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Fishing the Waters of Amazonia: Native Subsistence Economies in a Tropical Rain Forest

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This report provides a comparative look at the ecology of native fishing in Amazonia with respect to the geographic distribution of water types. It has been argued that viable populations of human foragers cannot exist in tropical rain forests such as those of Amazonia because naturally occurring dietary resources are poor in quality, variable in availability, and spatially dispersed (Bailey et al. 1989; Bailey, Jenike, and Rechtman 1991; Headland 1987). However, the basis for this argument rests on the exploitability of terrestrial food resources by humans, in particular the hunting of game animals, and reflects the common land and hunting bias inherent to most discussions on

foragers. When this argument is applied to South America, it overlooks the importance of fish to the diet of native groups (Colinvaux and Bush 1991; Beckerman 1989; Hames 1989). The available ethnographic information on native fishing for lowland South America is very selective. This report draws attention to those issues about fishing for which information is still inadequate for a full understanding of this subsistence strategy. Particular attention is given to issues pertaining to the relation of fishing to hunting.

Fishing and hunting in Amazonia have been proposed as interchangeable food-procurement strategies because, at a proximate level, both appear to be directed at the capture of protein (Hames 1989). Fishing and hunting, however, differ dramatically in their structure and organization as subsistence strategies because fishing and hunting trips and the techniques of procurement within each strategy differ in their associated risks and rewards (Beckerman 1983; Hill and Hawkes 1983; Yost and Kelly 1983; Hames 1979; Gragson 1991, 1992). The structural and organizational differences between fishing and hunting are a reflection of life-history characteristics of fish and game species used by humans as well as the inherent scaling of such ecosystem processes as landscape development, rates of production, and changes in habitat (Redford and Robinson 1987; Vickers 1984; Schindler 1988; O'Neill 1989; Hoekstra, Allen, and Flather 1991; Moran 1990; Räsänen, Salo, and Kalliola 1987; Frost and Miller 1987; Cummins 1988). If the structure, organization, and, by extension, function of fishing are to be understood and not simply described, then greater attention needs to be given to the life-history characteristics of the species used as food and the scalar attributes of the environments they occupy. Attention to these two issues is even more critical if human choices between alternative food-procurement strategies and their incorporation into subsistence economies are the objective of study (Smith 1991; Gragson 1992; Stephens and Krebs 1986).

Fishing and Fisheries Ecology in Amazonia

Tropical rain forest covers approximately 9.5×10^6 km² of the Amazon River basin and portions of adjacent river basins in lowland South America (Figure 1). Waterways in this vast region are optically separated into "white," "black," and "clear" types (Wallace 1889; Sioli 1967, 1984; Domínguez 1985). Whitewaters are characteristic of the largest river in the region, the Solimões-Amazon, but are seldom found in streams. These waters are yellowish-ochre in color and turbid as a result of the large sediment load they carry in suspension; their transparencies range between 10 cm and 60 cm (measured with a Secchi-disk). Blackwaters are found in the second-largest river in the region, the Negro, and in selected streams. The olive-brown to reddish-brown color characteristic of blackwaters derives from the humic and fulvic acids they carry in solution ("looking in a glass

like weak tea, in the riverbed like black coffee," Sioli 1984:158); they are transparent up to a depth of 290 cm. Clearwaters are the most common water type throughout Amazonia. They are found in a majority of *terra firme* (lands not subject to annual flooding) streams and drain a larger portion of the region than any other water type. They are green to olive-green in color, carry insignificant amounts of suspended sediments and dissolved organic substances, and are transparent up to a depth of 430 cm.

Although these three water types are a useful classificatory tool, many waterways throughout Amazonia change seasonally or more frequently in "type" and ionic composition (Furch 1984; Richey and Richey 1987; Richey et al. 1991; Junk and Furch 1985; Sioli 1984). Amazonian waters, in fact, reflect processes operating on time scales in excess of 10⁴ years, such as sea-level changes (eustatic uplift) and climate change, and processes operating on time scales of hours and

