy of my latest status report on the western pond turtle and (2) a copy of the listing petition. First of all, the status report contains some typographical and pagination errors that I hope will not cause too much of an inconvenience. For example, page 34 is not missing but was skipped. I would be interested in hearing your comments or suggestions on this report as it is convenient for you. This report contains sensitive locality and population structure information, and is intended for intra- or inter-agency use only. I would appreciate it if you do not make copies available to the general public or to consulting firms for a variety of reasons. Thank you in advance for your cooperation in this matter.

The petition is essentially an abstract of material contained in the report, and will be submitted in late December or early January to the US Fish and Wildlife Service. In co-operation with Mark R. Jennings (California Academy of Sciences) and Marc P. Hayes (Oregon State University), a joint petition to list the western pond turtle and the California red-legged frog (Rana aurora draytonii) will be submitted concurrently. We welcome your imput on this matter, and will advise you when the official notice is published in the Federal Register soliciting information.

As noted in the section of the report entitled "Ongoing Research", there are a number of ongoing and planned research activities involving the western pond turtle. In an effort to coordinate research plans, Bruce Bury (US Fish and Wildlife Service) and I will be hosting a pond turtle symposium/informational meeting in the Resources Agency Building, 1416 Ninth Street, Sacramento, California on January 31, 1992 from 0800-1700. The primary goals of this symposium are threefold 1) to coordinate and integrate research goals and methods for the species on at least a basic level 2) to present natural history and other information relevant to management concerns for resource agency personnel and 3) to develop a network of contacts to maintain communication concerning the status and management of the species. The basic purpose of this meeting is informational; we do not plan to hold any training sessions in survey methodology per se but we will consider holding a 1-2 day "school" for this purpose in May if there is sufficient interest.

To this end, we cordially invite your attendance or the attendance of other interested persons at this meeting. Please fill out the attached form and return it to Bruce Bury by Jan. 24th. While the meeting will be informal and registration is not required, filling out the enclosed form will assist our planning efforts. We will mail you an itinerary with maps, lodging information, etc. as soon as we finalize the details. Thank you for your interest, and I hope to see you in Sacramento on the 31st.

Sincerely,

Dan C. Holland

Dan C. Holland

THE WESTERN POND TURTLE (Clemmys marmorata)

This taxon (hereafter WPT or Clemmys marmorata) was historically the only native freshwater turtle over most of the west coast (Stebbins, 1985). The species was very abundant within large parts of its range, and commercial harvest of the species occurred from at least the 1870's (Lockington, 1879; Brown, 1940) to the 1920's (Storer, 1930), and possibly later. There are currently two described subspecies within this taxon (Seeilger, 1945). The northwestern pond turtle (Clemmys m. marmorata) occurs from the area of the American River northward to the Columbia River, and the southwestern pond turtle (Clemmys marmorata pallida) occurs from the vicinity of Monterey south through the coastal drainages to the vicinity of the Sierra San Pedro Martir in Baja California Norte. The central valley south of the American River to the vicinity of Tejon Pass is decribed as an area of intergradation of the two subspecies (Seeliger, 1945). Outlying populations of C. m. marmorata occur in the vicinity of Puget Sound (Washington), Grant County (Oregon) and the Carson and Truckee Rivers (Nevada). The Grant County population is probably the result of an introduction in the 1970's (Nussbaum et al, 1983). Outlying populations of C. m. pallida occur in the Mojave River (California). A map of the the range is provided in Stebbins (1985).

