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Local Control of Aquatic Resources: Community and Ecology in Lake Titicaca, Peru

All 151 fishing communities in Lake Titicaca, Peru, maintain and defend communally controlled fishing territories. Environmental factors, particularly the slope of the lake bottom and the presence and abundance of aquatic vegetation, influence the distribution of the three types of such territories, which differ in the area they cover and in the maximum depth of water they contain. A cost-benefit model is employed to explain this spatial patterning. This study emphasizes the interactions between aquatic and terrestrial resources. It discusses the conflicts between the formal legal codes of the Peruvian state and the informal regulations of peasant communities. It argues for a refining of the terminology used to describe and analyze common-property resources.

COMMUNAL SYSTEMS OF RESOURCE ALLOCATION have attracted a great deal of attention in recent years from researchers in many fields, such as anthropology, economics, history, and human ecology. This topic has broad theoretical significance, since it examines the interplay of individual choice and collective institutions. It also has considerable empirical importance, because it is tied so closely to the debates over different systems of resource management and their relative merits. It bears directly on the question of the environmental and economic consequences of common property tenure, an issue that has been marked by a controversy which began with Garrett Hardin's famous article "The Tragedy of the Commons" (1968) and which shows little sign of abating (McCay and Acheson 1987).

Much of the early work on communal systems of resource allocation concentrated on terrestrial cases, such as agricultural, pastoral, and hunting economies. More recently, researchers have focused on aquatic cases, in which the common property aspects of such systems are particularly clear. The nature of access to fishing territories influences the levels of fishing effort and catch; this access is often contested by different groups of people who claim the authority to regulate it. Since fisheries provide some of the most dramatic instances of the collapse of overexploited resources as well as striking examples of incorporation of communal systems of resource allocation into successful development, these aquatic cases have attracted a good deal of attention. In the last decade, a large number of studies have documented the existence of territorial fishing rights over exclusive fishing zones (Pollnac and Littlefield 1983; McGoodwin 1984; Cordell 1989). In such cases, systems of water tenure involve the holding of exclusive and limited rights by shore communities over fishing resources found in specific parts of the aquatic environment.

Our research examines one such case, the communally controlled fishing territories in Lake Titicaca, located on the border between Peru and Bolivia. Because of the large size of our sample of fishing communities ($n = 151$), we have been able to analyze attributes that are shared by all the communities (the patterning of control along different portions

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of the perimeter of the territories) and attributes that vary among them (the position of the outer edge of the territories). Three types of territories are found in this region; they differ in regard to the distance between the shore and the outer edge of the territories, and the depth of the water at this outer edge. The distribution of these types is strongly influenced by the environmental characteristics of the shores of the lake. Two factors are particularly important: the slope of the bottom of the lake in the littoral zone and the presence and abundance of aquatic vegetation. Each type of territory is restricted to one particular type of shore zone. To explain this patterning, we employ a model that examines the costs and benefits of each type of territory, emphasizing the particular environmental characteristics of the area in which it is found. In addition, we refine the terminology that describes the boundaries of territories, and we demonstrate the importance of interactions among different aquatic resources and between aquatic and terrestrial resources. Our study also includes an examination of the conflicts between the formal legal codes of the Peruvian state and the informal regulations of the peasant communities.

We focus on the patterned variability of communal fishing territories, rather than their economic and ecological consequences, a topic of interest to many researchers and managers who favor such territories in fisheries policy because of their ease of implementation and their potential to mitigate negative consequences of common property status, especially overcapitalization and overexploitation (Christy 1982; Johannes 1982; Pollnac and Littlefield 1983; Ruddle and Akimichi 1984; Acheson 1988). This focus is a deliberate choice, since we wish to examine previously unstudied details of the *operation* of communal systems of resource management rather than to examine the *consequences* of these systems for the sustainability of the resources themselves. We have discussed elsewhere (Levieil 1986, 1987; Orlove, Levieil, and Treviño 1990) the absence of overexploitation of the Lake Titicaca fisheries (with the exception of a few rather specialized fisheries, which in sum account for a fraction of the total catch and the total biomass), and argued that the presence of these territories has had a critical role in limiting fishing effort to levels that permit satisfactory incomes to the fishermen and the stable maintenance of fish populations. We have also examined in other contexts (Orlove 1988; Orlove and Levieil 1989) the relations between Lake Titicaca fishermen and the Peruvian government, with special emphasis on the importance of communal and common property institutions. Nonetheless, we note that, within the ongoing debates over the relative merits of different forms of resource allocation, the arguments in favor of locally controlled communal systems are supported, at least indirectly, by the regularity in the distribution of different types of fishing territory, since this patterning suggests that the behavior of small-scale fishermen follows environmental variables closely. Our analysis also supports the claim for the viability of communal fishing systems by showing the ability of the fishermen to maintain such systems in the face of government opposition.