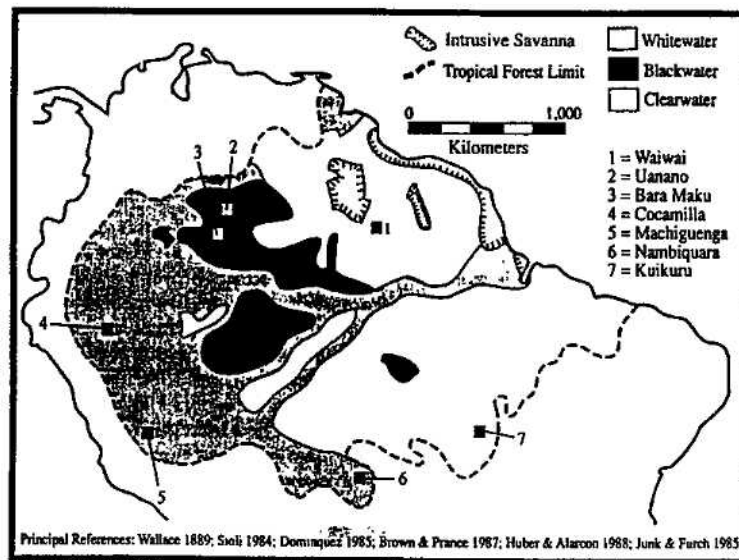


Figure 1
 Geographic location of native groups listed in Table 1 with respect to the distribution of water types throughout Amazonia.

days, such as daytime temperature change and seasonal weather patterns (Sioli 1984; Räsänen, Salo, and Kalliola 1987; Richey et al. 1991; Frechione, Posey, and da Silva 1989). Water type is also of debatable importance as far as native fishing efficiencies are concerned, despite the persistence of the "river of hunger" theory (Janzen 1974; Bailey et al. 1989). The Siona-Secoya, a western Tukanoan group living in eastern Ecuador, provide an interesting example of the relation between fishing efficiency and water type. This group lives in the drainage basin of the whitewater Napo and fishes both whitewater and blackwater rivers (Vickers 1989). The Siona-Secoya exploit the whitewater river only during the dry season, when fish density is highest per unit area because of low water levels: the concentration of fish is reflected in their annual fishing efficiency for this water type of 1.02 kg/hr. The blackwater river is exploited year-round without regard for the concentration of fish during low water and dispersal of fish during high water; despite seasonal changes in fish density, the Siona-Secoya still attain a mean annual efficiency in blackwater of 0.68 kg/hr, exceeding the central tendency of fishing efficiencies established for a sample of lowland South American cultures of 0.5 kg/hr (Beckerman 1989).

The effect of water type on the spatial distribution of fish throughout Amazonia appears to be less important than generally believed; fish seem to be distributed throughout Amazonia largely in response to short-term changes in landscape and habitat (Goulding, Carvalho, and Ferreira 1988; Roberts 1972; Goulding 1980; Lowe-McConnell 1964; Junk 1984). Annual floods with an amplitude of 5–20 m/yr affect significant portions of the Amazonian landscape known as *várzea* (Junk 1984). Flooding during the wet season allows for the movement of fish into flooded forest, where they feed on other fish, fruits and leaves falling into the water, aquatic and terrestrial insects, and other materials in order to accumulate fat that will carry them through the dry season, when fish typically fast (Figure 2; Roberts 1972; Goulding 1980; Goulding, Carvalho, and

Ferreira 1988; Saul 1975; Knöppel 1970). Areas not subject to flooding still undergo changes significant for fish as a result of the linkage of flooded and nonflooded areas through a watershed system (Franken and Leopoldo 1984; Cummins 1988). Survival and reproduction of fish are affected by changes in the concentration of dissolved substances and suspended particulates in fish habitats. These changes occur throughout the year as a result of: (1) dilution effects from increased amounts of water; (2) concentration effects from evaporation; (3) absorption effects from take-up of nutrients by living organisms; and (4) solution effects from added inputs resulting from decaying vegetation and animals (Sioli 1984; Richey and Ribeiro 1987; Richey et al. 1991; Goulding, Carvalho, and Ferreira 1988; Day and Davies 1986; Fittkau et al. 1975).

Native groups in Amazonia have frequently been classified on the basis of whether they live in areas subject to annual flooding or not (Lathrap 1968; Meggers 1971; Carneiro 1970; Moran 1989). In relying upon this dichotomy, Lathrap (1968) and others have stressed the reputed lack of aquatic resources in interfluvial *terra firme* areas as the factor determining the hunting dependence of groups living in these areas. By definition, interfluvial *terra firme* areas are not annually flooded, but they do contain abundant waterways. Drainage density in the watersheds of small Amazonian streams (linear stretch of all waterways per unit area of collection area) is 2 to 4 km/km² and fish are readily available, although smaller in size (Franken and Leopoldo 1984; Saul 1975; Knöppel 1970; Lüeling 1981; Goulding 1980; Goulding, Carvalho, and Ferreira 1988; Junk 1984; Sioli 1984). The Maku, for example, are seminomadic foragers living in the *terra firme* forest of the blackwater area located on the Colombia-Brazil border (Figure 1). Although they cultivate bitter manioc on a small scale, they are more generally described as professional hunters who exchange game with local Tukanoan groups for garden produce (Reid 1979; Silverwood-Cope 1972; Milton 1984). Despite

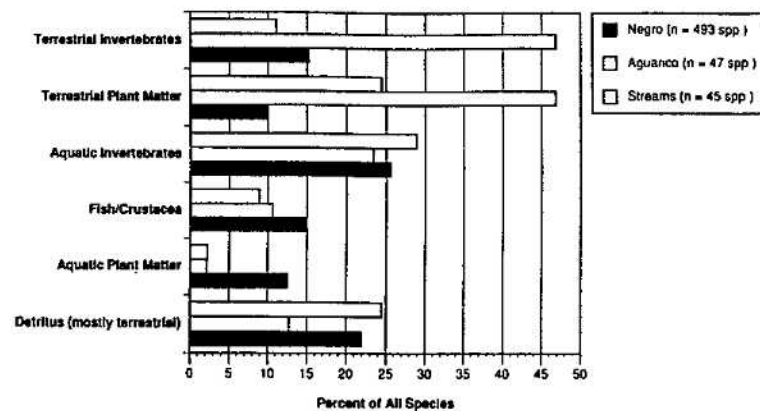


Figure 2
Principal food items of Amazonian fish in a blackwater river (Negro), a whitewater river (Aguarico), and *terra firme* streams, based on stomach contents. (Sources: Goulding, Carvalho, and Ferreira 1988; Saul 1975; Knöppel 1970.)

the description of the Maku as hunters, as much as 34.5% of all meat in their diet during the wet season derives from fish, and the acquisition of fish is said to increase during drier portions of the year (Silverwood-Cope 1972; Milton 1984).

Classifying native groups according to where they live is inadequate for understanding why they do or do not fish. It is necessary to know about the effects of landscape flooding on local fish and game resources, and to know how groups exploit spatially and temporally distinct habitats. Few ethnographers have addressed in any detail native use of fish habitats, although it is clear by inference that most groups do exploit a wide variety (Århem 1976; Stocks 1983; Chernela 1989; Carneiro 1957; Baksh 1985; Frechione, Posey, and da Silva 1989; Gragson 1991).

Amazonia has the highest species diversity of fish in the world, with an estimated 2,500 to 3,000 species for the entire region (Géry 1984; Goulding 1980; Roberts 1972; Lowe-McConnell 1987). In order to exploit the diversity of fish, native South Americans living in both riverine and interfluvial areas have developed a wide variety of fishing techniques (Table

1). Individual cultures frequently have an inventory of fishing techniques that includes various fixed and moving combinations of hook and line; spears, tridents, and harpoons; bow and arrow used from blinds, platforms, and canoes; various kinds of cultivated and wild poisons; and several kinds of traps and nets. The people using these devices to fish may be of either sex and may range in age from young children to very senior adults. During fishing events, individuals may act independently, as occurs when casting a hook and line from the bank of a river or in using certain types of nets; they may group in twos or threes, as when bow fishing or net fishing from a moving canoe; or they may join large interdependent groups of six or more people, as occurs in most fish-poisoning events (Carneiro 1957; Basso 1973; Baksh 1985; Beckerman 1983; Farabee 1918; Silverwood-Cope 1972; Stocks 1983; Århem 1976; Yde 1965; Gragson 1991). In comparison, hunting in lowland South America relies on a limited number of devices: women and children almost never participate; and most hunting events are carried out by single men (Vickers 1984; Hames 1989; Hill and Hawkes 1983).

Table 1
Physical, technical, and productive characteristics of fishing among selected native Amazonian groups.