Clemmys marmorata has a life history that is characterized by low fecundity, low survivorship in hatchling and juvenile turtles, high survivorship as an adult and a potentially long life span. Age and size at first reproduction varies geographically, a few animals from the southern part of the range (Transverse ranges of California south) may reproduce at sizes as small as approximately 110-115 mm and seven years of age (Holland, unpubl. data). However, most females seem to reproduce first at 120+ mm and 8-9 years of age. This situation also occurs on the central coast of California, with the smallest known gravid female being 122 mm. In northern California, the smallest known gravid female was 130 mm and probably 10-12 years old. In central Oregon, the smallest known gravid female was 138 mm and probably 12-14 years old. Examination of the reproductive status of 1735 females from 1987-1991 indicates that the majority of females in a population oviposit in alternate years, although a small percentage may deposit eggs every year. Clutch size is positively correlated with carapace length (r=0.754) and the range is 1-13 (mean=5.69). Females typically leave the watercourse in late afternoon or early evening and move a considerable distance overoverland to excavate one or more nests. All known nest sites are in non-riparian habitats adjacent to the watercourses turtles inhabit, and distances range from a minimum of 16 m to a maximum of 402 m (Storer, 1930; Holland, unpubl. data). Females are very sensitive to disturbance during overland nesting movements, and may excavate one or more nests (Holland, 1991; Rathbun et al, in press). Incubation time in captivity under controlled conditions is 73-80 days (Feldman, 1982) and the few records from naturally incubated nests (Holland, 1991) indicate a period of from 95-106 days. Hatchling western pond turtles are from 23-31 mm carapace length, and weigh 1.5-5 g. It is likely that the majority of hatchlings in many areas overwinter in the nest (Holland; 1985a, 1991). Hatchlings emerge and move to the watercourse in early spring, usually March to April. Survivorship

in hatchlings and first year animals is typically low, averaging about 8-12% (Holland, unpubl. data). Growth is rapid, with hatchlings effectively doubling their size in the first year of growth. Animals typically reach 80-90 mm by their fourth year, and growth rates vary significantly on both an intra- and interpopulation level after this point. Secondary sexual characteristics usually become apparent in both males and females at 110-120 mm carapace length. Survivorship in adults appears to be high once this size range is reached, and the adult population appears to average a 3-5% turnover rate/year (Holland, unpubl. data).

Western pond turtles are active year-round in the southern part of the range and along the central coast of California. In the central valley and areas north, activity typically begins in March and peaks in June-July, decreases gradually in August, increases briefly in September, and usually terminates by November. At least some percentage of the population apparently leaves the watercourse in October-November and moves into adjacent upland habitats. Animals have been found overwintering several hundred meters from the watercourse.

Western pond turtles spend considerable amounts of time engaged in thermoregulatory behavior. Emergent basking typically begins shortly after emergence from overwintering sites. Animals utilize logs, rocks, emergent vegetation, mud or sand banks, or human-generated debris as basking sites. Aggressive interactions on these sites are common (Bury, 1972; Bury and Wolfheim, 1973; Holland, 1985a), and as many as 70+ turtles have been observed on a single site. Turtles also engage in "aquatic" basking, utilizing thermal microenvironments within the aquatic habitat to engage in thermoregulatory behavior (Holland 1985a).

Clemmys marmorata can be classified as a dietary generalist, with the majority of the diet being composed of small aquatic invertebrates (Holland, 1985a, 1985b; Bury, 1986). However, some small vertebrates (fish and anuran larvae) are taken in northern California (Bury, 1986) and carrion is frequently utilized (Holland, 1985a, 1989; Bury, 1986). Plant material typically makes up a small percentage of the diet. WPTs typically forage throughout the water column, utilizing both vision and scent to locate prey items. Most foraging appears to occur during daylight hours, however turtles may be active throughout the night during the summer months. Turtles will also take trolled, floating or bottom-set baits used by fishermen (Holland, pers. obs.).