Lake Titicaca and the Peruvian Altiplano

Lake Titicaca (Figures 1–2) lies across the border between Peru and Bolivia. It is a large (8,100 km^2), high-altitude (3,808 m), tropical (16° S) lake which includes three connected basins: the Lago Grande, the Bahía de Puno and the Lago Pequeño (Richerson, Widmer, and Kittel 1977; Boulange and Aquize 1981). The complex geological history of the Altiplano, the plateau region in which the lake is located, has contributed to the diversity of the lake's shores. Activity along normal faults, particularly near the northeastern shore of the lake, produces steep slopes. In some areas of the Lago Grande, hills come right to the edge of the lake, and the bottom of the lake drops to depths greater than 200 meters within two kilometers of the shore. In other areas, particularly in the Bahía de Puno, the shoreline is dominated by sedimentation. In certain areas, the lake is bordered by plains, and a depth of five meters is not reached until nearly ten kilometers from the shore. In still other areas, the degree of slope is intermediate.

Virtually all of the lands around the lake are controlled by peasant communities, many of which have received formal recognition from the national government. A very small

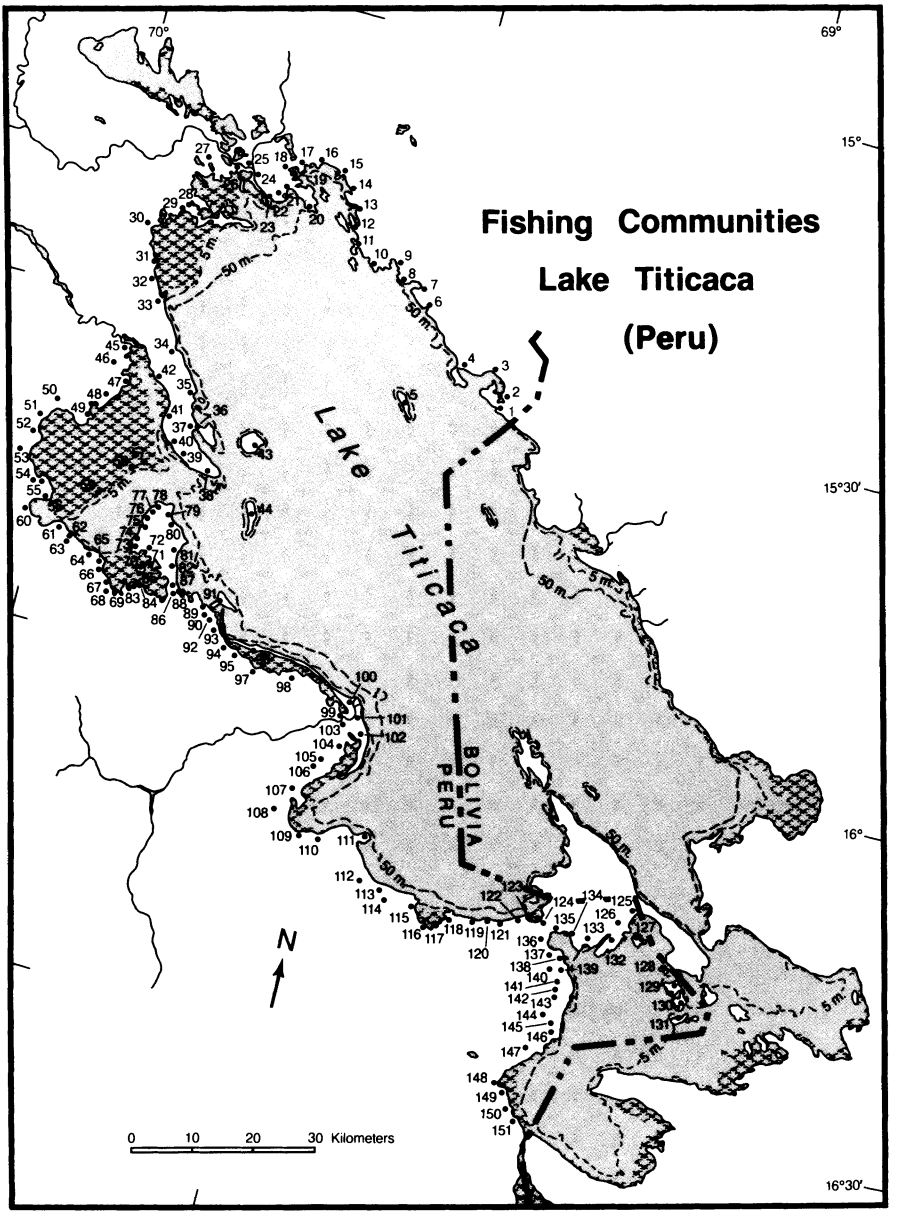

Figure 1
Map of fishing communities on the Peruvian shores of Lake Titicaca.

part of the shoreline belongs to collectively owned agrarian cooperatives, or to municipalities such as the city of Puno. Each of these communities consists of a set of households that have rights to a specific territory. (In a few instances, we were faced with decisions of whether to consider a specific cluster of houses as a single community or as a portion of a larger community that included other such clusters [cf. Albó 1972; Orlove and Godoy 1986:174]. In these cases, we followed the opinion of the majority of the individuals with whom we spoke.) Most agricultural plots are privately owned, but grazing, both on per-

1. Tilali-Patascachi	51. Pampa Ilipa	101. Huaylata
2. Pucuraya-Millilaya	52. Yanaricu	102. Cachipucara