Native group (Language group)	Kuikuru (Carib)	Cocamilla (Tupi)	Waiwai (Carib)	Machiguenga (Arawak)	Uanano (Tukano)	Bara Maku (Maku)	Nambiquara (Nambiquara)
Drainage basin	Xingu	Marañon	Essequibo/Trombetas	Urubamba	Uaupes	Uaupes	Guapore
Environment	Forest/Cerrado	Forest	Forest	Montaña forest	Igapo/Campina	Forest/Caatinga	Forest
Watercourse	Kuluene	Huallaga	Essequibo/Mapuera	Parotori	Uaupes	Baratore	Corrego Fundo
Water type	Clear/white	White	Clear	White	Black	Clear/black	White
Fish habitats used ^a	2,3,4,5,8	1,3,5,6,7,8	2,3,7,8	2,3,5,7,8	1,2,7,8	1,4,8	5,7,8
Fishing techniques used ^b	B/A (1,2) H/L (9) Poison (1?) Trap (1,2,5,6)	H/L (2) Poison (1,2) Net (1,2) Other (1,2,3)	B/A (1,2,3) H/L (1,2) Poison (9) Trap (1,2) Net (3)	B/A (9) H/L (1) Poison (1) Trap (3) Net (9)	H/L (3,9) Poison (9) Trap (1,3,5,6) Net (3)	B/A (9) H/L (3) Poison (9) Trap (1,4) Net (3)	B/A (9) H/L (9) Trap (5)
Bait used ^c	9	9	1,2,3,4,5	1,2,4,6	9	4,6	9
Catch diversity	30-43 varieties (est.)	21 varieties	21 varieties	22 varieties	—	42+ varieties	16 varieties
Measures of productivity	Fish = 10%-15% of diet by weight; provide most dietary protein. Effort = 1.5 hr/day.	Effic. = 0.29-7.0 kg/hr. Fish = 4.3%-17.2% of diet by weight.	—	Effic. = 0.2-0.56 kg/hr. Effort = 4.38 hr/day.	Effic. = < 0.5-2.1 kg/hr. Fish provide 85% of dietary protein.	Effic. ≤ 15 kg/day. Fish = 14.1%-34.5% of dietary meat by weight.	Fish provide 34% of dietary meat and 10% of all food by frequency of consumption; 67% of fishing events have positive returns.

Table 1 (continued)

Native group (Language group)	Kuikuru (Carib)	Cocamilla (Tupi)	Waiwai (Carib)	Machiguenga (Arawak)	Uanano (Tukano)	Bara Maku (Maku)	Nambiquara (Nambiquara)
Length of study	7 months	22 months	11 months in 2 trips	14 months	Unspecified, over 6 years	22 months; 5 months	2 months
Reference	Carneiro 1957, pers. comm. 1991	Stocks 1981, 1983	Yde 1965	Baksh 1985	Chernela 1985, 1989	Silverwood-Cope 1972; Milton 1984	Setz 1983

^a1 = flooded forest; 2 = river margin; 3 = river channel; 4 = swamps and meadows; 5 = lakes, ponds, and pools; 6 = oxbow lakes; 7 = point features (cascades, island points, etc.); 8 = streams and shallow water (<30 cm deep).
^bB/A (bow and arrow): 1 = stationary; 2 = moving; 3 = with surface baiting. Poison: 1 = *Lonchocarpus* sp.; 2 = *Jaquine* sp. Trap: 1 = weir and funnel; 2 = spring loaded; 3 = flow trap, various; 4 = loop and pole (eel); 5 = basket trap, various; 6 = other. Net: 1 = gill; 2 = cast; 3 = dip. Other: 1 = harpoon; 2 = spear; 3 = trident. A 9 in all cases indicates details of technique are unknown.
^c1 = manioc; 2 = fish-meat; 3 = fruits and berries; 4 = insects, worms, and larvae; 5 = game-meat; 6 = other; 9 = unknown.

While native groups are frequently said to have favorite species of fish (partly due to taste preferences, it seems), most groups still rely on 10 to 30 species or varieties of fish on a regular basis. The absolute number of fish varieties exploited ranges from about 20 among the Waiwai and Machiguenga to as many as 150 among the Aguaruna and Huambisa Jivaro (Yde 1965; Baksh 1985; Berlin and Berlin 1983). It is now fairly clear that the selection of game species in native South American hunting reflects both the natural history of the species and the procurement decisions of native hunters (Hawkes, Hill, and O'Connell 1982; Redford and Robinson 1987; Vickers 1984; Gragson 1992). The number of fish varieties used by native groups also appears to reflect natural history and procurement decisions, but little is actually known about the process of selection: this is because fish, unlike game, are frequently lumped into one lifeform when they are reported. A partial approximation of the selection process is revealed by contrasting the catch diversity of native groups living in middle to upper courses of waterways to groups living in lower courses of waterways.

Native groups living in middle to upper courses of whitewater, blackwater, and clearwater rivers generally (although not always) appear to use a larger number of fish species than groups living in the lower courses of rivers (Carniero 1957; Basso 1973; Clark and Uhl 1987; Stocks 1983; Arhem 1976; Silverwood-Cope 1972; Setz 1983). Certain species of fish in the lower courses of rivers can reach weights of 50–100 kg each, and people living in these areas appear to selectively exploit large fish species by using particular fishing tactics that target these species' general behavior, feeding habits, or physiology. For example, during the rainy season, when waters are turbid and fishing is generally regarded as difficult in the Essequibo River drainage, the Wapishana successfully capture *pacu* (*sic Mylietis pacu*, Farabee 1918). A fisherman drops fruits of *Genipa americana* or *Spondias myrobalanus* into the water from an overhanging branch, then shoots the fish with a har-

poon-arrow when it rises to feed. Fish in the middle to upper courses of waterways are uniformly smaller in size (commonly reported to weigh 100–300 g each) and there is probably less advantage in targeting selected species of fish (Chernela 1989; Baksh 1985; Junk 1984). Accordingly, fishing tactics that are less target-specific, such as poison and hook-and-line, may be relatively more important in these areas.

During periods of increased rainfall, water volume in waterways increases, while the density of harvestable fish decreases. Nevertheless, most investigators note that native groups practice fishing year-round, simply responding to changes in fish density by varying tactics and exploiting different habitats (Carniero 1957; Stocks 1983; Dufour 1983; Baksh 1985; Setz 1983; Silverwood-Cope 1972; Milton 1984; Gragson 1991). Native fishing efficiency varies by season with respect to changes in fish density, but the following three brief examples reveal in general terms how fishing tactics, fish habitat, and season relate to fishing efficiency among native groups. The Uanano-Tukano live along the mid-course of the blackwater Uaupes River (Figure 1) and have efficiencies ranging from <0.5 to 2.1 kg/hr based on technique, habitat, and maintenance costs of fixed facilities (Chernela 1989). The Machiguenga live in the headwater region of the Parotori River, which contains both white and clear waters (Baksh 1985). Depending upon technique used, and by implication fish habitat, fishing efficiencies range from 0.2 to 0.56 kg/hr; without regard for technique, efficiencies by season range from 0.31 to 1.11 kg/hr. The Cocamilla live in the várzea of the whitewater Huallaga River and, based on technique, habitat, and season, have efficiencies ranging from 0.29 to 7.00 kg/hr (Stocks 1983). These efficiencies are within the range of known values for native fishing in lowland South America compiled by Beckerman (1989) from a geographically dispersed set of Amazonian societies inhabiting whitewater, blackwater, and clearwater areas.

Relation of Fishing to Hunting

The life-history attributes of Amazonian fish are fast-growing, fast-reproducing, and short-lived (Goulding, Carvalho, and Ferreira 1988; Roberts 1972; Lowe-McConnell 1964; Junk 1984). Larger fish species reach reproductive maturity in one to two years and have life spans of less than ten years, while "miniature" fish (<20 mm standard length at maturity) are frequently annuals. Numbers of fish fluctuate from year to year in response to such environmental factors as climatic events, changes in habitat, and levels of predation, but fish populations recover quickly from severe depletions. The best predictor of annual fishing yield in tropical waters is the spawning success of the previous year (Lowe-McConnell 1987; Welcomme 1979). The life-history attributes of fish make native fishing a very low-risk strategy by comparison to hunting: the probability is small that an individual out fishing will return with no fish at all. Among the Pumé, fishing events have a risk of failure equal to 13% (Gragson 1989); among native groups living in forest areas of lowland South America, hunting events have an approximate risk of failure equal to 45% (Hames 1990; Hill and Hawkes 1983). Among the Maku, if game is not secured after a certain amount of time on any given hunting trip, individuals begin to fish; fish are said to be a more dependable food resource among the Maku than game, since an individual can always secure some fish if persistent (Silverwood-Cope 1972; Reid 1979; Milton 1984). Beckerman (1989) and Hames (1989) have suggested for Amazonia in general that returns from fishing drive hunting behavior in any given season. This proposition makes sense when the properties of standing biomass and production for fish are considered in relation to these properties for game.

Standing biomass of fish (amount of fish flesh present at a single point in time) in a variety of lowland South American aquatic habitats ranges from a minimum of 0.23 kg/ha to a maximum of 6,500 kg/ha; the median value is 175 kg/ha (Lowe-

McConnell 1987). The standing biomass of terrestrial mammals in Amazonia (based on the data available) is 14.50 kg/ha (Eisenberg, O'Connell, and August 1979; Janson and Emmons 1990), which gives an approximate ratio of fish biomass to terrestrial mammal biomass in Amazonia of 12:1. The large standing biomass of fish in Amazonian aquatic habitats is possible because fish do not depend predominantly upon autochthonous primary production for food, but rely instead on allochthonous inputs from the surrounding terrestrial ecosystem (Figure 2). Amazonian terrestrial and aquatic ecosystems are tightly linked (Goulding, Carvalho, and Ferreira 1988; Goulding 1980; Saul 1975; Knöppel 1970; Roberts 1972; Colinvaux and Bush 1991).

Fish have significantly higher annual production rates (growth and accumulation of tissue per unit area per unit time) than the birds and mammals used as food resources by native Amazonians. Amazonian aquatic food chains are shorter than local terrestrial food chains, and this tends to increase the efficiency of aquatic production (Marten and Polovina 1982; Lowe-McConnell 1987; Goulding, Carvalho, and Ferreira 1988). However, it is at the organismic level that most of the gains in fish production are achieved. Fish are ectotherms, which means their physiological costs of respiration are lower than those of endothermic organisms, such as birds and mammals. Fish populations convert energy into growth (trophic efficiency) at an approximate rate of 10%, while birds and mammals are able to convert energy into growth at an approximate rate of 1%. Fish populations by comparison to bird and game populations also contain higher proportions of juveniles, and these individuals alone can attain trophic efficiencies as high as 30% (Jones 1982; Pimm 1988; Morgan et al. 1980). Little information exists for Amazonia on the amount of fish flesh produced per unit area per unit time in natural communities, but in Brazil, experimental farming of *tambaqui* (*Colossoma macropomum*) in stocked ponds produced 6,800 kg/ha per year (Junk 1984). Based on information from other tropical areas,

production in stocked ponds is between six and ten times natural production (Morgan et al. 1980).

Assessing the potential of a given Amazonian environment to support native groups subsisting on fish is frequently undetermined by using fish yield (proportion of fish production cropped by humans) rather than fish production. Yield in managed fish ponds generally equals production, since the purpose of ponds is harvest for consumption; yield from natural habitats, however, accounts for 10% or less of actual production (Morgan et al. 1980). Yield becomes even less adequate to the task of establishing native harvest of fish for consumption when it is based on commercial fishermen. For example, yield values presented by Clark and Uhl (1987) are based on work by Bayley (1981), Goulding (1980), and Welcomme (1979) measuring harvest potential of large rivers by commercial-scale fishermen. The patterns of capital investment among commercial fishermen lead to technological constraints that limit their access to certain areas and direct their attention to marketable species (Bayley 1981; Russell and Poopetch 1990). Commercial fishermen no longer have the freedom of native groups to use a great variety of fishing tactics, fish habitats, or fish species.

Conclusion

There has been a general failure in the discussion of human foraging in Amazonia to recognize either the importance of fish to native subsistence or the scaling inherent to natural and human ecosystems. Fish are widely available as a food resource in Amazonia, even throughout interfluvial, blackwater areas. Fish are also used extensively by native groups year-round; native groups simply adjust their procurement tactics to account for changes in fish density resulting from changes in water volume and fish habitats. Overall, fish appear to be more dependable as a food resource than game because fish are significantly more abundant in time and productive over time than game are. What is currently needed to

better understand fishing as a procurement strategy as well as to understand its relation to other procurement strategies in native subsistence economics is information comparable in detail to what is currently available on hunting tactics and strategies (e.g., Hames 1979, 1989; Yost and Kelly 1983; Hawkes 1990; Hill and Hawkes 1983; Kaplan and Hill 1985).

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