There are numerous known predators on western pond turtles, including black bear (Euarctos americanus), coyote (Canis latrans), grey fox (Urocyon cinereoargenteus), domestic and feral dogs (Canis familiaris), river otter (Lutra canadensis), mink (Mustela vison), raccoon (Procyon lotor), bald eagle (Halietus leucocephalus), bullfrog (Rana catesbeiana) and largemouth bass (Micropterus salmoides). Suspected predators include striped skunk, opossum, beaver, nutria, bobcat, feral pig, osprey, great blue heron, red-shouldered hawk, black-crowned night heron, raven, common crow, giant garter snake, two-striped garter snake, California red-legged frog, striped bass, white bass, smallmouth bass, the larger species of catfish, rainbow trout (steelhead), and giant water bugs. Although there are few predators that can effectively deal with adult turtles in the water (such as mink and river otters), turtles are ex-

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tremely vulnerable on land. Raccoons and possibly skunks are major nest predators, and raccons also take adults. Adult female turtles typically show evidence of attempted predation (shell scarring, missing limbs) at a level 6-7 times that of males. These mutilations are probably incurred during overland nesting movements. Loss of a hind limb may effectively preclude the ability of a turtle to successfully excavate a nest.

The WPT is a habitat generalist, occurring in a wide range of both permanent and intermittent aquatic environments. This species historically occurred from sea level to 5000 feet, although turtles are scarce anywhere above 4500'. Two records are known for localities above 6000 feet, but these may represent introductions or waifs. Turtles occur in brackish-water habitats along the California coast, and can tolerate prolonged immersion in sea water (Holland, unpub. data). Historically, WPTs occurred in most watercourses throughout its range. Optimal habitat was the series of warm, shallow lakes and the extensive slough systems that formerly covered much of the floor of the central valley (Elliot, 1883; Brown, 1940, Harding, 1960; Preston, 1981). In the few remaining microhabitats that approximate these conditions, the WPT typically achieves densities in excess of 1000 animals per hectare of water surface, and densities as high as 3700 animals/ha are known. Given these densities, it is likely that this species constituted the dominant element of the vertebrate biomass in many aquatic ecosystems on the west coast. Currently, the primary habitat for this species are the small-medium sized streams in montane areas. Turtles are patchily distributed along some of the larger rivers, such as the San Joaquin, Sacramento, Klamath and Umpqua. Turtles are also found in some small farm ponds and other modified watercourses such as canals and reservoirs. Although WPTs are habitat generalists, hatchling and juvenile turtles have relatively specialized habitat requirements, and the microhabitats which hold these age/size classes are often very limited in a given area, and highly susceptible to disturbance of various types.

From 1976 to the present I have been conducting research on this species. Between 1976 and 1981 I made approximately 150+ surveys of the distribution and relative abundance of this species in central California. Although 100+ of these surveys were made at only 4 sites, an additional 40+ sites were surveyed throughout the area. From 1981 to the present I have conducted over 700 surveys at 250+ sites throughout the range of the species. The areas surveyed included many localities where WPTs were historically present as reflected in museum specimens or literature records. Of all sites surveyed, I would estimate that turtles were present in approximately 65-70% of the localities surveyed. However, over 100 additional sites that historically were likely to have held turtles were also examined. The degree of habitat alteration was such at these sites that it precluded the possible existance of WPTs. Although the WPT still occurs throughout the majority of its former geographic range, it has been completely or effectively extirpated from many areas. Total population size of the species has declined significantly from the levels present prior to the advent of European man on the west coast, and the few remaining areas that hold moderate-large viable populations face a variety of threats. The categories of threats

that historically and currently affect WPT populations follow those outlined by Soule (1991) as (1) loss of habitat (2) fragmentation of habitat with concommitant effects on population viability (3) overexploitation and (4) the spread of exotic species. Other threats which may pose significant problems for WPTs include pollution and long-term climatic change. What follow is a brief discussion of the impacts of each of these factors on the western pond turtle.

WPTs have been utilized as a food resource by a number of native American cultures, including the Modoc (Howe, 1968). However, there is no apparent mention of this use in other areas, such as by the valley-floor Yokuts in the Tulare Lake basin (Latta, 1949). Commercial exploitation probably began shortly after the California Gold Rush in 1849, but the first published record is that of Lockington (1879). The commercial demand for the food trade had already depleted populations of California red-legged frogs (Rana aurora draytonii) and WPTs in the immediate environs of San Francisco by this date, and market hunters for both species were moving as far afield as the area of Visalia (central California) to supply the market. At this time, extensive commercial operations were conducted on Tulare Lake, with the schooner Water Witch being used to support a fishing and turtling operation there in the late 1870's to early 1880's. Exact harvest figures are scarce, but it is known (Elliot, 1883) that one operation shipped at least 2160 turtles in one season to the San Francisco market. Other information (M. Jennings, pers. comm.) indicates that the total catch was enormously higher than this. Smith (1895) estimated that 18,000 turtles per year were offered for sale in the San Francisco market. According to incidental commercial collecting records sproadically maintained by the California Department of Fish and Game the trade continued until at least the late 1920's, with a minimum of several hundred to several thousand turtles being reported as taken each year. The commercial collection of WPTs for food undoubtedly played a significant role in initial population reductions in this species. The impact was probably most significant on populations where habitat conditions allowed for easy mass collection, such as in the lakes on the floor of the San Joaquin valley (Kern, Buena Vista and Tulare) and in slough and riverine habitats throughout the San Joaquin and Sacramento valleys. However, California Fish and Game records indicate that in the early part of the 20th century there were still substantial collections from many areas of the state that did not possess the types of habitats previously mentioned. There is some evidence that the illegal commercial collection of this species for food continues today, and may have a very significant impact on remaining populations, particularly in southern and central California.

Concurrent with the initial population reductions caused by commercial collecting, WPTs also suffered from two other types of impacts - habitat alteration and the introduction of exotic species. Widespread alteration of WPT habitat was well underway by the 1880's with the extensive "reclamation" of "swamp and overflow lands" (Elliot, 1883; Brown, 1940; Harding, 1960; Preston, 1981). The timing of extensive water diversion efforts for agricultural and other purposes varied, but led to the elimination or alteration of WPT habitat throughout much of its range. Among the most signiicant losses were in the central valley

of California and the Klamath and Willamette drainages in Oregon. Additional habitat losses were incurred through the construction of dams and the creation of reservoirs along many watercourses. The existance of these impoundments had several negative effects, among them 1) alteration of historical patterns of water flow within a drainage and negative impacts on downstream habitats 2) direct elimination of WPT habitat in the area of the dam and reservoir 3) creation of habitat suitable for the maintenance and spread of exotic species which have deleterious effects on WPTs (see below) 4) fragmentation of existing populations and interference with normal movement patterns and 5) creation of barriers to normal dispersal and concommitant decreases in the probability of reestablishment of extirpated populations. All of these factors have had moderate to severe negative impacts on WPT populations. Surveys of all reservoirs in the southern Sierra Nevada from the Merced River south from 1981-1991 and of selected northern Sierra reservoirs from 1987-1991 indicate that while WPTs are occasionally observed in these systems, no cases are known of the existence of viable populations within these impoundments are known. Similar situations have been observed along river systems in southern California, central coastal California, northwestern California, the Klamath, Rogue and Willamette drainages in Oregon, and along the Columbia drainage in both Oregon and Washington.

Other forms of habitat alteration have affected and continue to affect WPT populations. Widespread channelization of watercourses for flood control and water diversion have eliminated considerable amounts of WPT habitat along small to medium-sized watercourses, especially in the central valley of California and southern California. Urbanization facilitated by these efforts has also played a major role in the elimination of WPT habitats, particularly in southern California. Grazing may also play an important role in modifiying WPT habitats. California has a history of extensive grazing (Burcham, 1957), which is known to adversely affect the structure of aquatic and riparian habitats (Kauffman and Krueger, 1984; Marlow and Pogacnik, 1985). In particular, trampling or consumption of emergent vegetation along watercourses may adversely affect survivorship in WPTs as this decreases or eliminates the microhabitat utilized by hatchlings and juveniles. Cattle also trample streambanks and modify or eliminate undercut areas (Platts, 1981) typically utilized as refugia by turtles, thus increasing their susceptibility to predation.