3. Sucuni	53. Collana	103. Acaso
4. Cayanajoni	54. Muaraya	104. Queti
5. Isla Soto	55. Jirata Vizcachuni	105. Vilcamaquera
6. Chujucuyo-Maquercota	56. Chulluni	106. Quispemaquera
7. Lacasani	57. Titini	107. Santiago Mucho
8. Cariquita	58. Huacahuacani	108. Suahacota
9. Umuchi	59. Totorani	109. Irupaica
10. Iscajja	60. Puno Ciudad	110. Juli Pueblo
11. Jachaparu	61. Chimu	111. Chucasuyo Cajje
12. Quellojane	62. Ojerani	112. Sihuayro
13. Jacantaya	63. Ichu	113. Challapampa
14. Llachajata	64. Cusipata	114. Huacani
15. Aziruni	65. Barco-Chuculto	115. Pomata Pueblo
16. Vilquechico Pueblo	66. Chinchera	116. Sajo
17. Quellahuyo	67. Concachi	117. Santiago Ccama
18. Chujachi	68. Potojani	118. Chatuma
19. Huarisani	69. Camacani	119. Chimpu
20. Junsani	70. Isla Ouipata	120. Cuturapi
21. Jacincoya	71. Isla Chilata	121. Queñuani
22. Piata	72. Cochiraya	122. Acari
23. Cohasia	73. Ccarana	123. Imicato
24. Balsapata	74. Parina	124. Yunguyo Pueblo
25. Yucahue	75. Tacasaya	125. Tinacahi
26. Ramis	76. Pucani	126. Unicachi
27. Tuni Requeña	77. Luquina Grande	127. Isla Iscaya
28. Requeña	78. Luquina Chico	128. Isla Caana
29. Huancolluaco	79. Carina	129. Isla Yuspique
30. Corpa	80. Churo	130. Isla Anapia
31. Pusi Pueblo	81. Perca	131. Isla Suana
32. Carabuco-Llapas	82. Hustaraque	132. Vilurcuni
33. Escallani	83. Ccota	133. Pajjano
34. Chillora	84. Pallalla	134. Tapoje
35. Chiñón	85. Laccone	135. Calampune
36. Ccotos	86. Huarmeamaya	136. Santa Cruz Chambi
37. Siale	87. Sihuecani	137. Copapujo
38. Llachón	88. Añu Callejón	138. Chinomani
39. Yapura	89. Huincalla	139. Yanapata
40. Capano	90. Titilaca	140. Tahuaco
41. Silacachi	91. Isla Socca	141. Sanquira
42. Jilata	92. Santa Rosa Yanaque	142. Amaquilla
43. Amantani	93. Ccoccane	143. Calacoto
44. Taquili	94. Tumuhuaya	144. Challapampa
45. Lluco Costa	95. Ccoccosani	145. Tacapize
46. Carata	96. Isla Iscata	146. Copani
47. Faon	97. Amaya	147. Isani
48. Yasin	98. Sulicacatura	148. Zepita Pueblo
49. Moro	99. Camicachi	149. Huilacaya
50. Matare	100. Santa Rosa Huaylata	150. Ayrihua
		151. Santa Cruz Cuni

