2002 California Freshwater Shrimp (*Syncaris pacifica*) Surveys Within Point Reyes National Seashore and Golden Gate National Recreation Area

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Photo courtesy Gary Fellers, USGS-BRD

EXECUTIVE SUMMARY

During 2002, the lower gradient sections of 13 streams within Point Reyes National Seashore and the Golden Gate National Recreation were surveyed for the presence and status of the federally endangered California freshwater shrimp (*Syncaris pacifica*). Survey sites were chosen based on the professional judgement of National Park Service (NPS) staff regarding the habitat requirements of the shrimp and the location of potential shrimp habitat on NPS land. Field results confirmed the presence of freshwater shrimp within Olema Creek along a 650 m section near the confluence with Lagunitas Creek. However, no other freshwater shrimp were found in the remaining sample sites. Other species of interest that were collected during sampling activities included western pearlshell mussel (*Margaritifera falcate*) on Olema Creek and the Tomales asellid (*Caecidotea tomalensis*) on Glenbrook Creek. Post-metamorphic California red-legged frogs (*Rana aurora draytonii*) were observed at Glenbrook and Laguna Creeks.

INTRODUCTION

The California freshwater shrimp (*Syncaris pacifica*) is listed by the U.S. Fish and Wildlife Service as endangered (55 FR 43884) and is the only extant member of the genus. The shrimp is endemic to 16 coastal streams in Marin, Sonoma, and Napa counties north of San Francisco Bay, California.

The shrimp is found in low elevation (<116 meters), low gradient (generally <1 percent), perennial freshwater streams where banks are structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation. Existing populations are threatened by introduced fish, deterioration or loss of habitat resulting from water diversion, impoundments, livestock and dairy activities, agricultural activities and developments, flood control activities, gravel mining, timber harvesting, migration barriers, and water pollution.

Within Point Reyes National Seashore and Golden Gate National Recreation Area, the shrimp is found within the Lagunitas Creek watershed. The current range of the shrimp within Lagunitas Creek extends from Shafter Bridge in Samuel P. Taylor Park to roughly 1.6 km below the confluence with Nicasio Creek (Serpa 1994), and within the lower reach of Olema Creek, near its confluence with Lagunitas Creek. Shrimp habitat along main stem Lagunitas Creek within the Parks is generally protected from agricultural activities that are present within the watershed.

A survey of *Syncaris pacifica* (California freshwater shrimp, hereafter termed 'shrimp') was conducted by the National Park Service during the summer and fall, July-October, 2002, within 13 creeks of the Golden Gate National Recreation Area and Point Reyes National Seashore. Of these 13 streams, Olema Creek was the only creek surveyed in prior years (Serpa, 1996; Serpa, 1997; Fong, 1997) for the presence of shrimp that was also included in the 2002 survey. All other streams surveyed in 2002 had not previously been surveyed for shrimp. Streams chosen were presumed to have perennial flows, slow moving water, and low gradients, which have been shown to be preferred shrimp habitat features (Li, 1981; Serpa, 1994; Serpa, 1996). Five of the creeks surveyed are tributaries of Lagunitas Creek, the site of the largest known population of shrimp: Olema, Bear Valley, Zanardi, McIsaac, and Cheda Creeks. Another four streams sampled are feeder creeks to the bays of Drakes/Limantour Estero: Glenbrook, Muddy Hollow, Schooner, and Home Ranch Creeks. Four creeks drain directly into Drakes or Tomales Bay proper: Laguna, Shell Beach and Coast Creeks. Lastly, Kehoe Creek empties directly into the Pacific Ocean.

The main purpose of the 2002 study was to:

- Assess current status of shrimp in Olema Creek
- Determine presence and distribution of shrimp in previously unstudied streams within the Point Reyes National Seashore

A secondary goal of this study was the collection of atypical or non-native aquatic macroinvertebrate voucher specimens and as an indication of the general ecology of habitat associated with the presence/absence of shrimp. We were particularly interested in gathering additional distributional data for the rare Ricksecker's water scavenger beetle (*Hydrochara ricksecker*i), Tomales asellid (*Caecidotea tomalensis*), and California floater (*Anodonta californiensis*). Lastly, the number of salmonids was also recorded, as many creeks in this survey had not previously been evaluated for salmonid presence.

METHODS

The duration of survey time within each of the 13 Point Reyes creeks varied due to length of viable creek habitat, ease of upstream passage, and amount of organisms found. Survey time per creek lasted from one day to one week, depending on the aforementioned conditions. Those creeks with the highest likelihood of shrimp present were surveyed first: Olema and Bear Valley creeks. All other creeks were studied in no particular order. An individual stream was divided into reaches, and evaluated by each reach separately for species and habitat characteristics. A new numbered reach was established when habitat conditions changed notably. An example of such a change would be a stretch of creek running through marshland, with exposed, grassy embankments, giving way to a region of dense woodland with willow and alder cover. The change from marshland to woodland constitutes two separate reaches for that single creek. For some creeks there was only one reach noted.

Within all 13 streams surveyed for shrimp, a consistent sampling method was employed. Streams were surveyed from the mouth in an upstream direction, both sides of each creek's banks sampled equally with a single pass. The upstream direction of travel prevented clouding of the water in front of the surveyor. A butterfly net was used to vigorously shake undercut and overhanging vegetation and roots known to be suitable habitat, in areas of appropriate depth out of the main channel flow (Serpa, 1998). However, less ideal undercut and overhang habitats in varying flow conditions were also sampled, as most streams surveyed had no previous shrimp data established to rule out their presence in marginal habitat conditions; the assumption being that the shrimp's tendencies may adaptively vary from stream to stream. The butterfly net was frequently emptied, no more than approximately a hundred feet from the initial sample site, for two reasons: 1) Minimize duration of stress to organisms captured, and 2) Ability to return organisms (especially shrimp) back to their original substrate cover. Although the overall method of sampling is highly intrusive, particular care was taken to disturb the riparian habitat as little as possible. This included avoiding the use of bank edges for stepping into and out of creeks, not entering creeks in stretches clearly unsuitable for shrimp (i.e., depths of < 0.10m or fast-moving waters).

Net captures were emptied into a shallow pan of fresh creek water and carefully sifted through for organism identification, counts, and size measurements.

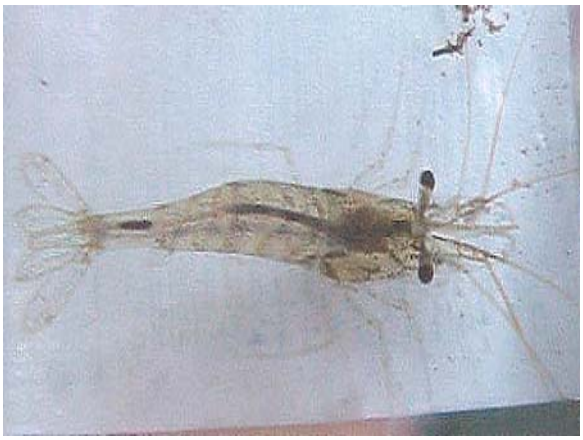
Organisms of specific interest, including shrimp and unknown species not to be retained as voucher specimens, were individually placed in small transparent containers of water for photographing. All shrimp were categorized as adults (≥ 25mm) or juveniles (< 25 mm), and sexed when possible. When applicable, notes were made on any shrimp injury or mortality. Those organisms intended as voucher specimens were placed in labeled jars of 70% alcohol. Subsequently, all remaining pan contents were returned to the vicinity of capture. No shrimp were retained as specimens under any circumstances. Sites where shrimp were found were marked by flagging and coordinates were recorded with a Trimble GPS unit. Besides species information, each creek was evaluated for vegetation overhang and undercut quality and quantity, water conditions, and overall suitability for shrimp. The environment immediately bordering the riparian habitat was also considered in the evaluation. Data sheets were used to record all parameters measured (Appendix I). A Sony Mavica 14x zoom camera was used for all photography, a standard Fisher thermometer for temperature readings, a meter stick for creek depth and length, and an Oakton TDSTestr 3 meter for specific conductance (± 0.02mS/cm). Although many parameters of this study were quantifiable, the overall habitat evaluations had to be qualified by description, which lends itself to a certain measure of subjectivity. However, determinations of potential shrimp habitat were based solely on present conditions observed and the known habitat preferences of this species (Serpa 1996). Photo documentation was recorded for each creek to further substantiate qualitative findings.

RESULTS

The following section provides an overview of the collected field data per creek. It also includes photographs that characterize the general habitat conditions observed at each creek during the survey. The data (in parentheses) included for each stream are survey duration, survey distance, and map information. If surveys had unsurveyed sections, those are noted as "discontinuous." Where possible, milepost markers along the roads were recorded to aid future relocation of sample sites. Appendix III contains the UTM coordinates for the starting and ending points for each surveyed creek reach.

<u>Olema Creek:</u> **(8 days, 3625 meters, Appendix II-Sheet 4)**

(Olema Creek, downstream view)



(A *Syncaris pacifica* individual found in Olema Cr)

The California freshwater shrimp population in Olema Creek is much smaller than is found in Lagunitas Creek, into which Olema empties. In 1996, a single adult was found in Olema Creek, and then 3 more adults and 1 juvenile were found there in 1997, which indicated a possible reproducing shrimp population present year round. In 2002, 7 shrimp individuals were found in different locations along the very lowest section of Olema; the first shrimp identified was approximately 200m upstream of the Olema and Lagunitas Creeks confluence, and the last one was found approximately 850m from that confluence. Thus all 7 individuals were found within about a 650m section of the creek. The last shrimp identification site was in line with the northern end of Olema pasture. Of the 7 shrimp individuals identified, 3 were juveniles (< 25mm long from rostrum to telson) and 4 were adults (25mm or > from rostrum to telson). There is no positive confirmation on the sexes of any individual.

Other species of macroinvertebrates found within the same environment as the shrimp were caddisflies (Family Phryganeidae), damselfly larvae (Suborder Zygoptera), freshwater snails (Order Gastropoda), predaceous diving beetle (Family Dytiscidae), dragonfly larvae (Suborder Anisoptera), mayfly larvae (Order Ephemeroptera), cranefly larvae (Family Tipulidae), and several unknown invertebrate larvae. Another interesting specimen found was the shell of the western pearlshell mussel (*Margaritifera falcate*), as identified by Elizabeth Cools, of the Invertebrate Zoology Department, California Academy of Science, San Francisco, CA. [Note: 'swimmers', or 'water striders' (Family Gerridae), were found in every creek surveyed and were too numerous to count in every instance, so they are not noted separately in each creek survey below]. Fish taxa that were also captured included sticklebacks (Family Gastrosteridae) and sculpins (Family Cottidae).