Another form of habitat alteration with significant consequences for WPT populations has been the five years of drought suffered by the west coast from 1986-1991. Surveys on several turtle populations in southern and central California during this time period have revealed an interesting pattern. Turtles were moderately abundant during 1987-1988 and capture rates/h were equivalent to many northern California watercourses presumably minimally affected by the drought. Increased drying of the watercourses concentrated turtles in smaller and smaller areas of the watercourse, such that by 1989-1990 capture rates were very high and turtles might be found in only a few small pools within several miles of river or stream channel. All turtles in these situations were obviously stressed, with no apparent body fat reserves. Increased mortality was expected and observed during 1990-1991, with some populations being completely extirpated, and other populations

displaying a 66% (minimum) to 90%+ decrease in size. The drought also exacerbated existing problems with population fragmentation and other forms of disturbance.

Another less obvious form of habitat alteration with major ramifications for WPT population viability is the destruction or alteration of nesting habitat. WPTs are known to make extensive overland movements to construct nests; distances of up to 1/4 mile are known (Storer, 1930) and other information (Holland, 1991) indicates that distances of over 150 m from the watercourse are not uncommon. Extensive alteration of upland areas or other habitats adjacent to watercourses in which WPTs occur is not uncommon, and in many of these sites the WPT populations are extremely adult-biased with evidence of recruitment declines or failures. In many of these situations the lack of recruitment cannot be easily assigned to a single cause, as introduced predators are also present. However, there is sufficient reason to indicate that alteration of nesting habitat is cause for concern.

Introduced predators have also had a major impact on WPT populations. The two most significant in this respect are bullfrogs and bass. An excellent analysis of the effects of bullfrogs and predaceous fishes on native frogs is provided in Jennings and Hayes (1985) and Hayes and Jennings (1986). Similar effects are known or postulated for these exotic species on WPTs. Bullfrogs are known predators on WPTs (Moyle, 1973; Holland, unpubl. data), as are bass (Holland, pers. obs.). Bullfrogs are particularly significant because of their catholic dietary habits, their widespread occurrence and large population sizes within the range of the WPT, and their habit of foraging in the microhabitats favored by hatchling and juvenile western pond turtles. Available information (Holland, unpubl. data) indicates a negative correlation between the presence of bullfrogs and the presence of hatchling and juvenile WPTs. A similar situation exists for bass and hatchling turtles, although in some special situations coexistence may be possible. Also of concern are the effects of other introduced fishes, specifically carp (Cyprinus carpio and Carassius auratus) which may impact WPT populations through elimination or modification of emergent vegetation, and sunfish (Lepomis spp. and Pomoxis spp.) which may compete with turtles for the avaialable food supply. Larger catfish (Ictalurus spp.) may also prey on turtles or compete for the available prey base.

There is considerable evidence that incidental human predation may also affect WPT populations. Accidental catch by fishermen, either by hook and line methods or by nets, often leads to the death of the animals involved. Surveys in California from 1981-1991, Oregon in 1987-1991 and Washington in 1990 indicate that this may be a significant source of mortality for some populations. Mortality through crushing by traffic may also be a significant problem in many areas, particularly as many turtle habitats are traversed by or parallel to roads. Loss of nesting females, which constitute a small percentage of any population, may be a major factor in the decline of the species in some areas. Off-road vehicles pose a significant threat to WPT populations in many areas due to direct loss through crushing or illegal collection and/or

f the aquatic or nesting habitat. In most areas where this curs, WPT populations small and existing in marginal habi- ɜ are less likely to be able to withstand the effects of disturbance. Furthermore, the isolation of these sites ɛtremely unlikely the possibility of re-establishment of :ions by immigration from adjacent habitats. Boat traffic ɜ may also pose a threat through disturbance of normal activity patterns, alteration of hatchling/juvenile vandalism (shooting) or illegal collecting, and/or hing access.

y also play a role in the decline of WPT populations. Evi- study in Washington in 1990 (Holland, 1991) indicates that eptible to a URD (Upper Respiratory Disease) syndrome at noted in the desert tortoise (Gopherus agassizi). The is not known with certainty, but may have been a virus or ead and moribund turtles were first observed in May and e noted throughout the study. Thirty-eight turtles were ng the epidemic and provided with extensive veterinary he efforts of the Washington Department of Wildlife, the Zoo and the Center for Wildlife Conservation. Despite the over $60,000 and extraordinary efforts by staff and con- narians, over 50% of the turtles in this group died. y in this population in the summer of 1990 was approxi- To date, this is the only documented example of this syn- However, at least one animal from the Willamette drain- same period displayed lung lesions similar to those noted n the Washington population. The only positive aspect of as that it occurred in an isolated population under inten- ould this disease become established in an area where ntinuously distributed (such as the Trinity River) it is ny effective measures could prevent massive mortality.

of the action of the various factors noted above has been ecrease in the total population size of the WPT as as ugh turtles are distributed throughout most of the phic range of the species, localized extirpations have WPT has been completely extirpated from the type locality Puget Sound. Localized extirpations have also occurred of the Columbia drainage, many areas in the San Joaquin ropolitan areas of San Francisco, Los Angeles and San aining populations are fragmented to varying degrees, a variety of threats. In Washington, WPTs are known tes along the Columbia River and the total population es not exceed 100-110 animals. A single population roximately 4 square miles is known from the Oregon side drainage. While exact estimates are not available, this robably does not number over 200 animals. Approximately conducted in the Willamette drainage in 1991, and le populations were found at only three sites. Eighty- all turtles observed in the Willamette surveys were qua drainage was the site of 41 surveys, and turtles

were noted at 62% of all sites. However, only two demonstrated viable populations were observed in the upper end of this drainage. The two largest populations in the lower part of the drainage consisted of 100% adult turtles. Approximately 30 surveys were made along the Rogue drainage in the same time period, and turtles were noted in 23% of all areas surveyed. A single moderate-large population was noted during this study, and consisted of 84% adults. Fourty-one surveys were made along the Klamath drainage and turtles were noted in 33% of all sites surveyed. A single viable population was noted in the extreme upper end of this drainage. Adults comprised 89% of all animals observed in this system and almost 96% of all animals captured. As noted above, although turtles were noted in a large number of sites, examination of the structure of these populations indicates that they are in almost all cases comprised primarily or solely of adults, with little or no evidence of recruitment.

Surveys conducted in Nevada in 1987-88 indicate that turtles are known only from the Carson River drainage, although a few animals may persist in the Truckee River. Adults comprised over 90% of the animals observed, and it is likely that the entire population in the state does not number more than a few hundred animals.

Surveys of drainage systems in California reveal a variety of patterns, many of them similar to those observed in Oregon. Turtle populations in the Klamath River drainage and its tributaries vary from small and heavily adult-biased to the largest remaining WPT populations known. The latter occurs in a very small portion of the drainage (one stream) and is subject to a variety of threats. Other populations in this area have been impacted by dam construction, introduced predators and other factors. In the central valley (Sacramento-San Joaquin drainage system and tributaries) most turtle populations have undergone dramatic declines in size and have become increasingly disjunct. Although the quality of the data varies from area to area, reasonable extrapolation from the known extent of the habitat(s), probable historical densities based upon known current densities and a thorough knowledge of the status and size of remaining populations, indicates that the most conservative estimate would be that turtle populations have declined in excess of 99.9% in the southern San Joaquin Valley, and by probably 95-99%+ in the remainder of this area. At present only one possibly viable population is known from the area south of Tulare County. The Pajaro-Salinas drainage contains relatively few turtle populations currently, and those remaining were severely reduced or in some cases extirpated by the effects of the drought. The few known viable populations remaining in this drainage are moderate in size, highly disjunct and occur in very limited habitats. The central coast (Monterey south to the Santa Clara River) contains a moderate number of moderate-sized populations. Although some of these populations are apparently stable, they face a growing number of current and future threats and their long-term stability cannot be guaranteed. Other populations in this area are beginning to show signs of recruitment declines or failures, due to some of the factors previously discussed. Many of the populations in this area were also severely affected by

the drought, with population declines of from 66-90% + being documented during 1990-1991. The Mojave River drainage at present contains one known population restricted to a few hectares of habitat. Surveys in 1989 indicated that the total population in this system probably does not number in excess of 100 animals, and may in fact be smaller than that. The extremely disjunct distribution of this population would effectively preclude any possibility of natural re-establishment should the population be extirpated. The status of the species in southern California has been examined by Brattstrom and Messer (1988) and the author. Brattstrom and Messer noted that south of Ventura County, only 12.8% of 218 sites surveyed held turtles, and only 5 sites (2.2%) held viable populations. Surveys by the author have verified the general conclusions of this report, south of the Santa Clara River (inclusive) there are only 7-9 viable populations known. Many of these populations were severely reduced during the drought, with losses of up to 66% noted in one population.

In summary, the data noted above and in the enclosed report indicate that the western pond turtle is in a general state of decline throughout the majority of its range. At present, populations appear to be stable in only about 20-25% (maximum) of the total area of the range. Localized extirpations have occurred in many areas, and significant reductions in population size and distribution have taken place in others. Existing populations in many areas are suffering from declines in or outright failure of recruitment, such that these populations are composed primarily or solely of adults. The reasons for the overall decline of the species and current recruitment problems are numerous, complex and not easily disentangled in terms of relative significance. The primary factors are thought to be direct or indirect alteration of aquatic and adjacent habitats, historical commercial exploitation, the effects of introduced predators, population fragmentation and drought. Other potentially significant effects may include pollution, disease and disturbance by human activities. That western pond turtles remain in many areas today is a testament to the resiliency of the species. However, the mere presence of turtles in an area is not a guarantee of a lack of problems. Due to the nature and long (potential) life-span of this species, significant numbres of WPTs may occur in an area for decades after the population has been <u>effectively</u> extirpated through lack of or declines in recruitment. Existing populations face a wide variety of current and future threats throughout their range, and the future of this species cannot be assured given the cuurent level(s) of protection afforded it under state law(s). Therefore, pursuant to provisions of the Endangered Species Act of 1973, we hereby formally petition the United States Fish and Wildlife Service to list the western pond turtle (<u>Clemmys marmorata</u>) as Endangered in the areas noted below, and Threatened in the remainder of its range (as specified below). As the nature and degree of threats vary between areas, the proposed listing status also varies.

Endangered: Washington - (entire state)
Nevada - (entire state)
Oregon - Columbia, Willamette and Klamath drainages and associated tributaries
California - Klamath River and tributaries downsream to confluence with Scott River, all Clear Lake internal drainages, all central valley drainages from the Mokelumne River (inclusive) south, Mojave River and all desert drainages, all southern California drainages from the Santa Clara River (inclusive) south

Threatened: Remainder of range, including but not limited to:
Oregon - Umpqua, Rogue and coastal drainages and tributaries
California - Klamath River and tributaries downstream from Scott River confluence, all other north coast drainages, all central valley drainages from Mokelumne River north, all non-central valley drainages from San Francisco Bay south to the Santa Clara River

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WESTERN POND TURTLE SYMPOSIUM/INFORMATIONAL MEETING
Resources Agency Building, 1416 Ninth Street
Sacramento, California
Jan 31, 1992

Name(s) _____

Agency or affiliation _____

Mailing Address _____

_____ZIP _____

Phone ( ) _____

☐ Yes I am interested in attending. Please send me further information.

☐ I will not be able to attend but would like receive additional information on the species and/or meeting results.

☐ No, I am not interested in attending or receiving additional information.

I will need (circle appropriate response):

Directions - yes no Lodging information - yes no

Parking directions - yes no Dining information - yes no

Other (specify) _____

_____

_____

Please return to: R. Bruce Bury
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