*Communities numbered sequentially along the shoreline

Figure 2
List of fishing communities on the Peruvian shores of Lake Titicaca.

manent pasture and on fallow fields, usually consists of communal grazing of privately owned herds. Most fields are acquired by inheritance, or, less frequently, by rental or sharecropping. Sale of land to outsiders violates both national law and local custom, and is quite infrequent.

Lake Titicaca Fisheries

Aquatic Resources

Lake Titicaca fish resources include both native and exotic species. The former are endemic to the lake and include the cyprinodont genus *Orestias*, which represents 67% of

the annual catch by weight, and the catfish genus *Trichomycterus*, which accounts for less than 4% of this harvest (Orlove 1986). The latter include the rainbow trout *(Salmo gairdneri)*, introduced to the lake in the early 1940s, and the silverside or *pejerrey (Basilichthys bonariensis)* introduced in the mid-1950s, each of which contributes about 15% of the total catch (Orlove 1986).[1]

Although 29 species of the genus *Orestias* can be found in Lake Titicaca (Parenti 1984), local fishermen only distinguish between four major groups: the *umanto*, the *boga*, the *ispi*, and the *carachis*. The genus *Trichomycterus* is represented by only one species on the Altiplano (Tchernavin 1944). The total catch in the Peruvian portion of Lake Titicaca has been estimated at 8,160 metric tons (95% confidence interval: 6,490 to 9,830 mt) in 1980 (Orlove 1986; Levieil 1987).

Aquatic macrophytes also contribute in major ways to the local economy (Levieil et al. 1987). The most important macrophytes are a reed, *totora (Scirpus tatora)*, and the *llachu*, an association of three genera of aquatic plants *(Myriophyllum, Elodea,* and *Potamogeton)*, which are harvested as cattle fodder (Collot 1980). The totora is also harvested when dry for roofing, handicrafts, and the construction of rafts known as *balsas* (Levieil et al. 1987).

Fishing Activities

Fishing on Lake Titicaca is artisanal, with low capitalization, simple gear, and small fishing craft. Fishing operations are rarely longer than an overnight trip. Gill nets are set late in the afternoon and checked or retrieved early the following morning. Most fishermen work unaccompanied, although some bring along a young male relative as an assistant. About half of the fishermen operate from reed rafts or balsas, propelled with poles, sculling oars, and small sails, while the other half fish from wooden boats propelled with sails and pairs of oars. Only a minority of fishermen (less than 5%) own outboard engines, which allow a greater range of operation. Over 90% of the fishing is carried out with nylon gill nets, although some fishermen also use pushnets, seines, and trawls (Alfaro et al. 1982).

Lake Titicaca fisheries are not spatially concentrated. Fishing is practiced by individuals from each shore community (Bustamante and Treviño 1976). There is little clustering of fishing craft into fleets operating from the same harbor, because fishermen leave their craft at a landing spot within easy reach of their home compounds, which are scattered among the fields rather than nucleated in villages. Only in areas with exposed shores do fishermen tend to congregate in small fishing harbors, which they have built.

Virtually all of the peasants who reside near the lake raise crops, but few of them can rely entirely upon their fields and herds to meet their food and cash needs. They also engage in a host of cash-generating activities, such as handicraft production, cattle fattening, small-scale marketing, and seasonal migratory wage labor. This lack of occupational specialization also characterizes the fishermen. Although the members of most fishing households spend less than a third of their labor time on fishing, they receive between a half and three-quarters of their income from this activity, since it offers higher returns than most alternative activities (Levieil 1987). They continue to cultivate their fields and raise livestock rather than to specialize in fishing, because of the economic security represented by home production of food in the context of the inflationary and unstable Peruvian economy and because of the social centrality and cultural salience of food production in the Altiplano.

About two-thirds of the catch is sold for cash. Another one-sixth of the catch is consumed directly by the members of the fishermen's households and by their relatives and neighbors to whom they give fish; the remaining sixth is bartered for foodstuffs (Orlove 1986). One advantage of fishing is its complementarity with the agricultural focus of the peasant households. Since fishing trips are concentrated in the late afternoon and early morning, they are compatible with work in the agricultural fields. The close proximity of residence, fields, shore, and fishing grounds reduces the necessary travel time. Further-

more, a fisherman who migrates outside the Altiplano for employment does not have to leave idle his craft and gear; he can lend them to a close male relative who can use them and provide him and his household with some income during his absence.

Lake Titicaca fishermen participate in four basic types of fisheries: the lake bottom or demersal gill-net fishery for native species, the offshore or pelagic gill-net fishery for introduced species, the trawl fishery for native species, and the ispi fishery. The demersal gill-net fishery for native species targets the carachi, although a few catfish may also be caught. Fishermen set multifilament nylon gill nets with mesh sizes between 38 and 63 mm along the lake bottom, not deeper than 30 meters, in the late afternoon, and check them at dawn the following morning. Fishermen from the Lago Grande and the Bahía de Puno practice a pelagic gill-net fishery for introduced species using nylon gill nets of mesh sizes between 63 and 152 mm. Fishermen set their nets overnight in the pelagic zone of the lake, and most spend the night in their boats drifting with their nets. Some fishermen use a combination of gill nets of different mesh sizes to participate simultaneously in the demersal fishery for native species and in the pelagic fishery for introduced species.

The remaining two fisheries are of much lesser economic importance. The trawl fishery, concentrated in the Lago Pequeño, mostly yields carachis. It involves pairs of craft, usually light rowboats. Ispi fishing is undertaken at night with beach seines or with small trawls when the fish come close to shore to spawn or to the surface to feed (Bustamante and Treviño 1976; Núñez 1982). Few ispi fishermen fish for other species, and most come from only four shore communities: Jacantaya, Llachón, Cachipucara, and Vilurcuni.

Organization of Lake Titicaca Fisheries

Local communities manage aquatic resources through a system of communal fishing territories. Each communal fishing territory is associated with a specific lakeshore community and a well-defined portion of aquatic space, to which community members have certain exclusive, though informal, rights. Sanctions are brought against outsiders who cross the territory boundaries. In certain circumstances, this exclusivity may be tempered by a varying degree of strictness of enforcement or by the transfer of certain rights on a temporary basis to outsiders. These rights focus principally on two types of resources: the beds of totora reeds, which in most cases consist of plots owned by individuals, and fish. Community members are the only ones who have rights to fish within the communal fishing territory; rather than having certain portions of a territory restricted to certain individuals, access to the entire territory is open to all the fishermen in a community. Such systems of open access within a communal fishing territory, rather than ones in which individuals have rights to private fishing spots, are common in settings such as Lake Titicaca, in which fish move from one area to another, and in which the size of fish populations can vary between seasons or years; by contrast, the predictability of totora yields encourages individual ownership of plots (Netting 1976, 1982; Ostrom 1987). For the Lake Titicaca fishermen, this contrast also corresponds to the manner in which terrestrial resources are allocated, since individuals typically have ownership or usufruct rights to agricultural fields, but communal control is more common for pasture, whether permanent grasslands or fallow agricultural fields (Brush and Guillet 1985; Orlove and Godoy 1986).

The communal fishing territories are approximately rectangular in shape. One edge is made up of the portion of the lakeshore that lies within the community; we refer to this edge as the "shore boundary" or simply as the "shore." Community members exercise informal rights over their shores, so outsiders do not ordinarily land their boats on shores of other communities. We call two other edges the "lateral boundaries." These edges run perpendicular to the shoreline at the end of the shore boundary. They are the extensions into the lake of the boundaries separating the lands of adjacent communities. Finally, a line roughly parallel to the shore marks the outer edge of the territory. We call this line

the "offshore boundary," since it separates the territory from the waters of the lake which, though little used, are open to all fishermen.

The maintenance and enforcement of the communal fishing territories are greatly aided by certain spatial and social characteristics. First, most of the territories are quite small. The 151 lakeshore communities in Peru share a shore less than 900 kilometers in length, so that the average length of a territory is under 6 kilometers. The width of the territories depends on the width of the totora beds. Where these beds are very narrow or entirely absent, the width is under 5 kilometers; where the beds are broader, the width extends at most a few hundred meters beyond the outer edge of the beds. The total area of the communal fishing territories thus tends to be under 30 square kilometers, an area that is not too large to monitor (Ostrom 1987). (It should be noted, though, that these small communal fishing territories might offer an exception to those writers, such as Cordell [1978], who see crowding as a condition that leads to the erosion of common property enforcement.) Furthermore, the average number of fishermen per community is just under 20, a size that is arguably well within some ideal middle range, neither so large that it would be difficult for all the fishermen to know one another nor so small that the task that fell to each member of policing the territory would be burdensome.

Second, the activities of totora collection and fishing encourage this policing. Most communities restrict totora collection to certain days of the week and months of the year; the responsibility for policing totora beds at other times is assigned to individuals for a year-long term. In this manner, the portion of communal fishing territories in which totora grows is either relatively full of community members, who can share the task of watching for outsiders, or quite vacant of community members, so that any distant figure is subject to suspicion. The fishermen can also watch the open-water portions of the territories. Since the average number of trips per fisherman per year is high, over 200, the fishermen have a regular presence in the lake and recognize each others' boats.

Third, the social organization of the communities favors the defense of the communal fishing territories. The members of communities know one another well, because of the concentration of the population in the lakeshore zone, with densities often exceeding 100 people per square kilometer, and because of the high rate of endogamy, with over 50% of marriages taking place between members of the same community. This knowledge of community membership is also increased by the frequent community assemblies and work groups. Andean communities have defended their collectively held territories for generations; the policing of a perimeter and the expulsion of outsiders are well-developed for fields and grazing lands, and are easily extended to totora beds and fishing grounds. In this sense, our study supports the claim of Alexander (1977), Ruddle (1985), and Durrenberger and Pálsson (1987) that the control of aquatic resources should be examined in the context of systems of land tenure, and the comments of Taylor (1987), McCay (1987), and Fernandez (1987) that general patterns of social interaction within communities also influence the viability of communal management of common property resources.

By contrast, the Peruvian state claims exclusive control over aquatic space and shoreline areas. According to national legislation, fisheries regulations are established by the Ministry of Fisheries and enforced by a division of the navy, the Coast Guard, which is also responsible for the registration of all fishermen and fishing craft. In practice, fishermen often ignore the regulations regarding closed seasons, and fewer than half the boats and fishermen, and none of the balsas, have been registered.

In general, local fishermen are unwilling to turn to the Coast Guard. However, some disgruntled outsiders do bring their complaints to the Coast Guard on occasion. Several forces seem to limit this supervision of the Coast Guard, which, if more continuous, could weaken the system of communal fishing territories. First, the Coast Guard has only a small staff (there are only about 40 navy personnel in the Peruvian portion of the lake, most of whom are concentrated in the city of Puno [Orlove and Levieil 1989]), and budgetary restrictions reduce the scope of their activities. Second, the Coast Guard receives

very little cooperation from local fishermen in general, many of whom fear, quite rightly, that they might be accused of breaking some regulation, and then be faced with the choice of bribing the Coast Guard official or of taking the time, expense, and risk of registering a complaint. In turn, some navy personnel also fear the fishermen. The two sailors stationed in the small navy post of Moho, for instance, were often without a boat, and had to pressure local fishermen to take them out on the lake; on some occasions, the fishermen threatened to beat the sailors and to throw them in the lake.

The communal fishing territories continue to operate, although the government directly opposes them. This lack of government recognition of communal fishing territories means that disputes between neighboring communities are usually resolved outside the courts. Although government agencies might back up the claims of a community whose members sought to fish in another community's territory, such support would undercut the ability of that community to expel outsiders from its own territory. In contrast, the granting of official recognition by the government to the terrestrial portions of communal territories has supported extensive litigation between neighboring communities, particularly over communal pastures.

Methods

Since exclusive use and defense both characterize territoriality (Dyson-Hudson and Smith 1978), a complete demonstration of the existence of communal fishing territories should show both that community members control access to fishing and that they exclude outsiders. Enforcement or defense must be documented to distinguish common property resources from cases where exclusive use results from the wide dispersion of available resources or their availability in quantities far beyond the abilities of local populations to catch or consume them (Dyson-Hudson and Smith 1978). To demonstrate the existence of communal fishing territories and their widespread distribution around Lake Titicaca, we used a series of bibliographical references, the official registration lists of fishermen and fishing craft, a census of local fishermen and a survey of the activities of 251 fishermen carried out in 1976 by scientists from the Peruvian Marine Institute (IMARPE), and interviews conducted during fieldwork in 1979–81 and 1984. We restrict our discussion to Peru, because our data from Bolivia provide less systematic coverage of that portion of the lake; nonetheless, the existence of territories virtually indistinguishable from the ones in Peru is demonstrated by intensive fieldwork in several Bolivian fishing communities both in the Lago Grande and the Lago Pequeño (Sotalaya and Limancachi in Ancoraimes and Chuquiñapi in Santiago de Huata, Omasuyos province; Yumani on the Isla del Sol, Sampaya, Manco Kapac province; and Parquepujio in Manco Kapac province) and a survey of 138 fishermen located in all five Bolivian shore provinces.

Field surveys and interviews in which informants were asked about difficulties encountered when fishing outside their own areas proved successful in documenting the enforcement of communal fishing territories because they allowed the fishermen to avoid self-incrimination. Trespassers were prompt to accuse community members of stealing nets, and the latter were equally willing to complain of the misbehavior of the former when they did not have to mention their own illegal enforcement activities. However, we systematically cross-checked trespassers' accounts with those of the victims of their trespassing activities.

To determine the position of boundaries of territories, direct accounts collected from informants during visits to lakeshore communities and direct observation of visual markers proved the most reliable sources. Informants often spontaneously mentioned the existence of boundaries, indicating their location and describing the visual markers used to delineate them. Whenever possible, direct observation of these markers was used for confirmation. We also relied heavily on maps that communities drew up and submitted to government agencies when they applied to the Ministry of Agriculture for official recognition of their lands and totora beds or for other purposes (Orlove 1988).

We have had to consider as insufficient evidence of the position of boundaries accounts of conflicts over communal fishing territory areas, such as reports of net theft or physical violence, which fail to indicate where these boundaries lie. Although references that mention the occurrence of trespass or indicate that the terrestrial territories of shore communities extend to the adjacent aquatic space (Tschopik 1946; Bustamante and Treviño 1976) confirm the existence of communal fishing territories, they fail to indicate the position of boundaries or the manner in which they are delineated.

Results

Existence of Communal Fishing Territories

Our data show that communal fishing territories are found along the entire shoreline of Lake Titicaca, with the sole exception of the water immediately adjacent to Puno, the one city located on the lake. (Peasants even control such territories in the communities and cooperatives of Lluco Coata, Faon, Yasin, and Moro, which form part of the SAIS Buenavista, the one agrarian reform enterprise whose lands reach the shores of the lake.) Government fishermen censuses confirm that shore dwellers have been able to prevent inland dwellers from entering local fisheries. The most common form of communal territory enforcement is verbal or physical interference, followed by destruction or theft of nets. More violent forms of retaliation may also be used occasionally, and rumor has it that some trespassers have been beaten to death.

When the 251 fishermen were interviewed about difficulties they encountered when operating in other fishing areas, 2.4% did not reply. Of the total fishermen interviewed, 40.6% answered positively, confirming both the existence and the enforcement of communal fishing territories. Among the negative respondents, who formed 57.0% of the survey population, 88.2% (50.3% of the total) indicated that they did not fish in other areas. The remaining 11.8% (6.7% of the total) did mention some specific fishing sites, but either named places we were unable to locate or did not provide the names of all the places they frequented; the replies of this group neither support nor challenge the existence of communal fishing territories. In sum, just over 90% of the fishermen interviewed in 1976 confirmed the existence of communal fishing territories, and more than 40% confirmed the active enforcement of these territories, while the remainder, under 10%, simply did not provide evidence either way. Not a single one of the 251 informants denied their existence.

Lateral Boundaries

Members of Lake Titicaca shore communities extend the lateral boundaries of their communal fishing territory areas in direct prolongation of the terrestrial boundaries that separate neighboring communities on land. In most cases, these are perpendicular to the shore; in a few instances, they follow some irregular but clearly defined trajectory. The same types of visual markers are often used to delineate both aquatic and terrestrial boundaries.

Offshore Boundaries

We have distinguished between three different types of communal fishing territories according to the distance from shore to which they apply. (Although a number of fishermen mentioned differences in the ways that specific communities controlled fishing grounds, they kept their discussions at the level of the particular communities with which they were most familiar, rather than speaking of types of fishing territories.) Most communal fishing zones include a shallow water area, often demarcated by the presence of aquatic macrophytes, and an area of open water, both of variable width. The presence of totora reeds is significant in distinguishing these three types, since this plant commonly grows in waters between 2 and 4 meters deep, and is rarely found elsewhere. It is analytically possible for these different types to grade continuously into one another, because

they are distinguished by the slope of the bottom. However, there are very few cases that cannot be unambiguously assigned to one type, because of the discontinuities geological processes have created in the characteristics of the shores and bottom of the lake. Table 1 lists the shore communities for which evidence of the position of offshore boundaries was available and indicates the sources of evidence that correspond to each of them. Table 2 and Figure 3 summarize the characteristics of the three types of territory. Figure 4 shows the distribution of the three types around the lake.

Table 1
Communities for which the location of communal fishing territory boundaries is documented.

Zone within Lake Titicaca (Peru)			
Bahía de Puno	Lago Grande (north)	Lago Grande (south)	Lago Pequeño
	Type I communal fishing territories		
Pujsin-Carata (1,2,5)	Balsapata (1)	Huarmeamaya (1)	
Faon (1,4,5)	Ramis (1,3,5)	Amaya (1)	
Yasin (1,4,5)	Requeña (3,5)	Sullcacatura (1)	
Moro (1)	Huancollusco (1,5)	Huayllata (1)	
Huaraya (1,3)	Pusi (1)	Santa Rosa Yanaque (1,3)	
Jirata Vizcachuni (1)		Cachipucara (1)	
Chulluni (1,2,3,4,5)		Vilcamaquera (1)	
		Quispemaquera (1)	
		Santiago Mucho (1)	
	Type II communal fishing territories		
Capano (1,5)	Umuchi (1)	Sihuecani (1)	Pajjano (1,5)
Yapura (1,5,6)	Quellojane (1)	Añu Callejón (1)	Tapoje (1,5)
Silacachi (1,5)	Jacantaya (1)	Huincalla (1,2)	Copapujo (1,2,5)
Ichu (1)	Jachaparu (1)	Titilaca (1,2)	Calampune (1,5)
Cusipata (1)	Quellahuyo (1)	Isla Socca (1)	Santa Cruz Chambi (1,5)
Barco-Chucuito (1,4)	Junsani (1,2)	Isla Iscata (1)	Chinomani (1,5)
Chinchera (1,4)	Huarisani (1,2)	Sajo (3,4)	Yanapata (1,5)
Concachi (1)	Jacincoya (1)		Sanquira (1,5)
Potojani (1)	Carabuco-Llapas (1,5)		Amaquilla (1,2,5)
Cochiraya (1)	Siale (1,5)		Challapampa (1,5)
Ccarana (1)			Tacapize (1,5)
Parina (1)			Copani (1,5)
Tacasaya (1)			Isani (1,5)
Pucani (1)			Zepita (5)
Luquina Grande (1)			
Luquina Chico (1)			
	Type III communal fishing territories		
Llachón (1,5,6)	Isla Soto (1,2)	Churo (1)	Isla Anapia (1,5)
	Piata (1,5)	Perca (1)	Isla Iscaya (1)
	Cohasía (5)		Vilurcuni (1,2,5)
	Escallani (1,5)		
	Chillora (1,5)		
	Amantaní (1,5)		
	Taquile (1,5)		

Sources: (1) Field observations by authors (1979–81 and 1984); (2) survey of 50 collaborating fishermen (1979–81); (3) maps at the Dirección de Comunidades Campesinas, Ministerio de Agricultura-Puno; (4) archival sources, Ministerio de Agricultura-Puno; (5) IMARPE-Puno 1976 field data, and Bustamante and Treviño 1976; (6) Núñez 1982.

Table 2
Characteristics of communal fishing territory types on Lake Titicaca.

	Type I	Type II	Type III
Width of totora bed	> 500 m	10–500 m	< 10 m
Lateral boundary	channels in totora beds, human-made markers	channels, human-made markers, land reckoning	human-made markers, land reckoning
	precise impermeable	precise impermeable	imprecise some permeability
Offshore boundary	100–200 m beyond outer edge of totora	200–400 m beyond outer edge of totora	5 km offshore when ispi schools are present
	precise impermeable	imprecise some permeability	very imprecise some permeability
Maximum depth	< 3–5 m	10–20 m	> 50 m

Territories of the first type are found where the shallow water area extends to a great distance from the shoreline, because of a gentle bottom slope. