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Author(s): John Cordell
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The Lunar-Tide Fishing Cycle in Northeastern Brazil[1]

John Cordell
Stanford University

The canoe fishermen who work the estuaries and mangrove swamps of the Brazilian coast are one of the most economically borderline peoples in Latin America. With the expansion of large-scale commercial fishing, the relative market value of third-class species such as mullet and catfish netted by traditional fishermen has rapidly declined. Moreover, their share of the total catch in inshore waters has been reduced through cut-throat competition with better equipped nylon net entrepreneurs and groundfish trawlers. The result is that canoe fishing specialists have had to gradually turn away from the market to marginal fishing, subsisting largely on the crabs and shellfish they can gather in the mangrove swamps.

In some outlying areas, however, marginalization has not yet run to this extreme and the remnants of a previous, highly viable, canoe fishing adaptation may be found. One such area is in southern Bahia along the Valença delta or *beirada*.

The purpose of this paper is to describe how canoe fishing functions as a man-environment system in its traditional estuarine setting. I do not intend so much to reconstruct a tradition that is fast disappearing as to provide a sense of what is being lost through marginality. In this connection, the question of the adaptive value of fishing lore takes on a special significance. The intricate knowledge of how to locate fish carries a formal elegance that helps transcend the spectre of poverty in swamp neighborhoods and may also explain how canoe fishermen have been able to survive the encroachment of outside entrepreneurs as long as they have.

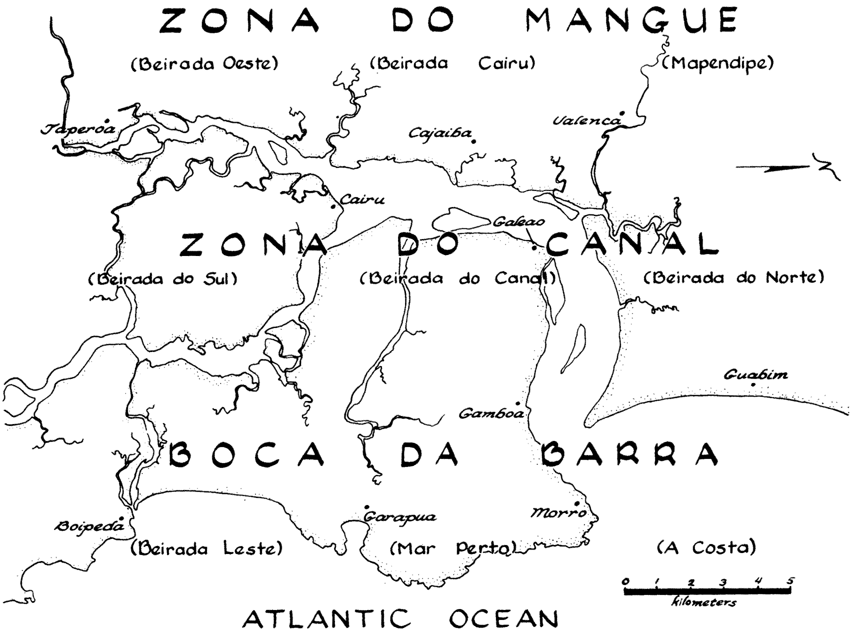
Perception of the Fishing Grounds

To understand what the *beirada* fishing universe is like we must take care not to assume that it contains the same unknowns and enigmatic qualities attributed to the ocean in Western or non-seafarers' folk beliefs. These preconceptions appear in fisheries theory usually as an exaggerated concern with the uncertainties and risks fishermen are up against. As far as locating fish is concerned, there is a tendency on the part of economists to discount important intuitive aspects of environmental decision-making; the assumption is that fish must be sought blindly (Christy and Scott 1965: 88). In general, there is little appreciation of how, and to what extent, fishermen make use of environmental clues to predict the behavior and movement of different species.

It would be quite misleading to assume that canoe fishermen face a kind of "separate" reality when they are dealing with their fishing environment. On the contrary, fishermen do consistently know where the fish are, and it is this widely shared knowledge, not simply the fact that they are using a common property resource, that makes fishing competitive. In this respect, canoe fishing is somewhat unique among inshore traditions. The decision of where to fish each day is made largely on the basis of pre-determined information about the environment (Andersen and Wadel 1972: 154). The source of this information is fishermen's perception of the cyclical regularities of the tides which affect both the mechanical operation of fishing methods and the distribution of species within the estuary. To net fish successfully in these waters, one must above all master the art of timing the tides.