Vegetation

Shrimp individuals were captured in fine and course undercut roots of willow, alder, and blackberry, along with overhanging blackberry vegetation. Other near-stream riparian vegetation present in the capture vicinities were native and non-native grasses, ferns, nettles, and poison oak; all of these species were in contact with the water either by root or vegetative parts. In the areas where shrimp were found, the estimated amount of submerged overhang out of total cover present was 55-65%, the estimated amount of submerged undercut out of total undercut present varied more, at 15-30%. (Note that all overhang and undercut percentage references throughout this report are based on amount of submerged vegetation or roots observed on the creek's immediate banks, out of all vegetation or roots present on the creek's banks. These values are only an observed estimate).

Water Conditions

The shrimp capture sites also varied by stream habitat type; although all individuals were found in main stem and scour pools, the percentage of pool-to-riffle environment ranged from 95-5%, respectively, to 75-25%. However, all capture sites were out of the riffles, along creek banks. Creek water levels at shrimp capture sites ranged from 0.2 to 0.5m deep. Creek width at these same sites varied from 1.5 to 6m wide. The water clarity was good in most of Olema Creek, with only a few sections of murky slack water where pools were dammed up from woody debris.

The temperature and specific conductance levels in the environment of shrimp sites were relatively stable: Water temperatures ranged from 17-22°C, and specific conductance, with one exception, ranged from 0.2-0.3mS/cm. In the overall vicinity of the initial shrimp capture near the Olema-Lagunitas confluence, the specific conductance reading was 1.5mS/cm. But at the time of measurement the tide was out and therefore the meter was much closer to the creek bottom, where salinities are higher. Furthermore, the Tomales Bay tidal influences greatly affect the water conditions at the mouth of Olema Cr, the point at which the specific conductance was measured. Again, this measurement was not taken directly at the site of capture.

Overall Environment

From essentially the beginning of Olema pasture to the end of the creek survey at Vedanta Bridge in Olema, no shrimp were found. This represents approximately 1½ miles of Olema Creek. Many of the above listed organisms continued to be found throughout most of the creek, although in much fewer numbers the closer the surveying approached the developed banks, where camping, lodges, and residential yards closely bordered the creek banks. People and dogs in the water were encountered at several points where Olema Creek Campground provided easy access to the water. In general, the lower section of Olema Creek provided a broad variety of habitat, from diverse submerged vegetation, varied amount of canopy cover, many areas of pools fed at

intermittent intervals by riffles. Near-stream habitat health for shrimp in the lowest section was found to be superior to the upper reach, being relatively undisturbed and free of human activity. Minimal erosion was seen in lower Olema Creek, until reaching the campground area.

<u>Bear Valley Creek:</u> (3 days, 1300 meters, discontinuous, Appendix II-Sheet 4)

(Bear Valley Creek, upstream view)

The mouth of Bear Valley Creek, like Olema Creek, empties into Lagunitas Creek, and is subject to tidal influences from Tomales Bay. The survey was initially started at the mouth with intention to move upstream, portaging out at Sir Francis Drake Boulevard (which crosses the creek at approximately 300m above the mouth), and re-entering the creek just across the road. When surveying began, the tide was out and the creek itself did not have any organized flow until a stagnant pool was found only 10m from the road crossing. Surveying began at this point, but was soon ended, as there was no access back into the creek on the other side of the road; no flow could be found through the dense vegetation. The creek was inaccessible for approximately a ½ mile until an opening was negotiable along Bear Valley Road (MP 1.28). From that point on surveying was conducted without break to the bridge at the Bear Valley Headquarters of Point Reyes National Seashore.

No shrimp were found in Bear Valley Creek during this survey. Invertebrate species found included caddisflies, freshwater snails, water boatmen, water beetle, mayfly larvae, stonefly nymphs (order Plecoptera), and unknown invertebrates. Sticklebacks were the only fish species captured in this creek.

Vegetation

The diversity of habitat in Bear Valley Creek was much like that of Olema Creek. A wide variety of vegetation included willow, blackberry, nettles, ferns, equisetum, alder, and poison oak. There was a much greater amount of canopy

cover over this creek, however, along with much denser amounts of overhang vegetation, making the creek impassable at many points. The estimated amount of submerged overhang out of total cover present ranged from 40 to 75%, the estimated amount of submerged undercut was at 10 to 30%. The undercut was sparsely distributed and often lacked the fine root hairs seen in Olema Creek.

Water Conditions

This is a relatively undisturbed creek with mostly clear-running water. However there were sections with large amounts of silt and mud: Some of this condition existed in the area of the creek adjacent to the National Park Service maintenance yard, but also in undisturbed regions of the creek that were "clogged" with scour deposits, creating murkiness from riffle disturbances.

There was a great deal of riffle that comprised the flow; the percentage of pool-to-riffle environment averaged to be 20 to 80%. The creek is fairly narrow and not many out pockets or backwater regions exist to pool water. This could be a seasonal condition, as higher ground is likely to flood in the rainy season, widening the channel and slowing down the flow with debris. However, the pool areas observed were of adequate to high quality as potential shrimp habitat. Creek levels ranged from 0.15 to 0.6m deep. Creek widths varied from 0.5 to 3.56m, but most of the section surveyed was 1.5m on average.

Overall Environment

Bear Valley Creek is generally very similar to Olema Creek in habitat composition, orientation, and water conditions. It differs from Olema Creek in exhibiting less affect from upstream tidal influences, as Olema Marsh is the recipient of most of the tidal inflow, and somewhat buffers the upstream creek from direct connection with Lagunitas and Tomales Bay. A great portion of this creek is inaccessible and undisturbed, with a variety of habitat conditions. Much of the vegetation is very dense and thus only small portions of the creek are exposed to direct sunlight. There was a lack of quality undercut and wide pools present at the time of this survey, but a large portion of the creek has yet to be sampled due to impassibility. The possibility of shrimp presence should not be ruled out.

<u>Zanardi Gulch</u>: (MP 1.80 Platform Bridge Rd, 1day, 775 meters, Appendix II-Sheet 5)

(Almost dry bed near the mouth of Zanardi)

(Rough-skinned newt found in Zanardi Gulch)

(Piles of cow manure found in the bed of Zanardi Gulch)

There is not an established name for this creek found on USGS maps of the area; the creek is under National Park Service jurisdiction, but is bordered by private ranch property. Therefore, for reference purposes, in this study the stream will be titled 'Zanardi property creek'. The stream drains into Lagunitas Creek, crossing under Platform Bridge Road just above the confluence with Lagunitas. The north bank is bordered by a working cattle ranch for the first (approximately) ½ mile, while the south bank is primarily steep forested hillside.

The mouth of the creek was dry at the time of survey (not connected to Lagunitas Creek), and creek water was not found until an isolated pool was seen about 250 m from the mouth. From that point upstream was a series of isolated pools, from 6-8 m^2 in surface area, which became increasingly bigger and finally connected by slight trickles and riffle. A single cow was in the creek bed itself, and continued to move upstream as the shrimp surveying moved closer.

No shrimp were found during this survey. Very shallow, rocky pools precluded adequate net sampling in places, as it was not possible to submerge the net fully in some instances, however there was almost a total absence of vegetation in most pools. Several rough-skinned newts (*Taricha granulosa*) were found in the pools. The only fish captured were sticklebacks.

Vegetation

An adequate amount of typical shrimp-preferred habitat lined the creek banks, including blackberry, willow, alder, and ferns. Other supporting vegetation observed was nettles, vine maple, poison oak, and equisetum. The tree canopy provided good cover for the creek, however much intermediate vegetation between tree canopy and bank-level vegetation was absent, likely due in part to cattle grazing traffic. The amount of submerged overhang and undercut was very minute since the water level was so receded from the banks. In the rainy season a much greater proportion of plant life would be in touch with the water, as the banks were lined with a good variety of species. The undercut was estimated at approximately 1%, consisting of a few adventitious roots. The estimated amount of submerged overhang out of total cover present was 5%.

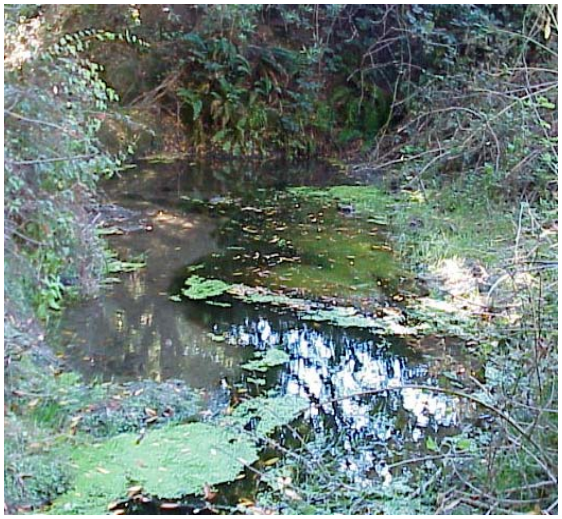
Water Conditions

Flows in Zanardi property creek appears to drop during the summer and fall season. It is unknown if an upstream dam or diversion could be a factor in the lack of flow. The creek water itself appears to be of adequate quality in the more pristine sections, but the lower reach is littered with cattle manure and parts have eutrophic slack water. A small amount of pipe and lumber debris was half submerged in the creek in one section. This creek is comprised of rocky bottomed, gradually stepped pools with very minute falls. There is an increasing grade upstream, indicating flow would move rapidly in the rainy season. The pool-to-riffle conditions at the time of the survey were 98 to 2%, which definitely could support the shrimp, but the expectation is that the ratio would dramatically decrease during the rainy season. Creek depth at the time of survey was 0.25m, and width was approximately 1.5m. Water temperature was notably cool at 14°C.

Overall Environment

The overall habitat showed evidence of cattle impact. Manure was present in the creeks and broken fences were also evident along the north bank pasture bordering the riparian habitat. Rutted and eroded banks from cattle paths were seen at several points along the creek. Whereas the plant community is diverse and suitable to shrimp, the ephemeral nature of this creek, its orientation, and cattle presence suggest a lack of long-term suitability for shrimp inhabitance. Without cattle presence there would be a possibility for shrimp to survive within the deep pools of the lower section.

<u>Cheda Creek:</u> (MP 19.21-Sir Francis Drake Rd., 2 days, 975 meters, Appendix II-Sheet 5)



(Eutrophic water near cattle entry point, Cheda Cr.) (Cattle hoof ruts and manure at Cheda Cr. edge)

This creek has very similar orientation and conditions to Zanardi property creek, and is only several miles away from it. Cheda Creek also empties into Lagunitas Creek and crosses under Sir Francis Drake Boulevard just above the confluence with Lagunitas. The north bank is bordered by a working cattle ranch for the first (approximately) ¾ mile, while the south bank is primarily steep forested hillside.

The mouth of the creek was close to dry at the time of survey, and if connected to Lagunitas Creek it was not perceptible. The creek water was detected in the culvert pipe under the road, about 25m from the Lagunitas confluence. From that point upstream was a series of connected pools, about 8 m² in surface size, which became increasingly bigger with more riffle connection heading in the upstream direction. Several cattle were grazing in the creek bed itself, and continued to move upstream as the shrimp surveying moved closer.

