COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
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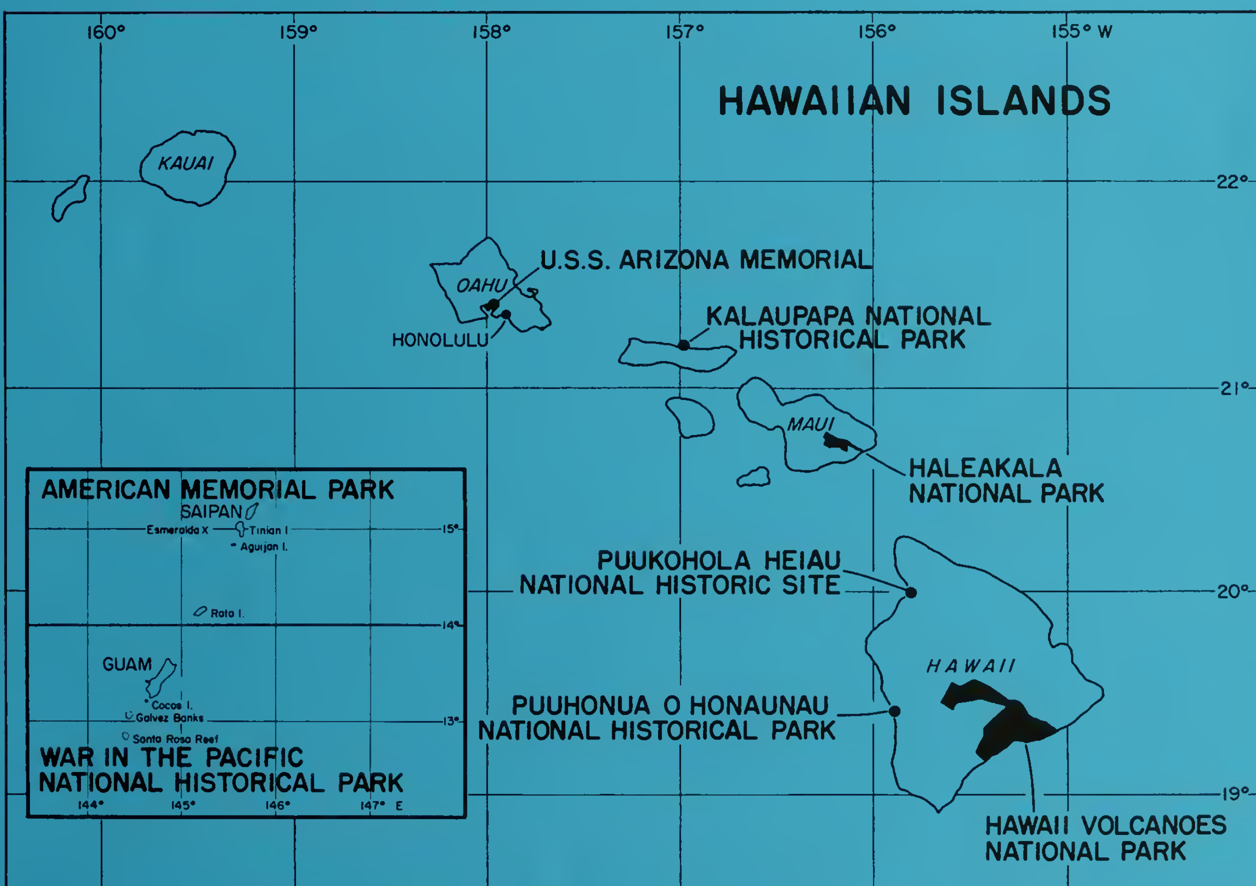
Technical Report 116
Habitat Use by Fish ('o'opu), Snails (hihiwai), Shrimp ('opae) and Prawns in Two Streams on the Island of Moloka'i.



UNIVERSITY OF HAWAII AT MANOA
HONOLULU, HAWAII 96822

WESTERN REGION, NATIONAL PARK SERVICE
SAN FRANCISCO, CALIF. 94102

The National Park Service and the University of Hawaii signed the memorandum of agreement establishing this Cooperative National Park Resource Studies Unit (CPSU/UH) on March 16, 1973. The CPSU/UH provides a multidisciplinary approach to studies on the biological resources in the National Parks in Hawaii, that is, Hawaii Volcanoes National Park, Haleakala National Park, City of Refuge National Historical Park, and Puukohola Heiau National Historic Site. Through the Unit Director, projects are undertaken in areas identified by park management. These studies provide information for resource management programs. The involvement of University faculty and students in the resource management of the National Parks in Hawaii leads to a greater awareness of the problems and needs of the National Park Service. At the same time, research not directly or immediately applicable to management is also encouraged through the CPSU/UH.

COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
UNIVERSITY OF HAWAI`I AT MANOA

Department of Botany
3190 Maile Way
Honolulu, Hawai`I 96822
(808) 956-8218

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Habitat Use by Fish ('o'opu), Snails (hihiwai), Shrimp ('opae) and Prawns in Two Streams on the Island of Moloka'i.

Anne M. Brasher

Department of Zoology
University of California at Davis

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ABSTRACT

Habitat use by gobies, molluscs and crustaceans was evaluated in two streams on the Island of Moloka`i, Hawai`i. One stream, Waikolu, is diverted while the other, Pelekunu, is not. The study focused on three native gobies (*Awaous guamensis, Sicyopterus stimpsoni* and *Lentipes concolor*), a native snail (*Neritina granosa*), a native shrimp (*Atyoida bisulcata*) and an introduced prawn (*Macrobrachium lar*). In both Waikolu and Pelekunu Streams, species showed less longitudinal separation than typically report Hawaiian stream systems. The range of habitat availability was wider in Pelekunu Stream than in Waikolu Stream, reflecting the fact that Waikolu Stream is diverted. Overall, habitat use tended to reflect availability, with animals utilizing the deeper and faster water available in Pelekunu Stream; consequently, species overlap was higher in Waikolu Stream. The impact of diversions on fauna in oceanic islands such as Hawai`i can be especially severe because dewatering will prevent downstream dispersal of larvae and upstream migration of post-larvae, critical to the lifecycle of amphidromous species.

INTRODUCTION

Hawai'i is the most isolated island archipelago in the world, located 4,000 km from the nearest continent. This extreme isolation has resulted in an aquatic macrofauna that is low in diversity but high in endemism (Hawai'i Stream Assessment 1990; Kinzie 1988, 1990; Maciolek 1975, 1977a,b). Native stream fishes (gobies) and the larger crustaceans and molluscs in Hawai'i are of marine origin and have retained an oceanic larval life stage. This amphidromous life cycle and the apparently random recruitment back to the streams can affect both species composition and abundance. Furthermore, Hawaiian streams are subject to periodic freshets (high flow spates) which are predicted to play an important role in regulating community structure (Kinzie and Ford 1982).

The natural variability in distribution and abundance of native species is accentuated by the fact that the majority of streams in Hawai'i have been severely altered by humans through diversions, channel modification, siltation and introduced species (Kinzie 1988; Maciolek 1975, 1977a,b). In 1978 at least 53% of the estimated 366 perennial streams had some type of water diversion and 15% of the streams in the state had been channelized (Parrish et al. 1978). In fact, only 14% of Hawaiian streams today may be considered physically pristine and there appear to be no biologically pristine streams, because at least one introduced species has been found in every stream that has been surveyed (Hawai'i Stream Assessment 1990; Timbol and Maciolek 1978).

The primary threat to native stream organisms throughout the state is the continuing loss and degradation of available stream habitats (Maciolek 1977a, b). To properly manage these stream systems and to evaluate the impact of water diversions on the stream fauna, a better understanding of the baseline conditions, microhabitat use and community structure in these streams is required.

Species profiles

The native Hawaiian freshwater fish fauna consists of three endemic gobies: Lentipes concolor ('o'opu alamo'o); Sicyopterus stimpsoni ('o'opu nopili); and, Stenogobius hawaiiensis ('o'opu naniha); an indigenous goby Awaous guamensis ('o'opu nakea); and, an endemic eleotrid Eleotris sandwicensis ('o'opu akupa). (See Appendix A for synonyms of all Latin and Hawaiian species names). Native crustaceans found in Hawaiian streams include the mountain shrimp Atyoida bisulcata ('opae kuahiwi) and an estuarine species Macrobrachium grandimanus ('opae 'oeha'a). Also present throughout the state is the introduced Tahitian prawn (Macrobrachium lar), which was first released in Hawai'i in 1956. Native gastropods found in Hawaiian streams include the limpet-like Neritina granosa (hihiwai) and the more estuarine Theodoxus vespertinus (hapawai). Snails in the families Thiaridae and Lymnaeidae are also present in some streams, and more frequently along the bank and in seeps.

Amphidromous life cycle.

The native stream fauna of Hawai'i is primarily diadromous. To complete their life cycle, the animals must migrate between the stream and ocean (Figure 1). As is typical of freshwater species on oceanic islands, the native gobies, shrimp and snails have an amphidromous life cycle (McDowall 1988). Eggs are laid in the stream, the eggs hatch and the larvae wash out to the sea. After spending a larval phase of four to seven months as marine plankton, gobies return to the streams as transparent postlarvae (hinana) approximately 2 cm long (Ego 1956; Kinzie 1988; Radtke et al. 1988). For hihiwai, each egg capsule contains approximately 250 larvae (Ford 1979). The snail larvae spend an undetermined amount of time in the ocean and then return to a stream where they spend the remainder of their life. Spates (high flood events) have been hypothesized as a cue for both reproduction and recruitment back to the stream (Kinzie 1988).

The factor responsible for stream identification and recruitment (post-larvae returning from the ocean to the stream) are not well understood, but there is no indication that larvae must return to natal streams (Ford and Yuen 1988). Genetic studies on gobies (Fitzsimons et al. 1990) and hihiwai (Hodges 1992) suggest that a large proportion of new recruits originated from the same stream. However, adequate mixing occurs between streams so that all are considered to be one population.

Erdman (1986) found upstream migration of the goby Sicydium plumieri in Puerto Rico to be triggered by moon phase, but this does not appear to be the case for Hawaiian gobies. It has been suggested that gobies may be timing such activities as spawning and return migrations from the sea by cueing on the high flows that occur during spates (Erdman 1968; Kinzie and Ford 1982; Manacop 1953). Postlarval gobies (hinana) were traditionally considered a delicacy by Hawaiians and were caught in great numbers along stream mouths (Titcomb 1972).

'O'opu.

Awaous guamensis ('o'opu nakea) is the most common Hawaiian freshwater goby. This species is found on all the major islands, although on Oahu the population sizes and number of streams inhabited are small (Kinzie 1990). 'O'opu nakea, which is the largest goby, tends to be found in lower reaches, especially in streams with precipitous waterfalls, and utilizes deeper slower moving waters (Ego 1956, Kinzie 1988). Nakea is an omnivore (Ego 1956; Kido et al. 1993). It has been suggested that 'o'opu nakea probably competes with alamo'o for food, and to some extent space (Timbol et al. 1980). A fishery exists for nakea on the Island of Kaua'i, where they are caught in large numbers during their annual spawning run to the stream mouth following heavy fall flooding (D. Heacock, pers. comm.).

Sicyopterus stimpsoni ('o'opu nopili) typically occurs in the mid reaches, overlapping with 'o'opu nakea in the lower parts and 'o'opu alamo'o in the upper sections, but utilizes the more rapid stream velocities (Fitzsimons et al. 1993, Kinzie 1988). 'O'opu nopili appear to be restricted to relatively undisturbed streams with good water quality and a high rate of discharge (Kinzie 1990). A tagging study by Kinzie and Ford (1982) showed nopili to be quite sedentary. 'O'opu nopili is primarily an algal grazer, feeding on diatoms and blue-green algae (Kinzie and Ford 1982; Tomihama 1972).

The least common goby in Hawai'i (Timbol et al. 1980), Lentipes concolor ('o'opu alamo'o) has been a candidate for federal listing as an endangered species. 'O'opu alamo'o is known for its remarkable climbing ability and is found in the middle to upper reaches of streams, although it may occur near the stream mouth in streams that end in terminal waterfalls (Maciolek 1977; Nishimoto & Kuamoo 1991). Pelekunu Stream and Waikolu Stream are notable for supporting high densities of 'o'opu alamo'o (Hawai'i Stream Assessment 1990). 'O'opu alamo'o spend more time in mid-water pools than other species, although they can also have a strong affinity for fast riffles (Kinzie & Ford 1982; Timbol et al. 1980).

The diet of 'o'opu alamo'o consists of algae, crustaceans, and insect larvae (Lau 1973). Larger 'o'opu alamo'o eat more animal material while smaller ones eat more algae (Lau, 1973). Mature males are aggressive and show territorial behavior (Fitzsimons & Nishimoto 1986; Lau 1973; Maciolek 1977). Female 'o'opu alamo'o tend to move freely up and down the stream and around pools, while males are very site specific (Nishimoto & Fitzsimons 1986). Individuals breed several times throughout an extended reproductive season (Kinzie 1993; Maciolek 1977).

Stenogobius hawaiiensis ('o'opu naniha) and Eleotris sandwicensis ('o'opu akupa) typically occur in lower stream reaches and estuaries. Although it possesses fused pelvic fins, naniha is apparently neither a strong swimmer nor climber and occurs mainly along stream margins and other low flow areas near the stream mouth (Fitzsimons and Nishimoto 1991). Akupa actually lacks the fused pelvic fins characteristic of true gobies and thus is found only in stream reaches below the first precipitous waterfall (Fitzsimons and Nishimoto 1991; Kinzie and Ford 1982). 'O'opu naniha is essentially absent from both Waikolu and Pelekunu Streams and 'o'opu akupa is present in Pelekunu Stream but rare in Waikolu Stream. Neither species is included in this microhabitat study.

'Opae.

Atyoida bisulcata ('opae kuahiwi) are typically found in the higher reaches along with alamo'o, or above the limits of fish distribution. 'Opae are considered a delicacy and are collected by humans for consumption. 'Opae are widespread in Hawai'i and can be found in habitats ranging from quiet pools to high velocity cascades (Couret 1976; Kinzie 1990). Typically this species is found in streams with swiftly flowing water (Kinzie 1990).

Hihiwai.

Neritina granosa (hihiwai) is a limpet-like snail that tends to hide under boulders and in crevices during the day, coming out at night to forage and mate. These snails require clear, cool well-oxygenated streams and avoid areas with high siltation (Ford 1979; Kinzie 1990). Hihiwai tend to be found in lower to mid-stream reaches, and are frequently collected by humans for consumption, although a ban on commercial sale went into effect in 1993. Stream dewaterment may provide an artificial upper boundary for hihiwai in Waikolu Stream. Snail populations were severely depleted by a large landslide in Pelekunu Stream in 1986 (Ford and Yuen 1988) and natural recolonization processes have been modified by humans attempting to restock the stream.

Macrobrachium lar.

The Tahitian prawn, Macrobrachium lar, was first introduced to Pelekunu Stream in 1956. Because it has an amphidromous life cycle like the native stream species, M. lar subsequently spread to every stream in the state. Several researchers have indicated potentially negative impacts of M. lar on native goby and snail populations. Yuen (1987) concluded that M. lar appears to disrupt courtship and mating behavior, as well as competing for space with nopili. Tomihama (1972) observed a large M. lar capturing a nopili in the field at night. M. lar has been observed interacting with alamo'o, and it has been suggested that M. lar may disrupt social behavior of alamo'o and possibly prey on the goby (Kinzie and Ford 1982; Timbol et al. 1980). M. lar was repeatedly observed feeding on hihiwai during our nighttime studies.

Longitudinal distribution.

Hawaiian stream species are known to separate out along the gradient from mouth to headwaters (Figure 2). The eleotrid (akupa), a goby (naniha), the native prawn (Macrobrachium grandimanus) and a neritid snail (Theodoxus vespertinus) are found in estuaries or below the first waterfall. 'O'opu nakea, the largest goby, tends to be found in lower reaches, especially in streams with precipitous waterfalls. The same is true for hihiwai and the introduced prawn, Macrobrachium lar. 'O'opu nopili often overlaps with nakea but may be found further upstream as well. 'O'opu alamo'o is found at the highest elevation of all the gobies. The native mountain shrimp, 'opae, may overlap the upper distribution of alamo'o, and also occurs further upstream. The number, and relative gradient, of waterfalls appears to play an important role in the overall distribution of species.

Stream descriptions

Waikolu Stream.

Waikolu Valley lies on Moloka'i's rugged north shore (Figure 3) within the Kalaupapa National Historical Park. Waikolu Valley (156°W, 21°N) is approximately 6.4 km (4 mi) long and the headwaters arise from mountain bogs just above an elevation of 1,219 m (4,000 ft). The upper valley is narrow with steep walls and widens to 1.6 km (1 mi) at the mouth of the valley. Total perennial tributary length is 14.32 km (8.9 mi) and drains an area of 11.9 km^2. Average annual rainfall in Waikolu Valley is 120 inches per year, with 65% of the annual total occurring during the wet season (November to April) and 35% during the dry season (May to October). Average mean daily discharge in Waikolu Stream from 1960 to 1994 was 18 cfs, and ranged from 6.1 cfs (24 October 1993) to 628 cfs (21 November 1992) during this study (U. S. Geological Survey 1994). Mean daily discharge during this study was 13.7 cfs in 1992, 17 cfs in 1993 and 17.8 cfs in 1994 (water years).

An extensive water collection system exists in upper Waikolu Stream. Water diversion through the 8.2 km (5.1 mi) Waikolu Tunnel began in November 1962. Three surface water diversion structures at approximately 304 m (1,000 ft) elevation include two that collect water from tributaries to Waikolu stream and one on the main stream (referred to here as the "upper dam"). There is also a surface water diversion structure (referred to here as the "lower dam") at 223 m (730 ft) where water is collected and pumped back up to the tunnel. There are three established wells (two in the valley and one in the tunnel) and three new wells, drilled in 1988, in the floor of Waikolu Valley. An annual average of 4.5 cfs is transported through the Waikolu tunnel for agricultural use on the other side of the island (U. S. Geological Survey, 1992-1994).

Since the diversions started, the intermediate reaches of Waikolu Stream carry only 50% of natural undiverted flow conditions, while in the lower reaches the percentage increases to 70%, due to the intermediate surface runoff and groundwater accretion (Diaz, in prep.). These estimated percentages have dramatic seasonal variations; while the difference in flow volume as an average for the rainy period is 10%, during the dry season that difference reaches 22% (Figure 4). The month of August is the most critical period in terms of water withdrawals from the stream, because flows are naturally low during this time (Walsh et al. 1992).

Pelekunu Stream.

Pelekunu Stream (156°W, 21°N), with seven named tributaries, lies in a large valley bounded on the south by Olokui and Wailau Valley and on the north by Pu'u Ali'i and Waikolu Valley. Total tributary length, including unnamed creeks and springs, is over 16 kilometers (10 miles) draining an area of 17.8 km^2. The main stem of Pelekunu Stream is not gauged. Long term records are available for Pilipililau tributary (at 300 m elevation) which has a drainage area of 0.49 mi^2. Average daily discharge for the past 25 years was 1.62 cfs, and ranged from 0.72 cfs (9 July 1993) to 25 cfs (21 November 1992) during the 1993 water year (U.S. Geological Survey 1994). Mean daily discharge in Pilipililau tributary during this study was 1.53 cfs (1993 water year). Pelekunu Stream is one of the last free flowing streams in the state. While at one time it could have been considered typical of Hawaiian perennial streams, Pelekunu is now one of the few streams that remains relatively unaltered by humans (Hawai'i Stream Assessment 1990).

Microhabitat use and community structure

Flows in Hawaiian streams are seasonally variable, with discharge fluctuations up to a thousand-fold recorded from summer lows to winter freshets (Timbol and Maciolek 1978). Discharge may vary greatly even from day to day depending on the amount of rainfall (Barnes and Shiozawa 1985). Such variations in temperate stream systems are known to affect fish assemblages (Moyle and Li 1979) and have been attributed with the capacity to override biological interactions such as competition and predation (Grossman et al. 1982). Assemblage stability (community structure) appears to be greater in benign environments than in those with extreme fluctuation (Matthews et al. 1988; Ross et al. 1985).

Winterbourne et al. (1981) emphasize the importance of flood events in regulating community structure in New Zealand streams, and Hynes (1970) argues that tropical streams are more likely than temperate streams to be regulated by flood events. It has been suggested that stochastic events may play an especially important role in structuring Hawaiian stream communities because the amphidromous species are subject both to large environmental fluctuations in the stream and to chance events during the larval ocean stage and as they recruit back to the freshwater (Kinzie 1988).

Most studies of tropical stream and river assemblages to date, however, suggest that they are powered by biological interactions (Lowe-McConnell 1987; Ross 1986). Moyle and Senanayake (1984) found fish assemblages in a wet-zone stream in Sri Lanka to be predictable, co-evolved systems with competition the predominant structuring principal component. Ross (1986) has concluded that high levels of ecological separation are generally characteristic of fish assemblages. This was confirmed for Hawaiian streams by Kinzie's (1988) discovery of distinct habitat preferences and a longitudinal separation of the three Hawaiian gobies that he studied; 'o'opu alamo'o, 'o'opu nakea and 'o'opu nopili.

Water diversions and community structure

Water diversions are one of the most damaging changes to stream systems in Hawai'i (Maciolek 1975). Pelekunu Stream is one of the few streams left in Hawai'i that is relatively pristine (Hawai'i Stream Assessment 1990). A comparison of Pelekunu Stream to nearby Waikolu Stream, which has a number of diversion structures, provides an excellent opportunity to evaluate the impacts of water diversion on community structure. The potential impacts of dewatering are especially important here as there is a possibility that Pelekunu Valley may be developed as a major source of water for the Island of Moloka'i at some time in the future (Ford and Yuen 1988).

Hawaiian gobies are dependent upon free access to the sea to complete their life cycle. The impact of diversions on fauna in oceanic islands such as Hawai'i can be especially severe because dewatering will prevent downstream dispersal of larvae and upstream migration of post-larvae (Timbol and Maciolek 1978). Impacts of dewatering may also be less immediately obvious, as in the case of niche shifts or decreases in niche breadth either in habitat use or feeding habits, which may lead to gradual long-term decline of species.

METHODS

Station locations

Six sampling stations in Waikolu Stream and five sampling stations in Pelekunu Stream were selected for microhabitat use studies (Figure 5). These stations were chosen to be comparable between Waikolu and Pelekunu, and were located in the vicinity of a long-term gauging station whenever possible. To evaluate longitudinal changes in physical parameters and species distribution, stations were located by the mouth, lower-mid reach, upper-mid reach, and a high reach (Table 1). Additional effort was focused on the upper midreach section of Waikolu Stream where a number of diversion structures exist and flow is reduced, at times to no water at all. Three sampling stations were placed in the upper-midreach of Waikolu Stream: one below the lowest diversion structure and two in the periodically dry area. Two stations, one corresponding to the area below the lowest diversion and one to the dewatered area were placed in Pelekunu Stream.

At each sampling station five transects were placed across the stream (Appendix B). A random number table was used to determine transect location, with the five transects placed within a 100 m stretch at each station. Transect location is the distance upstream in meters (as chosen by the random number table) from the origin of the station. Each transect was divided into half-meter square quadrats from one bank to the other. Because pool macrohabitat types were rare in both Pelekunu and Waikolu Streams, random placement missed them (Bovee 1982; T. Payne pers. comm.). Consequently two additional transects were added at three stations (P500, P4400, W1000) where pools were present. In one instance, the randomly placed quadrat fell on a small whitewater cascade where visibility was poor (Station P500). This transect was moved upstream to the first section of the stream with adequate visibility. Finally, in the uppermost station in Waikolu Stream (W4000), one transect was only two quadrats wide, so an additional transect was placed just upstream to increase the amount of information obtained.

Some randomly placed transects fell in completely dry sections in the diverted upper-mid reach of Waikolu Stream. Transects were moved to the next section upstream that had any water. This water usually consisted of isolated pools rather than a flowing stream.

Species identification

One or two snorkelers cautiously approached the transect from downstream and recorded all species present in each quadrat of the transect, moving from the bank and across the stream. Goby size was reported to the nearest half inch based on visual estimation. Shrimp were recorded without a length estimate, but no juveniles or new recruits were observed during the study. All shrimp observed were approximately one inch, standard carapace length. Snails were collected and measured using calipers after all other species information was recorded.

A standard method of recording location of each individual is to place a weighted marker in the spot the individual was observed. Preliminary studies in Waikolu and Pelekunu showed that this was not feasible in these streams because densities of gobies were often extremely high and because the weighted markers were swept away by the current. Consequently, at each quadrat, the snorkeler drew a diagram indicating the location of each individual that was observed. This method requires more training of observers, but was very effective here as all observers had substantial experience in conducting surveys of Hawaiian stream fauna prior to this study.

Habitat variables measured

After the location of individuals present in each quadrat across the transect had been recorded, a number of physical parameters were measured. Additionally, elevation of the station, distance from the mouth of the stream, and macrohabitat type were recorded. Microhabitat type was also recorded for each quadrat. Macro- and microhabitat types included cascade/ plungepool, boulder riffle, riffle, run, pool, and edgewater. Macrohabitat included the section 10 m up and downstream of each transect, and microhabitat described the area within the specific quadrat. Pools and edgewaters showed no measurable flow, with pools being deeper than 6 inches, and edgewaters shallower than 6 inches. Riffles were defined by the presence of whitewater.

Flow was measured at three spatial scales; the transect (discharge), the quadrat (as surface velocity and at the 6/10 depth) and at the location of each aquatic organism in the quadrat (always a benthic measurement), using a Marsh-McBirney Model 201 electronic flow meter. Velocity measurements were made using a Pygmy current meter at Station P20 in Pelekunu Stream because the electronic meter was malfunctioning at that time. Measurements were converted to metric units to be comparable with the Marsh-McBirney readings. Velocity measurements in each quadrat were used to calculate discharge (See Appendix C), using standard USGS methods (Buchanan and Somers 1969).

Stream width was measured across each transect using a measuring tape, and distance of each quadrat from the nearest edge was calculated. Center depth, deepest (maximum) depth, and depth of each aquatic organism observed was recorded for each quadrat. Rugosity (topographic heterogeneity) was determined using a 15 foot chain of small links, marked off every other link, draped in a diagonal across each quadrat (Friedlander et al. 1995). Care was taken to ensure that the chain followed the substrate contours across the diagonal exactly. Number of demarcations on the chain across the quadrat diagonal was counted, and compared to the number required (21) to cross a completely flat diagonal across the half-meter square quadrat.

Percent of each substrate type was determined for each quadrat, and the substrate each aquatic organism was observed on was also recorded. Size classes of substrate were based on a modified Wentworth particle scale (Bovee and Milhous, 1978) with modifications reflecting substrate available in Hawaiian streams: gravel ($\leq$ 2 mm); cobble ($\leq$ 10 mm); rock ($\leq$ 30 mm); boulder; and, bedrock.

Principal Components Analysis

Principal Components Analysis (PCA) is performed in order to simplify the description of a set of interrelated variables. Each Principal Component is a linear combination of the original variables. PCA takes a large number of variables and produces a set of relatively few principal components that describe the data (Afifi and Clark 1984; Gauch 1982; Sokal and Rohlf 1981).

Each Principal Component has a corresponding eigenvalue. The eigenvalue is the variance that is accounted for by that component (Ludwig and Reynolds 1988). One measure of the amount of information conveyed by a principal component is its variance. For this reason, principal components are arranged in order of decreasing variance such that the first principal component is the most informative and subsequent principal components are decreasingly informative (Afifi and Clark 1984; Sokal and Rohlf 1981). While PCA typically yields ten or more principal components, the first few usually account for most of the variance in the data. These components can then be plotted, with each component as an axis.

RESULTS

Sampling stations

Microhabitat studies were conducted between June 1994 and February 1995. Between one and five transects were sampled in a day, depending on the number of quadrats in each transect. A total of 32 transects in Waikolu Stream and 28 transects in Pelekunu Stream were used in the microhabitat study. Within these transects, 277 quadrats were sampled in Waikolu Stream and 322 quadrats were sampled in Pelekunu Stream. Three selected transect locations in Waikolu Stream were dry and were replaced with new transects in locations with water. Four quadrats were not used in the microhabitat analysis because the flow was too rapid (too much whitewater) to allow visual observation of the species present.

While microhabitat stations in Waikolu Stream and Pelekunu Stream were chosen to be similar in elevation, distance from the mouth, and channel morphology, the typical macrohabitat at each transect was different between Waikolu and Pelekunu. Waikolu Stream sampling stations were made up of pool (50%) and run (47%) habitat, with only one transect (3%) a boulder/riffle (Table 2). Pelekunu Stream, on the other hand, consisted mainly of runs (57%), followed by riffles (25%), boulder riffles (11%), with one transect (4%) a pool and one transect (4%) a plunge pool (Table 3).

The types of macrohabitats available in Waikolu Stream versus Pelekunu Stream reflect the decreased flow volume in Waikolu Stream. In fact, in and just below the diverted section in Waikolu Stream, 93% of the macrohabitat at sampling stations (W2300, W3000, W4000) was classified as "pool," indicating negligible flow through the section. At comparable stations (P4400, P100) in Pelekunu Stream, 50% of the macrohabitat was riffle (or boulder riffle) indicating high velocity (white water) and 50% was run habitat.

Station descriptions.

Average stream width at microhabitat sampling stations tended to be smaller in Waikolu Stream than at comparable stations in Pelekunu Stream, the one exception was the highest (located above all of the diversions) sampling station (Figure 6). Most notable however is the extremely limited variability in stream width in the diverted section of Waikolu Stream. All other stations in both Waikolu Stream and Pelekunu Stream show width to vary greatly between transects, except the highest stations (P600, W4000) where discharge is naturally relatively low.

As expected, average discharge measured during microhabitat sampling was lowest at the upper sites and highest at the lower sites (Figure 7). For stations at similar elevations, Pelekunu Stream consistently had more discharge than Waikolu Stream. The exception was the station above the diversions in Waikolu Stream, where discharge was higher than at the corresponding station in Pelekunu Stream. Discharge was essentially zero in the section of Waikolu Stream where the diversion structures are located (W2300, W3000, W4000).

Principal Components Analysis of flow characteristics.

A principal components correlation analysis (PCA) was run using summary data for selected physical habitat variables: elevation, distance from the mouth, depth, width, velocity and discharge, and scores obtained by each species for depth and velocity selection. A Pearson Correlation calculation showed fish depth to be highly correlated ($p<.01$) with center depth (0.89) and deepest depth (0.90), and fish velocity to be correlated with mean water column velocity (0.78) and surface velocity (0.62). "Fish" depth and "fish" velocity are the depth and velocity measured at the aquatic organism.

Analysis was run with and without the variables of elevation and distance (which should automatically group stations because they were chosen, in part, on the basis of their similarity in elevation and distance from the mouth). PCA was able to produce principal components that summarized these habitat variables well, with the first two factors explaining over 80% of the variance (Table 4). Variable score loadings show how much each variable contributed to a particular principal component. Loadings above 0.5 to 0.6 are generally considered an important variable in a given component.

Principal Component 1 consisted of "flow" variables (discharge, "fish" velocity, surface velocity and stream width) while Principal Component 2 was made up of the "depth" variables ("fish" depth, center depth and deepest depth). Principal Component 1 explained 56% and 58%, and Principal Component 2 explained 31% and 34% of the variance observed in the data, run with and without elevation and distance, respectively.

A plot of the variable score loadings on the two principal components shows the "depth" variables to form one group, the "velocity" variables to form a second group, and width and discharge to fall between them (Figure 8), with discharge close to the velocity group. This has intuitive value as discharge is a function of depth, width and velocity.

Principal Components Analysis was also used to plot the microhabitat sampling stations on the two explanatory principal components. Even without the most obvious "elevation" and "distance from the mouth" variables, the stations group on the two principal components as expected (Figure 9). Sampling stations at the mouth in Waikolu Stream (W200) and Pelekunu Stream (P500) group together as do those in the highest reach (W4000, P600). Also, the middle level (lower and upper) group together, except for the upper-mid stations in the diverted section of Waikolu Stream, which form their own group.

Species distribution

While the microhabitat sampling stations were not designed to be population surveys, because the stations were not randomly selected, and relatively little of the overall stream area was included, they do provide a "snap shot" of general trends in distribution, size classes, and relative species abundance. More complete information on 'o'opu distribution and abundance in Waikolu Stream and Pelekunu Stream, and hihiwai distribution and abundance in Waikolu Stream, are provided in the accompanying reports: "Monitoring the distribution and abundance of native gobies in Waikolu Stream and Pelekunu Stream" and "Life history of the native Hawaiian stream snail Neritina granosa (hihiwai)".

A total of 366 alamo'o (145 in Waikolu Stream, 221 in Pelekunu Stream), 61 nakea (12 in Waikolu Stream, 49 in Pelekunu Stream) and 429 nopili (102 in Waikolu Stream, 327 in Pelekunu Stream) were observed. With a relatively larger body size, there are typically fewer nakea.

The native shrimp ('opae) and snails (hihiwai) show especially clumped distributions. They were present in only a few quadrats, but typically abundant where present. A total of 170 'opae (140 in Waikolu Stream, 30 in Pelekunu Stream), 148 hihiwai (120 in Waikolu Stream, 28 in Pelekunu Stream), and 43 prawns (10 in Waikolu Stream, 34 in Pelekunu Stream) were observed. Additionally, in 215 of the quadrats sampled (4 in Waikolu Stream, 211 in Pelekunu Stream) there were no animals present.

Longitudinal distribution and abundance.

Lentipes concolor ('o'opu alamo'o) was more abundant in Waikolu Stream than Pelekunu Stream at the mouth, but the opposite was true upstream (Figure 10). In fact, there were four times as many alamo'o at the microhabitat stations in Pelekunu Stream than in the comparable stations in the diverted section of Waikolu Stream.

Awaous guamensis ('o'opu nakea) was most abundant at microhabitat stations closest to the mouth in both streams (Figure 11). The distribution of Sicyopterus stimpsoni ('o'opu nopili) is similar to that of nakea, but densities of nopili are much higher (Figure 12).

Atyoida bisulcata ('opae) tend to be found only in the upper reaches where goby densities are low, or gobies are not present. 'Opae were especially abundant at the microhabitat stations in the upper reaches of Waikolu Stream (Figure 13). While 'opae are typically found in clear, cool, well-oxygenated water, their tendency to move to the uppermost reaches (presumably to avoid predation by fish) may have provided ability to withstand temporary isolation in shallow pools.

Neritina granosa (hihiwai) were most abundant at the microhabitat site nearest the mouth in Waikolu Stream (Figure 14). Hihiwai face predation pressure from a number of species including the introduced prawn (Macrobrachium lar), the Black Crown Night

Heron (Nycticorax nycticorax) and humans. Human collection efforts are similar in both streams. A few people have access to the mouths of Waikolu Stream (by hiking along the coast) and Pelekunu Stream (boating in to camp in the summer). Likewise, some people helicopter in to upper reaches of Pelekunu or drive through the water diversion tunnel to get to the upper reaches of Waikolu Stream. People who do get to the stream are most likely harvesting snails and shrimp ('opae). However, because of the relative isolation, human predation pressure is likely less than in other Hawaiian streams.

The introduced Tahitian prawn, M. lar, was found in the lower reaches of both Waikolu and Pelekunu Streams (Figure 15). More M. lar were observed in Pelekunu Stream than in Waikolu Stream.

Size distribution

Figures 16 to 21 show the size distribution, at each station, of the three gobies; 'o'opu alamo'o, 'o'opu nakea and 'o'opu nopili.

'O'opu abundance and discharge

The range of fish abundance increased with increasing discharge (Figure 22), with the largest number of fish at higher discharges.

Physical principal components and species distributions

Depth.

Depth utilized by each species was highly variable. Center depth (Figure 23) and maximum (deepest) depth (Figure 24) in each quadrat were highly correlated (Pearson Correlation 0.91), and use followed the same pattern for both variables. Although there was much species overlap, 'o'opu nakea and Macrobrachium lar used the deepest water in both streams, with 'o'opu alamo'o using similar depths in Pelekunu Stream but deeper water in Waikolu Stream. Quadrats in which no animals were observed had the shallowest depths.

In Waikolu Stream, all three goby species showed high overlap in quadrat depth selection (Figure 25). In Pelekunu Stream, alamo'o showed no preference, while nakea occupied mainly deeper ($\geq$ 60 cm) quadrats and nopili was found mainly in shallow ($\leq$ 40 cm) quadrats (Figure 26).

The depth each animal was observed in reflected depth availability, and animals tended to use a depth in the quadrat approximating the center depth (Figure 27). Center depth in the quadrat, deepest (maximum) depth in the quadrat, and the depth where the fish was observed, was consistently deeper at corresponding stations in Pelekunu Stream. The one exception was in the stations at the highest elevation where animals used deeper depths in Waikolu Stream.

Velocity.

Water column and surface velocity were strongly correlated (Pearson Correlation: 0.771), consequently species showed a similar pattern of utilization for both mean water column (6/10 depth) velocity (Figure 28) and surface velocity (Figure 29). Gobies and shrimp showed much overlap in their use of mean water column velocity and surface velocity in each quadrat. Hihiwai in both streams and 'o'opu nopili in Pelekunu Stream showed the largest range, as well as the highest velocities selected.

All three species of goby tended to use velocities less than 30 cm/sec in Waikolu Stream (Figure 30). A higher proportion of nakea used velocities recorded as "-5", a slow back-eddy, and zero velocity locations. 'O'opu nopili in Pelekunu Stream used a wider range of velocities than in Waikolu Stream, while the other two species showed similar patterns in both streams (Figure 31).

Because the gobies, shrimp, and snails are benthic dwellers, velocities measured at the animal were typically much lower than the velocities measured at the 6/10 depth (mean water column velocity) or surface (Figure 32). Exceptions to this occurred at the station in Waikolu Stream where the water is diverted, and all measured velocities (stream, surface and fish) in the isolated pools were essentially zero.

Substrate.

Substrate composition was determined for each quadrat in a transect. At all stations in Waikolu Stream, boulder was the most common substrate (Figure 33). Boulder was also the most common substrate in Pelekunu Stream, except at the highest elevation where bedrock predominated (Figure 34). Boulders tended to make up about 50% of the substrate in each quadrat at all stations, with rocks, cobble, and gravel, in that order, making up the remainder of the substrate.

Substrate utilization by 'o'opu alamo'o in both Waikolu and Pelekunu Streams tended to reflect what was available (Figure 35). Nakea, on the other hand, rarely used boulder substrate and showed a strong tendency to occur on gravel and cobble (Figure 36). Substrate utilization by 'o'opu nopili showed a less clear pattern, although a tendency to select boulder and avoid gravel was apparent (Figure 37). 'Opae were quite varied in their habitat utilization, showing no particular pattern (Figure 38). In different quadrats; gravel, cobble, rock and boulder were each utilized with proportionately greater frequency than the other substrates.

Substrate use by 'opae did not reflect substrate availability. Longitudinally, 'opae show the most overlap with 'o'opu alamo'o, both being more frequent in the upper reaches. The two species also show a fair amount of substrate overlap. At the one station where 'opae and the introduced prawn both occur, 'opae used the larger substrates and M. lar used the smaller substrates.

Hihiwai were almost always found on the larger substrates; rock, boulder, and bedrock (Figure 39), while one of its predators, the introduced prawn M. lar most frequently selected the smallest substrates; cobble and gravel (Figure 40).

Distance from edge.

The width of the stream, and whether there are exposed portions of streambed in the middle of the channel, determine the amount of "edge" habitat present in a stream. While new recruits often prefer shallow edgewaters, larger fish tend to be found in deeper faster flowing water away from the banks.

Because sections of Waikolu Stream are dewatered, a much higher proportion of habitat available in Waikolu Stream is edge habitat. 38% of the quadrats in Waikolu

Stream and 22% of the quadrats in Pelekunu Stream were 0.5 or less meters from the edge. And while 35% of the quadrats in Pelekunu Stream were 2.5 or more meters from the edge, only 12% of the quadrats in Waikolu Stream were 2.5 or more meters from an edge (Figure 41).

'O'opu abundance showed a trend of increasing with increasing distance from the edge in both Waikolu Stream and Pelekunu Stream (Figure 42), despite proportionally fewer quadrats being available as distance increased. More than half of the fish observed in Pelekunu Stream were in quadrats four or more meters from an edge.

Rugosity

Rugosity, or topographic heterogeneity, is a measure of the amount of substrate available to be used by benthic organisms. In general, the higher the rugosity score, the more substrate is available. Additionally, quadrats with higher rugosity would tend to provide more shelter from high velocity flow and from predators. Rugosity scores ranged from 6 to 69 (Figure 43), with most between 23 and 47. It is possible to get a score of less than 21 when a quadrat is not completely covered with water; for example in very shallow areas, along edges, or when one large boulder fills most of the vertical space in the quadrat.

Principal Components Analysis of species habitat utilization

Principal Components Analysis (PCA) was run separately for Waikolu Stream and Pelekunu Stream. The best fit was provided with a correlation matrix and no rotation. Detrended Correspondence Analysis (DCA) is currently recommended as an alternative to PCA when data are nonlinear. However, when examining the Hawaiian stream data, PCA provided a better model (each principal component explained more of the variance) than DCA. Hawaiian stream systems appear to be more amenable to PCA than other systems because there are relatively few species, and because the range of each microhabitat variable is rather limited.

Results of the Principal Components Analysis were similar, but not identical, for Waikolu Stream and Pelekunu Stream. Three principal components emerged, explaining a total of 54% of the variance in both Waikolu Stream (Table 5) and Pelekunu Stream (Table 6). The first principal component encompassed stream flow variables (velocity and discharge) and station location (elevation and distance from the mouth). The second principal component put depth variables with stream width and fish distance from the edge in Waikolu Stream, and depth variables with proportion of boulders in Pelekunu Stream. The third principal component summarized substrate variables.

Species were plotted against the first two principal components, flow variables (Principal Component 1) and depth variables (Principal Component 2) to determine similarity in habitat utilization across species. Most of the species plotted fairly close together, but in both streams, 'opae received high negative scores on both Principal Component 1 and Principal Component 2 (Figure 44). In Waikolu Stream, 'o'opu nakea showed habitat utilization different from other species, like 'opae plotting negative on Principal Component 1. In Pelekunu Stream it was 'o'opu nopili that plotted separately, the only species showing a positive mean score on Principal Component 1. Overall, habitat utilization overlap was very high for all species, with 'opae, nakea and nopili again showing the least overlap (Figure 45).

CONCLUSIONS

Summary

Habitat availability was different in Waikolu and Pelekunu Streams, reflecting the fact that Waikolu Stream is diverted and Pelekunu Stream is not. Stations consisted primarily of pools (low velocity) and runs in Waikolu Stream and runs and riffles (high velocity) in Pelekunu Stream, indicating lower flow velocity in Waikolu Stream. Stream width was less and quadrat depth was shallower in Waikolu Stream, than at each comparable station in Pelekunu Stream, except at the highest station (which is above the diversion structures in Waikolu Stream). Likewise, for stations at similar elevations, Pelekunu Stream consistently had more discharge than Waikolu Stream.

Overall, all three goby species were more abundant in Pelekunu Stream than in Waikolu Stream. ‘O‘opu alamo‘o was more abundant at the station closest to the mouth in Waikolu stream, but there were four times as many alamo‘o in Pelekunu Stream at the higher reaches. There were also substantially more ‘o‘opu nakea and ‘o‘opu nopili in Pelekunu Stream than at comparable stations in Waikolu Stream.

‘Opae were especially abundant at the stations in the upper reaches of Waikolu Stream. ‘Opae are typically found only in higher reaches or where fish densities are low or fish are absent. This tendency to move to the uppermost reaches, where water depth is often shallow, may have provided the ability to withstand temporary isolation in the shallow pools in the diverted area. Hihiwai were most abundant at the station by the mouth of Waikolu Stream. Hihiwai populations were severely depleted by a large landslide in Pelekunu Stream in 1986, so the natural distribution and abundance for that stream can not yet be determined.

In Waikolu Stream, all three goby species showed high overlap in quadrat depth utilization. In Pelekunu Stream, ‘o‘opu alamo‘o showed no preference while nakea used mainly deeper quadrats and nopili used mainly shallow quadrats. Alamo‘o was found in many more deep quadrats in Pelekunu Stream than in Waikolu Stream, reflecting the higher availability of deeper quadrats in Pelekunu Stream. Species tended to be located at a depth corresponding to the center depth of the quadrat. Since the mean depth in Pelekunu Stream was deeper than at corresponding stations in Waikolu Stream, aquatic organisms were found at deeper depths in Pelekunu Stream. Again, the exception is at the highest station, which in Waikolu Stream is above the diversion structures.

All three species of fish tended to be found in quadrats with lower velocities in Waikolu Stream than in Pelekunu Stream. In both streams ‘o‘opu nakea used habitats with the slowest velocities. ‘O‘opu nopili used a wider range of velocities in Pelekunu Stream than in Waikolu Stream, while the other two species showed similar patterns in both streams. Nopili was found more often in quadrats with higher velocities in Pelekunu Stream than in Waikolu Stream, suggesting a tendency to use higher velocities when they are available. ‘Opae showed considerable overlap with the fish species in mean water column velocity utilization. Hihiwai used quadrats with the largest range of velocities and also the highest velocities in both streams.

For stations at corresponding elevations, substrate composition was similar in Waikolu Stream and Pelekunu Stream. ‘O‘opu alamo‘o tended to use substrate in the same proportion it was available. ‘O‘opu nakea rarely used boulder substrate and occurred mainly on gravel and cobble. ‘O‘opu nopili, on the other hand, tended to use boulder substrate and not the gravel. ‘Opae showed no particular utilization pattern for substrate. Hihiwai were almost always found on the larger substrates; rock, boulder and bedrock.

‘O’opu abundance increased with distance from the edge, in both Waikolu and Pelekunu Stream, despite proportionately fewer quadrats being available as distance increased. Because sections of Waikolu Stream are dewatered, a much higher proportion of habitat available in Waikolu Stream is edge habitat. The gobies however tend not to use this edge habitat.

Future research

The microhabitat studies described here provide information on habitat use by the native and introduced macrofauna. Subsequent microhabitat use studies could determine seasonal variation in habitat use and whether habitat use differs between the day and the night.

Using the information obtained in these studies, three additional areas can be investigated:

1) how habitat use changes in relation to species density and composition within the stream;
2) the impact of the introduced prawn on the habitat use by the native species; and,
3) experimental studies to examine changes in habitat use as discharge and flow velocity change.

Management recommendations

Fish density is much lower in Waikolu Stream, especially in the diverted area, than in corresponding stations in Pelekunu Stream. In order to maintain the integrity of the stream system, a resource management goal should be to maintain fish populations in Waikolu Stream are at natural densities.

A wider range of habitats was available in Pelekunu Stream than in Waikolu Stream and the aquatic animals in Pelekunu Stream used this wider range. Higher overlap may lead to increased competition and subsequently decreased viability of the native organisms. Increased discharge would increase the range of a number of habitat parameters including velocity, depth and non-edge habitat. While this is especially important in the area of the stream that is currently diverted (as little usable habitat was available), areas downstream of the diversion are also impacted by the reduced discharge and could benefit by increased flow. Additionally, increased diversion rates causing further reduction of flow would eventually reduce habitat suitability of downstream areas, and should be avoided.

In Waikolu Stream the reduced flow not only reduces habitat availability, but periodic dewatering of the stream inhibits the ability of the native organisms to disperse downstream and to make return migrations necessary to complete their life cycle. A continuous flow of water through the dewatered section of Waikolu Stream would improve habitat for the native stream animals and would enhance both downstream dispersal of larvae and upstream migration by post-larvae.

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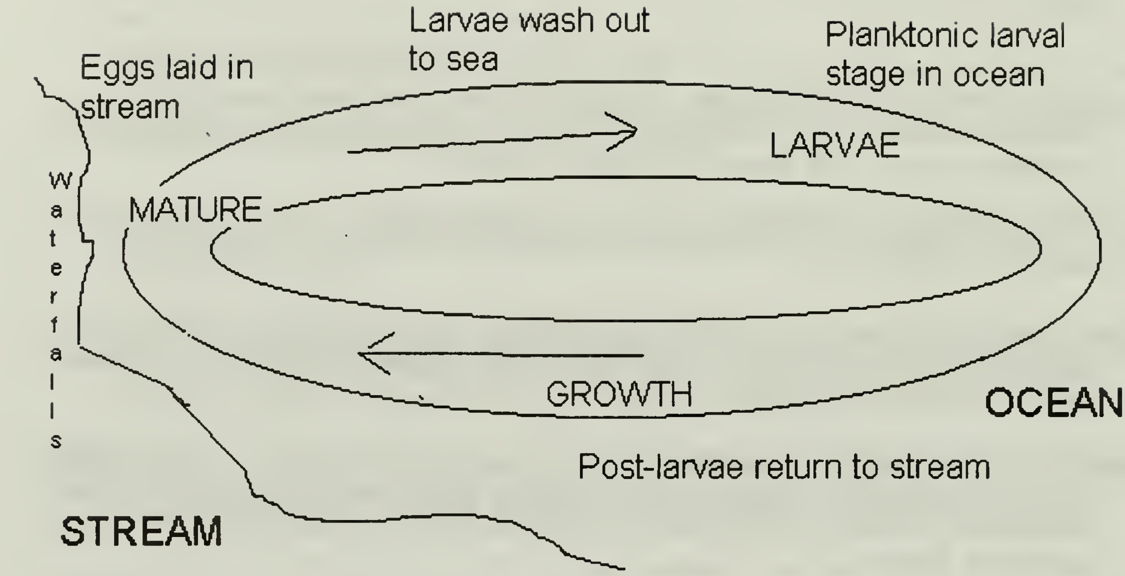


Figure 1. Amphidromous life cycle of Hawaiian Stream macrofauna.

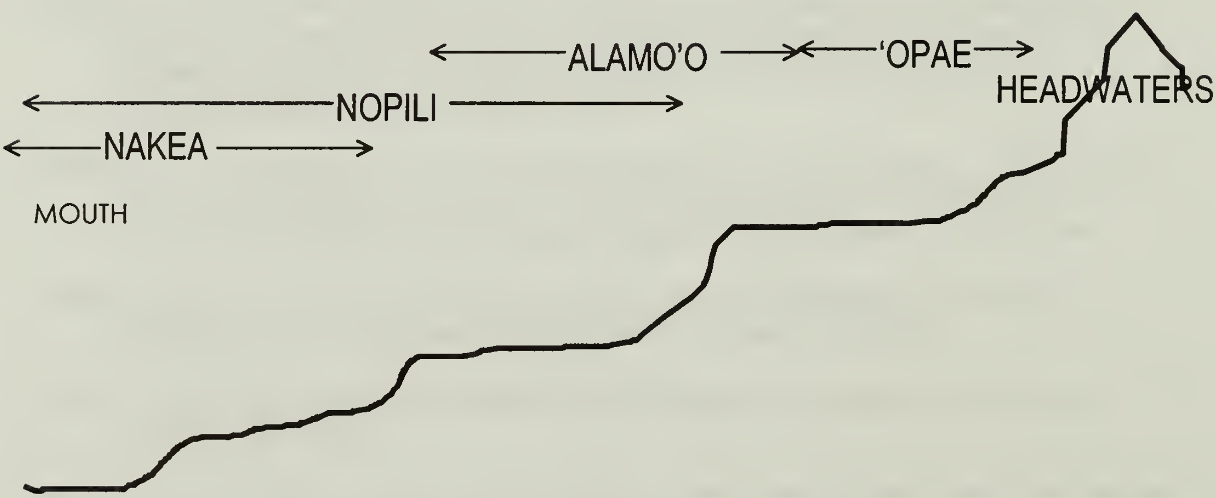


Figure 2. General longitudinal distribution pattern of native stream species included in the microhabitat studies.

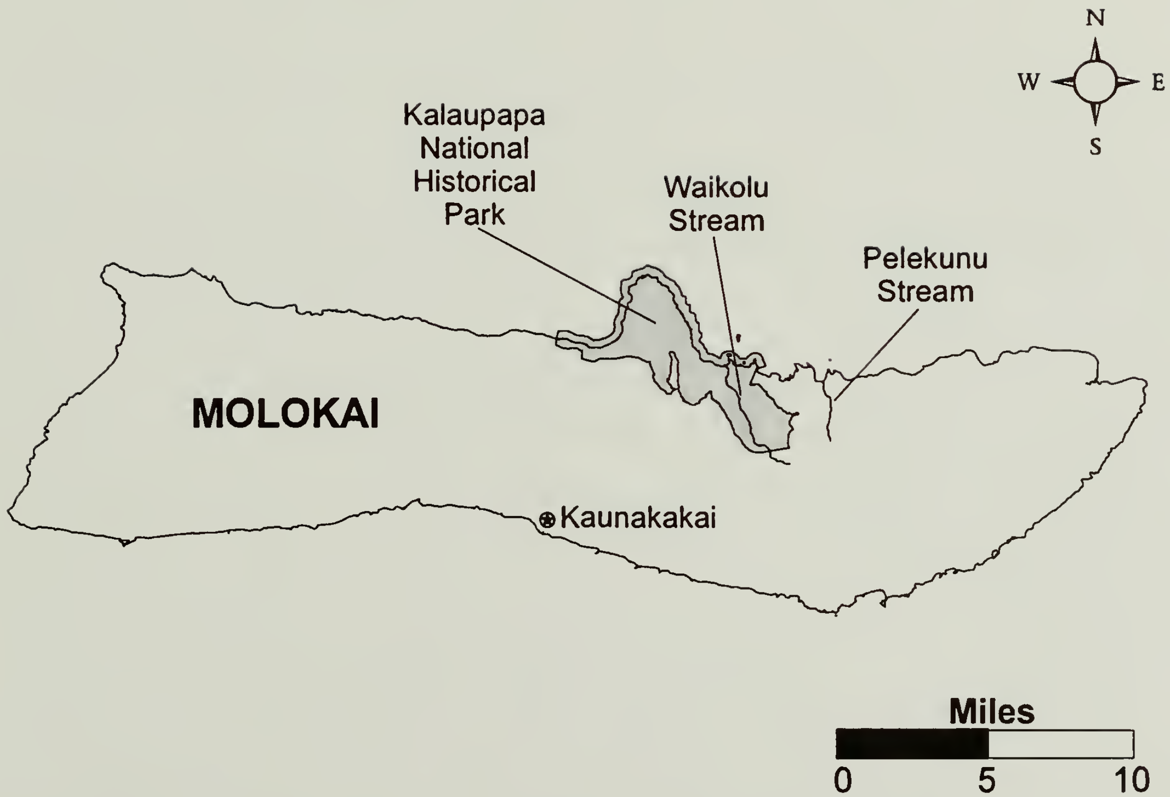


Figure 3. Location of Waikolu Stream and Pelekunu Stream on the Island of Moloka'i

Figure 4. Impact of water diversions on flow volume in Waikolu Stream. Seasonal variation of mean daily flows comparing pre- and post-tunnel periods (from Diaz, in prep.). Mean daily flows from 1921 - 1995 at the "lower" USGS stream gage, located below the diversions.

Figure 5. Location of microhabitat sampling stations in Waikolu Stream and Pelekunu Stream.

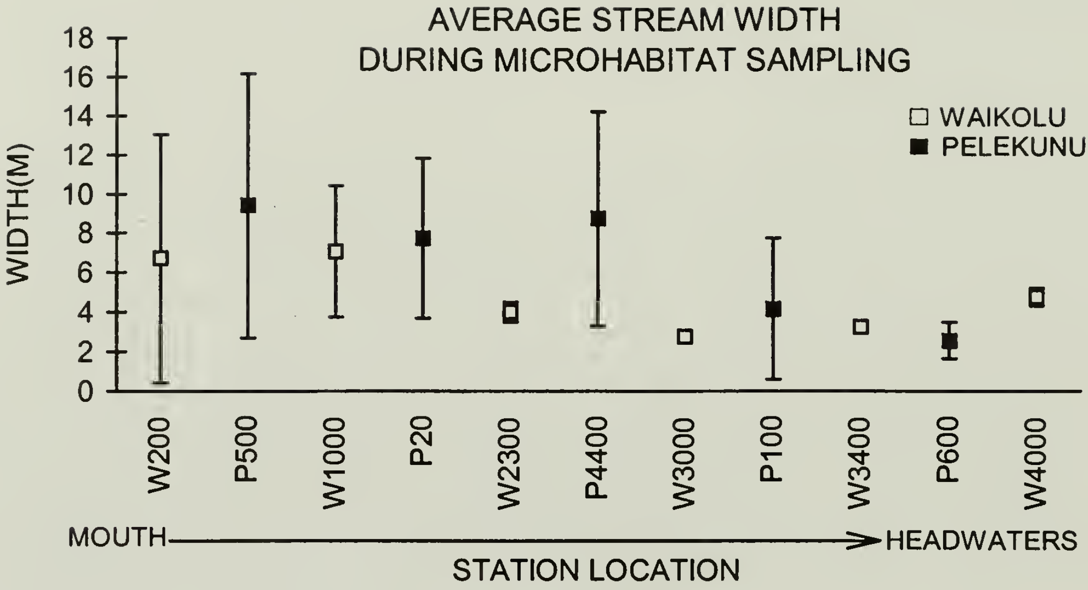


Figure 6. Mean stream width (error bars equal ± one standard deviation) of microhabitat sampling transects at each station in Waikolu Stream and Pelekunu Stream.

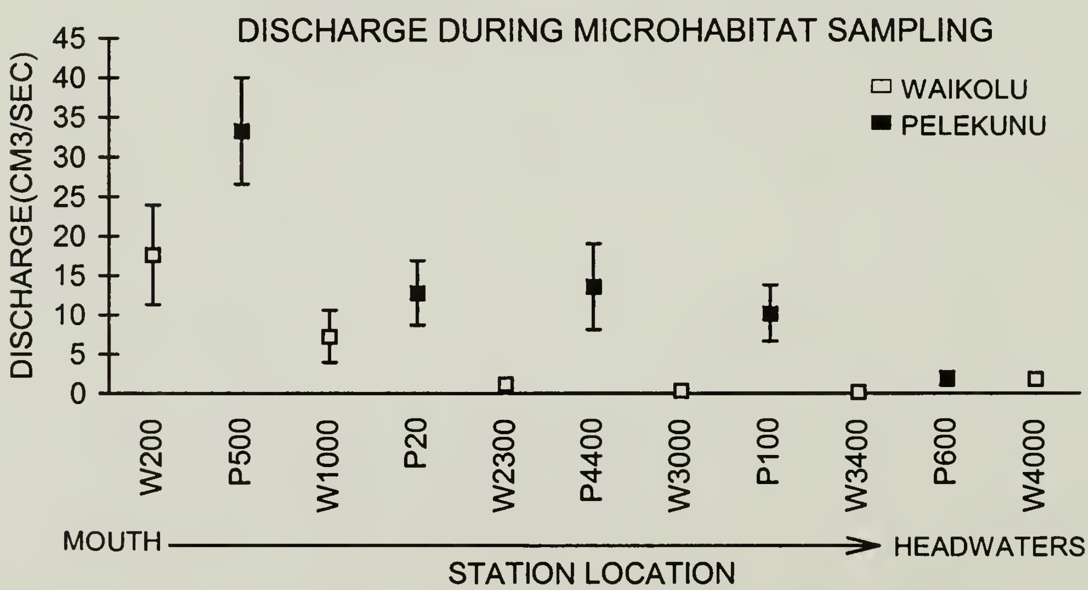
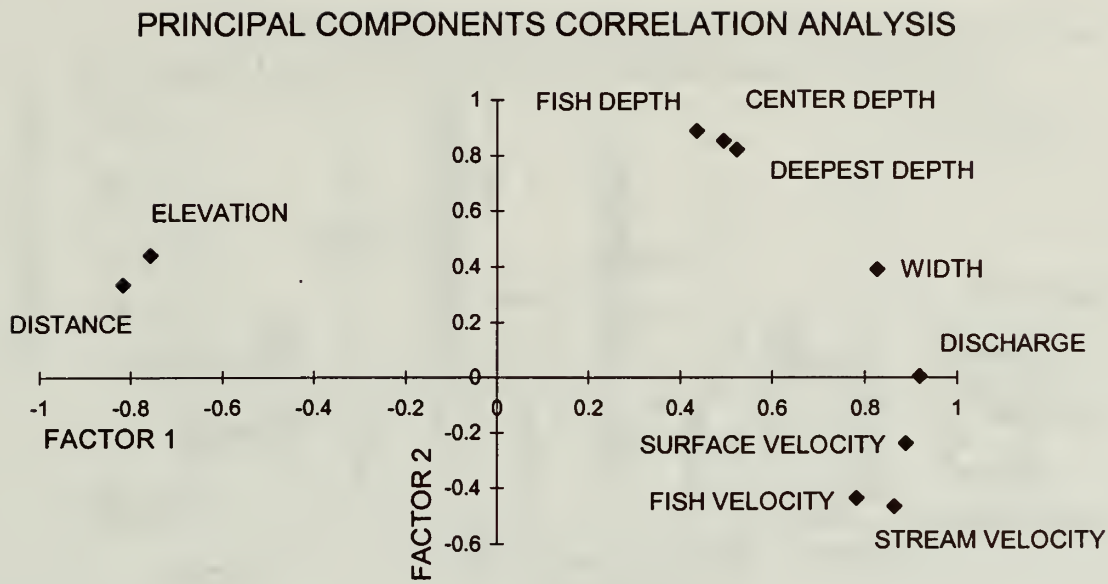


Figure 7. Mean stream discharge (error bars equal ± one standard deviation) calculated at microhabitat sampling transects at each station in Waikolu Stream and Pelekunu Stream.



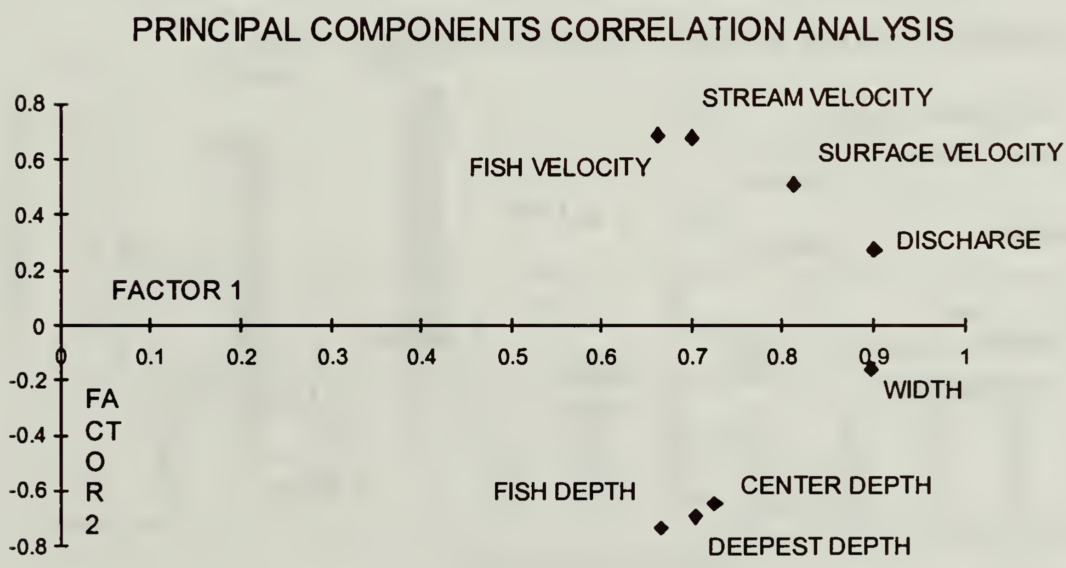
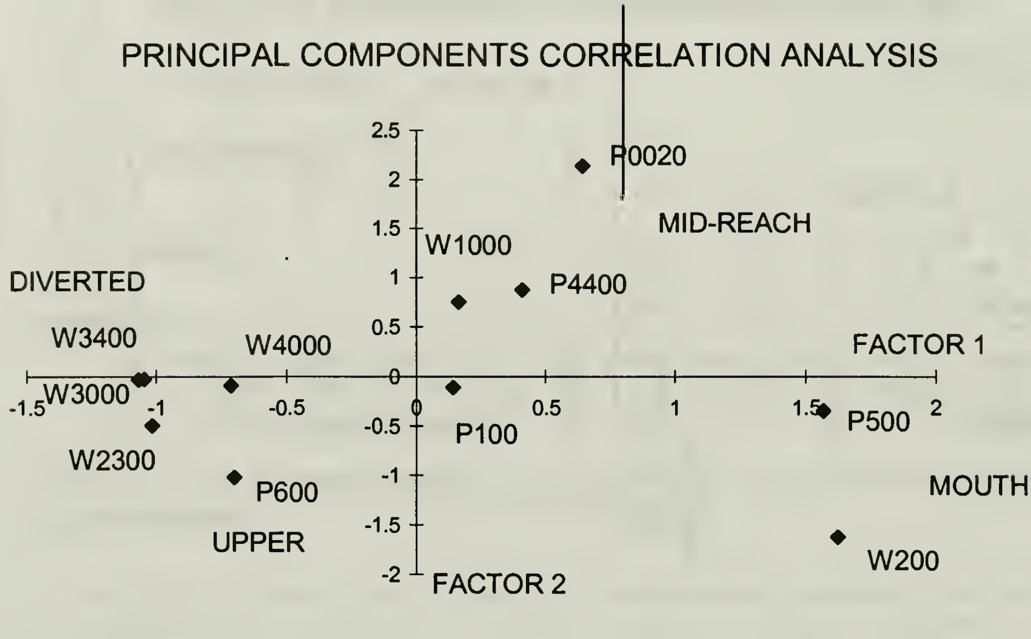


Figure 8. Plot of selected habitat variables as determined by Principal Components Correlation Analysis. Top graph includes the variables of distance from the mouth and elevation, lower graph omits these variables.



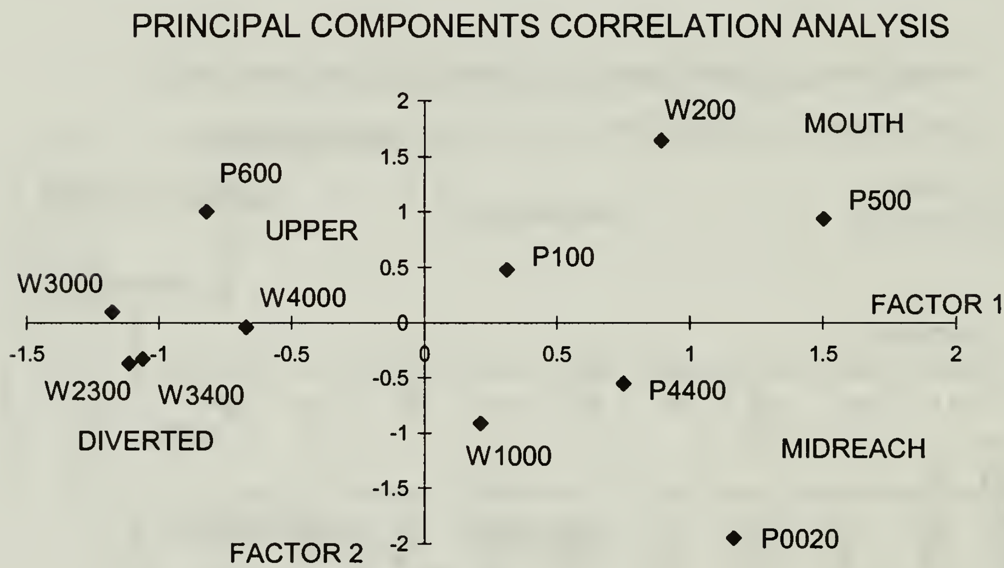


Figure 9. Plot of microhabitat sampling stations as determined by Principal Components Correlation Analysis using selected habitat variables. Top graph includes the variables of distance from the mouth and elevation, lower graph omits these variables.

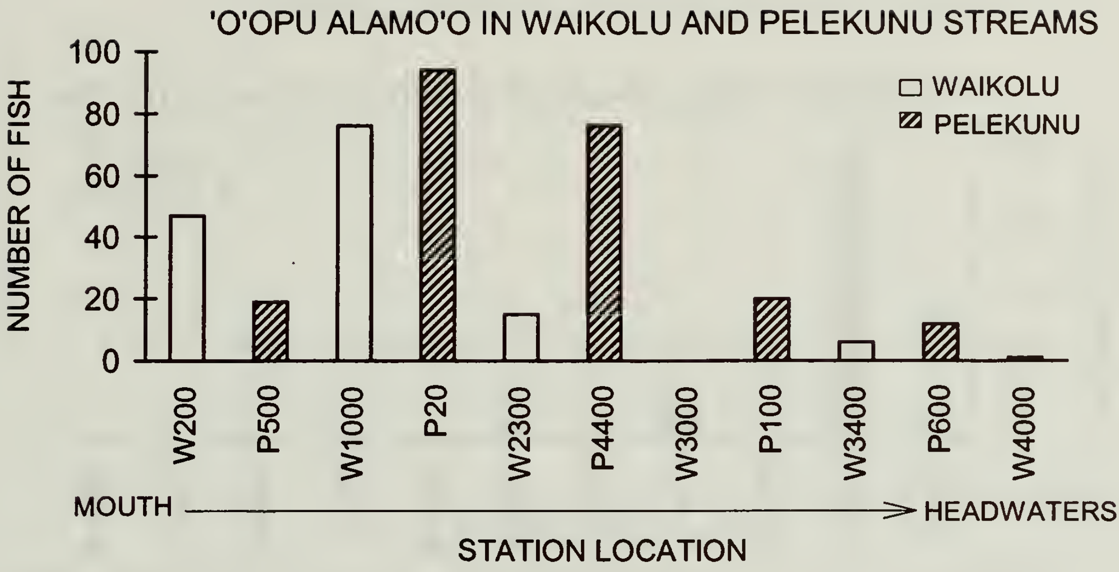


Figure 10. Abundance of 'o'opu alamo'o at microhabitat sampling stations in Waikolu Stream and Pelekunu Stream (total number of fish at all transects combined for each station).

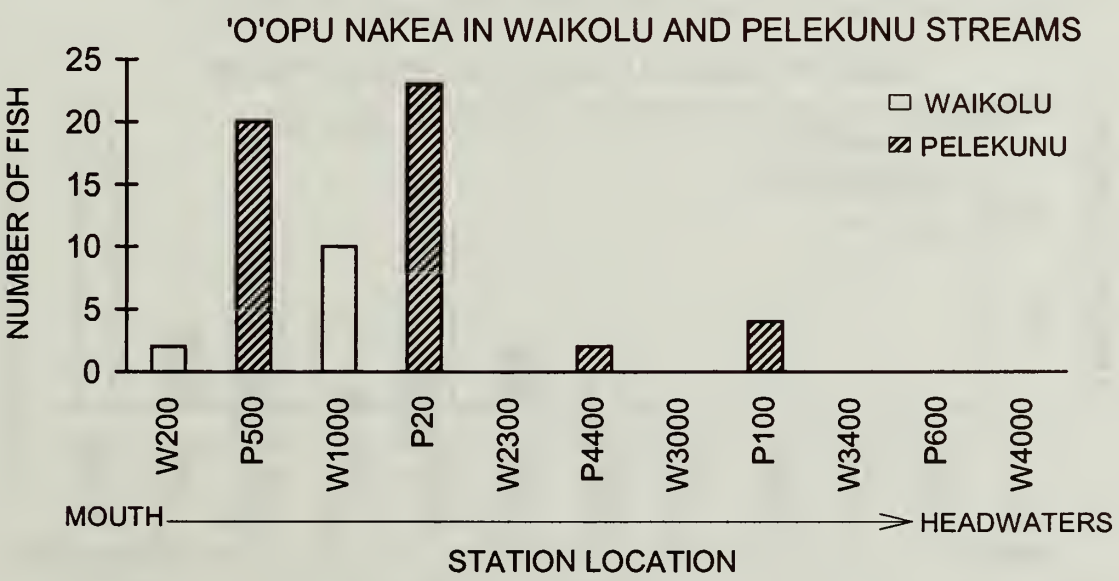


Figure 11. Abundance of 'o'opu nakea at microhabitat sampling stations in Waikolu Stream and Pelekunu Stream (total number of fish at all transects combined for each station).

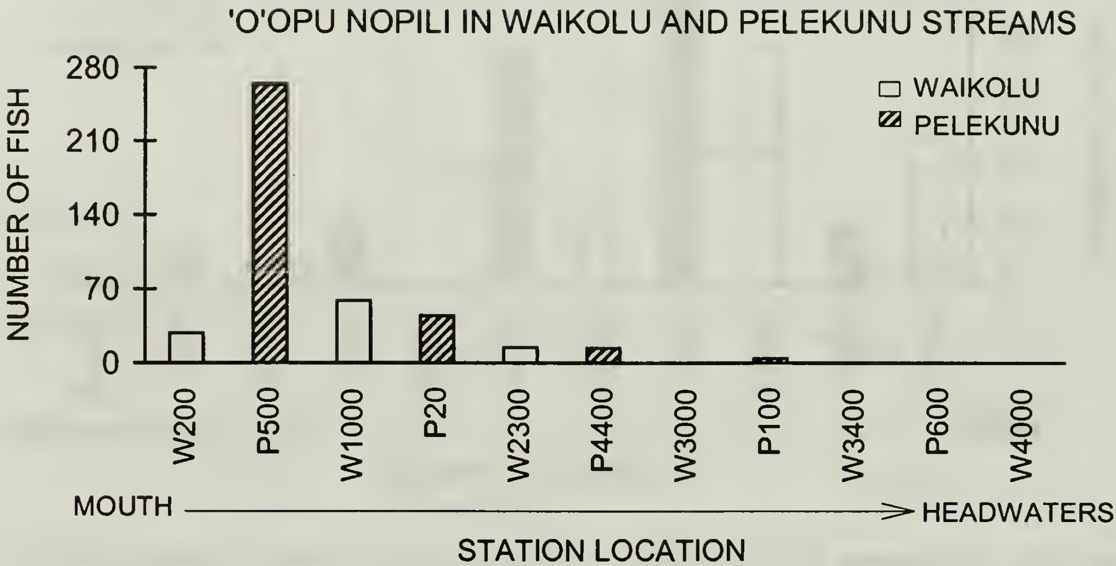


Figure 12. Abundance of 'o'opu nopili at microhabitat sampling stations in Waikolu Stream and Pelekunu Stream (total number of fish at all transects combined for each station). Note scale on Y axis is different than preceding fish graphs.

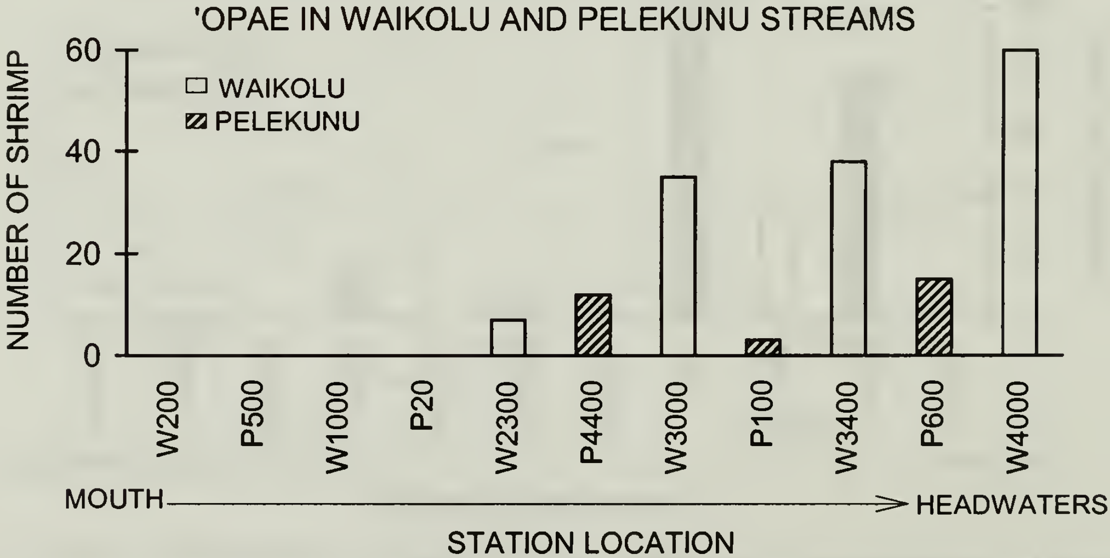


Figure 13. Abundance of 'opae at microhabitat sampling stations in Waikolu Stream and Pelekunu Stream (total number of shrimp at all transects combined for each station).

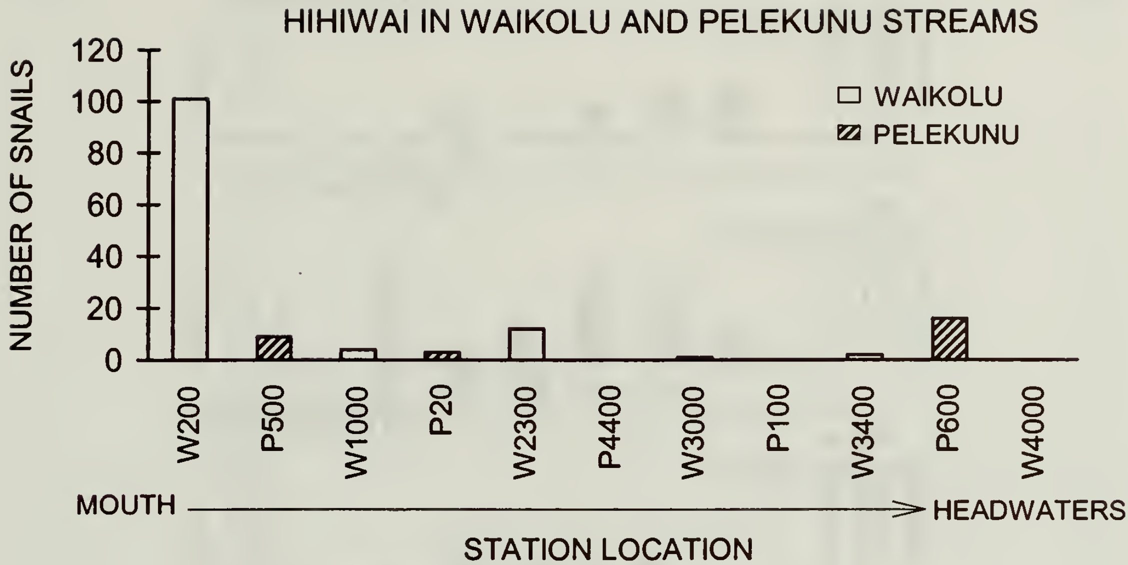


Figure 14. Abundance of hihiwai at microhabitat sampling stations in Waikolu Stream and Pelekunu Stream (total number of snails at all transects combined for each station).

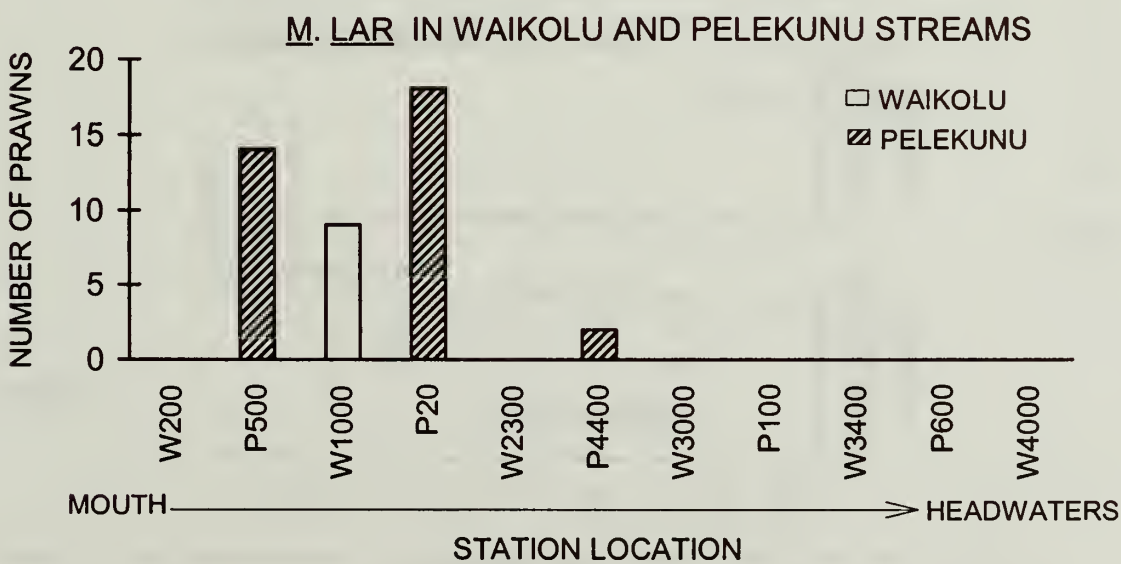


Figure 15. Abundance of the introduced prawn (Macrobrachium lar) at microhabitat sampling stations in Waikolu Stream and Pelekunu Stream (total number of prawns at all transects combined for each station).

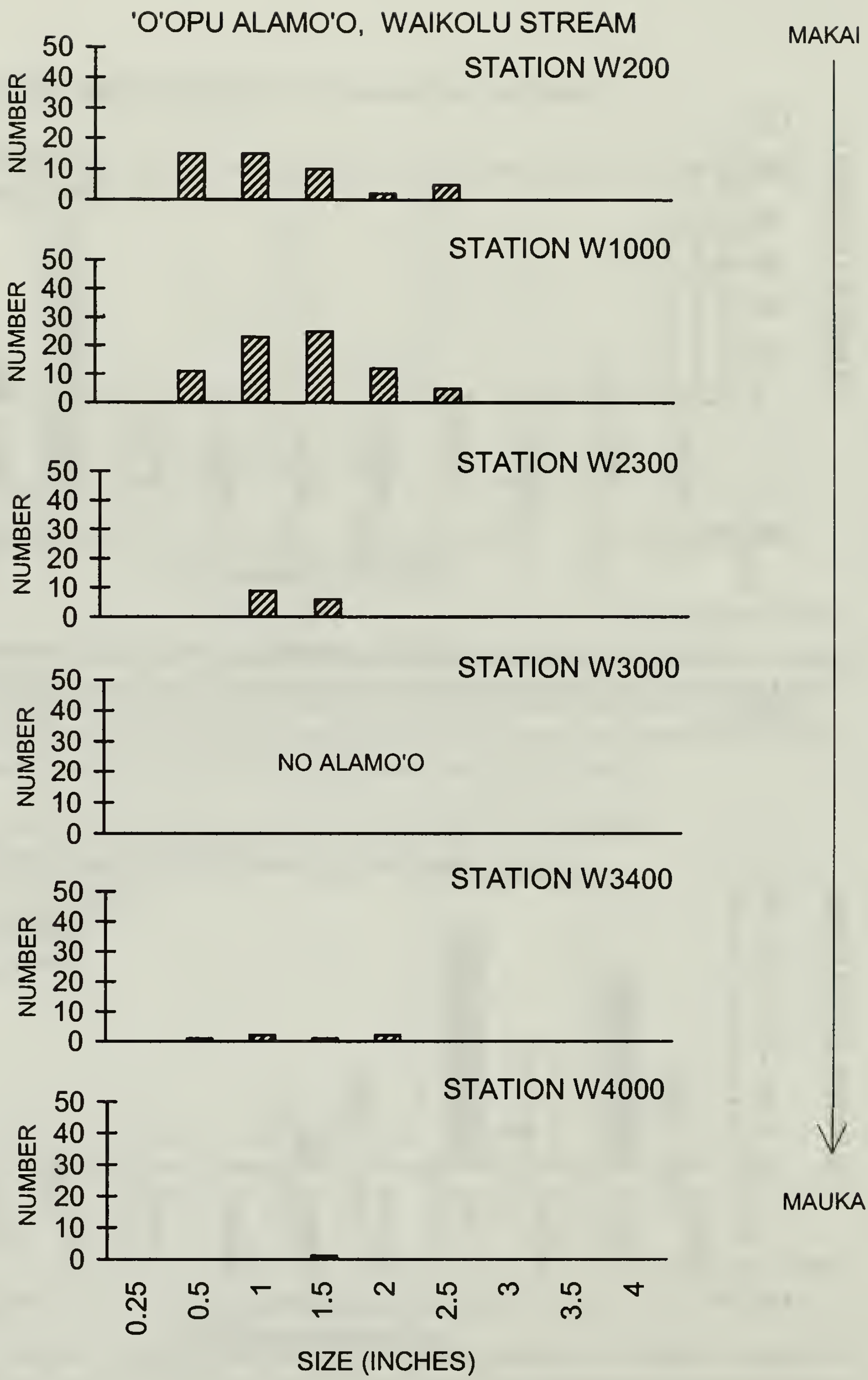


Figure 16. Size distribution of 'o'opu alamo'o at microhabitat sampling stations in Waikolu Stream. Stations arranged from the mouth (makai) to the headwaters (mauka).

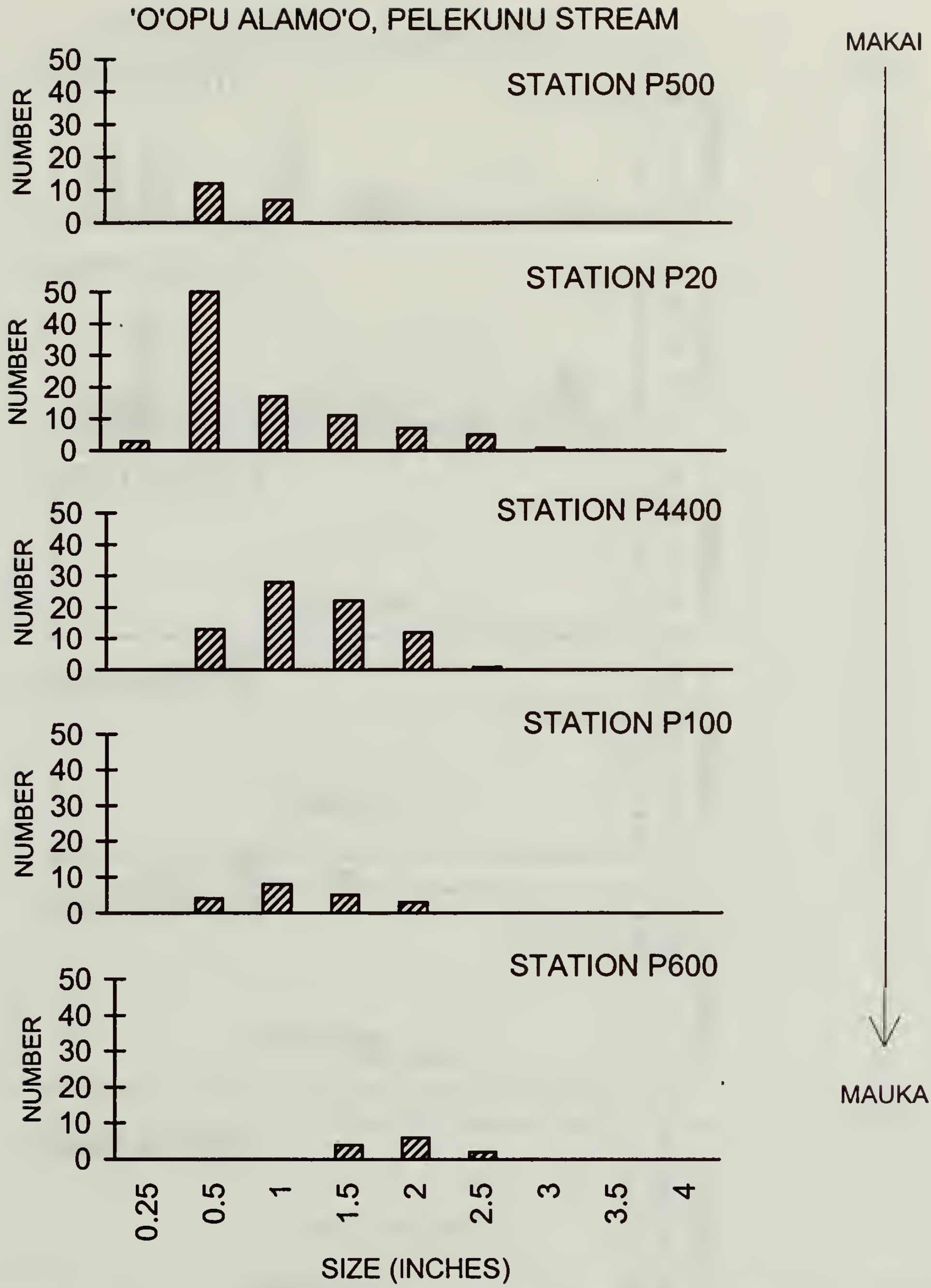


Figure 17. Size distribution of ‘o‘opu alamo‘o at microhabitat sampling stations in Pelekunu Stream. Stations arranged from the mouth (makai) to the headwaters (mauka).

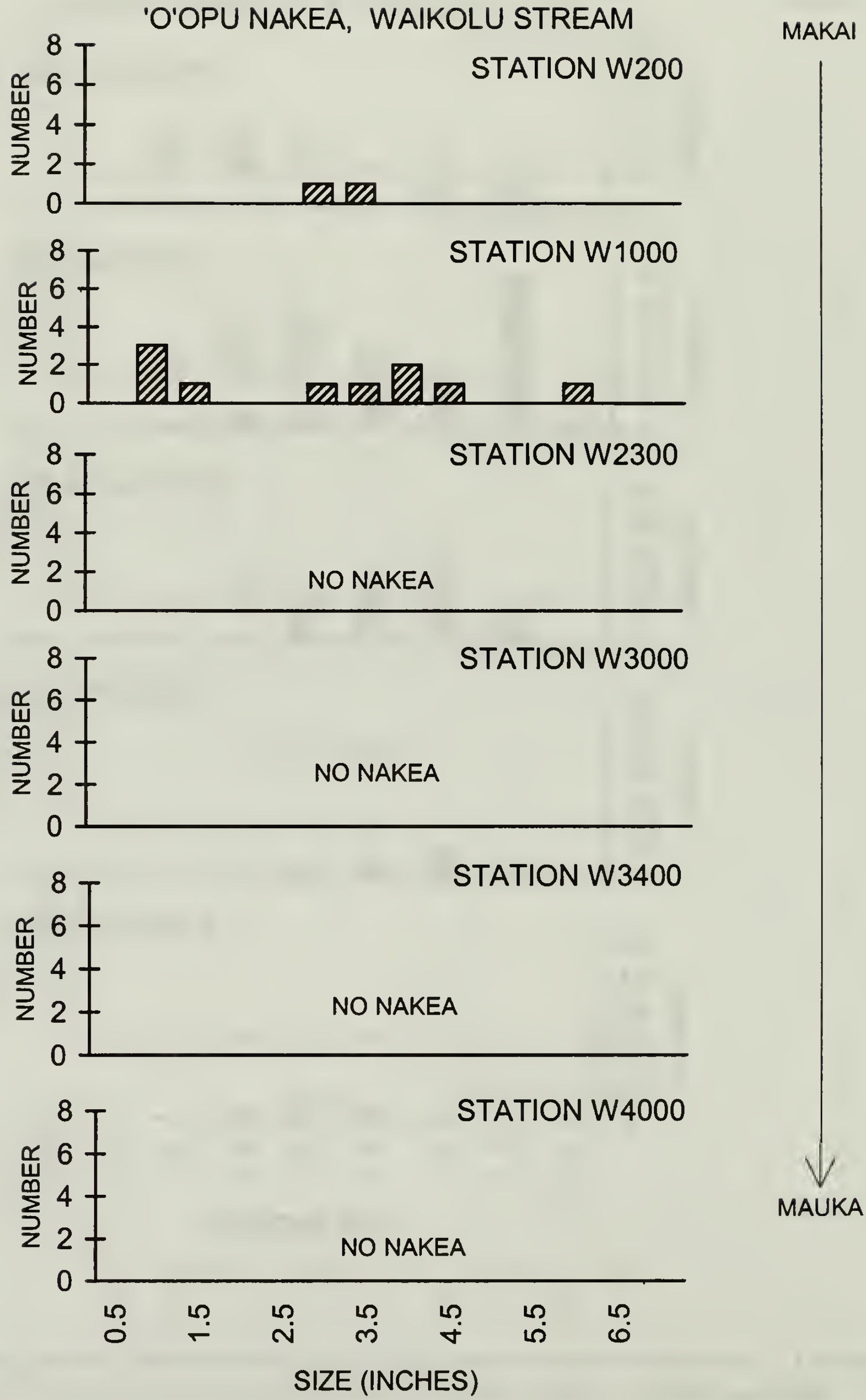


Figure 18. Size distribution of 'o'opu nakea at microhabitat sampling stations in Waikolu Stream. Stations arranged from the mouth (makai) to the headwaters (mauka).

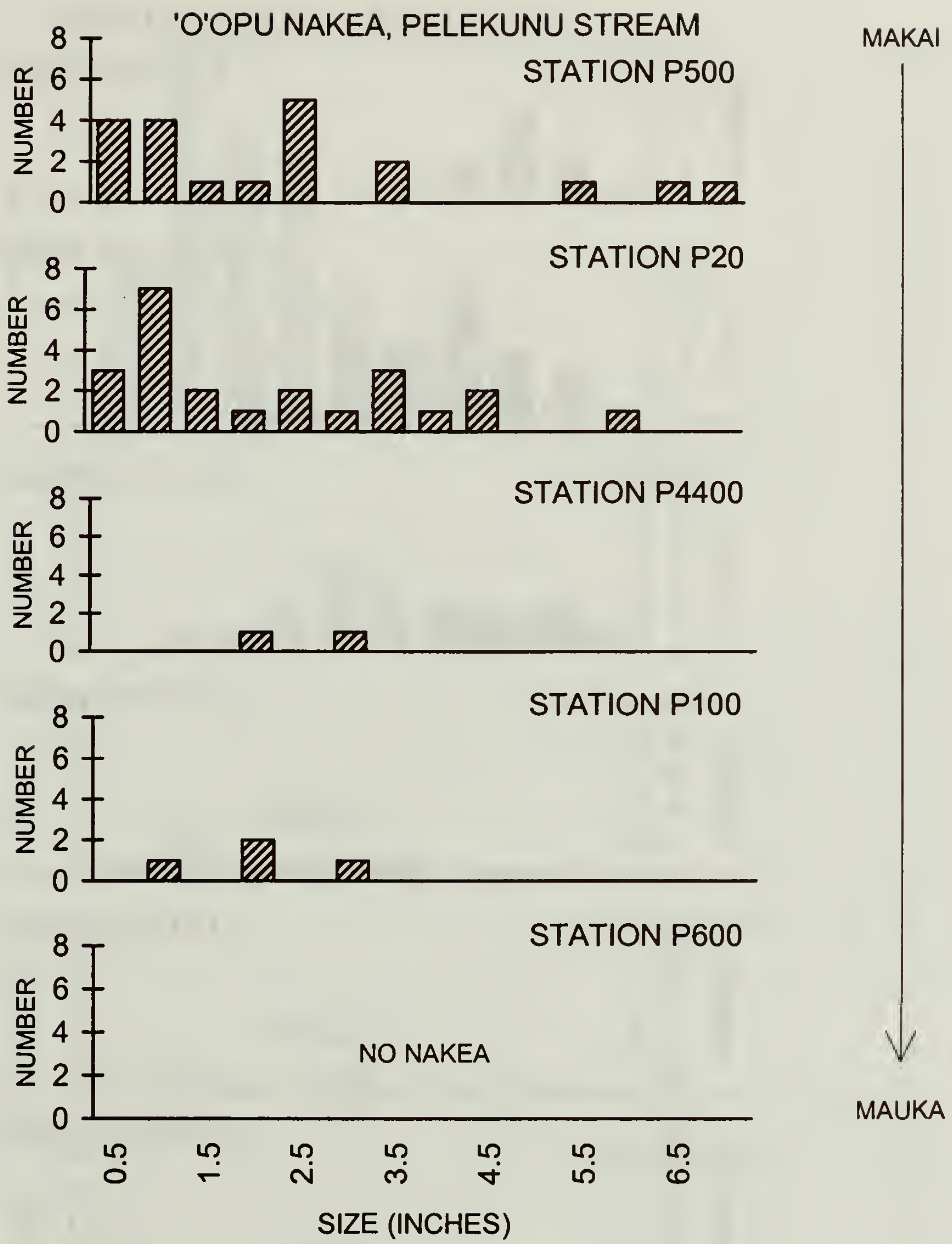


Figure 19. Size distribution of 'o'opu nakea at microhabitat sampling stations in Pelekunu Stream. Stations arranged from the mouth (makai) to the headwaters (mauka).

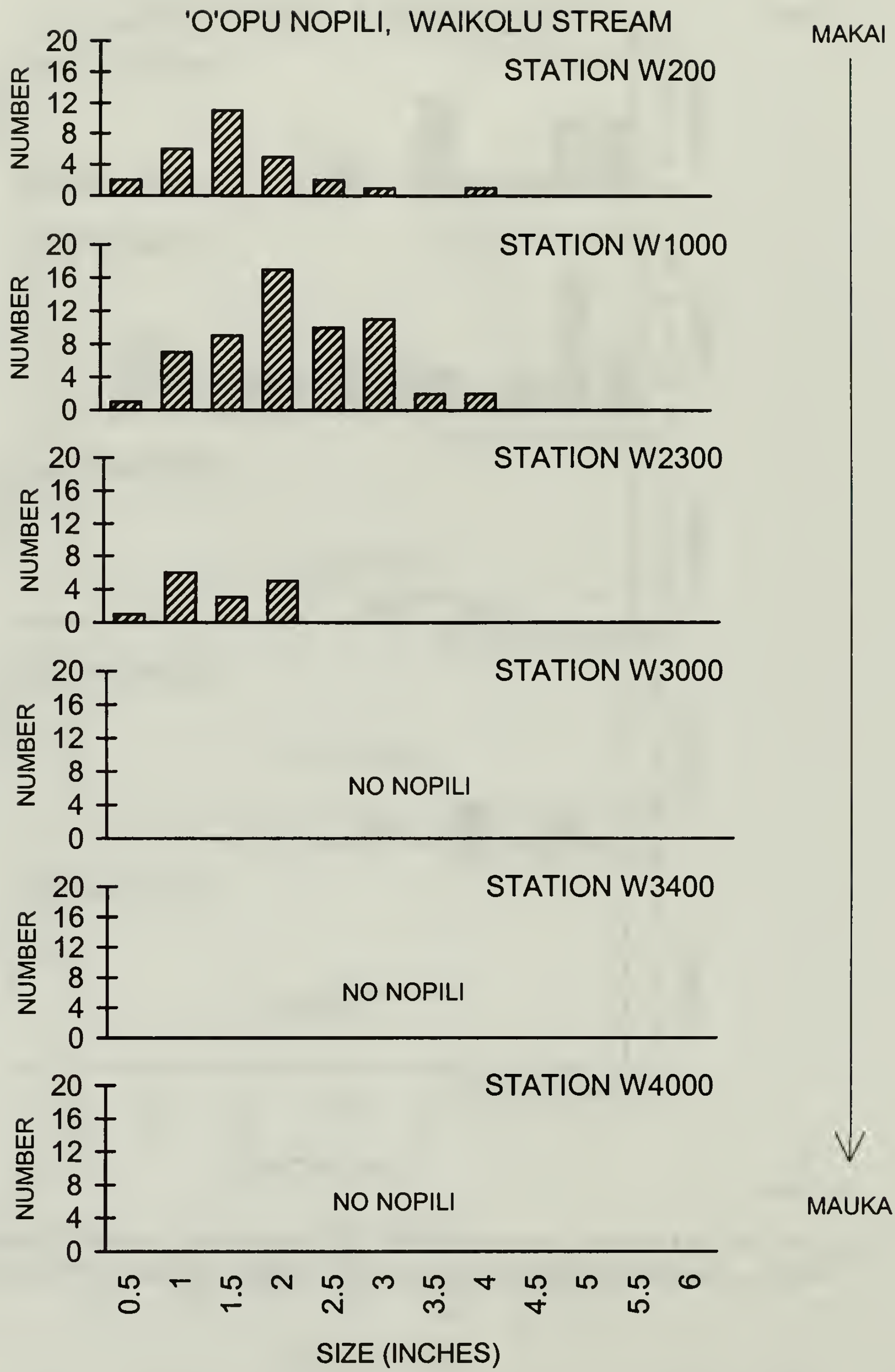


Figure 20. Size distribution of 'o'opu nopili at microhabitat sampling stations in Waikolu Stream. Stations arranged from the mouth (makai) to the headwaters (mauka).

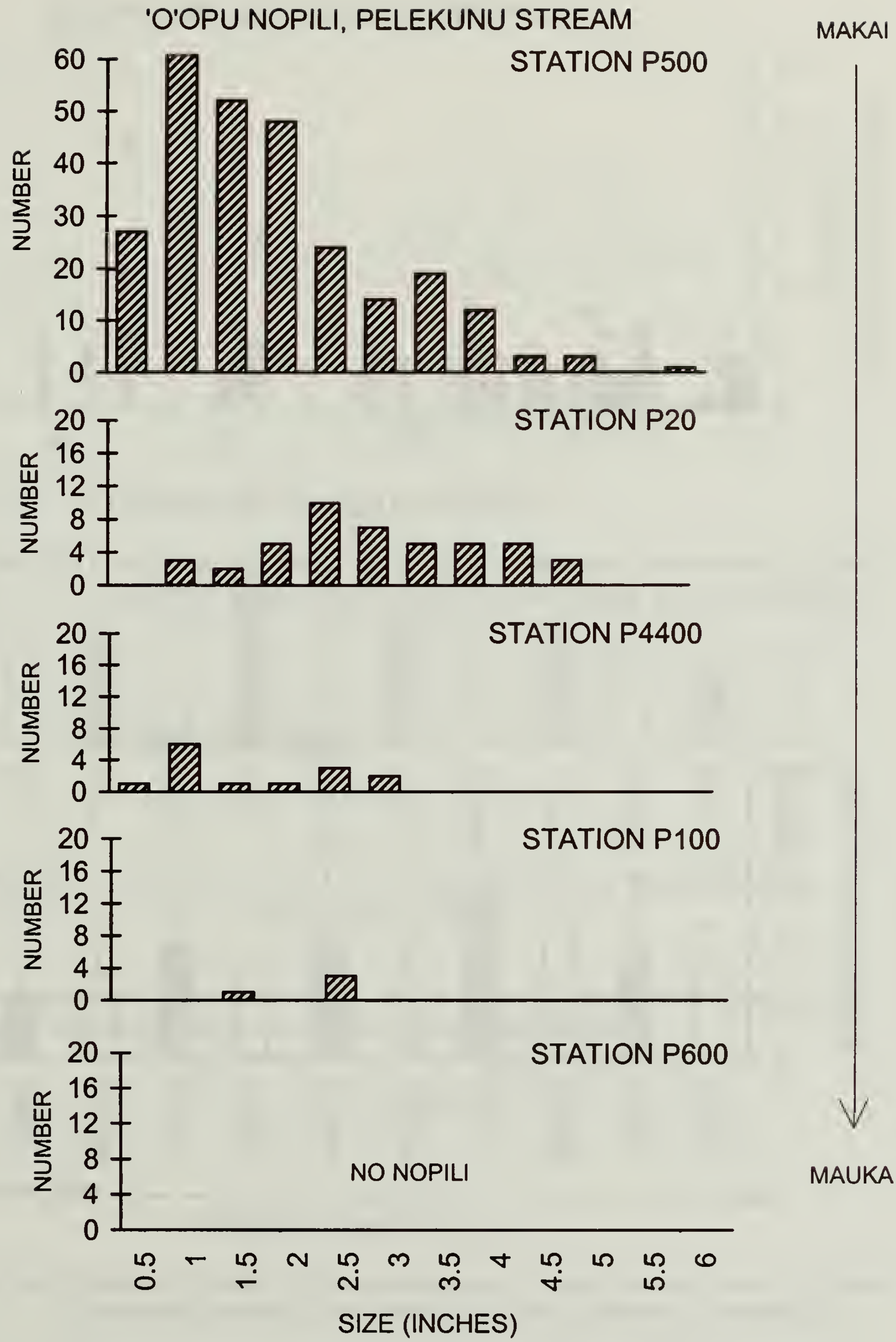


Figure 21. Size distribution of 'o'opu nopili at microhabitat sampling stations in Pelekunu Stream. Stations arranged from the mouth (makai) to the headwaters (mauka).

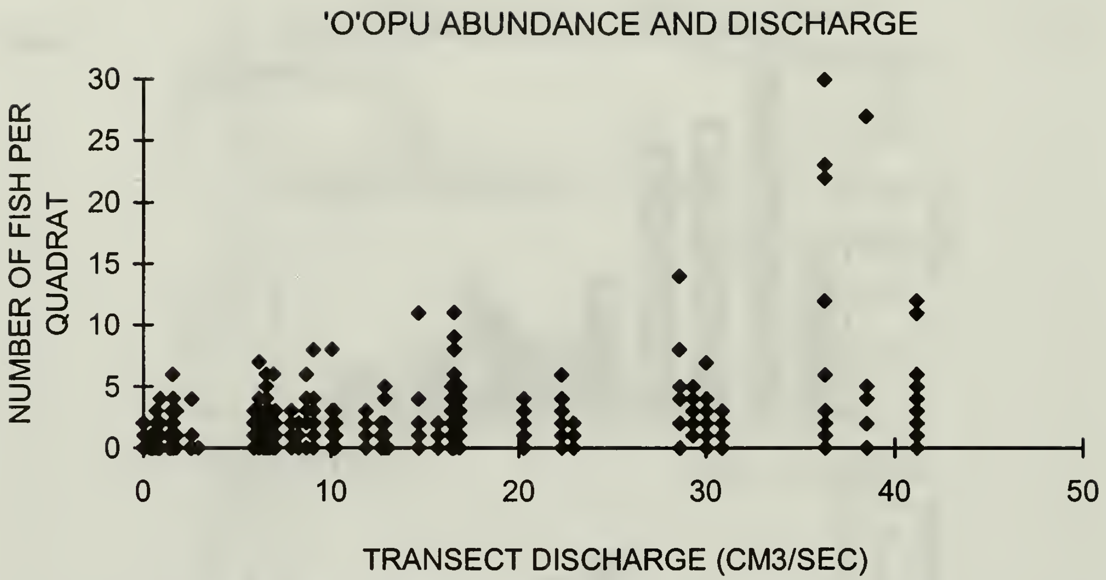


Figure 22. Relationship between 'o'opu abundance and discharge calculated for each transect at each station on the day of microhabitat sampling.

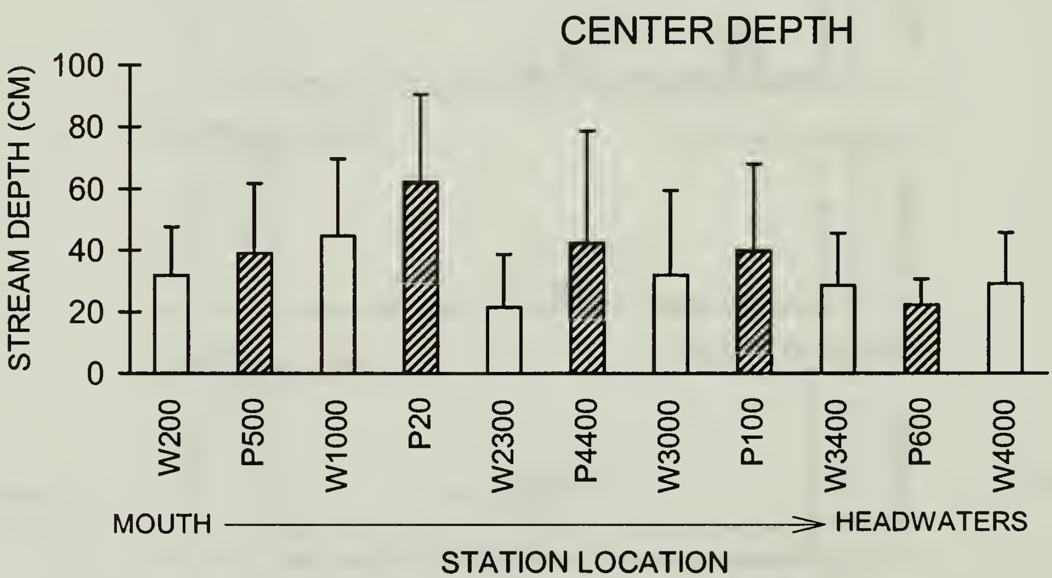


Figure 23. Mean center depth of quadrats used by aquatic organisms during microhabitat sampling (error bars equal one standard deviation).

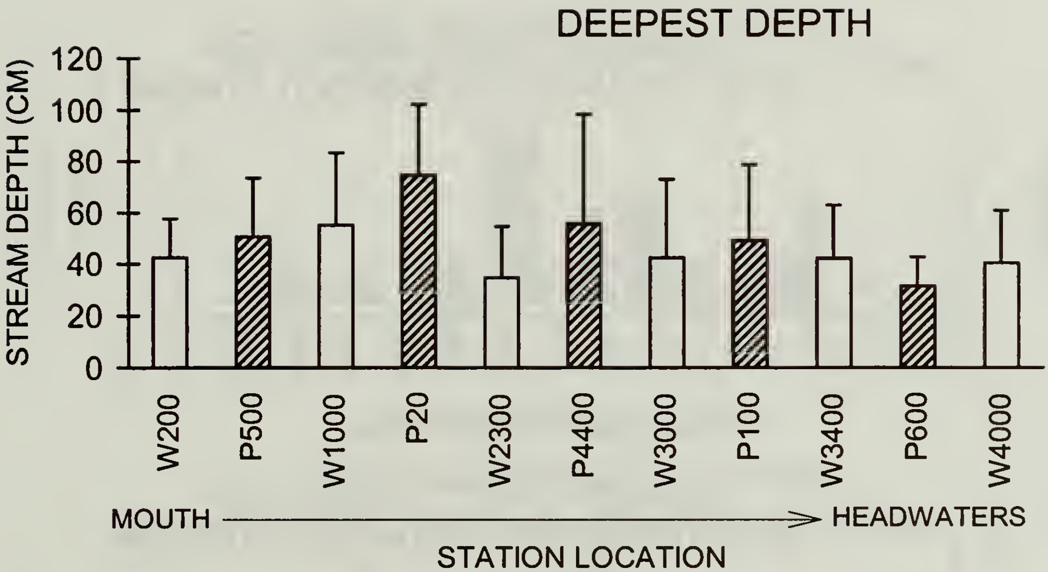
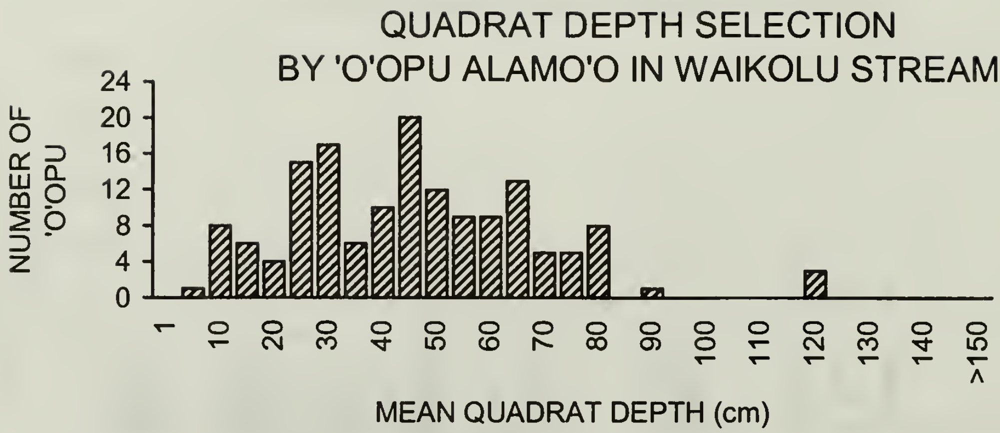
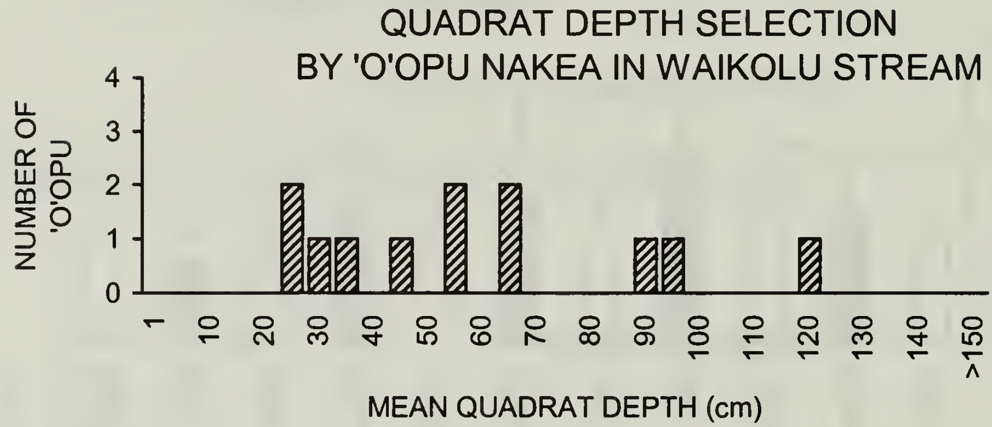


Figure 24. Mean deepest depth of quadrats used by aquatic organisms during microhabitat sampling (error bars equal one standard deviation).





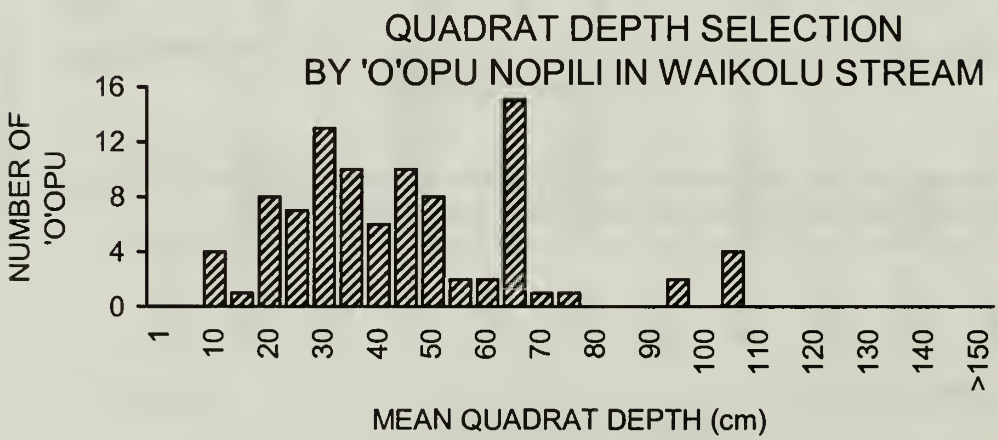


Figure 25. Depth of quadrats used by ʻoʻopu in Waikolu Stream during microhabitat sampling. Mean calculated for center depth and maximum depth of each quadrat. Note scale on Y axes is different for each graph.

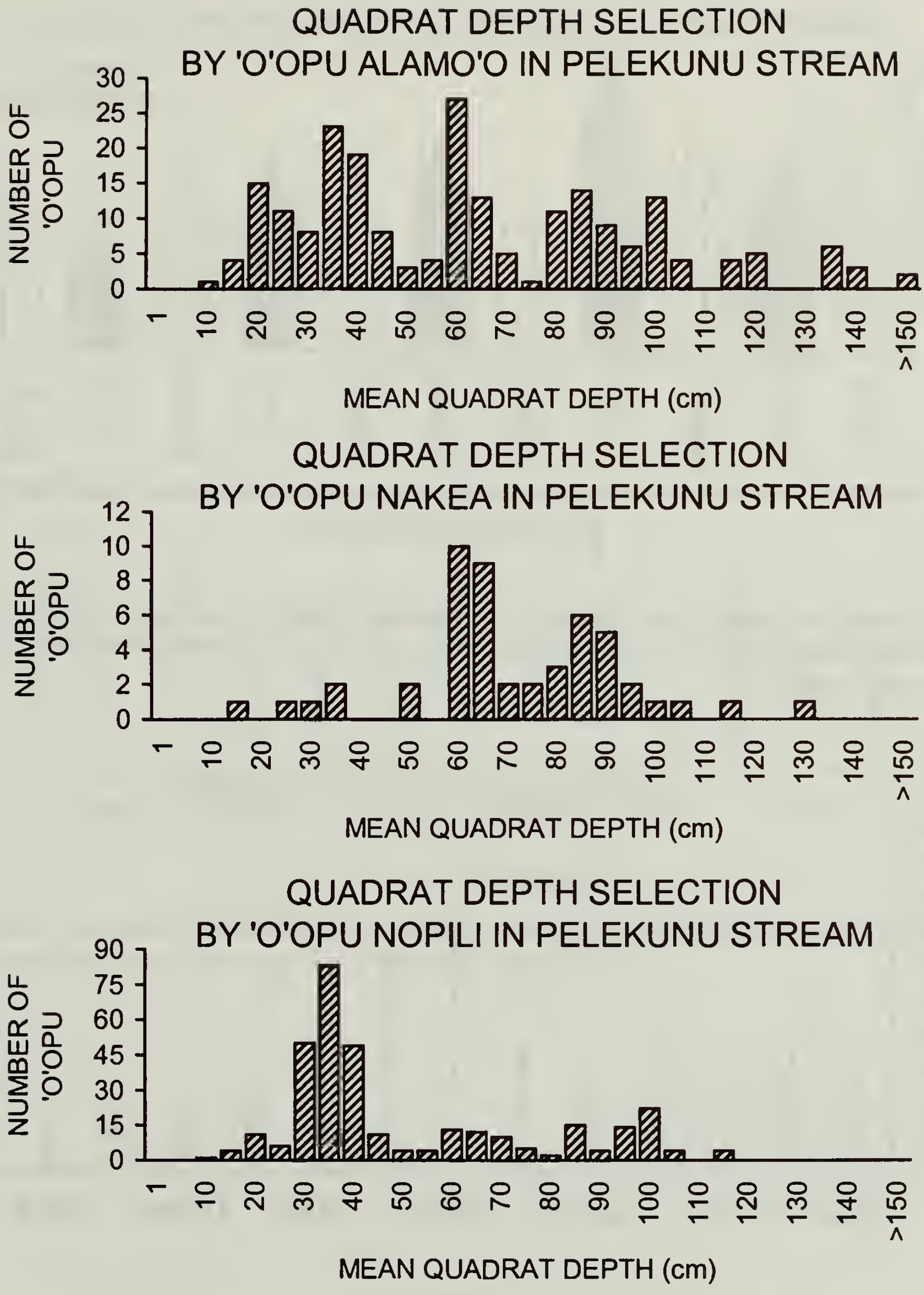


Figure 26. Depth of quadrats used by ʻoʻopu in Pelekunu Stream during microhabitat sampling. Mean calculated for center depth and maximum depth of each quadrat. Note scale on Y axes is different for each graph.

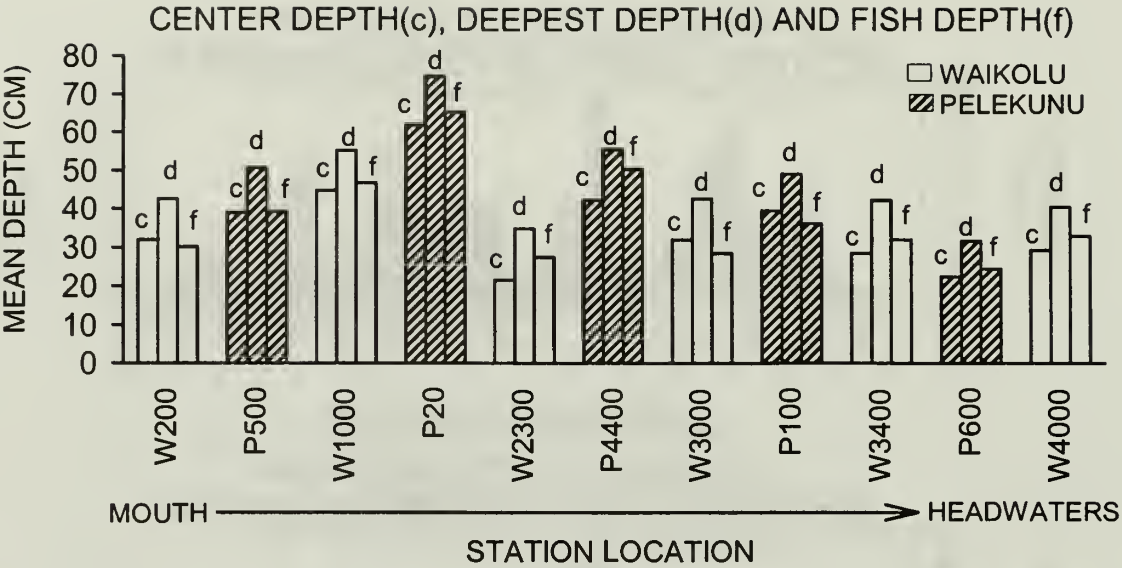


Figure 27. Depth availability (center depth and deepest depth) and depth utilized by fish (mean for all quadrats in all transects at each station) in Waikolu Stream and Pelekunu Stream.

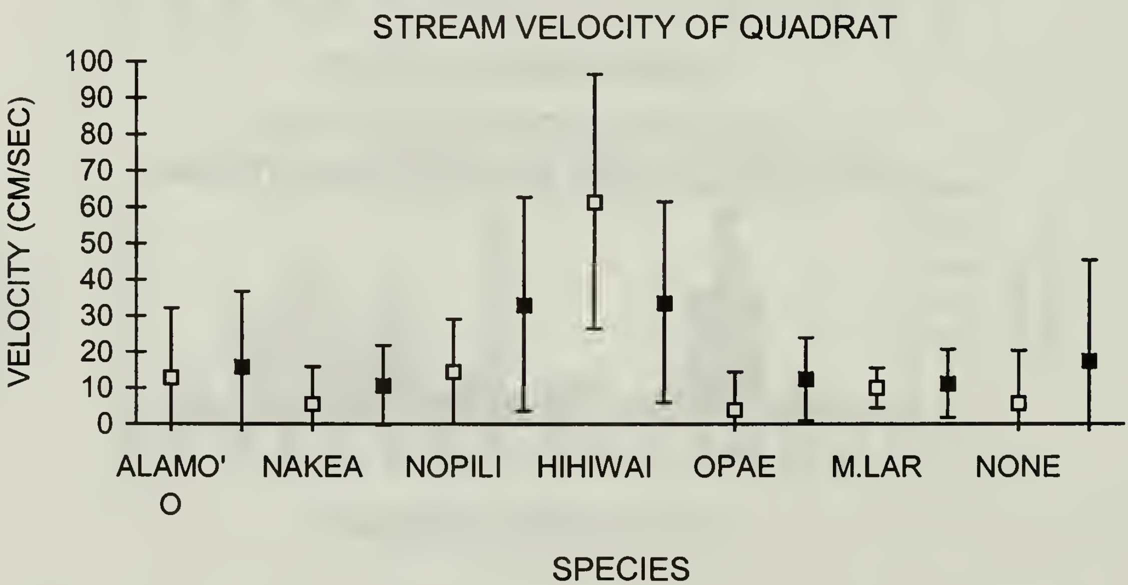


Figure 28. Mean water column velocity (measured at 6/10 depth) of quadrats used by each species (error bars equal ± one standard deviation).

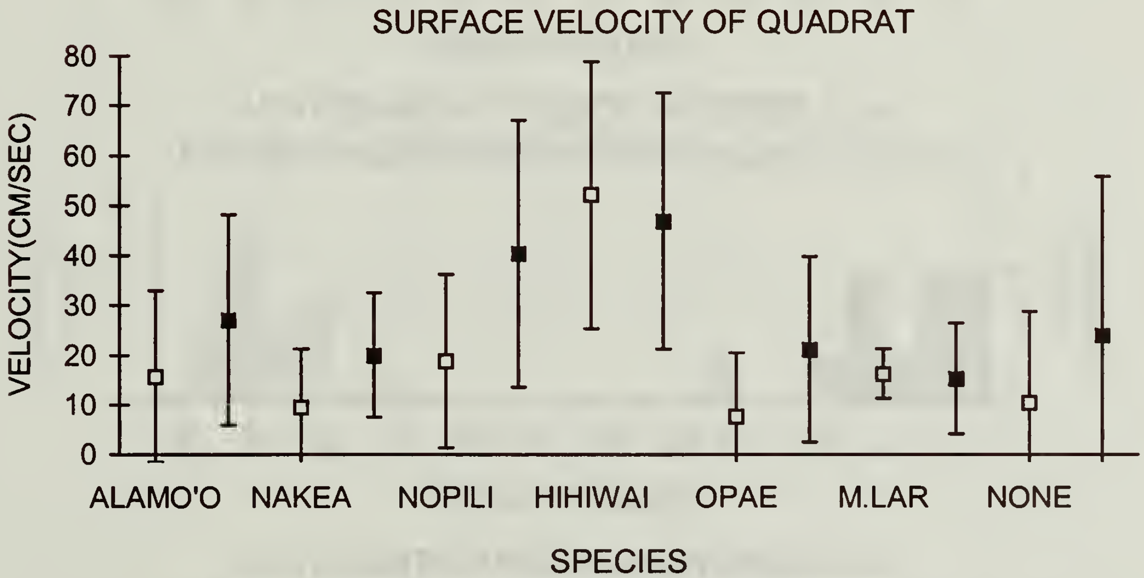
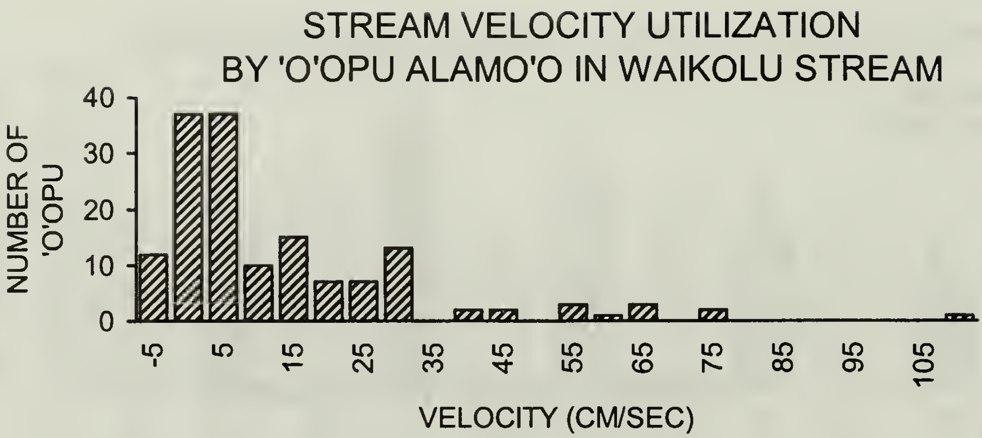
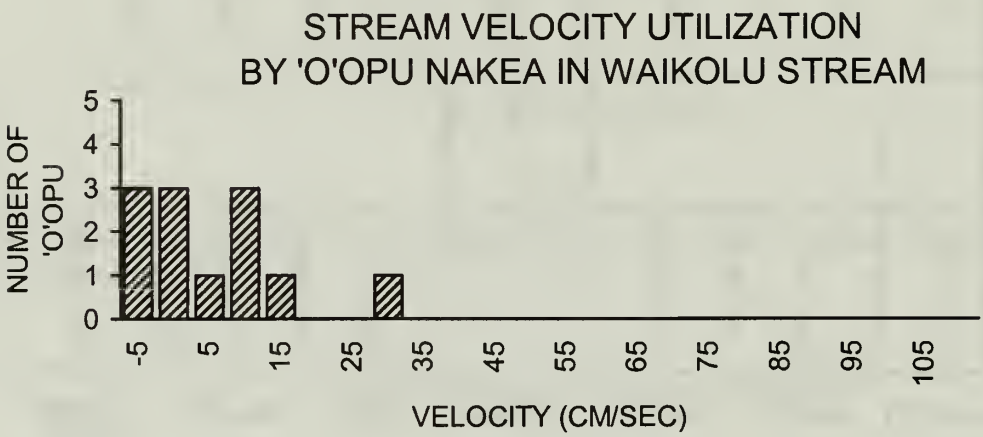


Figure 29. Mean surface velocity of quadrats used by each species during microhabitat sampling (error bars equal ± one standard deviation).





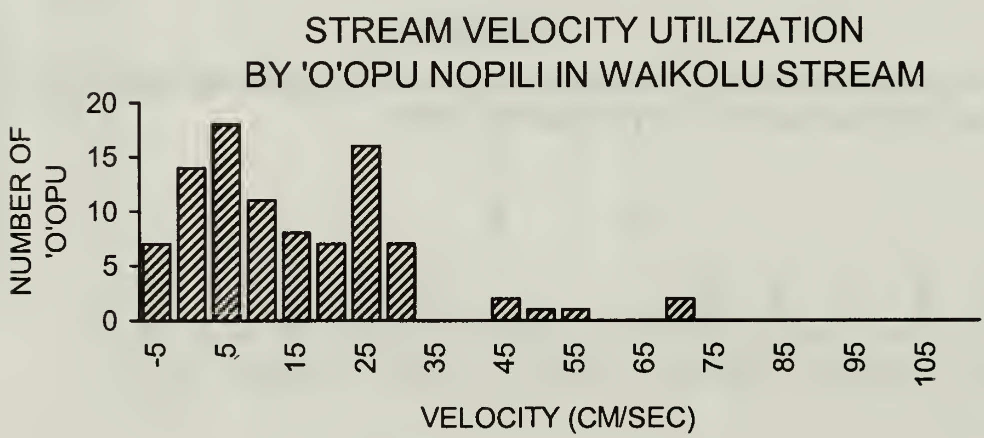


Figure 30. Distribution of mean water column velocity (measured at the 6/10 depth) in quadrats used by ʻoʻopu in Waikolu Stream during microhabitat sampling. Note scale on Y axes is different for each graph.

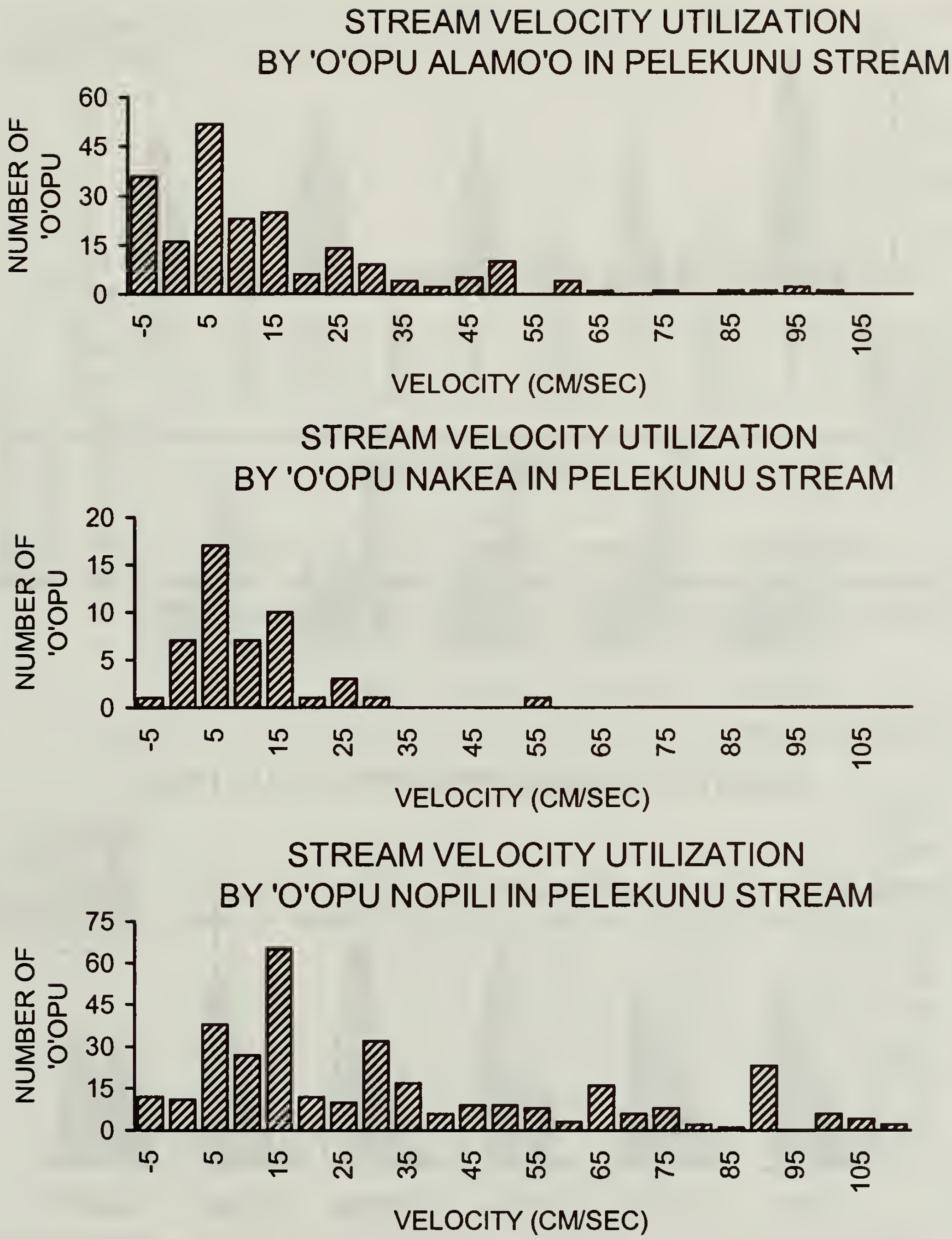


Figure 31. Mean water column velocity (measured at the 6/10 depth) in quadrats used by ‘o‘opu in Pelekunu Stream during microhabitat sampling. Note scale on Y axes is different for each graph.

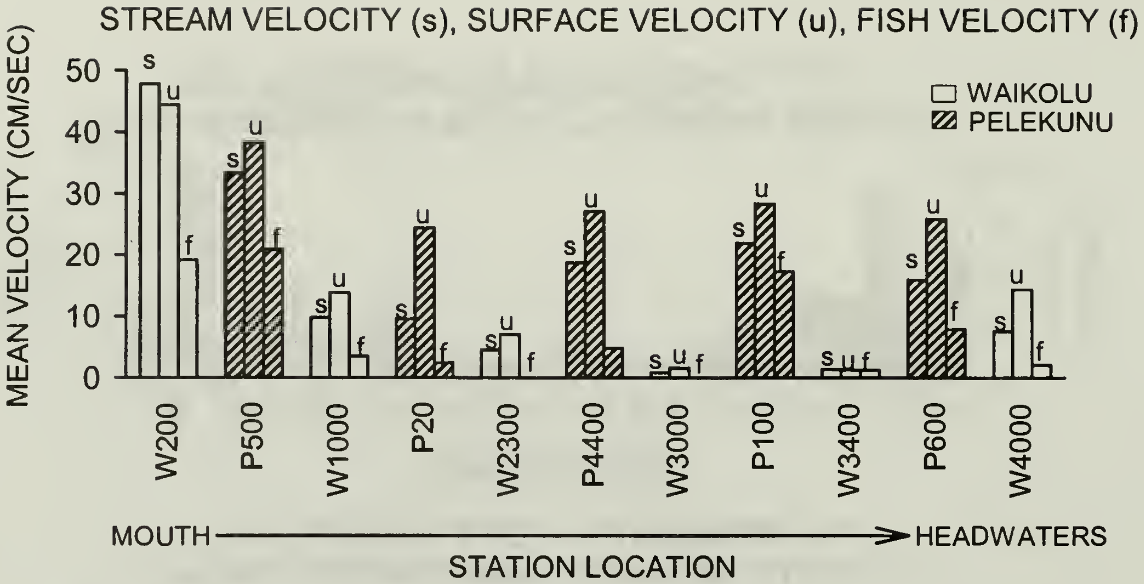


Figure 32. Mean water column velocity (stream velocity, measured at the 6/10 depth) and surface velocity availability and velocity utilized by fish (mean for all quadrats in all transects at each station) in Waikolu Stream and Pelekunu Stream.

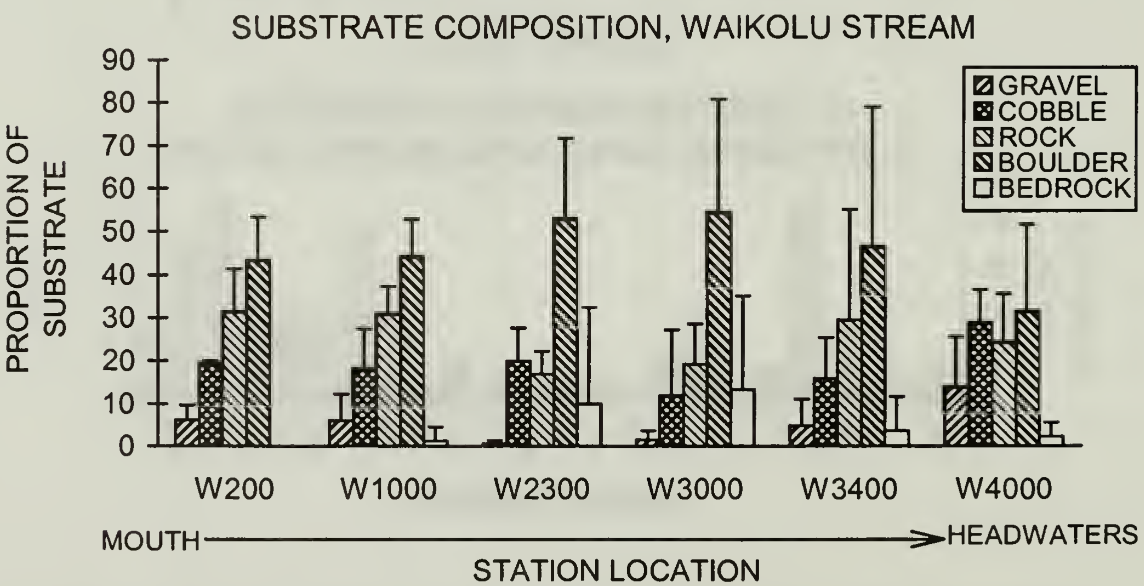


Figure 33. Substrate composition at each sampling station (mean of all quadrats in all transects) in Waikolu Stream. Error bars equal one standard deviation.

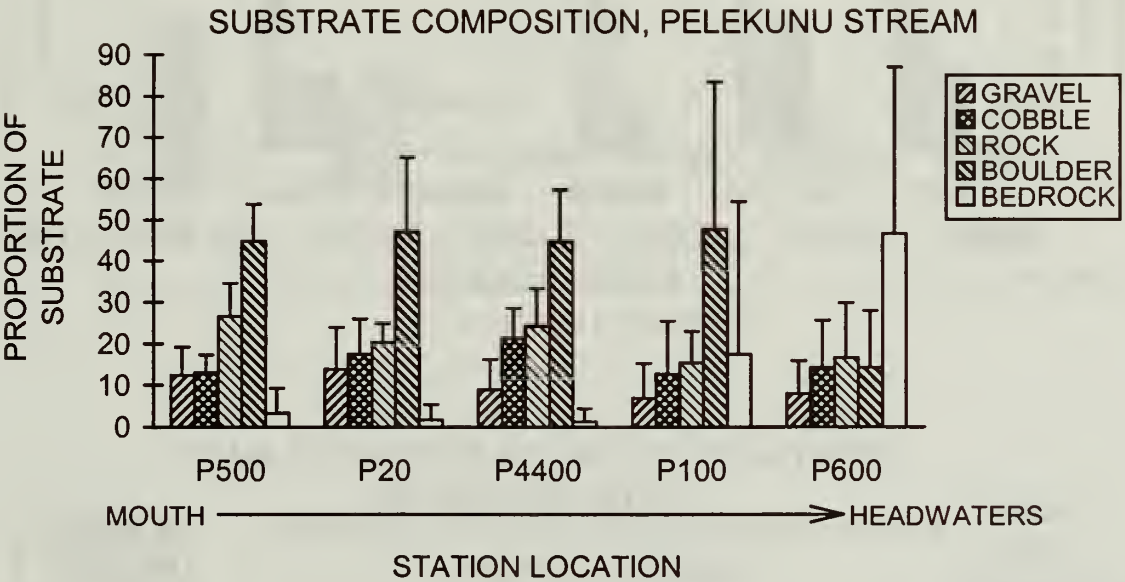
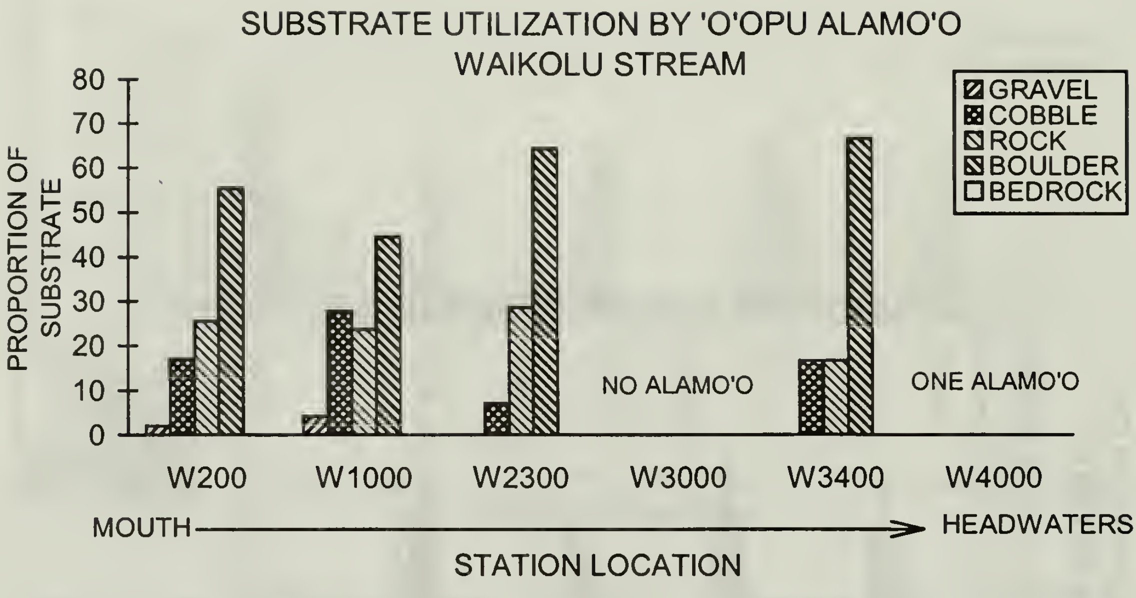


Figure 34. Substrate composition at each sampling station (mean of all quadrats in all transects) in Pelekunu Stream. Error bars equal one standard deviation.



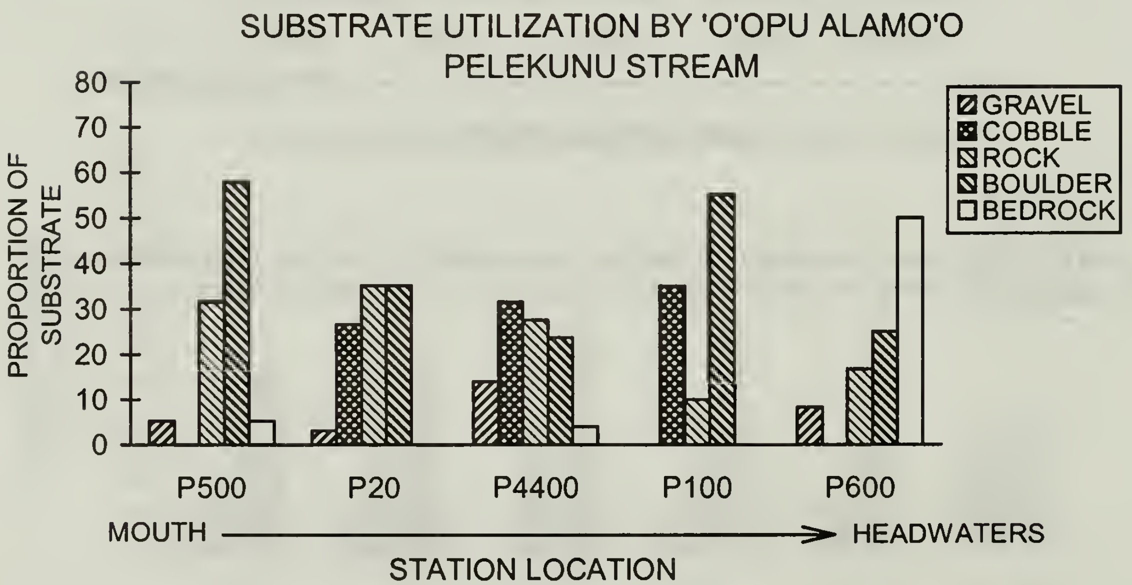
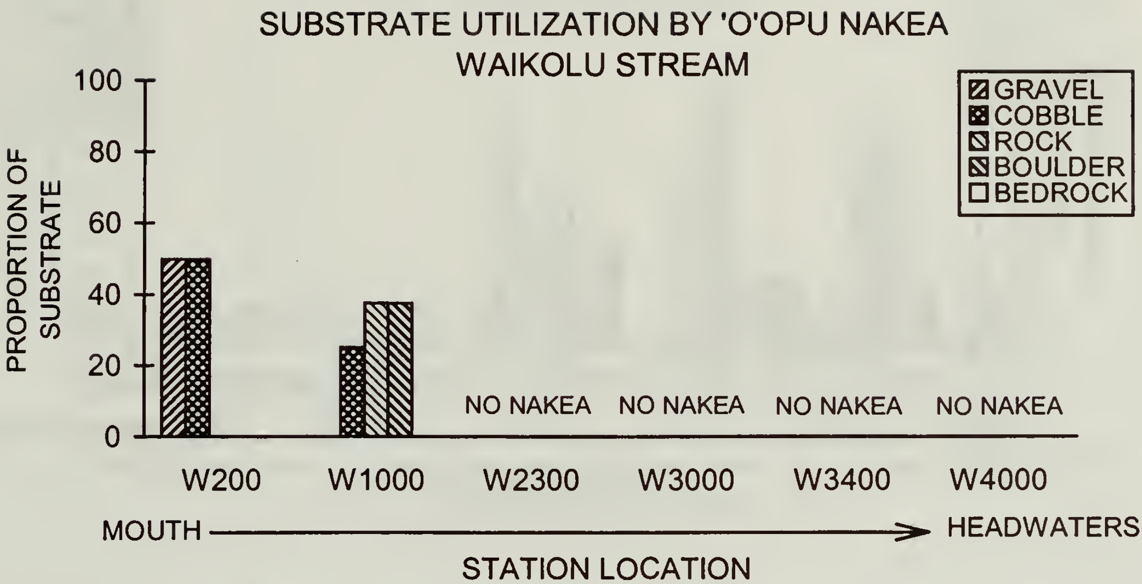


Figure 35. Substrate utilization by ‘o‘opu alamo‘o at each microhabitat station in Waikolu Stream and Pelekunu Stream.



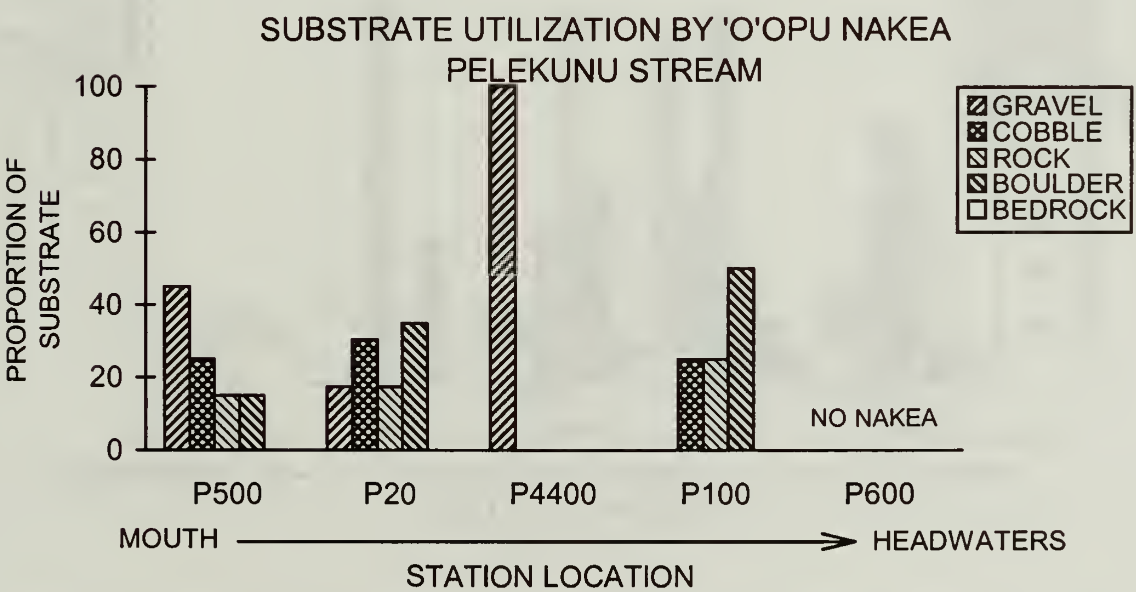
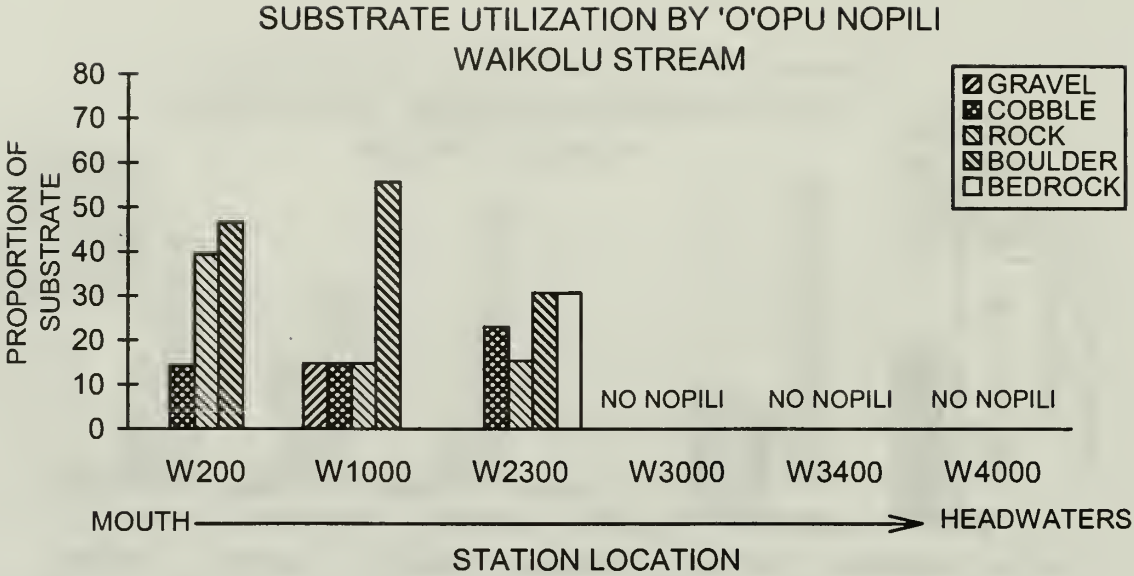


Figure 36. Substrate utilization by ʻoʻopu nakea at each microhabitat station in Waikolu Stream and Pelekunu Stream.



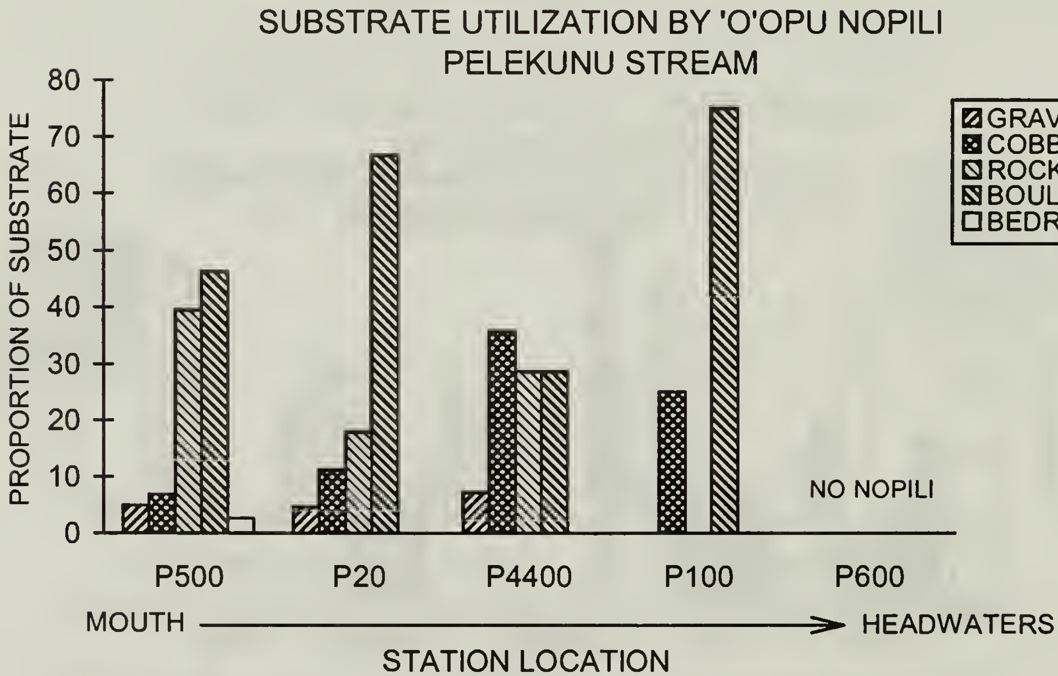
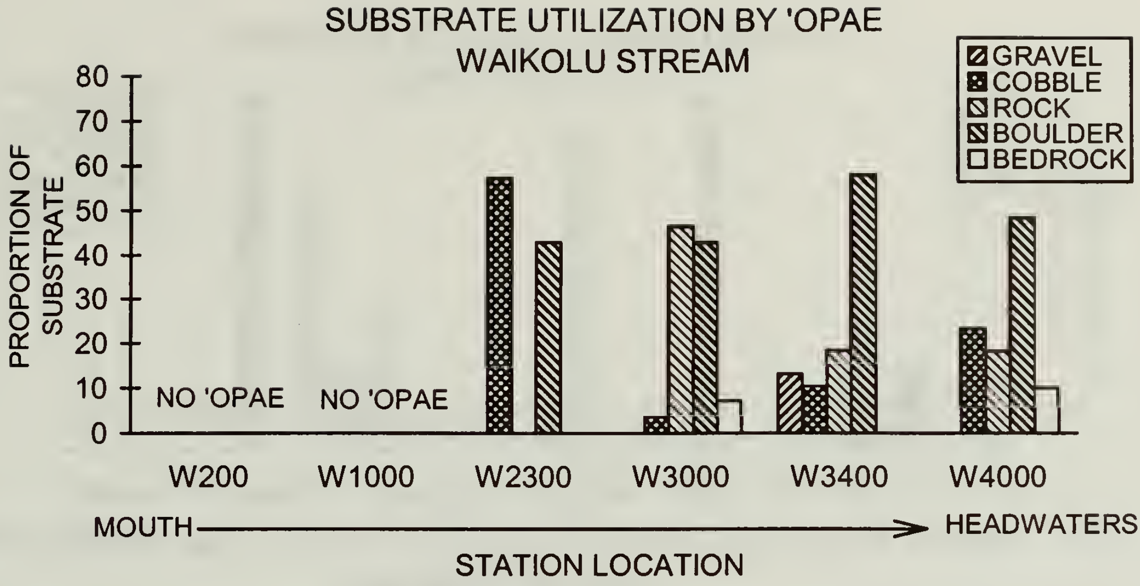


Figure 37. Substrate utilization by ‘o‘opu nopili at each microhabitat station in Waikolu Stream and Pelekunu Stream.



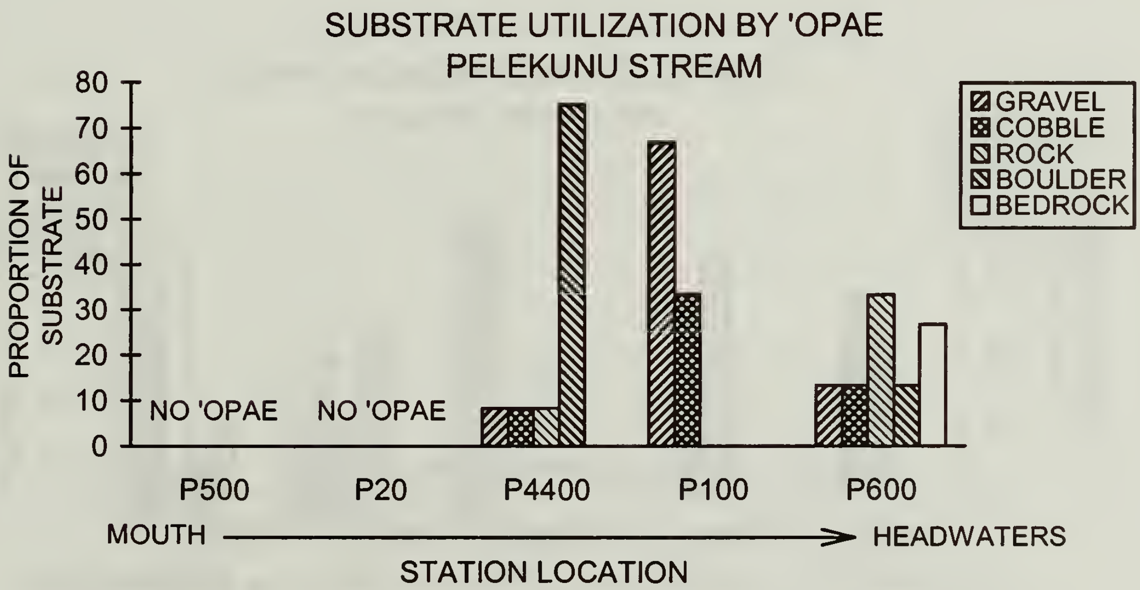
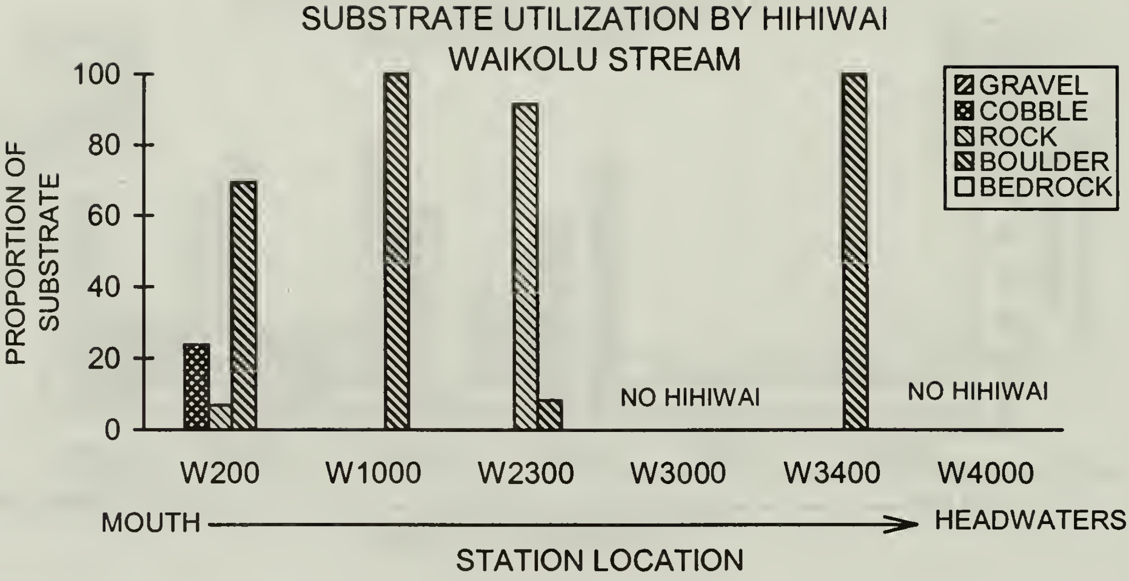


Figure 38. Substrate utilization by ‘opae kuahiwi at each microhabitat station in Waikolu Stream and Pelekunu Stream.



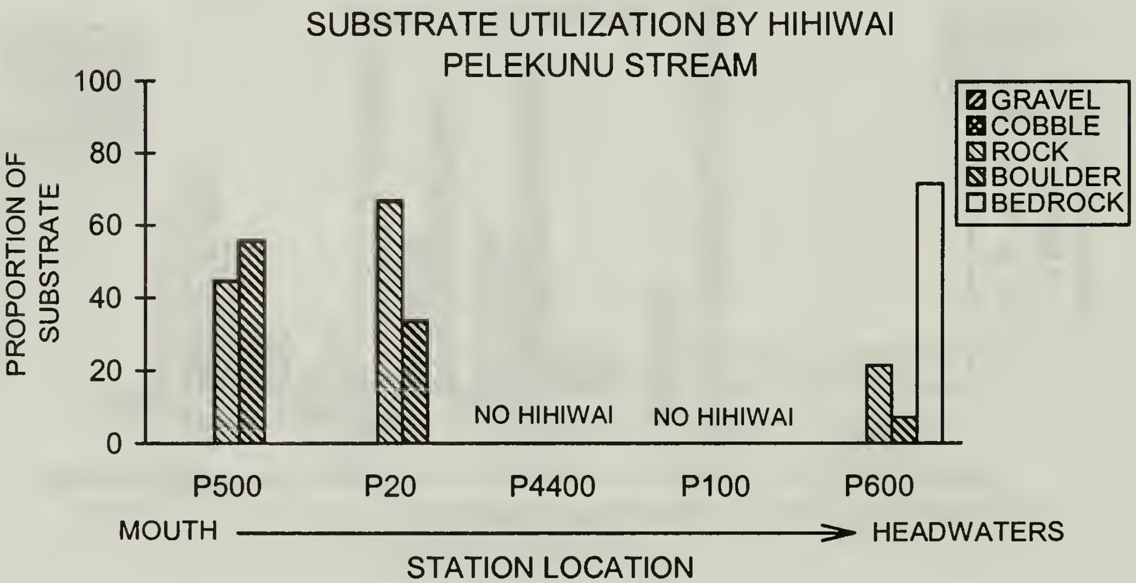
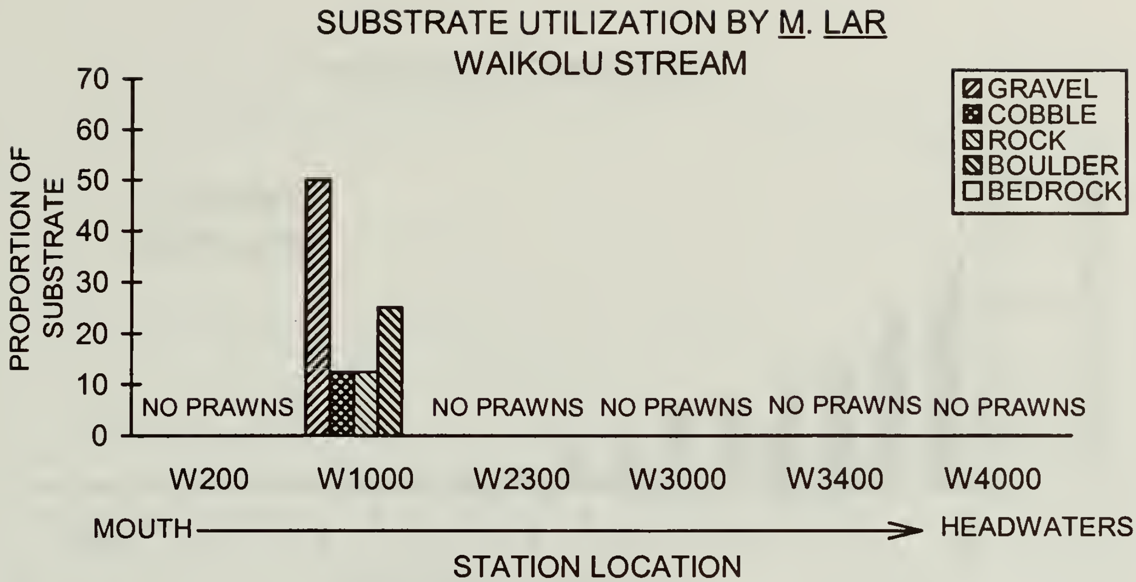


Figure 39. Substrate utilization by hihiwai at each microhabitat station in Waikolu Stream and Pelekunu Stream.



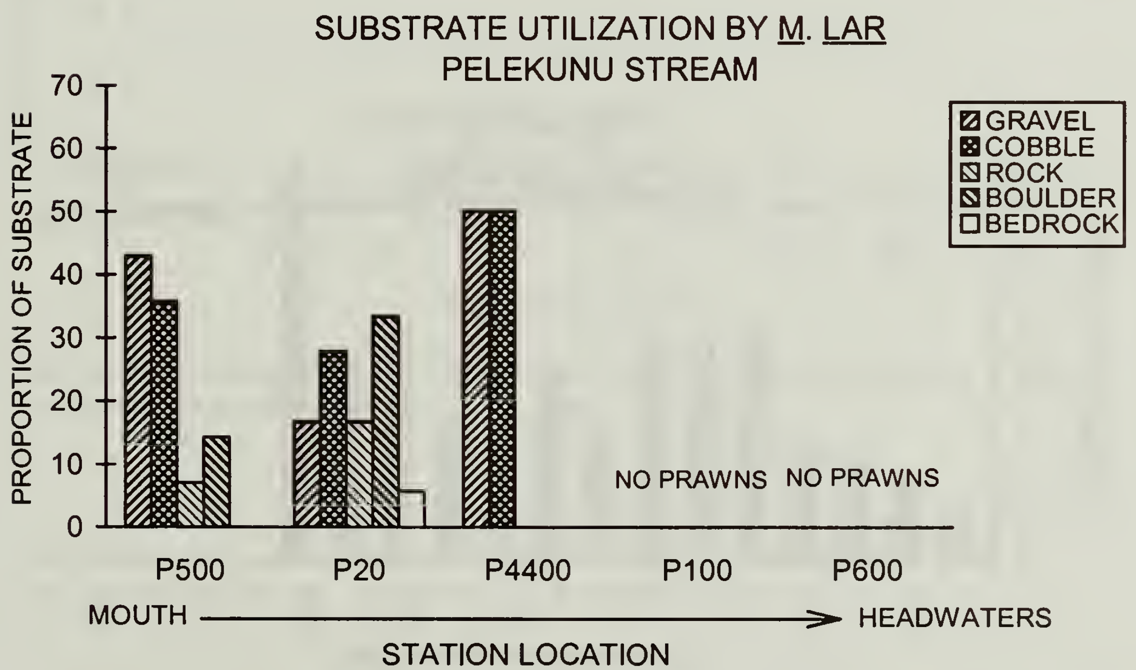


Figure 40. Substrate utilization by the introduced prawn (Macrobrachium lar) at each microhabitat station in Waikolu Stream and Pelekunu Stream.

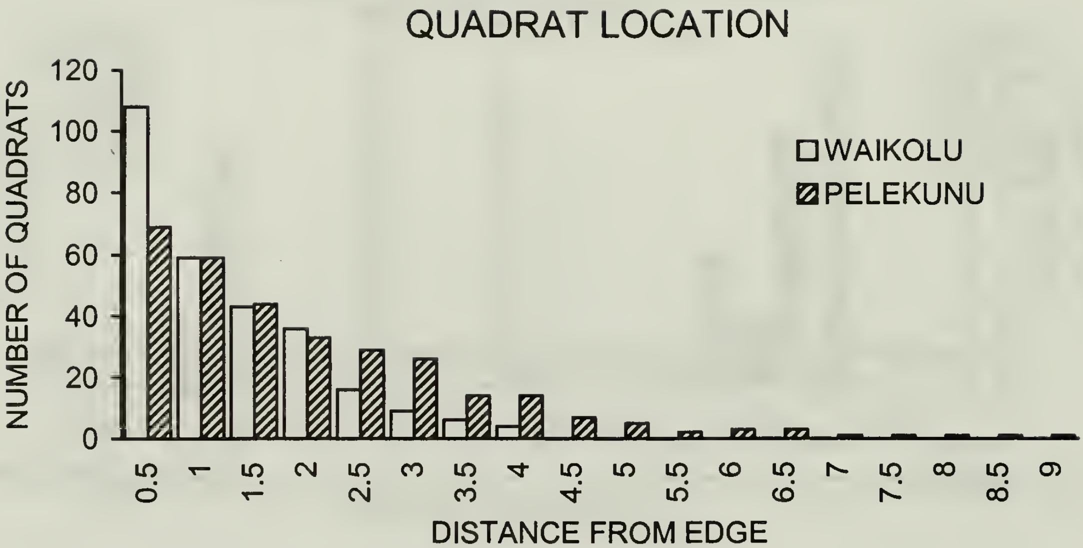


Figure 41. Distance (meters) each sampling quadrat in Waikolu Stream and Pelekunu Stream is located from a stream edge.

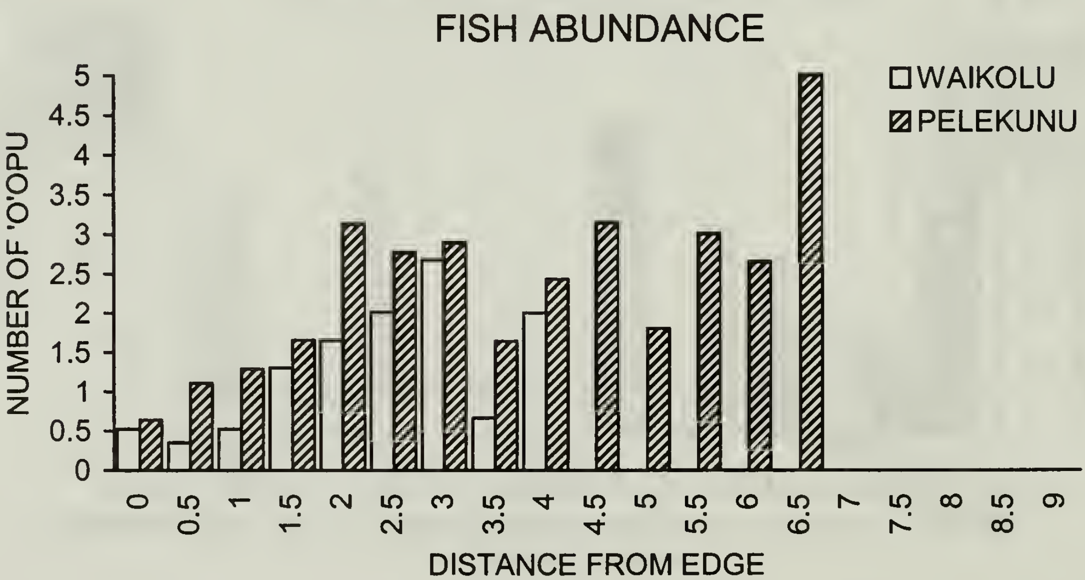


Figure 42. Fish abundance in relation to distance (meters) a quadrat is located from a stream edge.

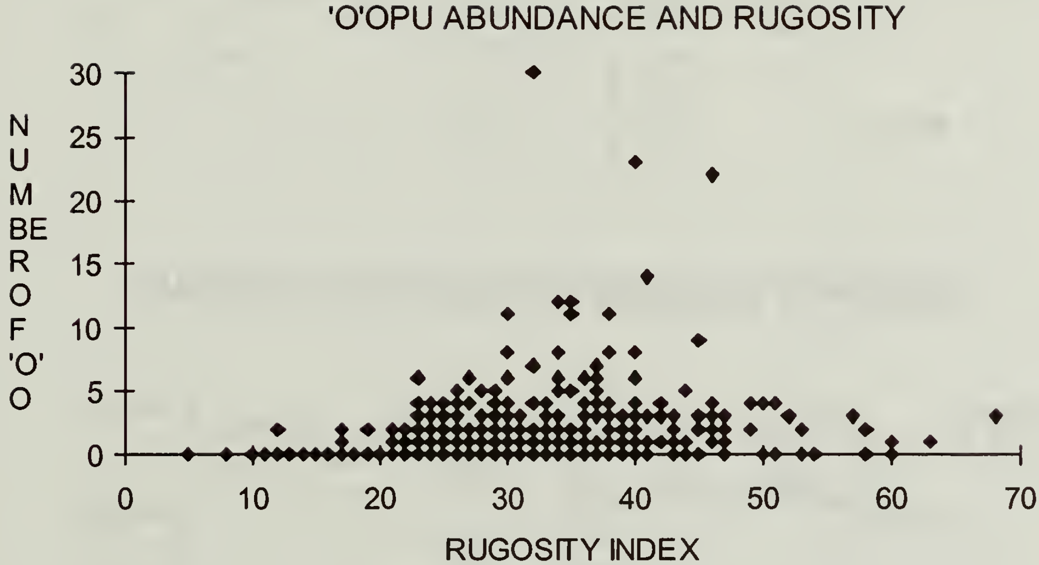
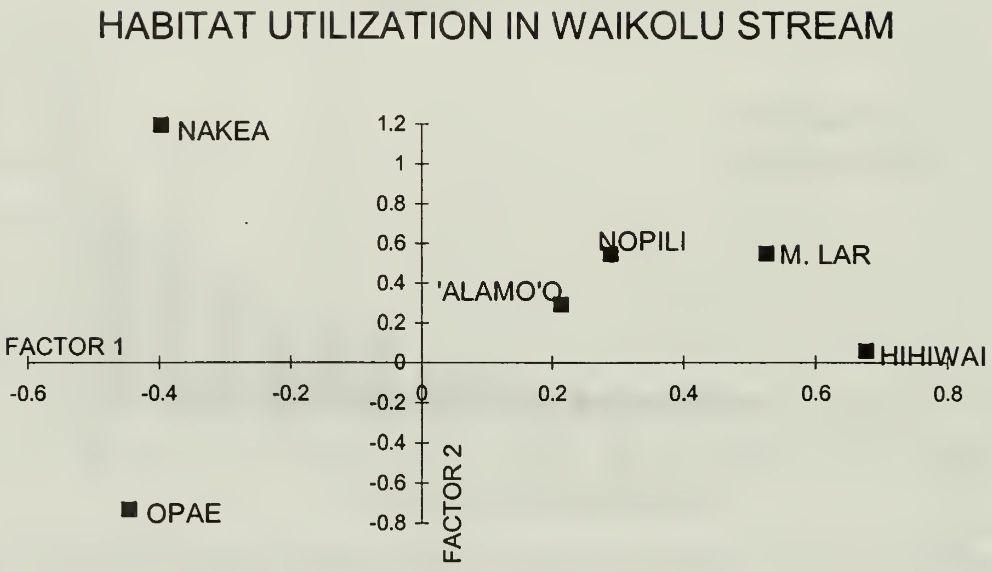


Figure 43. Relationship between rugosity (topographic heterogeneity) and ‘o‘opu abundance in each quadrat.



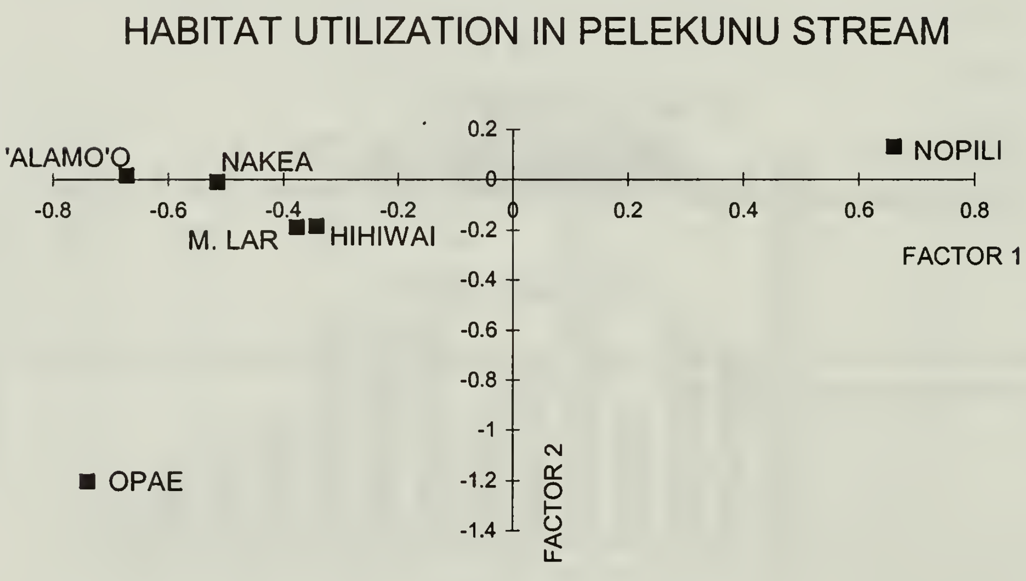


Figure 44. Habitat utilization in Waikolu Stream and Pelekunu Stream as determined by Principal Components Correlation Analysis using all measured habitat variables. Mean score loadings for each species on Principal Component 1 and Principal Component 2.

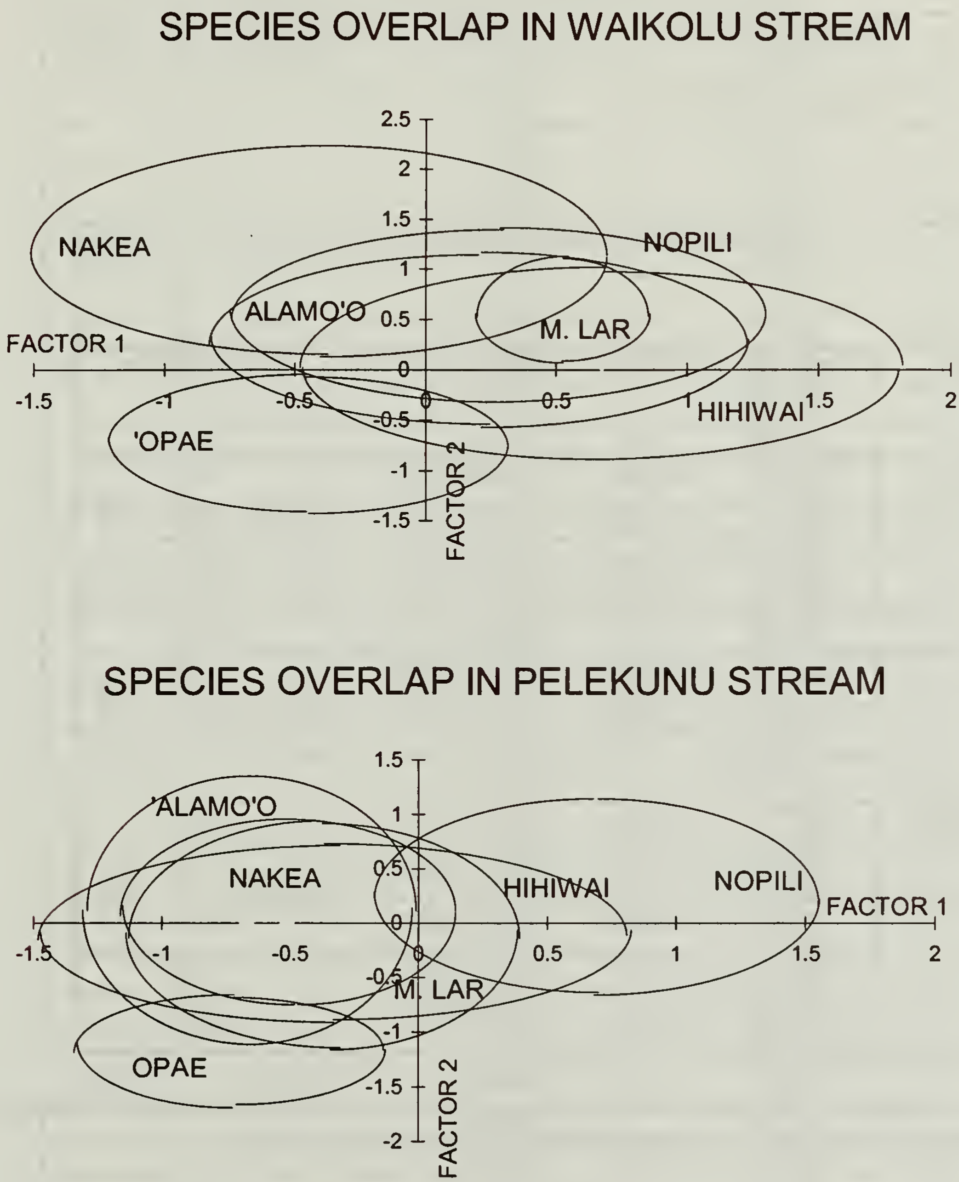


Figure 45. Species overlap in habitat utilization in Waikolu Stream and Pelekunu Stream as determined by Principal Components Correlation Analysis using all measured habitat variables. Mean score loadings for each species on Principal Component 1 and Principal Component 2.

LOCATION OF SAMPLING STATIONS				
STREAM	SITE	STATION	DISTANCE (m)	ELEVATION (m)
WAIKOLU	W1	W200	300	0
	W2	W1000	1323	90
	W3	W2300	3062	220
	W4	W3000	3631	275
	W5	W3400	3978	310
	W6	W4000	4050	320
PELEKUNU	P1	P500	755	40
	P2	P20	2356	165
	P3	P4400	3537	200
	P4	P100	3948	255
	P5	P600	3941	325

Table 1. Location of microhabitat sampling stations in Waikolu Stream and Pelekunu Stream. Distance from mouth (meters) and elevation (meters).

WAIKOLU STREAM SAMPLING STATIONS			
SITE	STATION	TRANSECT	MACROHABITAT
W1	W200	W229	RUN
		W231	BOULDER/RIFFLE
		W257	RUN
		W266	RUN
		W269	RUN
W2	W1000	W1003	RUN
		W1004	RUN
		W1024	RUN
		W1059	RUN
		W1093	RUN
		W1111	POOL
		W1122	POOL
W3	W2300	W2314	RUN
		W3251	POOL
		W2378	POOL
		W2381	POOL
		W2391	POOL
W4	W3000	W3001	POOL
		W3013	POOL
		W3014	POOL
		W3041	POOL
		W3055	POOL
W5	W3400	W3492	POOL
		W3497	POOL
		W3888	POOL
		W3444	POOL
		W3555	POOL
W6	W4000	W4015	RUN
		W4022	RUN
		W4041	RUN
		W4050	RUN
		W4064	RUN

Table 2. Macrohabitat description at Waikolu Stream sampling stations.

PELEKUNU STREAM SAMPLING STATIONS			
SITE	STATION	TRANSECT	MACROHABITAT
P1	P500	P506	BOULDER/RIFFLE
		P558	RUN
		P574	RUN
		P577	RIFFLE
		P599	BOULDER/RIFFLE
		P511	RUN
		P522	POOL
P2	P20	P20	RUN
		P39	PLUNGE POOL
		P48	RUN
		P82	RUN
P3	P4400	P4409	RIFFLE
		P4432	BOULDER/RIFFLE
		P4463	RIFFLE
		P4474	RUN
		P4492	RIFFLE
		P4100	RUN
		P4200	RIFFLE
P4	P100	P107	RUN
		P141	RUN
		P178	RIFFLE
		P192	RUN
		P197	RUN
P5	P600	P619	RUN
		P624	RUN
		P647	RUN
		P659	RIFFLE
		P692	RUN

Table 3. Macrohabitat descriptions at Pelekunu Stream sampling stations.

INCLUDING DISTANCE AND ELEVATION		
VARIABLE	FACTOR 1	FACTOR 2
DISCHARGE	0.919	0.005
FISH DEPTH	0.437	0.889
FISH VELOCITY	0.783	-0.437
CENTER DEPTH	0.523	0.819
DEEPEST DEPTH	0.495	0.852
SURFACE VELOCITY	0.889	-0.238
STREAM VELOCITY	0.866	-0.465
STREAM WIDTH	0.828	0.39
DISTANCE (LN)	-0.817	0.336
ELEVATION (LN)	-0.758	0.442
VARIANCE EXPLAINED	56	31

WITHOUT DISTANCE AND ELEVATION		
VARIABLE	FACTOR 1	FACTOR 2
DISCHARGE	0.901	0.274
FISH DEPTH	0.666	-0.733
FISH VELOCITY	0.662	0.684
CENTER DEPTH	0.726	-0.647
DEEPEST DEPTH	0.705	-0.691
SURFACE VELOCITY	0.812	0.507
STREAM VELOCITY	0.701	0.677
STREAM WIDTH	0.897	-0.157
VARIANCE EXPLAINED	58	34

Table 4. Variable score loadings from Principal Components Correlation Analysis of selected habitat variables, measurements at sampling stations in Waikolu Stream and Pelekunu Stream combined. Analysis with and without distance from the mouth and elevation.

WAIKOLU STREAM					
VARIABLE	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
MICROHABITAT	0.681	0.016	0.19	0.382	-0.198
DISCHARGE	0.631	0.562	0.076	-0.279	0.074
FISH DEPTH	-0.274	0.811	-0.267	0.126	0.112
FISH VELOCITY	0.58	0.032	0.075	0.301	0.264
FISH SUBSTRATE	-0.302	0.17	0.713	0.008	0.21
FISH DISTANCE	0.063	0.725	-0.217	0.092	0.039
MACROHABITAT	0.733	0.017	0.096	0.115	0.025
CENTER DEPTH	-0.297	0.791	-0.228	0.214	0.077
DEEPEST DEPTH	-0.39	0.829	-0.091	0.206	0.096
SURFACE VELOCITY	0.791	0.122	0.185	0.38	-0.002
STREAM VELOCITY	0.787	0.061	0.125	0.335	0.081
BEDROCK (LN)	-0.182	-0.18	0.222	0.102	0.836
BOULDER (LN)	-0.127	0.252	0.641	0.03	-0.616
ROCK (LN)	0.367	-0.073	-0.446	0.05	-0.172
COBBLE (LN)	0.221	-0.067	-0.631	-0.274	-0.141
GRAVEL (LN)	0.394	-0.276	-0.575	0.275	0.095
STREAM WIDTH	-0.048	0.76	-0.027	-0.225	0.006
RUGOSITY	-0.016	0.466	0.046	0.358	-0.222
DISTANCE (LN)	-0.681	-0.4	-0.086	0.563	-0.099
ELEVATION (LN)	-0.695	-0.239	-0.156	0.571	-0.096
VARIANCE EXPLAINED	23	20	11	8	7

Table 5. Variable score loadings for Principal Components Correlation Analysis of all measured habitat variables in Waikolu Stream.

PELEKUNU STREAM					
VARIABLE	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
MICROHABITAT	0.501	0.401	-0.209	-0.013	0.293
DISCHARGE	0.866	0.039	0.266	-0.164	-0.132
FISH DEPTH	-0.406	0.747	0.363	0.201	-0.053
FISH VELOCITY	0.652	0.053	-0.347	0.436	0.051
FISH SUBSTRATE	0.173	0.342	-0.549	-0.177	-0.105
FISH DISTANCE	0.441	0.003	0.433	0.028	0.442
MACROHABITAT	0.026	0.451	0.005	-0.347	0.358
CENTER DEPTH	-0.409	0.726	0.379	0.231	-0.085
DEEPEST DEPTH	-0.4	0.802	0.3	0.148	-0.111
SURFACE VELOCITY	0.518	0.365	-0.313	0.533	0.173
STREAM VELOCITY	0.669	0.097	-0.327	0.516	0.161
BEDROCK (LN)	-0.215	0.007	-0.689	-0.042	-0.212
BOULDER (LN)	0.324	0.504	0.169	-0.328	0.101
ROCK (LN)	0.304	-0.4	0.345	0.1	-0.135
COBBLE (LN)	-0.19	-0.421	0.403	0.447	0.183
GRAVEL (LN)	-0.258	-0.315	0.439	0.392	-0.133
STREAM WIDTH	0.513	-0.15	0.414	-0.277	0.417
RUGOSITY	0.401	0.362	0.127	0.013	-0.3
DISTANCE (LN)	-0.822	-0.035	-0.25	0.066	0.423
ELEVATION (LN)	-0.838	-0.031	-0.264	0.061	0.398
VARIANCE EXPLAINED	25	16	13	8	6

Table 6. Variable score loadings for Principal Components Correlation Analysis of all measured habitat variables in Pelekunu Stream.

APPENDIX A. Latin and Hawaiian Species Names

CURRENT NAME	FORMER CLASSIFICATION	HAWAIIAN NAME
Eleotris sandwicensis (Vaillant & Sauvage, 1875)	Eleotris fusca	'o'opu akupa 'o'opu 'oau
Stenogobius hawaiiensis	Stenogobius genivittatus (Cuvier & Valenciennes, 1837)	'o'opu naniha
Awaous guamensis	Awaous stamineus (Eydoux & Souleyet, 1841)	'o'opu nakea
Sicyopterus stimpsoni (Gill, 1860)	Sicydium stimpsoni	'o'opu nopili
Lentipes concolor (Gill, 1860)	Lentipes seminudus	'o'opu alamo'o 'o'opu hi'ukole
Neritina granosa (Sowerby, 1825)		hihiwai wi
Theodoxus vespertinus (Sowerby, 1849)	Neritina vespertina	hapawai
Atyoida bisulcata	Atya bisulcata	'opae kuahiwi (Randall, 1840) 'opae kala'ole
Macrobrachium grandimanus (Randall, 1840)	Palaemon grandimanus	'opae 'oeha'a

APPENDIX B. Microhabitat Stations and Transect Locations

WAIKOLU STREAM MICROHABITAT STATIONS

SITE	STATION	TRANSECT	LOCATION	NOTES
W1	W200	229	MOUTH	
		231		
		257		
		266		
		269		
W2	W1000	1003	LOWER USGS GAGE	
		1004		
		1024		
		1059		
		1093		
		1111		POOL
		1122		POOL
W3	W2300	2314	LOWER NPS GAGE	
		2351	(BELOW LOWER DAM)	
		2378		
		2381		
		2391		
W4	W3000	3001	BETWEEN STREAM	
		3013	CROSSINGS	
		3014		
		3041		
		3055		
W5	W3400	~~3412~~	BELOW UPPER DAM	DRY
		~~3415~~		DRY
		~~3424~~		DRY
		3492		
		3497		ONLY 2 QUADRATS
		3888		ADDS TO 3497
		3444		REPLACES DRY
		3555		REPLACES DRY
W6	W4000	4015	UPPER NPS GAGE	
		4022	(ABOVE UPPER DAM)	
		4041		
		4050		
		4064		

PELEKUNU STREAM MICROHABITAT STATIONS

SITE	STATION	TRANSECT	LOCATION	NOTES
P1	P500	506	LOWER CABIN	
		558		
		574		
		577		
		~~585~~		TOO TURBID
		599		REPLACES 585
		511		POOL
		522		POOL
P2	P20	0020	JUST UPSTREAM	
		0039	FROM LANIPUNI	
		0048		
		~~0065~~		PRECIPICE
		0082		
P3	P4400	4409	TNC CABIN	
		4432		
		4463		
		4474		
		4492		
		4100		POOL
		4200		POOL
P4	P100	107	NEW USGS GAGE	
		141		
		178		
		192		
		197		
P5	P600	619	PILIPILILAU	
		624	(ABOVE USGS GAGE)	
		647		
		659		
		692		

APPENDIX C - Discharge Measurements

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 231						9/26/94	11:00A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.93								
1.2	0.36	1.180638	0.31	0	0	0.365998	0	
1.65	0.49	1.606979	0.4	0	0	0.642792	0	
2.18	0.45	1.475797	0.4	11	0.3608	0.590319	0.212987	
2.55	0.285	0.934671	0.15	9	0.2952	0.140201	0.041387	
2.75								
					DISCHARGE		0.254374	FT^3/S
16.3								
16.7	0.35	1.147842	0.42	43	1.4104	0.482094	0.679945	
17	0.4	1.311819	0.7	59	1.9352	0.918274	1.777043	
17.5	0.5	1.639774	0.5	108	3.5424	0.819887	2.904368	
18	0.375	1.229831	1.5	74	2.4272	1.844746	4.477568	
18.25	0.45	1.475797	1.6	64	2.0992	2.361275	4.956789	
18.9	0.575	1.885741	0.6	56	1.8368	1.131444	2.078237	
19.4	0.5	1.639774	0.65	29	0.9512	1.065853	1.01384	
19.9	0.55	1.803752	1.95	26	0.8528	3.517316	2.999567	
20.5	0.505	1.656172	0.51	28	0.9184	0.844648	0.775725	
20.91	0.55	1.803752	0.5	11	0.3608	0.901876	0.325397	
21.6	0.42	1.37741	0.43	10	0.328	0.592287	0.19427	
21.75	0.25	0.819887	0.42	12	0.3936	0.344353	0.135537	
22.1								
					DISCHARGE		22.31829	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 257						1/6/95	9:00A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.6								
1.75	0.25	0.819887	0.4	2	0.0656	0.327955	0.021514	
2.1	0.425	1.393808	0.6	5	0.164	0.836285	0.137151	
2.6	0.45	1.475797	0.85	17	0.5576	1.254427	0.699469	
3	0.45	1.475797	0.7	15	0.492	1.033058	0.508264	
3.5	0.45	1.475797	0.9	15	0.492	1.328217	0.653483	
3.9	0.45	1.475797	1.1	25	0.82	1.623377	1.331169	
4.4	0.4	1.311819	1	18	0.5904	1.311819	0.774498	
4.7	0.35	1.147842	1.3	25	0.82	1.492195	1.2236	
5.1	0.45	1.475797	1.5	30	0.984	2.213695	2.178276	
5.6	0.725	2.377673	1.5	37	1.2136	3.566509	4.328316	
6.55								
					DISCHARGE		11.85574	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 266						1/4/95	1:20	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
3								
3.25	0.375	1.229831	0.6	3	0.0984	0.737898	0.072609	
3.75	0.5	1.639774	0.7	10	0.328	1.147842	0.376492	
4.25	0.5	1.639774	1	7	0.2296	1.639774	0.376492	
4.75	0.475	1.557786	1.2	15	0.492	1.869343	0.919717	
5.2	0.5	1.639774	1.9	20	0.656	3.115571	2.043815	
5.75	0.45	1.475797	1.3	28	0.9184	1.918536	1.761983	
6.1	0.425	1.393808	1	25	0.82	1.393808	1.142923	
6.6	0.5	1.639774	1.9	0	0	3.115571	0	
7.1	0.5	1.639774	0.75	0	0	1.229831	0	
7.6	0.3	0.983865	0.5	1	0.0328	0.491932	0.016135	
7.7								
					DISCHARGE		6.710167	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 269						7/9/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.95								
1	0.2	0.65591	0.3	6	0.1968	0.196773	0.038725	
1.35	0.4	1.311819	0.7	5	0.164	0.918274	0.150597	
1.8	0.475	1.557786	1.1	4	0.1312	1.713564	0.22482	
2.3	0.475	1.557786	1	23	0.7544	1.557786	1.175193	
2.75	0.45	1.475797	0.95	30	0.984	1.402007	1.379575	
3.2	0.45	1.475797	0.8	44	1.4432	1.180638	1.703896	
3.65	0.45	1.475797	0.75	60	1.968	1.106848	2.178276	
4.1	0.45	1.475797	1.2	20	0.656	1.770956	1.161747	
4.55	0.475	1.557786	1.25	18	0.5904	1.947232	1.149646	
5.05	0.5	1.639774	0.7	26	0.8528	1.147842	0.97888	
5.55	0.475	1.557786	0.6	0	0	0.934671	0	
6	0.27	0.885478	0.5	0	0	0.442739	0	
6.09								
					DISCHARGE		10.14136	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1003						10/6/94	11:06A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
2								
2.5	0.5	1.639774	0.5	2	0.0656	0.819887	0.053785	
3	0.5	1.639774	0.5	3	0.0984	0.819887	0.080677	
3.5	0.5	1.639774	1.8	1	0.0328	2.951594	0.096812	
4	0.5	1.639774	1.5	2	0.0656	2.459662	0.161354	
4.5	0.5	1.639774	1.4	30	0.984	2.295684	2.258953	
5	0.5	1.639774	0.8	30	0.984	1.311819	1.29083	
5.5	0.5	1.639774	0.7	23	0.7544	1.147842	0.865932	
6	0.45	1.475797	0.8	25	0.82	1.180638	0.968123	
6.4	0.5	1.639774	1.3	21	0.6888	2.131707	1.46832	
7	0.45	1.475797	1	25	0.82	1.475797	1.210153	
7.3	0.5	1.639774	1	4	0.1312	1.639774	0.215138	
8	0.6	1.967729	0.6	0	0	1.180638	0	
8.5	0.375	1.229831	0.2	0	0	0.245966	0	
8.75								
					DISCHARGE		8.670077	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1004						10/6/94	1:45P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.7								
2.05	0.325	1.065853	1.95	5	0.164	2.078414	0.34086	
2.35	0.4	1.311819	0.85	8	0.2624	1.115047	0.292588	
2.85	0.475	1.557786	1.6	15	0.492	2.492457	1.226289	
3.3	0.475	1.557786	1.6	13	0.4264	2.492457	1.062784	
3.8	0.5	1.639774	2	12	0.3936	3.279549	1.29083	
4.3	0.5	1.639774	1.9	11	0.3608	3.115571	1.124098	
4.8	0.475	1.557786	1.6	10	0.328	2.492457	0.817526	
5.25	0.475	1.557786	1	14	0.4592	1.557786	0.715335	
5.75	0.375	1.229831	0	0	0	0	0	
6	0.475	1.557786	0	0	0	0	0	
6.7	0.5	1.639774	0.2	0	0	0.327955	0	
7	0.475	1.557786	0.2	3	0.0984	0.311557	0.030657	
7.65	0.55	1.803752	0.5	1	0.0328	0.901876	0.029582	
8.1	0.375	1.229831	1.3	0	0	1.59878	0	
8.4								
					DISCHARGE		6.930549	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1024						1/5/95	2:14P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
2.5								
2.75	0.375	1.229831	0.4	3	0.0984	0.491932	0.048406	
3.25	0.5	1.639774	0.9	7	0.2296	1.475797	0.338843	
3.75	0.475	1.557786	0.9	10	0.328	1.402007	0.459858	
4.2	0.45	1.475797	1	70	2.296	1.475797	3.38843	
4.65	0.475	1.557786	1.3	65	2.132	2.025121	4.317559	
5.15	0.5	1.639774	1.4	70	2.296	2.295684	5.270891	
5.65	0.375	1.229831	1.1	42	1.3776	1.352814	1.863636	
5.9								
					DISCHARGE		15.68762	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1059						1/5/95	12:15	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.05								
1.3	0.375	1.229831	0.8	8	0.2624	0.983865	0.258166	
1.8	0.5	1.639774	0.9	10	0.328	1.475797	0.484061	
2.3	0.475	1.557786	1.1	0	0	1.713564	0	
2.75	0.45	1.475797	1	20	0.656	1.475797	0.968123	
3.2	0.475	1.557786	1.5	16	0.5248	2.336678	1.226289	
3.7	0.5	1.639774	1.2	0	0	1.967729	0	
4.2	0.5	1.639774	1	40	1.312	1.639774	2.151384	
4.7	0.45	1.475797	0.9	50	1.64	1.328217	2.178276	
5.1	0.4	1.311819	0.7	20	0.656	0.918274	0.602388	
5.5	0.35	1.147842	0.5	0	0	0.573921	0	
5.8								
					DISCHARGE		7.868687	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1093						1/5/95	9:00A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.5								
0.75	0.375	1.229831	0.7	2	0.0656	0.860882	0.056474	
1.25	0.5	1.639774	0.9	0	0	1.475797	0	
1.75	0.5	1.639774	0.85	7	0.2296	1.393808	0.320018	
2.25	0.5	1.639774	1.1	20	0.656	1.803752	1.183261	
2.75	0.475	1.557786	1.2	10	0.328	1.869343	0.613144	
3.2	0.45	1.475797	0.95	0	0	1.402007	0	
3.65	0.45	1.475797	1.3	18	0.5904	1.918536	1.132704	
4.1	0.475	1.557786	0.8	30	0.984	1.246229	1.226289	
4.6	0.5	1.639774	0.8	15	0.492	1.311819	0.645415	
5.1	0.5	1.639774	0.7	0	0	1.147842	0	
5.6	0.5	1.639774	0.8	15	0.492	1.311819	0.645415	
6.1	0.5	1.639774	0.9	0	0	1.475797	0	
6.6	0.375	1.229831	0.5	3	0.0984	0.614915	0.060508	
6.85								
					DISCHARGE		5.883228	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1111						10/7/94	1:36P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.1								
0.3	0.35	1.147842	0.9	4	0.1312	1.033058	0.135537	
0.8	0.475	1.557786	1.3	1	0.0328	2.025121	0.066424	
1.25	0.475	1.557786	1.1	2	0.0656	1.713564	0.11241	
1.75	0.475	1.557786	1.35	4	0.1312	2.103011	0.275915	
2.2	0.475	1.557786	1.4	0	0	2.1809	0	
2.7	0.55	1.803752	1.1	0	0	1.984127	0	
3.3	0.55	1.803752	1.1	0	0	1.984127	0	
3.8	0.45	1.475797	0.7	0	0	1.033058	0	
4.2	0.5	1.639774	1.22	1	0.0328	2.000525	0.065617	
4.8	0.525	1.721763	1.6	1	0.0328	2.754821	0.090358	
5.25	0.475	1.557786	1.95	2	0.0656	3.037682	0.199272	
5.75	0.5	1.639774	1.7	2	0.0656	2.787616	0.182868	
6.25	0.525	1.721763	1.5	3	0.0984	2.582645	0.254132	
6.8	0.5	1.639774	1	3	0.0984	1.639774	0.161354	
7.25	0.425	1.393808	0.7	1	0.0328	0.975666	0.032002	
7.65	0.4	1.311819	0.5	1	0.0328	0.65591	0.021514	
8.05	0.475	1.557786	0.2	0	0	0.311557	0	
8.6								
					DISCHARGE		1.597403	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 1122						10/7/94	11:21A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.1								
0.6	0.5	1.639774	1.2	0	0	1.967729	0	
1.1	0.45	1.475797	1.9	0	0	2.804014	0	
1.5	0.45	1.475797	1.9	6	0.1968	2.804014	0.55183	
2	0.5	1.639774	2.3	14	0.4592	3.771481	1.731864	
2.5	0.45	1.475797	2.2	32	1.0496	3.246753	3.407792	
2.9	0.55	1.803752	2	19	0.6232	3.607504	2.248196	
3.6	0.675	2.213695	1	3	0.0984	2.213695	0.217828	
4.25	0.45	1.475797	3.8	1	0.0328	5.608028	0.183943	
4.5	0.375	1.229831	3.9	0	0	4.79634	0	
5	0.5	1.639774	4	0	0	6.559097	0	
5.5	0.5	1.639774	4	1	0.0328	6.559097	0.215138	
6	0.5	1.639774	3	3	0.0984	4.919323	0.484061	
6.5	0.55	1.803752	3.3	0	0	5.952381	0	
7.1	0.5	1.639774	3	0	0	4.919323	0	
7.5	0.4	1.311819	3	0	0	3.935458	0	
7.9	0.35	1.147842	2.4	0	0	2.754821	0	
8.2								
					DISCHARGE		9.040653	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY							
WAIKOLU 2314						10/13/94	11:00A
meters	meters	feet	feet	flowmeter			
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q
1.95							
2.1	0.275	0.901876	0.6	15	0.492	0.541126	0.266234
2.5	0.4	1.311819	0.4	2	0.0656	0.524728	0.034422
2.9							
				DISCHARGE		0.300656	FT^3/S
10							
10.5	0.4	1.311819	0.3	5	0.164	0.393546	0.064542
10.8	0.4	1.311819	0.5	2	0.0656	0.65591	0.043028
11.3	0.375	1.229831	0.7	11	0.3608	0.860882	0.310606
11.55							
				DISCHARGE		0.418175	FT^3/S
			TOTAL DISCHARGE:			0.718831	

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 2351						10/13/94	12:05	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
2.6								
2.9	0.425	1.393808	0.5	1	0.0328	0.696904	0.022858	
3.45	0.425	1.393808	0.5	0	0	0.696904	0	
3.75	0.575	1.885741	0.4	0	0	0.754296	0	
4.6	0.575	1.885741	0.4	5	0.164	0.754296	0.123705	
4.9	0.4	1.311819	0.6	19	0.6232	0.787092	0.490516	
5.4	0.5	1.639774	0.2	4	0.1312	0.327955	0.043028	
5.9	0.3	0.983865	0.3	3	0.0984	0.295159	0.029044	
6								
					DISCHARGE		0.70915	FT3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 2378						10/10/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
3.25								
3.5	0.325	1.065853	0.3	4	0.1312	0.319756	0.041952	
3.9	0.5	1.639774	0.05	0	0	0.081989	0	
4.5	0.425	1.393808	0	0	0	0	0	
4.75	0.375	1.229831	0	0	0	0	0	
5.25	0.85	2.787616	0.8	16	0.5248	2.230093	1.170353	
6.45	0.775	2.54165	0.4	0	0	1.01666	0	
6.8	0.475	1.557786	0.35	0	0	0.545225	0	
7.4	0.6	1.967729	0.6	0	0	1.180638	0	
8	0.5	1.639774	0.7	4	0.1312	1.147842	0.150597	
8.4	0.45	1.475797	1	3	0.0984	1.475797	0.145218	
8.9	0.475	1.557786	0.8	0	0	1.246229	0	
9.35	0.45	1.475797	1	0	0	1.475797	0	
9.8	0.325	1.065853	0.2	0	0	0.213171	0	
10								
					DISCHARGE		1.50812	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 2381						10/10/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
2.2								
2.3	0.225	0.737898	0.3	1	0.0328	0.22137	0.007261	
2.65	0.3	0.983865	0.5	0	0	0.491932	0	
2.9	0.475	1.557786	0.3	4	0.1312	0.467336	0.061314	
3.6	0.6	1.967729	0.4	1.5	0.0492	0.787092	0.038725	
4.1	0.55	1.803752	0.6	4	0.1312	1.082251	0.141991	
4.7	0.5	1.639774	0.5	24	0.7872	0.819887	0.645415	
5.1	0.55	1.803752	0.2	40	1.312	0.36075	0.473304	
5.8	0.45	1.475797	1.1	5	0.164	1.623377	0.266234	
6	0.35	1.147842	1	3	0.0984	1.147842	0.112948	
6.5	0.425	1.393808	0.9	0	0	1.254427	0	
6.85								
					DISCHARGE		1.747193	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 2391						10/10/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.4								
0.9	0.5	1.639774	0.6	0	0	0.983865	0	
1.4	0.45	1.475797	1.4	0	0	2.066116	0	
1.8	0.45	1.475797	2	0	0	2.951594	0	
2.3	0.5	1.639774	1.7	5	0.164	2.787616	0.457169	
2.8	0.45	1.475797	1.7	5	0.164	2.508855	0.411452	
3.2	0.45	1.475797	0.7	1	0.0328	1.033058	0.033884	
3.7								
					DISCHARGE		0.902506	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3001						10/11/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.85								
1.8	0.725	2.377673	0.3	17	0.5576	0.713302	0.397737	
2.3	0.5	1.639774	0.5	2	0.0656	0.819887	0.053785	
2.8	0.5	1.639774	0.1	0	0	0.163977	0	
3.3	0.5	1.639774	0.4	0	0	0.65591	0	
3.8	0.6	1.967729	0	33	1.0824	0	0	
4.5	0.65	2.131707	0	0	0	0	0	
5.1	0.5	1.639774	0.2	1	0.0328	0.327955	0.010757	
5.5	0.5	1.639774	0.2	0	0	0.327955	0	
6.1	0.425	1.393808	0.5	4	0.1312	0.696904	0.091434	
6.35								
					DISCHARGE		0.553712	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3013						10/11/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.9								
0.95	0.2	0.65591	0.42	0	0	0.275482	0	
1.3	0.475	1.557786	1.2	3	0.0984	1.869343	0.183943	
1.9	0.5	1.639774	0.3	7	0.2296	0.491932	0.112948	
2.3	0.425	1.393808	0.35	4	0.1312	0.487833	0.064004	
2.75	0.5	1.639774	1.9	2	0.0656	3.115571	0.204381	
3.3								
					DISCHARGE		0.565276	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3014						10/11/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.9								
1.7	0.6	1.967729	0.2	0	0	0.393546	0	
2.1	0.425	1.393808	0.2	0	0	0.278762	0	
2.55	0.35	1.147842	0.8	1	0.0328	0.918274	0.030119	
2.8	0.425	1.393808	1.5	2	0.0656	2.090712	0.137151	
3.4	0.45	1.475797	1.1	2	0.0656	1.623377	0.106494	
3.7	0.2	0.65591	1.3	2	0.0656	0.852683	0.055936	
3.8								
					DISCHARGE		0.3297	FT3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY							
WAIKOLU 3041						1/24/95	3:00P
meters	meters	feet	feet	flowmeter			
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q
REW	0.3						
LEW	4.75		FLOW IS ABSOLUTELY 0				
9 STATIONS							

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 692						10/11/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
4.4								
4.6	0.3	0.983865	0.9	1	0.0328	0.885478	0.029044	
5	0.45	1.475797	0.9	1	0.0328	1.328217	0.043566	
5.5	0.4	1.311819	0.4	0	0	0.524728	0	
5.8								
					DISCHARGE		0.072609	FT3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3492						11/23/94	2:24P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.1								
0.35	0.325	1.065853	0.8	2	0.0656	0.852683	0.055936	
0.75	0.45	1.475797	0.6	2	0.0656	0.885478	0.058087	
1.25	0.5	1.639774	0.6	4.5	0.1476	0.983865	0.145218	
1.75	0.475	1.557786	0.5	2.5	0.082	0.778893	0.063869	
2.2	0.525	1.721763	0.3	1.5	0.0492	0.516529	0.025413	
2.8	0.6	1.967729	0.8	0.5	0.0164	1.574183	0.025817	
3.4	0.45	1.475797	0.8	2.5	0.082	1.180638	0.096812	
3.7	0.325	1.065853	0.8	0	0	0.852683	0	
4.05	0.325	1.065853	0.1	1.5	0.0492	0.106585	0.005244	
4.35								
					DISCHARGE		0.476397	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3497						1/23/95	2:45P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.25								
0.45	0.25	0.819887	0.3	4	0.1312	0.245966	0.032271	
0.75	0.3	0.983865	0.2	8	0.2624	0.196773	0.051633	
1.05								
					DISCHARGE		0.083904	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3888						1/23/95	3:01	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.25								
0.4	0.275	0.901876	0.9	3.5	0.1148	0.811688	0.093182	
0.8	0.45	1.475797	1.3	1.5	0.0492	1.918536	0.094392	
1.3	0.5	1.639774	0.7	1.5	0.0492	1.147842	0.056474	
1.8	0.4	1.311819	0.65	2.5	0.082	0.852683	0.06992	
2.1	0.325	1.065853	0.7	1.5	0.0492	0.746097	0.036708	
2.45								
					DISCHARGE		0.350676	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3444					1/23/95	11:36A		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.8								
2	0.4	1.311819	1.5	0	0	1.967729	0	
2.6	0.75	2.459662	1.5	0	0	3.689492	0	
3.5	0.55	1.803752	0.9	0	0	1.623377	0	
3.7	0.275	0.901876	0.6	0	0	0.541126	0	
4.05	0.425	1.393808	0.4	0	0	0.557523	0	
4.55								
					DISCHARGE		0	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 3555						1/23/95	12:56P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.2								
0.6	0.4	1.311819	0.6	0	0	0.787092	0	
1	0.4	1.311819	1.3	0	0	1.705365	0	
1.4	0.45	1.475797	1.55	0	0	2.287485	0	
1.9	0.5	1.639774	1.3	0	0	2.131707	0	
2.4	0.5	1.639774	2	0	0	3.279549	0	
2.9	0.45	1.475797	2.15	0	0	3.172963	0	
3.3	0.45	1.475797	0.5	0	0	0.737898	0	
3.8	0.45	1.475797	1.1	0.5	0.0164	1.623377	0.026623	
4.2	0.45	1.475797	2	0	0	2.951594	0	
4.7								
					DISCHARGE		0.026623	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 4015					1/24/95	11:00A		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.3								
0.65	0.425	1.393808	0.2	1	0.0328	0.278762	0.009143	
1.15	0.475	1.557786	0.6	13	0.4264	0.934671	0.398544	
1.6	0.4	1.311819	0.8	21	0.6888	1.049456	0.722865	
1.95	0.375	1.229831	0.8	9	0.2952	0.983865	0.290437	
2.35								
					DISCHARGE		1.420989	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 4022						1/24/95	11:30A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.2								
0.25	0.45	1.475797	0.2	2	0.0656	0.295159	0.019362	
1.1	0.65	2.131707	0.25	3	0.0984	0.532927	0.05244	
1.55	0.475	1.557786	0.2	4	0.1312	0.311557	0.040876	
2.05	0.5	1.639774	0.9	5	0.164	1.475797	0.242031	
2.55	0.475	1.557786	0.54	11	0.3608	0.841204	0.303506	
3	0.45	1.475797	0.65	11	0.3608	0.959268	0.346104	
3.45	0.35	1.147842	0.55	16	0.5248	0.631313	0.331313	
3.7	0.365	1.197035	0.6	16	0.5248	0.718221	0.376922	
4.18								
					DISCHARGE		1.712555	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 4041						1/24/95	11:53A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.5								
0.75	0.35	1.147842	1	16	0.5248	1.147842	0.602388	
1.2	0.475	1.557786	1.5	2	0.0656	2.336678	0.153286	
1.7	0.55	1.803752	1.2	0	0	2.164502	0	
2.3	0.55	1.803752	0.85	0	0	1.533189	0	
2.8	0.4	1.311819	0.6	2	0.0656	0.787092	0.051633	
3.1	0.185	0.606717	0.1	0	0	0.060672	0	
3.17								
					DISCHARGE		0.807307	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 4050						1/24/95	12:22	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.2								
1.4	0.375	1.229831	0.9	50	1.64	1.106848	1.81523	
1.95	0.5	1.639774	0.7	19	0.6232	1.147842	0.715335	
2.4	0.475	1.557786	0.35	0	0	0.545225	0	
2.9	0.35	1.147842	0.1	0	0	0.114784	0	
3.1								
				DISCHARGE		2.530565	FT^3/S	

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
WAIKOLU 4064						1/24/95	1:25P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.1								
0.2	0.275	0.901876	0.8	4	0.1312	0.721501	0.094661	
0.65	0.425	1.393808	1.2	0	0	1.67257	0	
1.05	0.55	1.803752	0.3	73	2.3944	0.541126	1.295671	
1.75	0.575	1.885741	0.3	3	0.0984	0.565722	0.055667	
2.2	0.475	1.557786	0.5	3.5	0.1148	0.778893	0.089417	
2.7	1.025	3.361537	0	0	0	0	0	
4.25	1.025	3.361537	0	0	0	0	0	
4.75	0.475	1.557786	0.4	0	0	0.623114	0	
5.2	0.525	1.721763	0.2	6	0.1968	0.344353	0.067769	
5.8	0.5	1.639774	1.5	2	0.0656	2.459662	0.161354	
6.2	0.4	1.311819	1.3	0	0	1.705365	0	
6.6	0.45	1.475797	1.85	0	0	2.730224	0	
7.1	0.55	1.803752	2.3	0	0	4.148629	0	
7.7	0.5	1.639774	1.2	0	0	1.967729	0	
8.1	0.4	1.311819	0.65	0	0	0.852683	0	
8.5	0.375	1.229831	0.7	0	0	0.860882	0	
8.85								
					DISCHARGE		1.764538	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 506						6/23/94	12:10	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0								
0.25	0.375	1.229831	0.1	0	0	0.122983	0	
0.75	0.525	1.721763	0.1	11	0.3608	0.172176	0.062121	
1.3	0.645	2.115309	0.1	0	0	0.211531	0	
2.04	0.625	2.049718	0.1	3	0.0984	0.204972	0.020169	
2.55	0.425	1.393808	0.1	1	0.0328	0.139381	0.004572	
2.89	0.475	1.557786	0.1	19	0.6232	0.155779	0.097081	
3.5	0.605	1.984127	0	0	0	0	0	
4.1	0.5	1.639774	0.53	25	0.82	0.86908	0.712646	
4.5	0.4	1.311819	0.5	10	0.328	0.65591	0.215138	
4.9	0.4	1.311819	0.59	42	1.3776	0.773974	1.066226	
5.3	0.45	1.475797	0.4	50	1.64	0.590319	0.968123	
5.8	0.5	1.639774	0.4	22	0.7216	0.65591	0.473304	
6.3	0.575	1.885741	0.5	10	0.328	0.94287	0.309261	
6.95	0.55	1.803752	0.81	5	0.164	1.461039	0.23961	
7.4	0.375	1.229831	0.8	100	3.28	0.983865	3.227076	
7.7	0.45	1.475797	1.15	88	2.8864	1.697166	4.898701	
8.3	0.7	2.295684	1.2	63	2.0664	2.754821	5.692562	
9.1	0.55	1.803752	1	90	2.952	1.803752	5.324675	
9.4	0.35	1.147842	1.2	68	2.2304	1.37741	3.072176	
9.8	0.5	1.639774	0.7	78	2.5584	1.147842	2.936639	
10.4	0.55	1.803752	1	0	0	1.803752	0	
10.9	0.5	1.639774	0.7	7	0.2296	1.147842	0.263545	
11.4	0.425	1.393808	0.8	41	1.3448	1.115047	1.499515	
11.75	0.45	1.475797	1.3	62	2.0336	1.918536	3.901535	
12.3	0.475	1.557786	1.2	83	2.7224	1.869343	5.089099	
12.7	0.55	1.803752	0.7	27	0.8856	1.262626	1.118182	
13.4								
					DISCHARGE		41.19196	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 558					6/24/94	11:37A		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.3								
0.4	0.375	1.229831	0.7	25	0.82	0.860882	0.705923	
1.05	0.55	1.803752	0.2	21	0.6888	0.36075	0.248485	
1.5	0.5	1.639774	0.5	35	1.148	0.819887	0.94123	
2.05	0.525	1.721763	3	20	0.656	5.165289	3.38843	
2.55	0.425	1.393808	2	32	1.0496	2.787616	2.925882	
2.9	0.475	1.557786	3	24	0.7872	4.673357	3.678867	
3.5	0.6	1.967729	3	19	0.6232	5.903188	3.678867	
4.1	0.55	1.803752	0.6	33	1.0824	1.082251	1.171429	
4.6	0.475	1.557786	0.9	0	0	1.402007	0	
5.05	0.45	1.475797	1.4	1	0.0328	2.066116	0.067769	
5.5	0.425	1.393808	1.4	0	0	1.951331	0	
5.9	0.4	1.311819	0.9	1	0.0328	1.180638	0.038725	
6.3	0.3	0.983865	0.5	0	0	0.491932	0	
6.5								
					DISCHARGE		16.84561	FT^3/S

DISCHARGE MEASUREMENTS WITH PYGMY METER								
PELEKUNU 574								
meters	meters	feet	feet	PYGMY				
STA	WidthM	WidthF	Depth	rev/sec	VELft/s	Area	q	
0								
0.45	0.45	1.475797	0.7	3.05	3.00785	1.033058	3.107283	
0.9	0.475	1.557786	0.5	3.65	3.59405	0.778893	2.79938	
1.4	0.475	1.557786	1.7	3.5	3.4475	2.648236	9.129792	
1.85	0.525	1.721763	1.4	3.1	3.0567	2.410468	7.368079	
2.45	0.525	1.721763	1	2.075	2.055275	1.721763	3.538697	
2.9	0.5	1.639774	0.8	1.463415	1.457756	1.311819	1.912313	
3.45	0.5	1.639774	0.7	0.439024	0.456927	1.147842	0.52448	
3.9	0.425	1.393808	0.9	0.116279	0.141605	1.254427	0.177633	
4.3	0.25	0.819887	0.6	0.075	0.101275	0.491932	0.04982	
4.4								
					DISCHARGE		28.60748	FT^3/S

DISCHARGE MEASUREMENTS WITH PYGMY METER								
PELEKUNU 577								
meters	meters	feet	feet	PYGMY				
STA	WidthM	WidthF	Depth	rev/sec	VELft/s	Area	q	
0								
0.4	0.45	1.475797	0.9	3.00	2.959	1.328217	3.930195	
0.9	0.55	1.803752	1.4	2.75	2.71475	2.525253	6.855429	
1.5	0.5	1.639774	1.9	2.5	2.4705	3.115571	7.697019	
1.9	0.4	1.311819	1.7	2.15	2.12855	2.230093	4.746865	
2.3	0.475	1.557786	1.7	1.75	1.73775	2.648236	4.601971	
2.85	0.3	0.983865	1.6	0.925	0.931725	1.574183	1.466706	
2.9								
					DISCHARGE		29.29819	FT^3/S

DISCHARGE MEASUREMENTS WITH PYGMY METER								
PELEKUNU 599								
meters	meters	feet	feet	PYGMY				
STA	WidthM	WidthF	Depth	rev/sec	VELft/s	Area	q	
0.5								
0.75	0.425	1.393808	0.4	1.00	1.005	0.557523	0.560311	
1.35	0.475	1.557786	0.45	0.3	0.3211	0.701004	0.225092	
1.7	0.425	1.393808	0.8	0.317073	0.33778	1.115047	0.376641	
2.2	0.5	1.639774	1.02	0.5	0.5165	1.67257	0.863882	
2.7	0.475	1.557786	1.3	0.525	0.540925	2.025121	1.095439	
3.15	0.5	1.639774	1.2	0.9	0.9073	1.967729	1.785321	
3.7	0.475	1.557786	0.8	0.975	0.980575	1.246229	1.222021	
4.1	0.55	1.803752	0.8	1.55	1.54235	1.443001	2.225613	
4.8	0.575	1.885741	1	1.65	1.64005	1.885741	3.092709	
5.25	0.475	1.557786	1.3	1.275	1.273675	2.025121	2.579346	
5.75	0.45	1.475797	0.6	1.097561	1.100317	0.885478	0.974307	
6.15	0.475	1.557786	1.2	2.975	2.934575	1.869343	5.485727	
6.7	0.5	1.639774	0.5	2.6	2.5682	0.819887	2.105634	
7.15	0.5	1.639774	1.1	2.075	2.055275	1.803752	3.707206	
7.7	0.425	1.393808	0.6	1	1.005	0.836285	0.840466	
8	0.45	1.475797	1	2.725	2.690325	1.475797	3.970373	
8.6	0.55	1.803752	0.8	2.425	2.397225	1.443001	3.459199	
9.1	0.475	1.557786	0.6	1.2	1.2004	0.934671	1.12198	
9.55	0.5	1.639774	0.2	1.55	1.54235	0.327955	0.505821	
10.1	0.4	1.311819	0.1	1	1.005	0.131182	0.131838	
10.35								
					DISCHARGE		36.32893	FT^3/S

DISCHARGE MEASUREMENTS WITH PYGMY METER								
PELEKUNU 511								
meters	meters	feet	feet	PYGMY				
STA	WidthM	WidthF	Depth	rev/sec	VELft/s	Area	q	
0								
0.3	0.4	1.311819	1	0.45	0.469976	1.311819	0.616524	
0.8	0.525	1.721763	2.35	0.5	0.5165	4.046143	2.089833	
1.35	0.5	1.639774	2.51	0.425	0.443225	4.115834	1.82424	
1.8	0.475	1.557786	2.85	0.609756	0.623732	4.439689	2.769175	
2.3	0.525	1.721763	2.8	0.425	0.443225	4.820937	2.13676	
2.85	0.525	1.721763	2.7	0.5	0.5165	4.64876	2.401085	
3.35	0.475	1.557786	2.45	0.195122	0.218634	3.816575	0.834434	
3.8	0.475	1.557786	1.9	0.675	0.687475	2.959793	2.034784	
4.3	0.5	1.639774	1.95	0.725	0.736325	3.19756	2.354443	
4.8	0.525	1.721763	2.3	0.7	0.7119	3.960055	2.819163	
5.35	0.525	1.721763	2.05	0.75	0.76075	3.529614	2.685154	
5.85	0.475	1.557786	2	0.525	0.540925	3.115571	1.68529	
6.3	0.475	1.557786	1.82	0.425	0.443225	2.83517	1.256618	
6.8	0.525	1.721763	1.8	0.5	0.5165	3.099174	1.600723	
7.35	0.525	1.721763	2	0.525	0.540925	3.443526	1.862689	
7.85	0.475	1.557786	2	0.325	0.345525	3.115571	1.076508	
8.3	0.475	1.557786	1.85	0.243902	0.266293	2.881903	0.76743	
8.8	0.8	2.623639	0.7	0	0.028	1.836547	0.051423	
9.9								
					DISCHARGE		30.86628	FT^3/S

DISCHARGE MEASUREMENTS WITH PYGMY METER								
PELEKUNU 522								
meters	meters	feet	feet	PYGMY				
STA	WidthM	WidthF	Depth	rev/sec	VELft/s	Area	q	
0.25								
0.35	0.25	0.819887	2.85	0.46	0.480756	2.336678	1.123372	
0.75	0.475	1.557786	2.85	0.55	0.56535	4.439689	2.509978	
1.3	0.575	1.885741	2.6	0.829268	0.838195	4.902925	4.109608	
1.9	0.525	1.721763	1.8	0.85	0.85845	3.099174	2.660486	
2.35	0.525	1.721763	1.2	1.525	1.517925	2.066116	3.136209	
2.95	0.5	1.639774	0.65	1.9	1.8843	1.065853	2.008387	
3.35	0.425	1.393808	1	1.725	1.713325	1.393808	2.388046	
3.8	0.5	1.639774	2.1	1.2	1.2004	3.443526	4.133609	
4.35	0.525	1.721763	2.2	0.35	0.36995	3.787879	1.401326	
4.85	0.5	1.639774	1.91	0.95	0.95615	3.131969	2.994632	
5.35	0.475	1.557786	1.95	0.3	0.3211	3.037682	0.9754	
5.8	0.5	1.639774	2	0.45	0.46765	3.279549	1.533681	
6.35	0.525	1.721763	0.75	0.325	0.345525	1.291322	0.446184	
6.85	0.5	1.639774	1	0.219512	0.242463	1.639774	0.397585	
7.35	0.5	1.639774	1.8	0	0.028	2.951594	0.082645	
7.85	0.525	1.721763	1.89	0	0.028	3.254132	0.091116	
8.4	0.575	1.885741	0.4	0	0.028	0.754296	0.02112	
9								
					DISCHARGE		30.01338	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 0020						2/4/95	12:30P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.35								
0.6	0.225	0.737898	0.6	4	0.1312	0.442739	0.058087	
0.8	0.3	0.983865	1.1	0	0	1.082251	0	
1.2	0.475	1.557786	2	2	0.0656	3.115571	0.204381	
1.75	0.55	1.803752	2.55	31	1.0168	4.599567	4.67684	
2.3	0.5	1.639774	2.7	13	0.4264	4.427391	1.887839	
2.75	0.475	1.557786	2.55	3	0.0984	3.972353	0.39088	
3.25	0.525	1.721763	2	1	0.0328	3.443526	0.112948	
3.8	0.475	1.557786	1.75	12	0.3936	2.726125	1.073003	
4.2	0.425	1.393808	1.65	34	1.1152	2.299784	2.564719	
4.65	0.55	1.803752	1.25	33	1.0824	2.25469	2.440476	
5.3	0.525	1.721763	0.8	25	0.82	1.37741	1.129477	
5.7	0.425	1.393808	0.35	4	0.1312	0.487833	0.064004	
6.15	0.475	1.557786	0.2	6	0.1968	0.311557	0.061314	
6.65	0.4	1.311819	0.05	0	0	0.065591	0	
6.95								
					DISCHARGE		14.66397	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 0039					2/4/94	3:10P		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.3								
0.7	0.35	1.147842	0.7	19	0.6232	0.803489	0.500735	
1	0.425	1.393808	0.9	0	0	1.254427	0	
1.55	0.45	1.475797	1.3	8	0.2624	1.918536	0.503424	
1.9	0.4	1.311819	2.9	10	0.328	3.804277	1.247803	
2.35	0.55	1.803752	0.3	33	1.0824	0.541126	0.585714	
3	0.575	1.885741	0.1	80	2.624	0.188574	0.494818	
3.5	0.4	1.311819	0.3	35	1.148	0.393546	0.451791	
3.8	0.525	1.721763	1.2	142	4.6576	2.066116	9.62314	
4.55	0.5	1.639774	0.6	13	0.4264	0.983865	0.41952	
4.8	0.475	1.557786	0.7	8	0.2624	1.09045	0.286134	
5.5	0.6	1.967729	2.9	0	0	5.706415	0	
6	0.5	1.639774	2.6	1	0.0328	4.263413	0.13984	
6.5	0.55	1.803752	2.3	1	0.0328	4.148629	0.136075	
7.1	0.525	1.721763	3	6	0.1968	5.165289	1.016529	
7.55	0.45	1.475797	2	8	0.2624	2.951594	0.774498	
8	0.325	1.065853	1.9	3	0.0984	2.025121	0.199272	
8.2	0.32	1.049456	1.9	3	0.0984	1.993966	0.196206	
8.64								
					DISCHARGE		16.5755	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 0048					2/5/95	10:52A		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
-0.9								
-0.75	0.325	1.065853	1.95	3	0.0984	2.078414	0.204516	
-0.25	0.525	1.721763	1.95	4	0.1312	3.357438	0.440496	
0.3	0.555	1.82015	1.53	2	0.0656	2.784829	0.182685	
0.86	0.55	1.803752	2.1	6	0.1968	3.787879	0.745455	
1.4	0.52	1.705365	2.7	6	0.1968	4.604486	0.906163	
1.9	0.45	1.475797	2.4	4	0.1312	3.541913	0.464699	
2.3	0.4	1.311819	3	3	0.0984	3.935458	0.387249	
2.7	0.45	1.475797	3	1	0.0328	4.427391	0.145218	
3.2	0.6	1.967729	2.8	6	0.1968	5.509642	1.084298	
3.9	0.6	1.967729	3	0	0	5.903188	0	
4.4	0.425	1.393808	2.9	0	0	4.042044	0	
4.75	0.45	1.475797	2.9	0	0	3.689492	0	
5.3	0.525	1.721763	2.9	2	0.0656	4.304408	0.282369	
5.8	0.425	1.393808	2.2	0	0	3.066378	0	
6.15	0.425	1.393808	1.6	11	0.3608	2.230093	0.804618	
6.65	0.475	1.557786	1.1	16	0.5248	1.713564	0.899278	
7.1	0.4	1.311819	0.6	0	0	0.787092	0	
7.45	0.3	0.983865	0.62	0	0	0.609996	0	
7.7								
					DISCHARGE		6.547043	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 0082						2/5/95	2:30P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.3								
0.5	0.35	1.147842	0.4	9	0.2952	0.459137	0.135537	
1	0.6	1.967729	0.9	0	0	1.770956	0	
1.7	0.5	1.639774	0.5	60	1.968	0.819887	1.613538	
2	0.4	1.311819	0.2	19	0.6232	0.262364	0.163505	
2.5	0.475	1.557786	1.4	10	0.328	2.1809	0.715335	
2.95	0.5	1.639774	0.9	55	1.804	1.475797	2.662338	
3.5	0.525	1.721763	1.3	40	1.312	2.238292	2.936639	
4	0.45	1.475797	0.7	45	1.476	1.033058	1.524793	
4.4	0.375	1.229831	1.2	20	0.656	1.475797	0.968123	
4.75	0.875	2.869605	1.3	13	0.4264	3.730487	1.59068	
6.15	0.825	2.705628	0.6	7	0.2296	1.623377	0.372727	
6.4	0.375	1.229831	0.4	4	0.1312	0.491932	0.064542	
6.9	0.38	1.246229	0.45	5	0.164	0.560803	0.091972	
7.16								
					DISCHARGE		12.83973	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 4409						7/23/94	12:10	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.4								
0.49	0.2	0.65591	0.1	0	0	0.065591	0	
0.8	0.355	1.16424	0.1	0	0	0.116424	0	
1.2	0.5	1.639774	0.1	0	0	0.163977	0	
1.8	0.6	1.967729	0.2	0	0	0.393546	0	
2.4	0.425	1.393808	1.5	45	1.476	2.090712	3.085891	
2.65	0.4	1.311819	2	55	1.804	2.623639	4.733045	
3.2	0.625	2.049718	2.1	29	0.9512	4.304408	4.094353	
3.9	0.5	1.639774	1.3	10	0.328	2.131707	0.6992	
4.2	0.375	1.229831	1.2	60	1.968	1.475797	2.904368	
4.65	0.5	1.639774	0.9	15	0.492	1.475797	0.726092	
5.2	0.55	1.803752	0.3	10	0.328	0.541126	0.177489	
5.75								
					DISCHARGE		16.42044	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 4432						7/23/94	1:45P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.79								
0.89	0.305	1.000262	1	0	0	1.000262	0	
1.4	0.305	1.000262	1.2	38	1.2464	1.200315	1.496072	
1.5	0.34	1.115047	1.4	49	1.6072	1.561065	2.508944	
2.08	0.6	1.967729	1.8	5	0.164	3.541913	0.580874	
2.7	0.585	1.918536	1.4	0	0	2.68595	0	
3.25	0.5	1.639774	0.9	0	0	1.475797	0	
3.7	0.5	1.639774	1	24	0.7872	1.639774	1.29083	
4.25	1.425	4.673357	0	0	0	0	0	
6.55	1.3	4.263413	0	0	0	0	0	
6.85	0.25	0.819887	0.75	15	0.492	0.614915	0.302538	
7.05								
					DISCHARGE		6.179259	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 4463						7/23/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.6								
2	0.35	1.147842	0.1	0	0	0.114784	0	
2.3	0.4	1.311819	0.69	13	0.4264	0.905155	0.385958	
2.8	0.45	1.475797	0.5	44	1.4432	0.737898	1.064935	
3.2	0.45	1.475797	0.7	100	3.28	1.033058	3.38843	
3.7	0.5	1.639774	0.8	100	3.28	1.311819	4.302768	
4.2	0.5	1.639774	1.05	43	1.4104	1.721763	2.428375	
4.7	0.45	1.475797	0.9	25	0.82	1.328217	1.089138	
5.1								
					DISCHARGE		12.6596	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 4474						11/8/94	9:00A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.15								
1.4	0.425	1.393808	0.1	0	0	0.139381	0	
2	0.5	1.639774	0.5	51	1.6728	0.819887	1.371507	
2.4	0.4	1.311819	0.4	0	0	0.524728	0	
2.8	0.45	1.475797	0.8	38	1.2464	1.180638	1.471547	
3.3	0.5	1.639774	0.9	33	1.0824	1.475797	1.597403	
3.8	0.45	1.475797	0.8	25	0.82	1.180638	0.968123	
4.2	0.45	1.475797	0.7	12	0.3936	1.033058	0.406612	
4.7	1.35	4.427391	0.3	0	0	1.328217	0	
6.9	1.3	4.263413	0.1	0	0	0.426341	0	
7.3	0.55	1.803752	0.4	4	0.1312	0.721501	0.094661	
8	0.55	1.803752	0.4	4	0.1312	0.721501	0.094661	
8.4	0.5	1.639774	0.8	20	0.656	1.311819	0.860554	
9	0.55	1.803752	0.2	1	0.0328	0.36075	0.011833	
9.5	0.45	1.475797	0.3	4	0.1312	0.442739	0.058087	
9.9	1.95	6.39512	0.1	0	0	0.639512	0	
13.4	2.05	6.723075	0.2	0	0	1.344615	0	
14	0.45	1.475797	0.2	1	0.0328	0.295159	0.009681	
14.3	0.4	1.311819	0.35	1	0.0328	0.459137	0.01506	
14.8	0.55	1.803752	0.5	35	1.148	0.901876	1.035354	
15.4	0.55	1.803752	0.5	11	0.3608	0.901876	0.325397	
15.9	0.5	1.639774	0.7	2	0.0656	1.147842	0.075298	
16.4	0.4	1.311819	0.4	25	0.82	0.524728	0.430277	
16.7	0.45	1.475797	0.4	48	1.5744	0.590319	0.929398	
17.3	0.6	1.967729	0.6	10	0.328	1.180638	0.387249	
17.9								
					DISCHARGE		10.1427	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 4492					11/10/94	11:30A		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.55								
1.7	0.325	1.065853	1	12	0.3936	1.065853	0.41952	
2.2	0.5	1.639774	0.7	0	0	1.147842	0	
2.7	0.5	1.639774	1.4	60	1.968	2.295684	4.517906	
3.2	0.475	1.557786	1.4	65	2.132	2.1809	4.649679	
3.65	0.575	1.885741	1.2	25	0.82	2.262889	1.855569	
4.35	0.525	1.721763	0.4	60	1.968	0.688705	1.355372	
4.7	1.925	6.313131	0.3	28	0.9184	1.893939	1.739394	
8.2	1.925	6.313131	0.3	76	2.4928	1.893939	4.721212	
8.55	0.4	1.311819	0.2	25	0.82	0.262364	0.215138	
9	0.425	1.393808	0.9	84	2.7552	1.254427	3.456198	
9.4	0.28	0.918274	0.6	0	0	0.550964	0	
9.56								
					DISCHARGE		22.92999	FT^3/S

PELEKUNU 4100						11/9/94	1:05P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.4								
1.9	0.4	1.311819	0.2	19	0.6232	0.262364	0.163505	
2.2	0.4	1.311819	0.5	24	0.7872	0.65591	0.516332	
2.7	0.45	1.475797	0.9	20	0.656	1.328217	0.871311	
3.1	0.475	1.557786	1.2	17	0.5576	1.869343	1.042346	
3.65	0.45	1.475797	1.8	20	0.656	2.656434	1.742621	
4	0.475	1.557786	2.2	14	0.4592	3.427128	1.573737	
4.6	0.575	1.885741	2.6	10	0.328	4.902925	1.60816	
5.15	0.5	1.639774	2.9	6	0.1968	4.755346	0.935852	
5.6	0.525	1.721763	3.4	5	0.164	5.853994	0.960055	
6.2	0.45	1.475797	1.4	6	0.1968	2.066116	0.406612	
6.5	0.35	1.147842	1.2	5	0.164	1.37741	0.225895	
6.9	0.3	0.983865	1	6	0.1968	0.983865	0.193625	
7.1								
					DISCHARGE		10.24005	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 4200						11/9/94	9:45A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0								
0.5	0.4	1.311819	3	12	0.3936	3.935458	1.548996	
0.8	0.35	1.147842	3.6	0	0	4.132231	0	
1.2	0.45	1.475797	4.5	0	0	6.641086	0	
1.7	0.475	1.557786	4.7	0	0	7.321593	0	
2.15	0.5	1.639774	3.85	0	0	6.313131	0	
2.7	0.575	1.885741	4.8	0	0	9.051555	0	
3.3	0.55	1.803752	4.7	50	1.64	8.477633	13.90332	
3.8	0.525	1.721763	3.4	6	0.1968	5.853994	1.152066	
4.35	0.5	1.639774	3.3	16	0.5248	5.411255	2.839827	
4.8	0.475	1.557786	3	0	0	4.673357	0	
5.3	0.55	1.803752	1.8	8	0.2624	3.246753	0.851948	
5.9	0.35	1.147842	1.8	0	0	2.066116	0	
6								
					DISCHARGE		20.29616	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 107						7/9/94	10:00A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.2								
0.33	0.275	0.901876	2	0	0	1.803752	0	
0.75	0.36	1.180638	1.8	0	0	2.125148	0	
1.05	0.375	1.229831	1.7	0	0	2.090712	0	
1.5	0.425	1.393808	0.7	0	0	0.975666	0	
1.9	0.515	1.688968	0.3	0	0	0.50669	0	
2.53	0.51	1.67257	0.9	15	0.492	1.505313	0.740614	
2.92	0.26	0.852683	0.8	45	1.476	0.682146	1.006848	
3.05	0.34	1.115047	2	40	1.312	2.230093	2.925882	
3.6	0.4	1.311819	2.7	15	0.492	3.541913	1.742621	
3.85								
					DISCHARGE		6.415965	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 141						7/9/94	11:56A	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.3								
0.4	0.3	0.983865	0.3	0	0	0.295159	0	
0.9	0.475	1.557786	0.3	4	0.1312	0.467336	0.061314	
1.35	0.475	1.557786	0.9	5	0.164	1.402007	0.229929	
1.85	0.5	1.639774	1.2	15	0.492	1.967729	0.968123	
2.35	0.425	1.393808	1.8	25	0.82	2.508855	2.057261	
2.7	0.45	1.475797	1.3	100	3.28	1.918536	6.292798	
3.25	0.45	1.475797	0.2	55	1.804	0.295159	0.532468	
3.6								
					DISCHARGE		10.14189	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 178						7/9/94	1:00P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.1								
0.4	0.4	1.311819	0.1	0	0	0.131182	0	
0.9	0.5	1.639774	1	5	0.164	1.639774	0.268923	
1.4	0.45	1.475797	2.3	21	0.6888	3.394333	2.338017	
1.8	0.45	1.475797	1.3	50	1.64	1.918536	3.146399	
2.3	0.575	1.885741	1.3	120	3.936	2.451463	9.648957	
2.95	0.5	1.639774	1	5	0.164	1.639774	0.268923	
3.3	0.45	1.475797	0.3	10	0.328	0.442739	0.145218	
3.85	0.5	1.639774	0.2	55	1.804	0.327955	0.591631	
4.3	0.425	1.393808	0.2	4	0.1312	0.278762	0.036574	
4.7								
					DISCHARGE		16.44464	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 192						7/9/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.3								
0.4	0.2	0.65591	0.1	0	0	0.065591	0	
0.7	0.45	1.475797	0.1	0	0	0.14758	0	
1.3	0.5	1.639774	0	0	0	0	0	
1.7	0.5	1.639774	0	0	0	0	0	
2.3	0.55	1.803752	1.8	38	1.2464	3.246753	4.046753	
2.8	0.475	1.557786	1.2	30	0.984	1.869343	1.839433	
3.25	0.45	1.475797	1.2	32	1.0496	1.770956	1.858796	
3.7	0.45	1.475797	1	30	0.984	1.475797	1.452184	
4.15	0.4	1.311819	0.8	25	0.82	1.049456	0.860554	
4.5								
					DISCHARGE		10.05772	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 197						7/9/94		
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.15								
0.25	0.275	0.901876	0.9	4	0.1312	0.811688	0.106494	
0.7	0.475	1.557786	0.75	0	0	1.168339	0	
1.2	0.45	1.475797	0.6	5	0.164	0.885478	0.145218	
1.6	0.4	1.311819	0.8	5	0.164	1.049456	0.172111	
2	0.5	1.639774	1.4	5	0.164	2.295684	0.376492	
2.6	0.425	1.393808	2.1	5	0.164	2.926997	0.480028	
2.85	0.275	0.901876	2	10	0.328	1.803752	0.591631	
3.15	0.275	0.901876	3.1	15	0.492	2.795815	1.375541	
3.4	0.435	1.426604	1.8	45	1.476	2.567887	3.790201	
4.02								
					DISCHARGE		7.037715	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 619						2/3/95	11:48a	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.75								
0.8	0.275	0.901876	0.2	0	0	0.180375	0	
1.3	0.5	1.639774	0	0	0	0	0	
1.8	0.45	1.475797	0	0	0	0	0	
2.2	0.375	1.229831	0.8	0	0	0.983865	0	
2.55	0.325	1.065853	1.5	13	0.4264	1.59878	0.68172	
2.85								
					DISCHARGE		0.68172	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 624						2/3/95	12 noon	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.1								
1.3	0.4	1.311819	0.5	34	1.1152	0.65591	0.731471	
1.9	0.475	1.557786	1	14	0.4592	1.557786	0.715335	
2.25	0.4	1.311819	1.1	24	0.7872	1.443001	1.135931	
2.7	0.375	1.229831	0.8	0	0	0.983865	0	
3								
					DISCHARGE		2.582736	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 647						2/3/95	1:38P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.45								
0.9	0.375	1.229831	0.5	0	0	0.614915	0	
1.2	0.375	1.229831	0.6	0	0	0.737898	0	
1.65	0.44	1.443001	0.55	10	0.328	0.793651	0.260317	
2.08	0.55	1.803752	0.5	0	0	0.901876	0	
2.75	0.56	1.836547	0.3	130	4.264	0.550964	2.349311	
3.2	0.475	1.557786	0.9	7	0.2296	1.402007	0.321901	
3.7	0.3	0.983865	0.78	0	0	0.767414	0	
3.8								
					DISCHARGE		2.93153	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 659						2/3/95	2:33P	
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
1.2								
1.45	0.25	0.819887	0.8	58	1.9024	0.65591	1.247803	
1.7	0.25	0.819887	0.3	20	0.656	0.245966	0.161354	
1.95								
					DISCHARGE		1.409157	FT^3/S

DISCHARGE MEASUREMENTS WITH MARSH MCBIRNEY								
PELEKUNU 692								
meters	meters	feet	feet	flowmeter				
STA	WidthM	WidthF	Depth	VELcm/s	VELft/s	Area	q	
0.5								
0.95	0.55	1.803752	0.27	1	0.0328	0.487013	0.015974	
1.6	0.475	1.557786	0.8	18	0.5904	1.246229	0.735773	
1.9	0.375	1.229831	0.25	18	0.5904	0.307458	0.181523	
2.35	0.5	1.639774	0.5	15	0.492	0.819887	0.403384	
2.9	0.395	1.295422	0.1	7	0.2296	0.129542	0.029743	
3.14								
					DISCHARGE		1.366398	FT^3/S