The most characteristic aspect of an estuarine fishing environment like the *beirada,* is that it is a region of steep and variable gradients in environmental conditions (Emery and Stevenson 1957: 673). Two processes are responsible for this: tidal currents and active sedimentation. Together they act to produce remarkable depth and substrate changes over a short distance. The principles of estuarine zoning have been carefully taken into account in the way canoe fishermen classify their fishing grounds. Three main subdivisions are recognized: *boca da barra, canal,* and *mangué* (see Map 1). These terms correspond respectively to the mouth (tidal inlet including sandbanked

Map 1. Three Main Subdivisions of Estuarine Fishing Grounds



headlands), main body, and head of an estuary as defined by biologists. Two additional terms designate fishing areas used during the summer season: *a costa* (a long beach fronting the village of Guaibim) and the *mar perto* (the inshore reef areas fringing the island of Tinhare between the villages of Morro and Garapua). The existence of these grounds outside the estuary and the network of waterways accessible to fishermen as far south as the villages of Boipeba and Barra de Cavalho give an impression of the considerable extent of the canoe fishing grounds. As a result of trip time differences involved in fishing this territory, fishermen distinguish between the inner grounds (*beirada do canal*) and those to the south, their home port of Valença (*beirada do sul*). Since the estuary forks both eastward and westward from the island of Cairu, the southern fishing territory is subdivided into a *beirada leste* and a *beirada oeste*.

While the above terms enable one to refer to all major parts of the fishing ground, a second set of terms is used to mark off physiographic zones within these areas. Shores are *costeiros,* and the areas of shoreline exposed at low tide are *baixos*. *Riachos* are tidal creeks and rivers forming the brackish water portions of the estuary, *enseadas* are shoals within the mangrove swamp, and *coroas* are tidal flats. *Ilhas* are tidal flats which have been covered with mangrove vegetation.

Most of the bottom materials in the estuary are unconsolidated muds and sand. Mud is usually characteristic of the upper reaches of the estuary, the region of reduced current action, where sand is found near the mouth and channels. *Costeiros* in the northern *beirada* are normally rock strewn. The tidal flats which line and fill parts of the southern *beiradas* consist mostly of mud. Their surfaces are intertidal and thus periodically exposed to air and then covered with water. A large proportion of the prism of water that covers the flats at high tide travels via large channels, called *esteiros*. Minor channels vein the bottom of the estuary and may act as either tributaries or distributaries. These are known as *regos* and along their sides are natural levees which may rise to a foot or more.

These bottom features within the different physiographic zones of the estuary constitute the basic micro-environmental units from the standpoint of the distribution of fishing methods. Since most net fishing requires fishermen to leave their canoes and seine along the bottom, the pattern of substrate zoning and composition is known with great accuracy. Depth changes are similarly known to a fine degree.

Superimposed on the mirco-environmental framework of fishing is the influence of the tide. It is the most important ecological factor in the estuary not only because of its effect on animals, but because of the way it affects the positioning of fishing techniques. The periodic changes in sea level produced by the tides sub-divide the estuary into zones having nearly horizontal boundaries. The height of these zones varies with their distance from the tidal inlet. Like most estuaries with a gradual deepening from head to mouth, the tidal range decreases going away from the entrance. Thus, at the mouth of the Valença estuary, the tide range is relatively great (from 1 meter on the average at neap tide to 2.5 meters at a spring tide), but in the mangrove areas the neap and spring ranges are reduced by about half. The tide sweeps strongly in and out, invading the seaward end of the flood plain, but has a much less pronounced effect on the foreshores and in the tidal creeks and rivers. The tidal currents in the Valença estuary range from six knots at the mouth to three knots at the head at spring tides, while at neap tides the range is from three knots at the mouth to less than one knot at the head.

Several other points about currents in the estuary deserve mention as a background for understanding the fishing system. First, towards the bottom and sides of the channels, the current speed is reduced by frictional drag. The fastest currents are therefore found at the surface and at mid-stream. Also, there are counter-currents which result from irregularities in the shape of the estuary, and in the case of canoe fishing, from multiple tidal inlets. Where these currents cross in a channel, eddies are set up which considerably reduce the strength of current. Fishermen identify these areas as *reversas*. Finally, in the southern hemisphere the earth's rotation deflects inward flowing sea water counterclockwise. This results in stronger flood currents on the right-hand side of an estuary (looking down estuary) and stronger ebb currents on the left-hand side. This distinction is recognized in the vocabulary of fishing by the terms *canal de vazante* (flood channel), and *canal de enchente* (ebb channel).

Prior to the recent introduction of nylon gill nets, estuarine canoe fishing utilized thirteen different methods. It will not be necessary here, however, to launch into an elaborate discussion of fishing technology. From the range of methods available, most are viewed by fishermen as subsidiary in terms of cost and production to the large drag net (*rede grande*) and encircling net (*calao*). We must now consider what it is about these categories of nets that serves as a basis for environmental specialization. In this connection, the limiting variables are current strength, depth, and substrate. Depth and substrate considerations give rise to a distribution of these nets in micro-environments that is both lateral and vertical. Thus, some nets are located higher on shore (*artes de terra*) while others are situated lower down (*artes de fora*). At the same time, they may be submerged or floating.

Depths in the estuary range from surface to twenty meters in the deepest holes which lie in the direction of the northern tidal inlet. Although the estuary, viewed overall, becomes shallower from mouth to head, the depth range in a transect at any given point is fairly constant. This means that at least some environments with depths appropriate for net fishing can be found at almost any point. By the same token, fewer environments with depths suitable for shallow water nets will be found as one approaches the tidal inlets, and fewer environments for deep-water nets will be found in the inner reaches of the estuary. Finally, the distribution of techniques in a wedge of water is always such that nets of different categories do not overlap and compete for the same space.

The role of current conditions in the zoning of fishing methods adds an element of complexity to the distribution that emerges from depth and substrate considerations. The same current may impede the efficiency of one technique, increase the efficiency of another, or preclude altogether the use of a third. Techniques set low on shore may be quite safe during a neap tide, but on a spring tide will be moved to higher ground because the currents lower on shore would sweep them away. Similarly, techniques set at a neap tide in the outer estuary may not be able to withstand a spring tide in the same location, and will be moved inward. On the other hand, daily tide level changes often dictate both where and when a technique may be used. These restrictions are especially true for the large nets which must be operated against the tidal flow, with catches removed at turntide.

By all indications, the risk of loss or damage and the difficulty of handling heavy gear under incompatible tide conditions is enough to compel fishermen to closely observe the following restrictions in planning their fishing operations:

1. Gill nets, trot lines, and fish traps which are anchored and may drift slightly in the channels work best at neap tide when currents are weakest.

2. Barricade devices and fish corrals work best at any tide but neap, since they require considerable current and depth changes to snare fish at locations high on shore and in the tidal creeks.

3. The dragged nets and encircling nets do not function well at either spring or neap tide since they require medium velocity currents, and these only come at rising and falling phases during the tide cycle.

It should be noted, however, that these restrictions are not as limiting as they first appear. Because of the way the shape of the estuary conditions current action, a spring tide in its inner reaches is more like a neap tide in its outer reaches, and vice versa. The result is that fishermen can use most of their techniques on a daily schedule throughout the tidal cycle, as long as the choice of fishing spots conforms to the particular current regime on any given day.

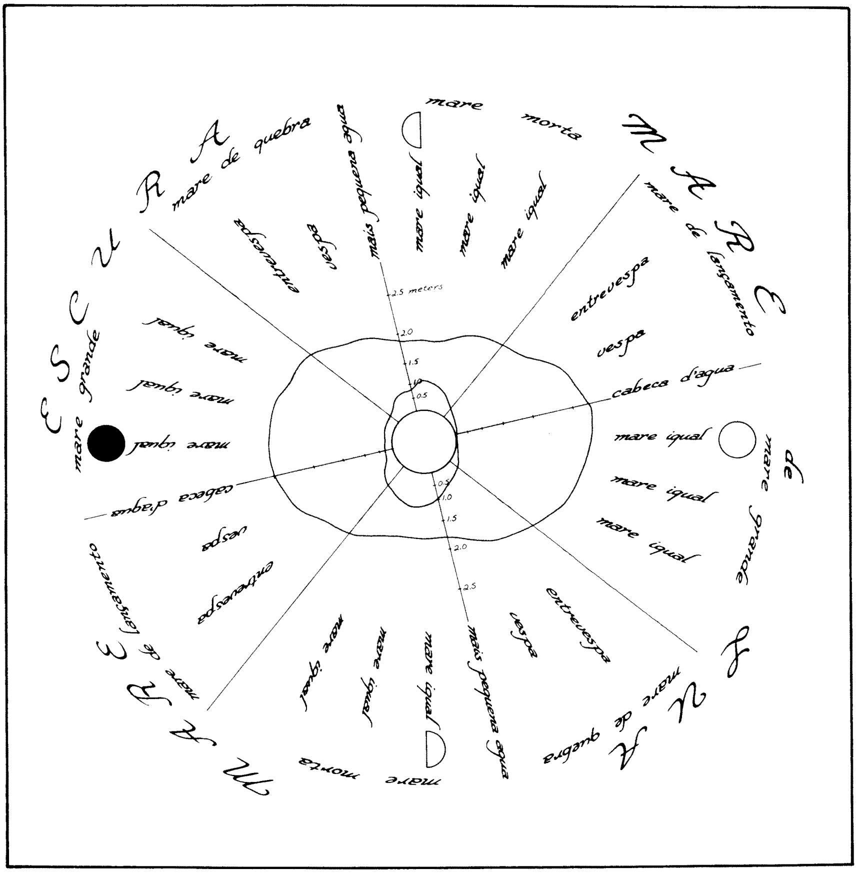
TIMING THE CHOICE OF FISHING SPOTS

Choosing a fishing spot is largely a matter of timing— putting together information on tides, techniques, and fishing areas so that there is a good chance of locating a school of fish. To make this decision, fishermen need to know as finely as possible the details of tide sequences and spatial configuration of the fishing grounds. This knowledge defines the micro-environments for all techniques, but the tide cycle serves also as a calendrical device to mark off major fishing events and catalogue information on production.

Contrary to what one might expect, a fishing spot is not thought of as a purely spatial point. Rather, its existence is always relative to the different phases of the lunar month which in turn are recognized as the source of tide level changes. The way canoe fishermen classify the effect of lunar periodicity of tides is depicted in the polar diagram (Figure 1). By their system of reckoning, names are given to each day in the 28 day lunar cycle which mark the corresponding water level changes. An important feature of this system is that the moon's phases are regarded essentially as boundary markers for the semi-monthly ebb and flood of the tides, rather than as names for specific days in the cycle.

This taxonomy is founded on two principles: (1) the difficulty of visualiz-

Figure 1. Fishermen's Classification of the Fluctuations by Lunar Phases



ing finer changes within each lunar phase as precisely corresponding to degrees of water level change, and (2) the fact that the greatest rise and fall in tides does not come exactly on the days of the new and full moon. Instead, there is generally an interval of one or two days between full moon and the greatest range of the tide, and a like interval is found between the first and third quarters of the moon and the smallest tides (Marmer 1926:11). Thus, a set of terms (*mais pequena agua, cabeca d'agua*) exists to denote the days of smallest and greatest tide range.

Finally, the entire lunar-tide calendar is sub-divided by a set of terms indicating when the moon is moving from first to third quarter through full (*mare de lua*) and from third to first through new (*mare escura*). The significance of these terms is the way they partition the lunar month according to the duration and intensity of light available for night fishing. Moonlight is critical for navigation purposes and, what is even more important, may influence certain aspects of fish behavior such as migration and ability to see nets in the water. This topic will be explored in a later section of the paper. Here, however, the point is that the choice of fishing spots can be shown to vary, not only with the tide cycle, but with the lighting conditions associated with phases of the moon. The fact that this is an important consideration in choosing where to fish is revealed by the way the fishermen group the tide cycles into darker and lighter periods in their calendar.

The lunar-tide classification thoroughly maps the repetitive fortnightly rise and fall in tidal height and current. However, there is another interesting dimension in the tides which fishermen recognize in planning trips. This is the relationship between lunar transit and the timing of the daily tide-change sequences from one phase of the tide cycle to the next (e.g. from spring to neap). Thus, just as fishermen watch the lunar phases which define the boundaries of tide changes, they also keep close track of the moon's position in the sky each day. This series of changes is recorded by a set of expressions (see Table 1.) which identify the position of the moon on the horizon relative to land or sea, depending on whether it is first seen at sunset or sunrise, and if so, where. These expressions are *passagem de lua, sol por lua, lua em terra,* and *lua no mar*. In this order, roughly translated, they mean whether the moon is beginning a new passage, whether it is fully exposed to the sun, whether it is over the land or over the sea.

At first these expressions seem to duplicate the information already given by the lunar-tide calendar (*passagem de lua* necessarily corresponds to a new moon, *sol por lua* is a reference to the full moon, *lua em terra* to first quarter, and *lua no mar* to last quarter). However, the observations of moon transit/tide change conveyed in these expressions provide a variety of relevant information which could not be arrived at by simple reckoning of phases and tides. The terms refer to the sequential variation in daily tides over a lunar month that results from a constant retardation in the moon's passage (Marmer 1926: 12-13). Thus, each day as the lunar cycle progresses, there is a fifty minute retardation in the interval between high and low waters. This means that each week the time of a particular daily tide will be advanced

TABLE 1
Tide Sequence According to Moon's Transit

Tide Cycle Phase	Lunar Phase	Time of Moonrise	Daily Tide Sequence 1st Hi Water	1st Lo Water	Moonlight Duration	Position Terms
Spring	New	Dawn	Noon	Dusk	——	passagem de lua
Spring	Full	Dusk	Midnight	Dawn	12 hours	sol por lua
Neap	1/4	Noon	Dusk	Midnight	(increasing) 6 hours	lua em terra
Neap	3/4	Midnight	Dawn	Noon	(decreasing) 6 hours	lua no mar

nearly six hours over the week before. Thus, when fishermen see the moon over the meridian in a particular phase, they may be certain that six hours later the tide will be halfway through its semi-diurnal cycle. For instance, when a spring tide occurs with a full moon, the moon will rise at dusk and the first high tide of the day will occur shortly after midnight. From his initial lunar position observation, a fisherman will be able to time the daily tide phase sequences for approximately a week.

At this point one may wonder why canoe fishermen bother with such minute details. The answer, I think, follows not only from the previous discussion of how tides govern the use of techniques, but also from a consideration of how a fishing trip must be planned. The lunar position terms, together with observations of phases indicate changes in moonlight and thus whether night fishing is feasible. Moreover, fishermen must know what specific sequence of tide changes will occur during the part of the day they set aside for a trip. Timing a fishing trip properly is seen as even more crucial when one considers the location of the fishermen's home base relative to the estuary.

The main fishing neighborhoods are situated on a river eight kilometers from the mouth of the estuary and four kilometers from the main net casting channels. Most of the river is closed in by mangrove swamps which reduce the wind available for sailing. The pronounced effect of the tide on the river thus becomes the main bond between fishermen in their non-motorized canoes and the fishing grounds. So that the tide will not be working against them each day, fishermen must rely on the lunar-tide system to solve three essential timing problems: (1) getting out to the fishing grounds on a favorable tide; (2) once out, finding a tide compatible with the micro-environment suitable for their nets; and (3) getting back home without running into adverse currents. The sequence of tide changes that will allow smooth fishing must therefore be in keeping with the semi-diurnal tidal rhythm and there are only two full sequences daily. Consequently, most fishing trips are timed to take place over six-hour periods: beginning at some point on an ebb tide (depending on the distance of the fishing spot), and ending on the subsequent floodtide. The changes in daily tide levels are generally observable by the relationship of water height to the base of the mangrove swamp. However, in some cases tides can be predicted from lines of stakes driven into the mud across the inter-tidal zone at various points along shore. It should be noted that there are six terms for daily tide changes (*preamar, descanso degua, vazante, baixa-mar, virada,* and *enchente*), reflecting the fine breakdown in timing choices.

More than once during my stay in the *beirada,* a fishing captain whose crew did not assemble in time to leave on an appropriate tide would refuse to leave at all rather than having to compensate later for the timing error. Perhaps, though, the utility of the lunar-tide system can only be appreciated by trying to imagine oneself in a predicament that may result from poor timing. A fishing crew may easily be caught becalmed at the mouth of the estuary on a spring ebb tide of up to five knots and have to row home with a valuable load of fish about to spoil.

Having defined the categories of timing elements in fishing, it is now possible to show how they are built into the notion of a fishing spot, or *pesqueiro*. The first thing to consider is that *pesqueiros* are the minimal micro-environmental units of fishing, but depending on their location in the estuary, they are only activated at certain times during the lunar cycle. *Pesqueiros* always fall within more inclusive types of physiographic zones, and are usually referred to as belonging to a specific shoreline (*costeiro*) which in turn is subsumed under one of the major sub-divisions of the fishing grounds (*beiradas*). Over 400 fishing spots are known and frequented by Valença fishermen and each has a name, ordinarily taken from a coastal landmark such as a plantation which it may front.

Fishing spots are found continuously along the shores of the estuary, but are actually distributed in discrete clusters. This is because each spot is always defined with reference to the phase of the lunar-tide cycle (neap, spring, light or dark tide) when it may be used. However, since a fishing spot may accommodate a range of techniques, three further factors act to partition it into what are called *lancos* or water spaces for casting nets: (1) fortnightly current changes (*morta, lancamento, quebra, grande*), (2) daily tide level changes, and (3) the position of the particular water space relative to the slope of the shore. Thus, a water space may be an area reserved for shooting nets, for setting trotlines, or for construction of a fish corral, but because of the different zoning and current considerations which apply to each, they do not overlap. *Lancos,* like *pesqueiros,* have distinctive names taken from their boundary markers, such as bottom type (e.g., *bugaial,* a type of gravel, *tabatinga,* a clay) or their position on shore relative to other *lancos* (e.g., *lanco de fora; dentro; meio; cima; baixo*). In any case, the overall effect of timing considerations is to subdivide *pesqueiros* according to an order of technical priorities in which they and the *lancos* they contain are thought of by fishermen as geographical points within the lunar month.

By eliciting the characteristics of several hundred fishing spots, I was able to derive the pattern whereby, at least in theory, fishermen shift the focus of their activity during the tide cycle. This pattern was then compared with the locational data on actual fishing trips, and the correspondence between boat positions and tidally activated fishing zones proved extremely close. Moreover, the fishing pattern as shown by trip frequencies is striking in the way all groups of specialists consistently tend to concentrate in the same general locations from one tide level to the next. At neap tide the concentration is on the *costeiros* at the northern end of the estuary; as the tide begins to rise (*lancamento*) people move into the main body of the estuary (*o canal*), in from the mouth. At spring tide, activity shifts to the southern *costeiros,* and finally as the tide begins to fall (*quebra*), fishermen move back up the estuary into the main channels. Canoe fishing, in other words, moves in a circuit of logistic areas which are activated periodically by a tide cycle which has a differential impact along the course of the estuary.

ADAPTIVE USE OF FISHING KNOWLEDGE

In the *beirada,* learning how to reckon moons and tides goes hand in hand with learning how to fish, until the necessary relationships between timing and production have been mastered. A sufficient number of locations must be cognitively marked in this way for a fisherman to be able to work throughout the tide cycle and at different seasons. The continuity and viability of the fishing tradition depends on successfully transferring this environmental lore to new generations of fishermen.

It is difficult to conceive the backlog of trial and error experience that must have preceded the codification of fishing knowledge into the present orientation system. Yet to some extent this process is repeated each time a man is recruited to fishing. In other words, the system is always being modified and updated by new experiences and events which arise in the course of fishing to shape future plans.

However, it is one thing to understand the basic principles of environmental variability but another problem entirely to apply them by consistently selecting sites which yield good catches. In deciding where to fish, the production history of individual fishing spots becomes a vital point of reference. Because of the cyclical framework of the fishing environment, no production event is considered to be unique. Instead, memories of more or less abundant catches are stored in the lunar-tide reference system as a series of events set in spatial context. For instance, when a good catch is recorded twice in the same spot at the same time in the tide cycle, this is taken by fishermen as evidence of a casual link between moons, tides, and fish behavior. Later this is recalled in making subjective probability assessments of production potential in deciding where to fish.

The significance of ordering environmental data in this fashion across generations raises a critical question about canoe fishing: what is the actual economic value, if any, of such a system of orientation in predicting the location and concentration of fish? Is adaptive use being made of this body of knowledge by conferring a productivity advantage on those who inherit it over those who do not? Or, does the tide exert such a restricting influence on estuary fishing that the system of orientation is maladaptive for individuals and the fishing population as a whole? To answer this question one would need, along with time-series data on production, some independent biological measures of the relative abundance of fish at different points during the tide cycle, through different seasons, and at different fishing locations, including those deactivated for fishing as the tide changes. This way, in theory, it would be possible to see what advantages or disadvantages in terms of production are involved in long-term use of the orientation system, but still leaves the problem of understanding why lunar-tide lore should be predictive of fish behavior.

Despite these complexities, it is still possible to evaluate this aspect of canoe fishing, based simply on a consideration of some of the adaptive tendencies which seem inherent in the way the system works. First, it is necessary to think of the question of adaptation in terms of differences in production potential among fishermen. *Beirada* fishermen may be easily ranked in this regard, since they have clear ideas as to whom is good at fishing and why. Holding efficiency of equipment constant, factors of age, experience in fishing local waters, eyesight, endurance, drinking habits, and a host of related impressions enter into these informal rankings. Most importantly is the special knowledge confined to fishing captains to *fazer o lanco certo* (properly time a net-cast). This in turn implies the ability of a fisherman to bring his knowledge of production history to bear on the choice of where to fish. Since, as I have shown, the influence of the tide is variable from *costeiro* to *costerio,* a fisherman has a lot to consider in making this decision. It is not surprising, then, that the basis for productivity ranking among fishermen is mainly the finer ability of experienced fishermen over new recruits to simplify the range of locational alternatives specified by the lunar tide system. It is from this standpoint that environmental knowledge begins to take on considerable economic value.

It is at least an intriguing possibility to ask whether the very precise work routines established by certain fishing captains are adaptive in the sense that they are based on some of the same environmental principles that determine fish behavior. If this could be demonstrated, it would mean that the sustained large catches by some captains are not just based on fishermen's luck.

Unfortunately, very little is known about estuarine species on this part of the Brazilian coast and not much work has been done in marine biology that is relevant to our question. Korringa (1957: 921) points out that biologists have been inclined to underestimate the importance of tidal rhythms to marine animals. This, he adds, is possibly because the tides are not considered that biologically important to us. Generally speaking, the lunar-tide system incorporates several variables which are known to be important elements in fish behavior, especially migration and spawning.

The first point to mention in this connection concerns the salinity of the tide range. Since the *beirada* estuary is fairly large, with several deep inlets, there is a fairly stable salinity gradient from head to mouth. This gradient will move backwards and forwards with the tides. On a flood tide the salinity will increase along the length of the estuary, and the salinity at any one point will depend on the extent to which sea water travels upstream. On a spring tide the sea will penetrate further into an estuary than on a neap tide, and so will cause a more widespread increase in salinity. There is actually very little fresh water runoff into the estuaries so the brackish water conditions conducive to mangrove formation are found mainly along the inner reaches of the estuary, with sea water penetrating far up the tidal creeks.

The distribution of fish according to their salinity tolerances (ability to osmoregulate) will conform to this gradient. The significance of this conformity from the standpoint of fishing is that the abundance of fish populations will change relative to this gradient (Hedgepeth 1957: 702). Thus, preliminary work on the comparative productivity of various regions in estuaries indicates that productivity is probably lowest in the transition between marine and fresh water regions in the same gradient. Assuming this finding is indicative of the productivity pattern in all estuaries with stable salinity gradients, zones of the *beirada* estuary may be at least tentatively ranked in terms of fishing potential. This task is fairly straightforward since the estuary, again like most estuaries with deep channels and sheltered middle reaches, has very nearly vertical salinity gradients. True brackish water conditions (that is, the zone of transition between marine and fresh water and therefore the zone of lowest productivity) should be found only in the mangrove swamps. This means that as the tide rises, its isolhaline zone bulges upstream and when the tide falls, the bulge is reversed to point downstream. In terms of the logistic pattern of canoe fishing defined by the lunar-tide system, this alternation would virtually eliminate the zones of least productivity. At neap tides, when fishing is concentrated in the outer estuary, it is well away from the zone of transition even though it moves somewhat out from the mangrove swamps. At rising and falling monthly tide phases, the main channels become the foci of fishing, and similarly they lie beyond the zone of transition or least productivity. Finally, at spring tides, fishing moves up into the inner estuary but still does not fall within the zone of transition, since the mangrove swamps are well innundated with sea water which pushes the zone far inland. It is possible to suggest, then, that canoe fishermen may benefit by not being in the areas of least productivity potential during the tide cycle. In this sense, there may be some adaptive value in adhering to the lunar-tide system.

The current which accompanies the tidal wave may be of considerable significance in relation to the way fish move in an estuary (Green 1968: 274-291). By its means, creatures having little or no powers of resistance may be carried inshore. This is important to the migrations of the young stages of animals and plants on which larger fish feed. The retreating tide in an estuary may carry them out to sea and the advancing tide may convey young stages from the sea to the estuary or from lower to higher shores. Estuaries are rich in invertebrate life and support large populations of fish which primarily feed on the invertebrates. Thus, the flounder (*linguado*) and guppy (*morea*) are important predatory animals appearing in the Valença estuary, and the behavior of the invertebrates on which they feed, especially certain larval plankton forms, may be governed almost entirely by the current regime (Green 1968: 96). In a second sense, then, the lunar-tide system might be interpreted as having some adaptive functions, since the logistic pattern of fishing may take advantage of the differential distribution of the organisms that fish feed on during the tide cycle.

Finally, there is the variable of lunar periodicity to consider. Canoe fishermen mentally tag all their catches in terms of the moon's phases (e.g., *mare de lua, mare escura,*). At the same time, it is assumed that moonlit nights are categorically poor for some types of fishing—sardine fishing for example. Presumably, on moonlit nights, these fish can see the nets and so are vulnerable only on moonless nights. Still, there are other fishing routines that simply must conform to the proper phase of the lunar cycle, which may be either light or dark. It should be noted that these occasions relate principally to the spawning activities of species such as catfish and bluerunner.

The widespread utilization of estuaries as nursery grounds is one of the features that distinguishes them from other marine environments (Hedgpeth 1957: 700). Thus, not only do many of the motile invertebrates and vertebrates found in estuaries come in with the tide and leave on it, but there is ample evidence that cycles other than daily and annual rhythms are involved

(Korringa 1957: 917). This does not necessarily mean there is a direct causal link between the moon's phases and the reproductive behavior of fish such as those which spawn in the *beirada*. In fact, it is entirely possible that these animals are sensitive to both the tide cycle and the moonlight rhythm.

In any event, it is this aspect of lunar tide knowledge that most seems to aid fishermen in making large catches. The spawning cycles they recognize seem to run so closely parallel to the lunar cycle that it is difficult not to attach considerable adaptive significance to the system of orientation. On these grounds I do not think it is too farfetched to suggest that ultimately the lunar-tide system has been perfected as an index of spawning periodicity. It is as though the purely mechanical considerations dictating the positioning of techniques put fishermen onto habits of fish concentration similarly influenced by the tidal level change.

CONCLUSIONS

Catches in the *beirada* often consist of large quantities of estuarine spawning fish. Therefore, it would not seem too bold to characterize canoe fishing as basically an economic adaptation which relies on the fishermen's ability to trace and capitalize on fish spawning behavior. This is accomplished by organizing environmental knowledge of moons and tides into a system for choosing fishing spots that also seems to be a fairly accurate index of the migration of estuarine species. The lunar-tide calendar is closely adhered to by all traditional fishing captains on this part of the Brazilian coast. As a culturally shared four-dimensional mental map of the fishing grounds, it synchronizes boat movements, the choice of fishing methods, and the availability of fishing spots according to bi-weekly and daily tide fluctuations. The cumulative effect of following this system has been to stabilize the fishing community as a whole in an ecologically adaptive, moderately competitive economic routine. The cyclical shift from inner to outer fishing grounds that results from the tide changes also tends to work again over-fishing. It should be noted that over-fishing would not, in any case, be a very real possibility, given the small fishing population using the *beirada* waters and the fact that many pelagic schools enter the estuary during their ocean-spanning migratory cycles. The real danger to canoe fishermen is not that their system is economically inefficient or maladaptive due to the peculiarities of estuary fishing, but that government agencies and/or private investors will introduce over-efficient catching systems into these areas before expansion capabilities can be realistically evaluated.

NOTE

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