No shrimp were found in Cheda Creek during this survey. However, a National Park Service fishery biologist found a single adult shrimp, while conducting salmonid surveys in early July, 2002 (photo on report cover). This individual was found several hundred meters from the mouth. Shallow, rocky pools precluded adequate net sampling in places, as it was not possible to submerge the net fully in some instances. Macroinvertebrate species captured included caddisflies, water boatmen, mayfly larvae, isopods, and water penny beetle (Family Psephenidae). Many rough-skinned newts (*Taricha granulosa*) were found in the pools. The only fish captured were sticklebacks, but many unidentified salmonids were observed, of either steelhead or coho species.

Vegetation

An adequate amount of typical shrimp-preferred habitat lined the creek banks, including blackberry, willow, alder, grasses, ferns, and bay laurel. Other supporting vegetation observed was vine maple and poison oak. The tree canopy provided good cover for the creek, however much intermediate vegetation between tree canopy and bank-level vegetation was absent, likely due in part to cattle grazing traffic. The amount of submerged overhang and undercut was very minute since the water level was somewhat receded from the banks. In the rainy season a much greater proportion of plant life would be in touch with the water, as the banks were lined with a good variety of species. The undercut was estimated at approximately 10%, consisting of blackberry, alder, and adventitious roots. The estimated amount of submerged overhang out of total cover present was 5%.

Water Conditions

Intermittent sections of this creek contained large areas of eutrophic, algae and duckweed-covered pools. These algae laden sections were nearest to the eroded embankments of cattle travel. The creek water and surrounding dry bed was often littered with cattle manure. At the time of survey Cheda creek was observed to be rocky-bottomed pools connected by narrow trickles or riffle sections, on a gradual upslope in the upstream direction. Unlike the Zanardi property creek, Cheda Creek stays relatively flat for a longer stretch before the grade begins to increase upstream. It appears that water would move somewhat rapidly through parts of this creek, however there is more structural barriers (rock, debris and vegetation) positioned to support pool formation. The pool-to-riffle conditions at the time of the survey were 90 to 10%, which definitely could support the shrimp, but the expectation is that considerably less pool habitat would be present during the rainy season. Creek depth at the time of survey was 0.25m, and width was approximately 1.5m.

Overall Environment

Cheda Creek is has a much lower water level in the dry season and likely fast-moving in the rainy season, but with pool habitat year round that has shrimp support potential. However, the overall habitat showed evidence of cattle manure from cows grazing loose in and around the stream itself. Some broken fences were also evident along the north bank pasture bordering the riparian habitat, from which cattle trails had been made down to the creek itself. Rutted and eroded banks from cattle paths were seen at several points along the creek. There was a large amount of dumped litter and household debris along many parts of the slope above Cheda Creek, next to the cattle ranch. Beyond the cattle ranch the creek becomes much more pristine, but at that point the creek becomes steep and it is unlikely that shrimp would inhabit such areas. Whereas the plant community is diverse and an individual shrimp was observed in the lowest reach, the cattle presence and pollution found in many parts of this stream suggest a lack of long-term suitability to sustain a population of shrimp in the creeks present condition.

McIsaac Creek: **(MP 20.13-Sir Francis Drake Rd, 1 day, 150 meters, Appendix II-Sheet 5)**

(Isolated pool in McIsaac Cr)

(Household debris & lumber dumped in McIsaac)

This creek has very similar orientation and conditions to Zanardi property creek and Cheda Creek, and lies between the other two, only several miles away in either direction. McIsaac Creek also empties into Lagunitas Creek and crosses under Sir Francis Drake Boulevard just above the confluence with Lagunitas. The north and south banks are bordered by working cattle ranch and grazing pastures for the first (approximately) ¾ mile, the south bank gives way to primarily steep forested hillside after a few hundred meters. The mouth of the creek was close to dry at the time of survey; only a thin trickle connected it to Lagunitas Creek. Most of the creek remained shallow upstream. Cattle presence damage in and around the creek was evident in the entire lower reach, prior to and after the waterfall area.

No shrimp were found in McIsaac Creek during this survey. Macroinvertebrate species captured included caddisflies, freshwater snail, midge worms (Family Tipulidae), and mayfly larvae. Many rough-skinned newts were found in the pools. Unidentified juvenile salmonids were observed. A signal crayfish was observed just above the waterfalls area.

Vegetation

An adequate amount of typical shrimp-preferred habitat lined the creek banks, including blackberry and alder. Other supporting vegetation observed was nettles, vine maple, poison oak, equisetum and California buckeye. The tree canopy provided good cover for the creek, however much intermediate vegetation between tree canopy and bank-level vegetation was absent, likely due in part to cattle grazing traffic. The amount of submerged overhang and undercut was very minute since the water level was so receded from the banks. In the rainy season a much greater proportion of plant life would be in touch with the water, as the banks were lined with a good variety of species. The undercut was

estimated at approximately 1%, consisting of alder, blackberry and adventitious roots. The estimated amount of submerged overhang out of total cover present was 15%.

Water Conditions

Flows in McIsaac Creek appears to drop greatly during the summer and fall season, when there is no runoff to feed the creek. The creek water itself and surrounding dry bed is littered with cattle manure and many parts have eutrophic slack water. Pipe, lumber, and household debris was half submerged in the creek, just below a residential unit at the cliff of the north embankment, approximately 500m from Sir Francis Drake Boulevard. At the time of survey McIsaac creek was observed to be heavily receded, with rocky-bottomed interrupted pools, eventually connected by narrow trickles or riffle sections. Initially the creek was only gently sloped, then about ? mile upstream there is a 6 foot high boulder structure and steep embankments. Although only a small fall was present at this rock wall during the survey, the physical structure of that section suggests a rapidly moving, large waterfall during the rainy season. Water would move somewhat rapidly through parts of this creek, however there are some structural barriers (rock, debris and vegetation) positioned to support pool formation. The pool-to-riffle conditions at the time of the survey were 98 to 2%, which definitely could support the shrimp, but the expectation is that the ratio would decrease greatly during the rainy season. Creek depth at the time of survey was 0.15m, and width was approximately 1.5m. Specific conductance was 0.4mS/cm throughout the surveyed section.

Overall Environment

McIsaac Creek has a low water level in the dry season, and year-round pool habitat is sparse. The habitat showed a large amount of degradation due to cattle manure from cows grazing loose in and around the stream itself, pollution, and debris. Some broken fences were also evident along the north and south bank pastures bordering the riparian habitat, from which cattle trails had been made down to the creek itself. Deeply rutted and eroded banks from cattle paths were seen at many points along the creek. Beyond the cattle ranches the creek becomes much more pristine, but at that point the creek becomes steep and it is unlikely that shrimp would inhabit such areas. Whereas the plant community is diverse and suitable to shrimp, the cattle presence and pollution found in many parts of this stream suggest a lack of long-term suitability to sustain a population in the creeks present condition. It appears very unlikely that shrimp could be supported by the creek environment in its present condition.

<u>Glenbrook Creek:</u> (2 days, discontinuous 275 meters, Appendix II-Sheet 2)

(Dense vegetative cover over Glenbrook Cr)

Glenbrook is a creek of substantial size (2½ miles long, and up to 10m wide in the lower reach). It empties into an inlet of Limantour Estero, which subsequently drains to Drakes Bay. Surveying began at the bridge crossing of Estero Trail, several hundred meters above the inlet, as water was too deep to survey at the entrance to the mouth. The channel narrows very abruptly only 100m after the bridge and splits off into 2 feeder creeks: One leads to a marshy dead-end, and the other shortly becomes impassable due to a large amount of overgrown vegetation completely covering the channel. The creek surveying portaged around the vegetation until an access route could be re-established. Therefore about ¼ mile stretch of the creek was not surveyed.

No shrimp were found in Glenbrook Creek during this survey. Macroinvertebrate species captured included the rare Tomales asellid (*Caecidotea tomalensis*), caddisflies, aquatic sow bugs, mayfly larvae, and water boatmen. A red-legged frog was observed.

Vegetation

Cover was very dense along most of the creek, making this a very shaded stream. Blackberry, willow, and alder dominated the banks, with supporting vegetation such as ferns, cattails, and nettles. The amount of submerged overhang was very high (averaging 80%), and slowed flow considerably, as it was so overgrown into the creek. However the undercut was estimated at approximately 10%, consisting of alder, blackberry and fern roots sparsely distributed.

Water Conditions

The depth of the creek was generally consistent at 0.3-0.6m, with perennial but very minimal flow. There was mostly at least trickle movement of the water along the length of the survey. Except for the initial slack water, duckweed-covered

section surveyed, the water surface was generally clear. In a few sections the stream bed consisted of muddy red clay that created murky conditions in shallow parts of the creek. Sheltered pools were only found sparsely, as the channel was mostly straight without many scour bends. The pool-to-riffle conditions at the time of the survey were 30 to 70%. Creek depth at the time of survey was very shallow in certain sections, with an overall average depth of 0.15m, and width of approximately 1.5m. Water temperature was notably cool at 14.5° C.

Overall Environment

Glenbrook Creek is a mostly undisturbed stream running through protected parkland in Pt. Reyes National Seashore. Only minor disturbances to the creek banks are evident in the form of elk and deer trails. The likelihood of shrimp being found here may be hampered due to a lack of high quality bank or pool area in which shrimp could attach and feed year-round, and inconsistent flow conditions that range from deep to extremely shallow. However the plant community is diverse and hospitable to shrimp, and much of this creek was impassable to analyze the overall suitability. Therefore it is not possible to rule out that shrimp could be supported by this particular creek environment.

<u>Muddy Hollow Creek:</u> **(1 day, 1850 meters, Appendix II-Sheet 2)**

(Narrow portion of Muddy Hollow Cr)

This creek parallels Glenbrook and is only about 1 mile away. It also empties into an inlet of Limantour Estero, which subsequently drains to Drakes Bay. Surveying began just above the upper marsh, where the water organizes into a channeled flow with surveyable depth. Much of the creek length is bordered very closely by Muddy Hollow Trail, and in fact unauthorized trails intertwine through a pathway of the flow. There is easy and frequent access to at least the lower reach of this creek by off-trail hikers, elk, and many deer. Half of this creek meanders through woodland, and often diverges into dead-end puddles.

No shrimp were found in Muddy Hollow Creek during this survey. Macroinvertebrate species captured included caddisflies, freshwater snails, aquatic sow bugs, scuds, and mayfly larvae.

Vegetation

Canopy-level alder cover was very dense along most of the creek, making this a very shaded stream. But the amount of immediate bank overhang varied greatly throughout. Blackberry, non-native grasses, ferns, and nettles were the predominant overhang, with blackberry root undercut sparsely found. In areas of dense vegetation the amount of submerged overhang was high (averaging 60%), but much of the woodland area of the creek's flow had only about 30% overhang. Undercut estimate was approximately 5%.

Water Conditions

The depth of the creek was extremely shallow, averaging from 0.05-0.2m deep. For the first mile there was very minimal to no flow, and interrupted shallow

puddles-or just damp ground-at some points were the only evidence of creek. Much of the surveyable water was stagnant, with an oily surface residue. This is almost an ephemeral creek in the lower reach. About a mile upstream from the marsh the flow is viable, but narrow and with no visible pools; it is almost total riffle upstream of the woodland habitat. Pool-to-riffle conditions in the lower reach were 99 to 2%, and 5 to 95% in the upper reach.

Overall Environment

Muddy Hollow Creek is a very inconsistent stream with extreme variation in flow, vegetation, and surrounding environmental conditions. The lower part is too shallow and highly disturbed for shrimp to inhabit, and the upper reach has little to no pool habitat. It appears very unlikely that shrimp could be supported by this particular creek environment.

Laguna Creek: **(4 days, 2275 meters, Appendix II-Sheet 2)**

(Upstream view of Laguna Cr, just above the marsh)

This creek parallels Muddy Hollow Creek, and is only about a ½ mile away. It empties into a lagoon of Drakes Bay. Surveying began just above the lagoon marshland, where the water organizes into a channeled flow with surveyable depth. Much of the creek length is bordered by Laguna Trail, and the trail crosses the creek in several places. There is easy access to a few points of the creek by off-trail hikers, but it is mostly protected by vegetation and location away from the trail. Much of this creek meanders through woodland, and has several divergent drainages to dead-end seasonal pools.

No shrimp were found in Laguna Creek during this survey. Macroinvertebrate species captured included caddisflies, dobsonfly, freshwater snails, midge worms, aquatic sow bugs, water boatmen, water beetles, and mayfly larvae. A red-legged frog was observed. Fish captured included sticklebacks and juvenile steelhead. An unidentified salmonid was also observed.

Vegetation

Canopy cover is dense along most of the creek, making this a very shaded stream. Much of the banks varied greatly with a diverse assortment of trees and plant communities. The most frequent vegetation was alder, blackberry, ferns, nettles, *Equisetum*, *Juncus*, non-native grasses, and water parsley. The amount of submerged overhang ranged from 35 to 45%. There were areas of no undercut and then many regions of rich, diverse undercut of alder, blackberry, fern, and adventitious roots as well. The undercut ranged from 5 to 45%.

Water Conditions

The depth and width of the creek was also very varied, as this creek meanders through several distinct environment changes, but the average was about 0.35m deep and 1.5 m wide. This was often a very muddy-bottomed creek, but the water was mostly clear. Except for the initial slack water, duckweed-covered section surveyed, the water became clearer with a higher rate of flow upstream. The pool-to-riffle conditions at the lower sections of Laguna were 95 to 5%, but at the highest upstream survey point those numbers changed to 50 to 50%. Creek depth at the time of survey was 0.15m, and width was approximately Water temperature was increasingly cooler upstream, with the final point of the survey ending at 12.5°C. A portion of the creek in the upper reach of the survey (below the Pt. Reyes Youth Hostel) appears to have been channelized at some point and shows a substantial amount of erosion from sheer banks without stabilizing vegetation. This area is also heavily crossed by elk and deer. The water in this section is subject to a high amount of silt. Specific conductance ranged from 0.3-0.4mS/cm throughout the survey length.

Overall Environment

Laguna Creek is a mostly undisturbed stream running through protected parkland in Pt. Reyes National Seashore. Only minor disturbances to the creek banks are evident in the form of elk and deer trails. Except for several points where people can enter the creek and a small area where severe erosion has occurred, there is a rich diversity of environment, pool and flow conditions, and overall cover. Although no shrimp individuals were found in this survey, suitable habitat conditions exist for the support of shrimp populations.

<u>Kehoe Creek:</u> **(1 day, 875 meters, Appendix II-Sheet 1)**

(The mouth of Kehoe Cr, near Kehoe Beach)

This creek forms from two drainages (east and west) off the Inverness Ridge, into the Pacific Ocean at the vicinity of Kehoe Beach. At the east and west confluence, Kehoe Creek crosses Pierce Point Road and eventually becomes tidal marsh. Surveying began at the inlet to the marsh, above the beach. The creek is bordered by Kehoe Beach Trail up until Pierce Point Road, but mostly separated from the trail by at least 25 feet, and/or vegetation. Above Pierce Point Road the creek branches are bordered closely by grazing pasture.

No shrimp were found in Kehoe Creek during this survey. Macroinvertebrate species captured included dragonfly larvae, freshwater snails, and water boatmen. Sticklebacks were the only fish captured.

Vegetation

The lowest portion of Kehoe is a marshland community with mostly cattails and bunch grasses, affording little creek cover, but upstream the marsh gradually gives way to dense banks of willows, blackberry, nettles, and non-native grasses, and juncus. Some of the upper reach is so dense that a few 50-100 foot sections were impassable, thus not surveyable. The amount of submerged overhang in the lower reach averaged only 5%, whereas the upper reach was 80 to 60%. Undercut banks throughout the surveyed portion of Kehoe only amounted to 2%.

Water Conditions

The creek depth was greatest on the marsh side, averaging 0.3m deep, and became much shallower upstream, averaging 0.15m. The creek is also much wider at the marsh end and narrows considerably up into the pasture. The largest width measured was in the lower portion, at 4.0m, and the smallest width measured was in the upper portion, at 0.15m. The flow conditions were difficult to assess overall, as a few sections of the creek could not be viewed through the dense vegetation, but in general the pool to riffle was 80 to 20% below Pierce Point Road, approximately 10 to 90% above it. Whereas the lower section of the creek was mostly slack water with tidal flow, the upper portion was mostly riffle. The

upper section is highly-silted and muddy-bottomed in areas of cattle crossing. Specific conductance ranged from 0.5mS/cm (upper section) to 0.3mS/cm (lower section).

Overall Environment

Kehoe Creek is very varied in its near-stream habitat characteristics, due to the development that has taken place around it. The lower portion is protected parkland and a mostly undisturbed stream running through marshland to the ocean. However the upper portion crosses through active cattle pasture, and though heavily covered by vegetation, the creek is crossed at many points by cattle. Broken fence line and cattle trails were observed, as well as watching a cow step into the creek and through such a break in the fence. Although some classic shrimp vegetation is present, the upper reach is very narrow, riffled, and the creek and its bank are continually disturbed by cattle. In the lower, reach there is not enough cover, undercut, or overhang to provide necessary protection and feeding areas to shrimp. This creek does not appear to have suitable habitat conditions overall for the support of shrimp populations.

East Schooner Creek: **(2 days, 1700 meters, Appendix II-Sheet 3)**

(Very shallow waters in upper section of Schooner Cr)

This creek forms from two drainages (east and west) off the Inverness Ridge, emptying into the Schooner Bay inlet of Drakes Estero. At the east and west confluence, Schooner Creek crosses Sir Francis Drake Boulevard and eventually becomes tidal marsh. Surveying began at the inlet to the marsh, above Schooner Bay, on the eastern leg of the creek. The creek is initially an uncovered, almost straight channel of stream with pickleweed banks before entering dense vegetation cover about 100 yards from the creek mouth, wherein it becomes bordered by an active cattle grazing pasture, separated by fence and vegetation. The eastern leg is bordered by Sir Francis Drake Boulevard for approximately 2 miles; at some points the creek is only several feet from the road, but vegetation separates the majority of

the stream from the road. At about 1 mile above the mouth, the road again crosses over the creek, with a culvert connection below.

No shrimp were found in Schooner Creek during this survey. Macroinvertebrate species captured included damselfly larvae, an unknown group of isopods, and scuds.

Vegetation

The lowest portion of Kehoe is a marshland community with mostly pickleweed, cattails, non-native grasses and native bunch grasses, affording little creek cover, but upstream the marsh gradually gives way to dense banks of alder, willows, and blackberry. Although the overall environment in the initial open channel of the creek was not a likely support for shrimp, the rich supply of submerged, fine pickleweed roots were surveyed regardless, to examine what would be inhabiting the initial section of the creek. Although no overhang was present in this first reach, the undercut was approximately 50%. Beyond the first 100 yards, the creek becomes the more typical shrimp-type habitat with a variety of cover. About a 1/5 mile section near Rogers Ranch was so dense with vegetation it was impassable, thus not surveyable. The amount of submerged overhang in the upper reach averaged 80%. Undercut banks throughout the upper reach of Schooner Creek only amounted to 2%.

Water Conditions

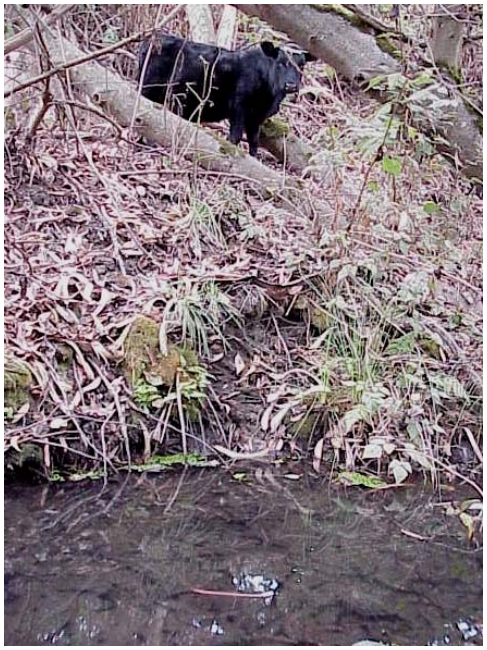
The creek water recedes appreciably in the dry season, and about half of the embankment height was not covered by water. The creek depth was greatest in the open lower reach, averaging 0.25m deep, and became much shallower upstream, averaging 0.3m. The creek is also much wider at the marsh end and narrows considerably upstream. The largest width measured was in the lower portion, at 1.5m, and the smallest width measured was in the upper portion, at 0.15m. Some portions of the creek through the woodland branched out into almost dry, dead-end flows. The flow conditions were difficult to assess overall, as a few sections of the creek could not be viewed through the dense vegetation, but in general the pool-to-riffle was 95 to 5% in the initial section, and approximately 75 to 25% above it. Whereas the lower section of the creek was mostly slack water with tidal flow, the upper portion had many sections of gentle riffle. Suitable pools for shrimp were very sparse. The upper section is silted and muddy-bottomed in areas closest to the Rogers Ranch grazing pasture. Areas of standing water with algae and slick residue were apparent at drainage points from the pasture hillsides. Specific conductance ranged from 1.0mS/cm (lower section) to 0.2mS/cm (upper section).

Overall Environment

Schooner Creek east runs through two different environments: open tidal marsh channel to upland tree-covered, dense riparian habitat. The lower portion is

exposed, mostly unprotected and has been disturbed by engineering of the culvert that allows tidal flow upstream of Schooner Bay into the creek's east and west branches. The upper portion of the creek is very shallow and narrow during the dry season, and although the stream is securely separated from cattle traffic, hillside sloping from the pasture drains water into sections of the creek; at these points run-off pollution and eutrophication is evident. Although some classic shrimp vegetation is present, the creek lacks the continuity of water level and pools necessary to sustain shrimp. This creek does not appear to have the overall habitat conditions suitable for the support of shrimp populations.

<u>Home Ranch Creek:</u> **(1 day, 950 meters, Appendix II-Sheet 3)**



(A ranch cow loose above Home Ranch Cr)

(HR Creek erosion & algae from cow ruts, manure)

(Upper section of Home Ranch Cr, above ranch)

This creek forms from a drainage off the Inverness Ridge, emptying into the Home Bay inlet of Drakes Estero. Much of the lower half of Home Ranch Creek runs through and along Home Ranch, a working ranch with horses and cattle. Active cattle and horse grazing pasture closely borders the creek. Upstream of the ranch the creek eventually enters protected park wilderness designation. Initially the creek is organized into a channeled flow approximately 50 yards from a lagoon at Home Bay. The ground between the lagoon and the creek was dry, and no above-ground connection could be located. The creek is open for several hundred feet before entering a mostly wooded cover habitat. At about 1 mile above the mouth, the main ranch road crosses over the creek, with a culvert connection below.

No shrimp were found in Home Ranch Creek during this survey. Macroinvertebrate species captured included dragonfly larvae, freshwater snails, water boatmen, midge worms, aquatic sow bugs, caddisflies, water beetle, mayfly larvae, and scuds. Sticklebacks were the only fish captured.

Vegetation

The lowest portion of Home Ranch Creek is a filled-in previous marshland community that has been modified into pastureland. Non-native grasses and weeds dominate the initial portion of the creek's banks, affording little creek cover, but a few hundred yards upstream the creek is covered by stands of alder, willow, blackberry, nettles, water parsley, equisetum, juncus and other bunch grasses. The amount of submerged overhang in the creek averaged 35%. Undercut banks were sparse through the lower portion of the creek, but became rich and diverse just above the ranch, with many sites of blackberry, alder, and bunch grass roots. The overall average of undercut was 10 to 15%.

Water Conditions

The creek depth and width varied considerably throughout the survey length, but generally increased above the ranch, averaging 0.25m deep and 2.0m wide overall. The pool-to-riffle conditions were 65 to 35%, with an adequate amount of potential shrimp pool habitat. Riffle points were intermittent and mostly low gradient. Severe bank erosion and algal bloom was observed in areas of cattle crossing. Cattle and horse manure was seen directly in the creek at several points. Specific conductance ranged from 0.2mS/cm (upper section) to 0.3mS/cm (lower section).

Overall Environment

Home Ranch Creek is very varied in its near-stream habitat characteristics, due to the development that has taken place around it. The lower portion of the creek borders and passes through an active cattle and horse farm, and the creek is crossed by cattle, horses, and deer. Most of the lower half of the creek has no

fencing to protect it, thus the banks are rutted and have little vegetation in some places where typically it would be densely covered. The point where the creek runs under the farm road the water is covered by algae and pollution slick. Broken fence line and cattle trails were observed, as well as an escaped cow standing on the creek bank. But above the ranch the creek takes on a much different habitat, with excellent diversity of undercut/overhang and pool/riffle habitat. The water has a more pristine appearance, and the creek becomes undisturbed with deep banks. Although the lower portion of the creek is much too degraded to effectively support shrimp, the upper portion is still in excellent overall condition. The fact that no shrimp were found in any part of the creek could be that the lower portion is too damaged for shrimp to survive and colonize higher reaches, or that individuals may be in the upper reach in very small numbers. In its present overall condition, this creek does not appear to have suitable habitat health for the support of shrimp populations, but further surveying under improved conditions may be necessary to completely rule out this possibility.

<u>Coast Creek:</u> **(2 days, 1100 meters, Appendix II-Sheet 7)**

(Downstream view of Coast Creek below Coast Trail bridge)

This creek runs through protected parkland of Point Reyes National Seashore and drains into Drakes Bay. Most of the creek length is bordered by Bear Valley Trail, and other trails cross the creek in several places. There is easy access to a few points of the creek by off-trail hikers, but it is mainly protected by vegetation and steep embankments, and has portions that flow far from the trail. Most of this creek meanders through woodland, with a short open portion at the mouth where it empties through beach, next to Arch Rock. Surveying began ¼ mile above the mouth, as the flow below this point contained whitewater; much too fast for shrimp to survive.

No shrimp were found in Coast Creek during this survey. Macroinvertebrate species captured included caddisfly, mayfly larvae, midge worms, water boatmen, and stonefly nymph (Family Capniidae).

Vegetation

Canopy cover is dense along most of the creek, making this a very shaded stream. Much of the banks varied greatly with a diverse assortment of trees and plant communities. The most frequent vegetation was alder, dogwood, blackberry, ferns, nettles, vine maple, and bunch grasses. The amount of submerged overhang ranged from 20 to 25%. There was an overall lack of undercut, but mostly bunch grass and adventitious roots were observed. The undercut ranged from 2 to 5%.

Water Conditions

The depth and width of the creek was did not vary much throughout the survey length except for the mouth, where it was estimated to be from 2-6m across. This was only an observation, as the creek cliffs are too steep and the water runs too fast at the mouth to do an in-creek measurement. The upstream surveyable portion of the creek averaged to be 0.2m deep and 1.0 m wide. Much of the water was receded during the time of the survey, and the depth of the banks indicate that the water level reaches about 1.0m deep and 2.0m in width in certain sections during the rainy season,. The narrow flow ran fast throughout much of this creek, with a sparse amount of pools adequately protected from the riffle. The pool-to-riffle conditions varied from 98 to 2% in the initial downstream reach, to 85 to 15% upstream. Water temperature was notably cool at an average of 12.0°C. Specific conductance was stable at 0.3mS/cm throughout the survey length.

Overall Environment

Coast Creek is a mostly undisturbed stream running through protected parkland in Pt. Reyes National Seashore. Except for several points where people can enter the creek there is a rich diversity of environment and overall cover. However, the physical creek features observed indicate a fast-moving stream in the rainy season with a lack of pool habitat. Though the creek was surveyed during the dry season the flow was already fairly rapid in some places. The lack of undercut was somewhat due to the receded water, as there was a great deal of exposed root systems just above the water level, but likely also due to the high rate of flow in parts of the creek. There appears to be excellent overhang vegetative habitat for shrimp, but a lack of stable pools and roots in many portions of the creek for the support of shrimp populations.

<u>Shell Beach Creek:</u> **(1 day, 30 meters, Appendix II-Sheet 6)**

(View of Shell Beach Creek near the mouth)

This creek runs through protected parkland of Point Reyes National Seashore, draining from Inverness Ridge into Tomales Bay via Shell Beach. The creek was accessed by boat, although there is a hiking trail that runs along the lowest ½ mile of the creek to the beach. Except for 50 m of the creek, which is flat and runs through dune grass habitat, most of this creek meanders through woodland and the grade becomes increasingly steep upstream. Due to the impassability of most of Shell Beach Creek, only the mouth of the creek could be surveyed.

No Shrimp were found in Shell Beach Creek during this survey. Macroinvertebrate species captured included mayfly larvae, midge worms, and scuds.

Vegetation

Canopy cover is dense along most of the creek, making this a very shaded stream. Blackberry and alder dominated the banks, with supporting vegetation such as dune and bunch grasses. Except for the initial 50 yards of exposed creek, where overhang consisted of dune grasses and pickleweed at 25%, the amount of submerged overhang was very high (averaging 80%), and was overgrown into the creek. Undercut at the mouth was approximately 5%, consisting of pickleweed and dune grass roots of limited quality for shrimp. The undercut after 50 yards could not be determined. After only 100 yards the creek became impassable due to thick walls of vegetation that completely cover the creek.

Water Conditions

The depth at the mouth of the creek was 0.5m, but it appeared that the depth would be lower in the upstream direction, judging from the progressively steep lie of the stream. The width started at 1.0, but again, this was narrowing in the upstream direction quickly, with the last measurable point being 0.75m. The flow initially was almost non-existent, with pool-to-riffle conditions of 95 to 5%, but faster flow could be heard upstream, although not seen through the dense vegetative cover. Water temperature was notably cold at an average of 8.0°C.

Specific conductance was extremely high in the measurable portion of the creek, at 7.8mS/cm.

Overall Environment

Shell Beach Creek is a stream running through sandy beach habitat in Pt. Reyes National Seashore, with probably some amount of disturbance at the mouth from hikers and boaters, as it is completely open and accessible for the first 50 yards. After that point it becomes essentially inaccessible and heavily covered through woodland. The high specific conductance, lack of quality undercut and protected banks makes the initial reach of Shell Beach Creek an unlikely support for shrimp, but the overall ability for this creek to sustain shrimp could not be determined due to impassability. The overall assumption would be that the creek becomes too narrow, shallow, and steep for shrimp habitat, but this is only based on the topography and flow trends observed.

CONCLUSION

Of the 13 streams surveyed for the California freshwater shrimp, only Olema Creek was confirmed to have shrimp present, with a total of 7 individuals (4 adults and 3 juveniles) found. In years prior to the 2002 survey, National Park Service shrimp surveys have had no more than 6 individuals found at one time in Olema Creek, and these surveys were conducted with multiple passes. Because this was a single pass survey and more individuals were found, it appears likely that Olema Creek has suitable habitat for long-term persistence of shrimp, and that the population is potentially increasing. Subsequent studies to monitor the lower reach population will be needed to confirm this.

Although none of the other 12 streams surveyed in 2002 showed shrimp individuals present, several creeks have definite potential as suitable environments for shrimp and should not be ruled out without further surveying. The streams chosen as having good potential shrimp habitat were based on the flow structure (pool/riffle, width, depth, consistency, grade, shape, and specific conductance), riparian vegetation present (undercut, overhang, nearby supporting plant community and canopy cover), and level of disturbance. These potential shrimp-supporting creeks include Bear Valley, Glenbrook, Laguna, and, unlikely but possible is Coast Creek.

The remaining set of creeks being listed for consideration have reasonable potential for future shrimp habitat only if the surrounding environment is returned to an undisturbed state. These creeks include Cheda, Zanardi, and McIsaac. All three of these streams empty directly into Lagunitas Creek, the creek with one of the largest known populations of California freshwater shrimp. In addition, the shrimp populations found in Lagunitas are not far from its confluence with any of these three creeks (Serpa, 1998). Furthermore, because a shrimp was found in Cheda Creek only two weeks prior to this study, it is reasonable to infer that the shrimp

have the ability to colonize, or at least temporarily inhabit, tributaries of Lagunitas. This is already evident in Olema Creek. In order for shrimp, and other ecologically important native species, to successfully inhabit Cheda, Zanardi, or McIsaac, these streams would have to be kept secure from encroachment by cattle and horses at all times. Seasonal flow and vegetation changes to these creeks may still preclude successful inhabitance by shrimp, but at this point that cannot be determined until livestock disturbance is completely ruled out.

Home Ranch Creek, like Cheda, Zanardi, and McIsaac, is also much degraded in sections, and yet has some excellent upstream habitat with some potential for shrimp inhabitance only with a great deal of modification to the surrounding developed environment. The exclusion of livestock, along with the diversion of waste run-off away from the creek, must occur for the possibility of future shrimp presence.

No other creeks surveyed appear to have potential habitat suited to sustain freshwater shrimp populations.

RECOMMENDATIONS

1. Re-survey Bear Valley, Glenbrook, Laguna, and Coast Creeks within the next several years to rule out the possibility that each stream could support the California freshwater shrimp. If possible, try to gain access to those sections of creek that were not yet surveyed due to impassibility.

2. Work with ranchers to repair/replace fencing and remove litter along Cheda, Zanardi, McIsaac, Kehoe, and Home Ranch Creeks, to protect those streams from livestock encroachment, thereby increasing the likelihood of future habitat for California freshwater shrimp, and/or for other native organisms.

3. Continue to monitor the Olema Creek shrimp to determine whether its range increases over the length of the creek and to determine population size over time.

ACKNOWLEDGEMENTS

Technical advice provided by Brannon Ketcham, Greg Brown (Point Reyes National Seashore), and the California Academy of Science. Dr. Paul daSilva (College of Marin) graciously provided assistance in identification of a diving beetle. Field assistance was provided by Darren Fong, Greg Brown, and Stacey Pogorzelski. All photos taken by Ro M. LoBianco, unless otherwise noted.

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Appendix I: DATASHEET FOR INVENTORIES

Stream: _____

Date: _____

Observ: _____

_____

_____

Weather (circle): cloudy foggy rain sunny

Air Temp (^oC):_____ H2O Temp (^oC):_____ Temp Time:_____

Gage height:_____ Secchi Depth. (m)_____ Spec. Cond. (mS/cm) _____

Sampling gear (circle): aquatic dipnet butterfly net other:_____

KEY TO ABBREV.:
m-male**, f**-female**, u**-unknown, j-juvenile, a-adult
u-unknown, **sb**-stickleback, **sh**-steelhead
co-coho**, sc**-sculpin**, mo**-mosquitofish

Gen. notes:

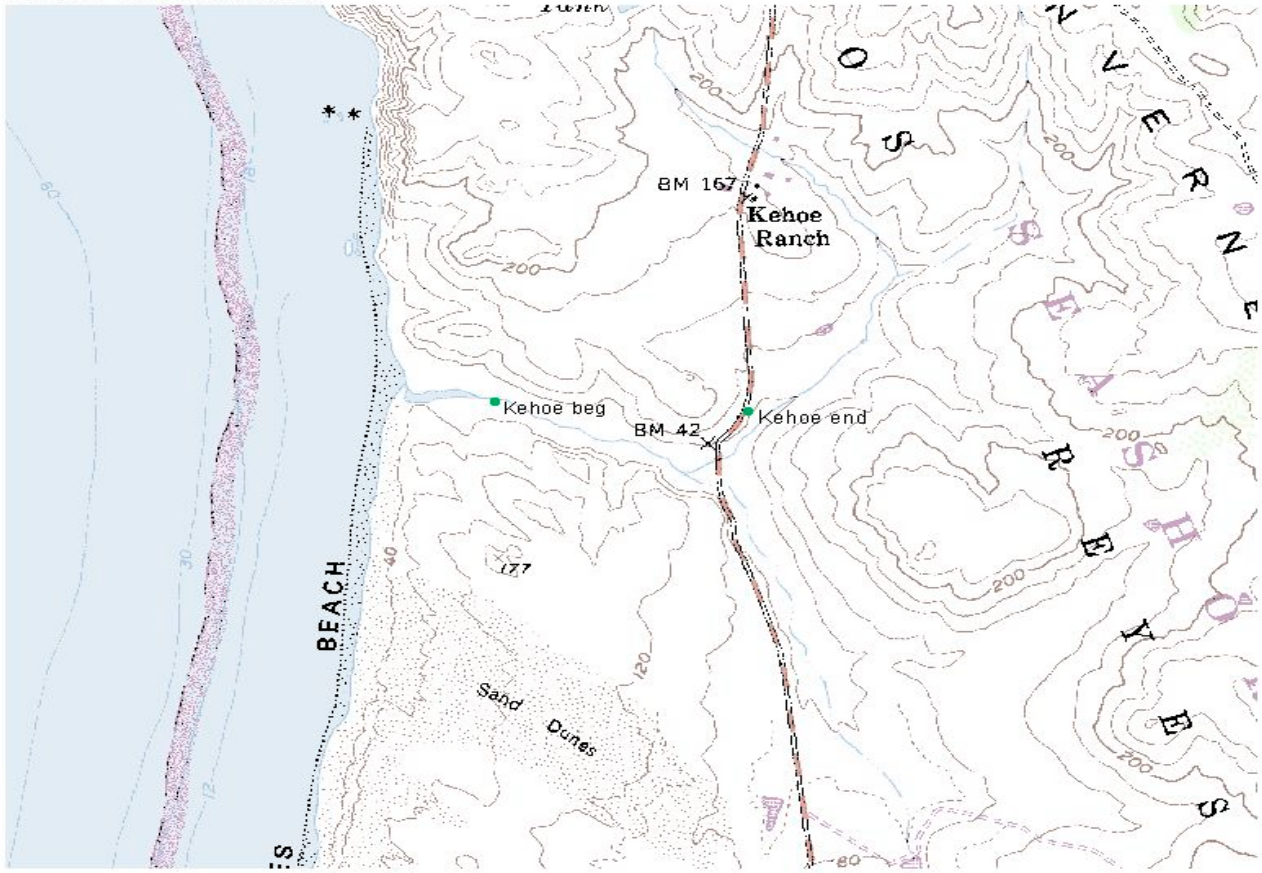
PHOTOS:

INVERT SAMPLES:

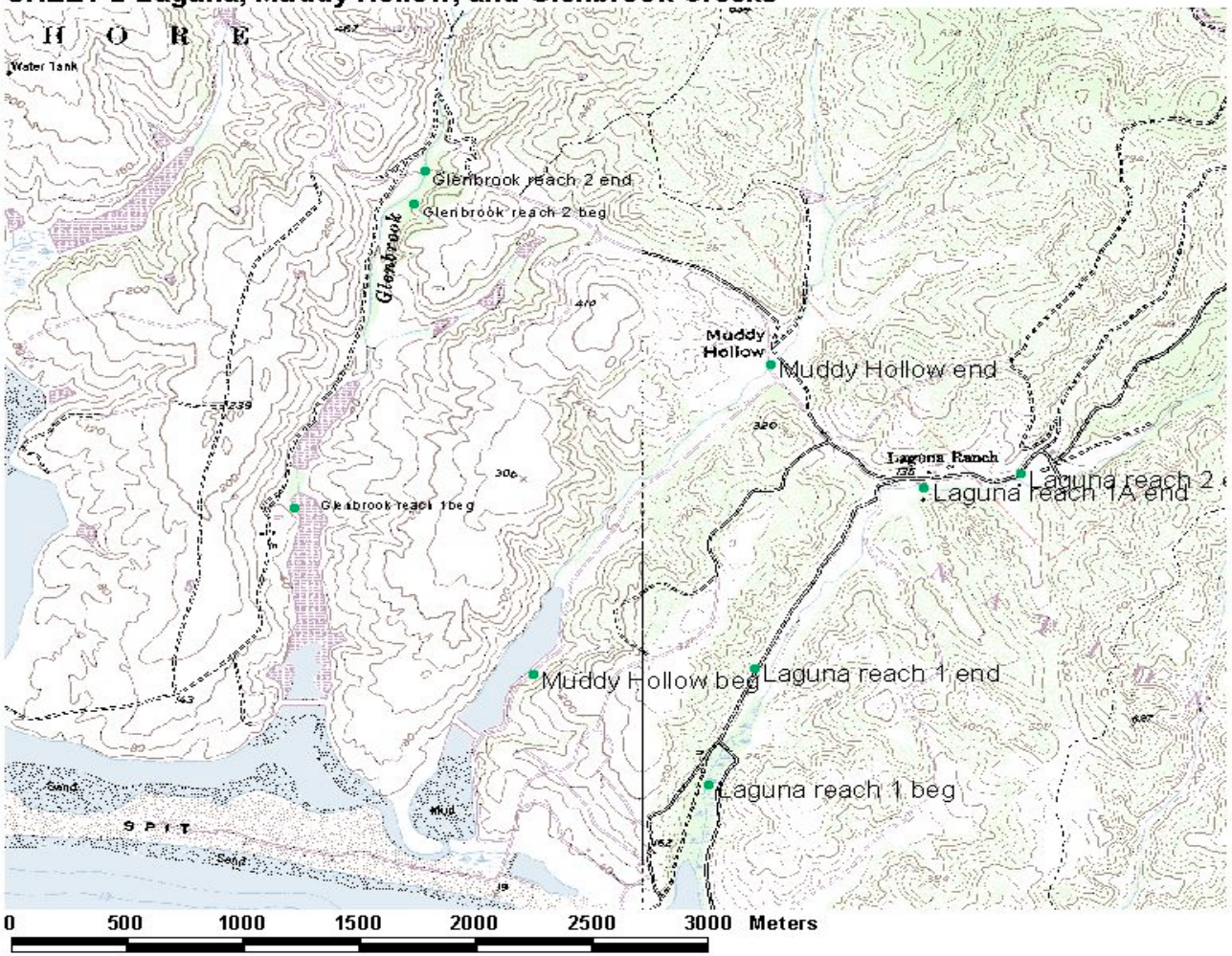
General						**Stream Habitat**		**Overhang**		**Undercut**		**Species**		
Reach	*Time In (hr)*	*Time Out*	*Survey Len (m)*	*Riffle (%-len.)*	*Pool (incl. fw) (%)*	*Est. Depth z (m)*	*Est. wdth (m)*	*Est.%*	*Characte r*	*Est.%*	*Characte r*	*Species*	*Numbe r*	*Length (mm)or Age Class*

Appendix II: MAPS OF CREEKS SURVEYED

California Freshwater Shrimp Survey Sites, Point Reyes National Seashore, Summer 2002
SHEET 1-Kehoe Creek

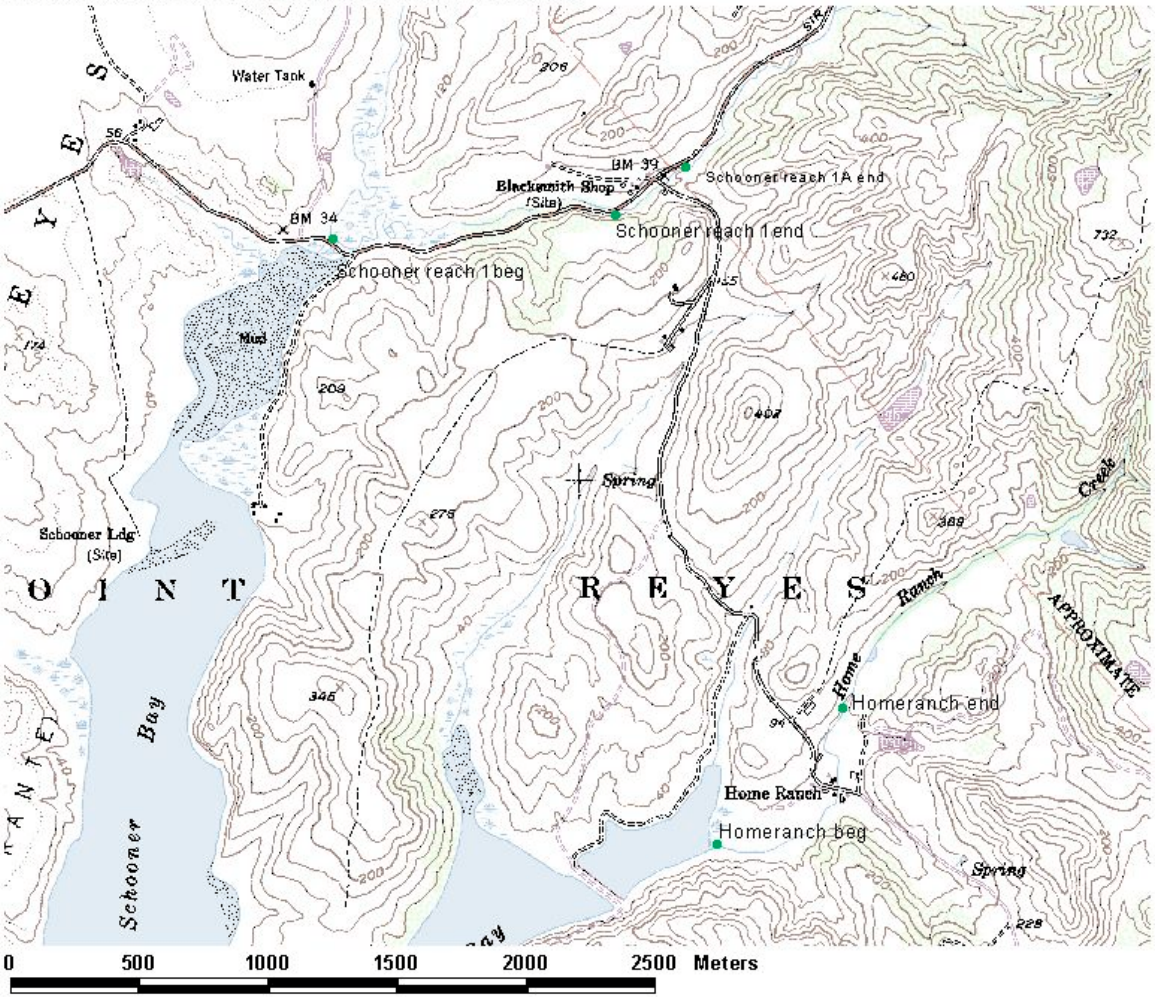


California Freshwater Shrimp Survey Sites, Point Reyes National Seashore, Summer 2002
SHEET 2-Laguna, Muddy Hollow, and Glenbrook Creeks



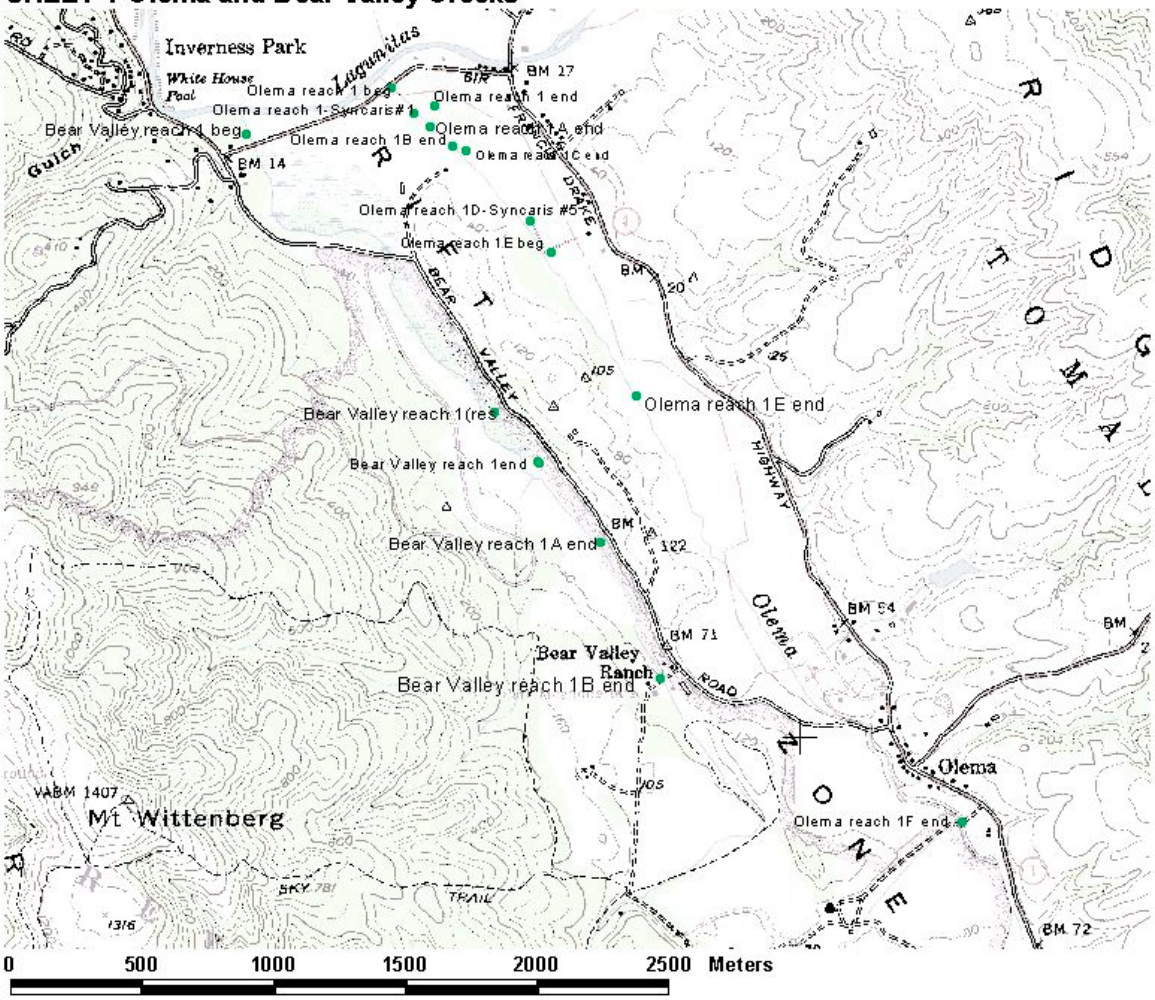
Base Map: Drakes Bay and Inverness 7.5 min. USGS Quad, California
File: Shrimp2002.apr
Created on Nov 15, 2002 by D.Fong

California Freshwater Shrimp Survey Sites, Point Reyes National Seashore, Summer 2002
SHEET 3-Schooner and Home Ranch Creeks



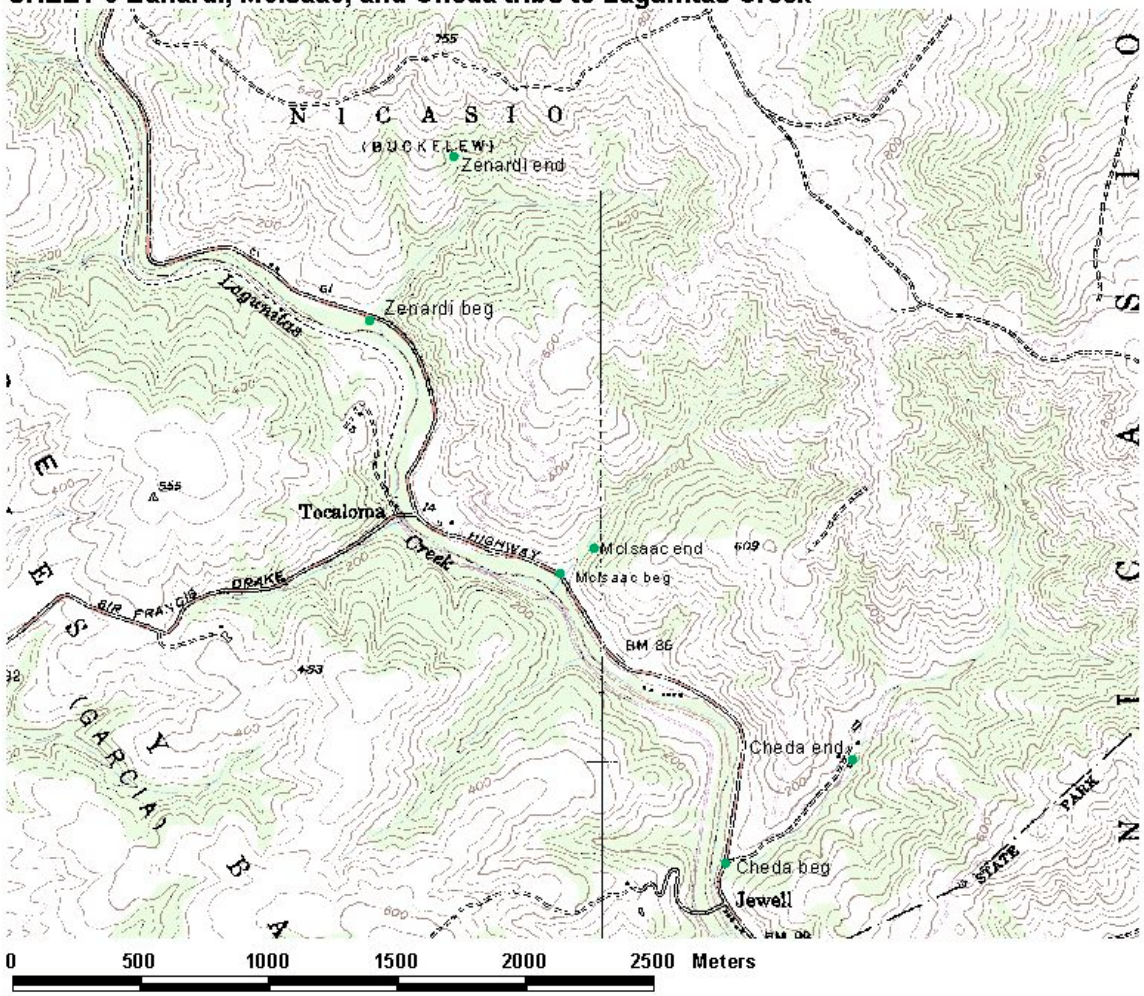
Base Map: Drakes Bay 7.5 min. USGS Quad, California
File: Shrimp2002.apr
Created on Nov 15, 2002 by D.Fong

California Freshwater Shrimp Survey Sites, Point Reyes National Seashore, Summer 2002
SHEET 4-Olema and Bear Valley Creeks



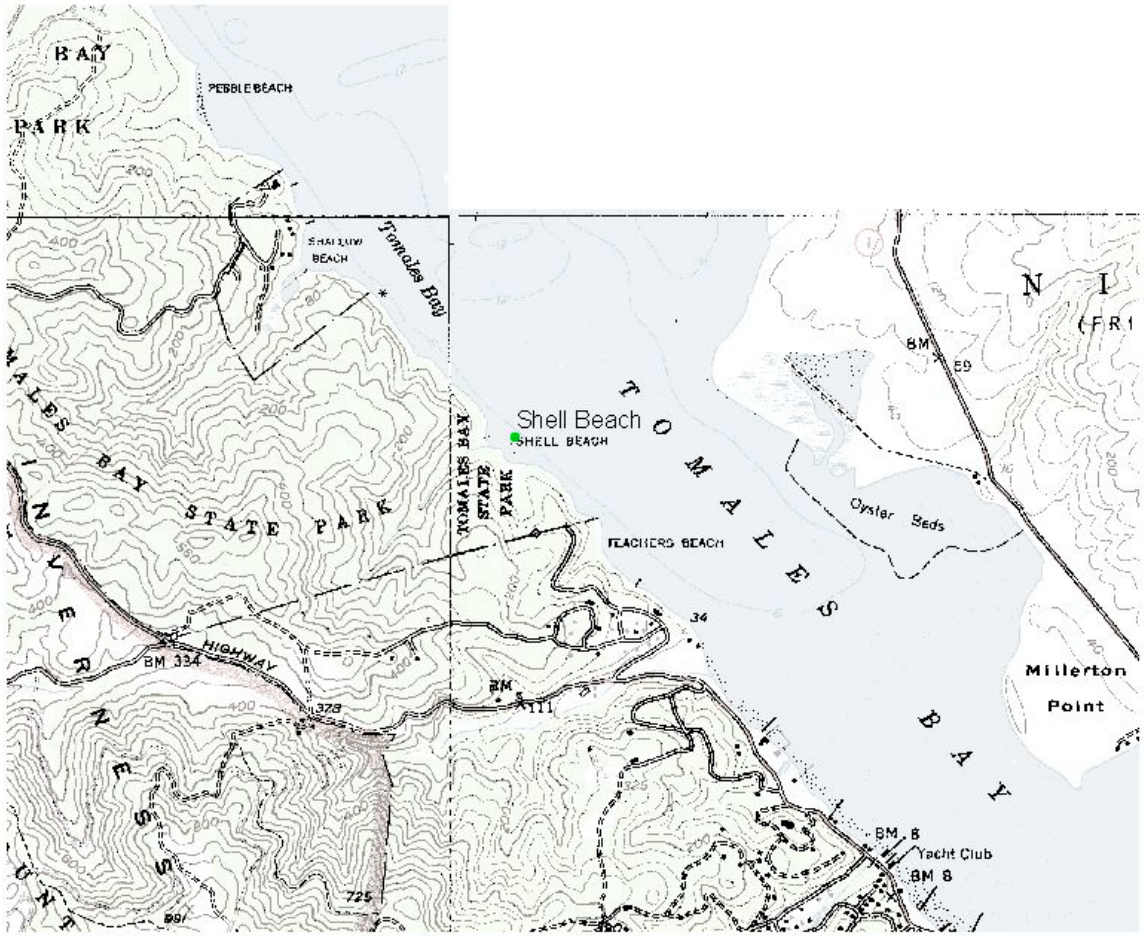
Base Map: Inverness 7.5 min. USGS Quad, California
File: Shrimp2002.apr
Created on Nov 15, 2002 by D.Fong

California Freshwater Shrimp Survey Sites, Golden Gate National Recreation Area, Summer 2002
SHEET 5-Zanardi, McIsaac, and Cheda tribs to Lagunitas Creek



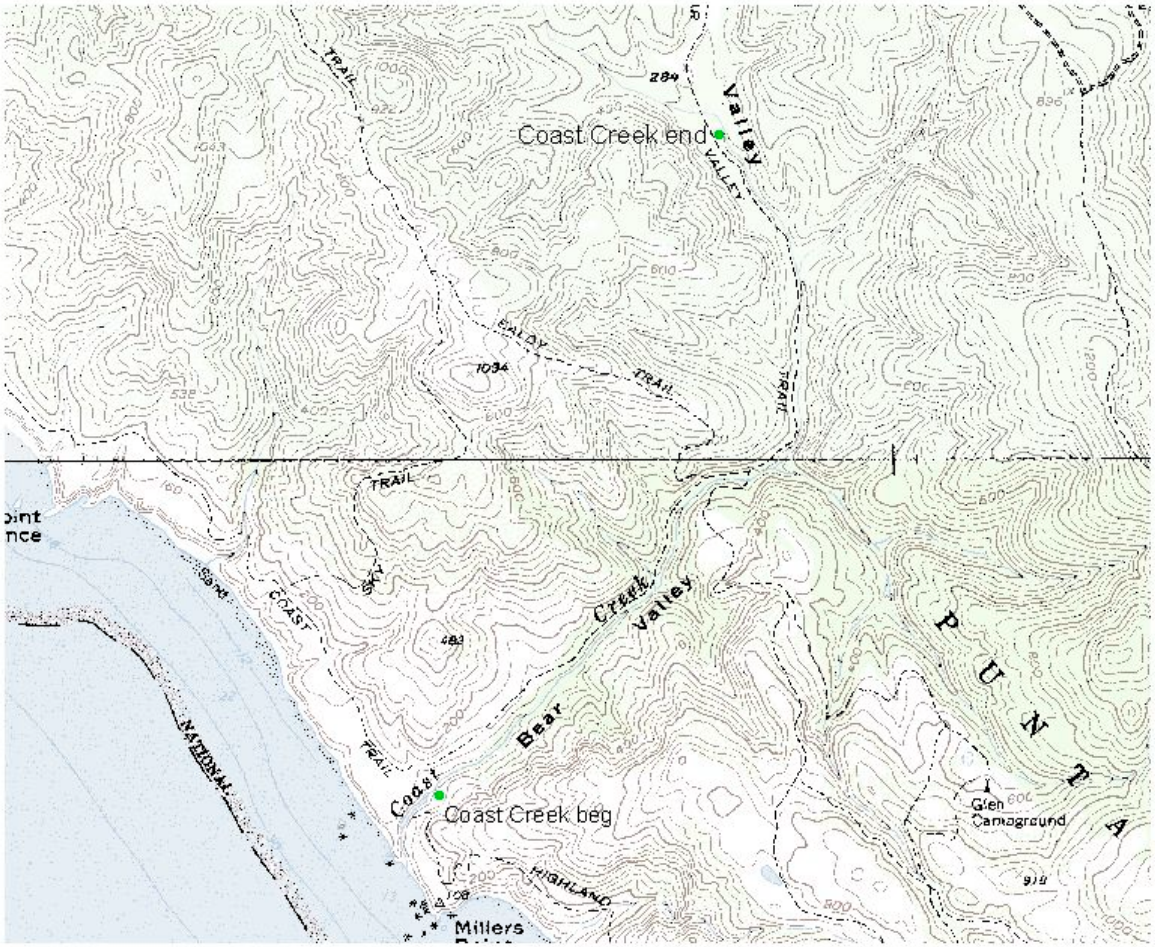
Base Map: San Geronimo and Inverness, 7.5 min. USGS Quad, California
File: Shrimp2002.apr
Created on Nov 15, 2002 by D.Fong

California Freshwater Shrimp Survey Sites, Point Reyes National Seashore, Summer 2002
SHEET 6-Shell Beach



Base Map: Inverness 7.5 min. USGS Quad, California
File: Shrimp2002.apr
Created on Nov 15, 2002 by D.Fong

California Freshwater Shrimp Survey Sites, Point Reyes National Seashore, Summer 2002
SHEET 7-Coast Creek



0 400 800 1200 1600 2000 2400 Meters

Base Map: Double Point & Inverness 7.5 min. USGS Quad, California
File: Shrimp2002.apr
Created on Nov 15, 2002 by D.Fong

Appendix III: UTM locations for starting and ending points of surveyed streams

CREEK	*NORTHING*	*EASTING*
Kehoe begin	4222891	504746
Kehoe end	4222861	505427
Home Ranch begin	4213647	507748
Home Ranch end	4214172	508235
Schooner reach 1 begin	4215988	506260
Schooner reach 1end	4216082	507356
Schooner reach 1A begin	4216082	507356
Schooner reach 1A end	4216267	507624
Laguna reach 1 begin	4209213	511165
Laguna reach 1 end	4209768	511359
Laguna reach 1A begin	4209768	511359
Laguna reach 1A end	4210632	512089
Laguna reach 2 begin	4210632	512089
Laguna reach 2 end	4210694	512504
Muddy Hollow begin	4209736	510409
Muddy Hollow end	4211217	511430
Glenbrook reach 1 begin	4210536	509384
Glenbrook reach 2 begin	4211985	509894
Glenbrook reach 2 end	4212139	509943
McIsaac begin	4211190	521683
McIsaac end	4211290	521813
Cheda begin	4210062	522329
Cheda end	4210468	522823
Zanardi begin	4212174	520942
Zanardi end	4212811	521267
Bear Valley reach 1 begin	4212733	516091
Bear Valley reach 1(res	4211684	517104
Bear Valley reach 1end	4211488	517268
Bear Valley reach 1A begin	4211488	517268
Bear Valley reach 1A end	4211189	517430
Bear Valley reach 1B begin	4211189	517430
Bear Valley reach 1B end	4210674	517657
Olema reach 1 begin	4212910	516636
Olema reach 1 1st FWS	4212817	516725
Olema reach 1 end	4212841	516800
Olema reach 1A 2nd FWS	4212841	516800
Olema reach 1A end	4212765	516788
Olema reach 1B begin	4212765	516788
Olema reach 1B end	4212688	516873
Olema reach 1C 3rd FWS	4212688	516873
Olema reach 1C end	4212670	516924
Olema reach 1D begin	4212670	516924
Olema reach 1D 4th FWS	4212670	516924
Olema reach 1D 5th FWS	4212405	517164
Olema reach 1E begin	4212290	517242
Olema reach 1E end	4211741	517565
Olema reach 1F begin	4211741	517565
Olema reach 1F end	4210129	518802
Coast Creek begin	4204599	516538
Coast Creek end	4207005	517557
Shell Beach	4218860	511103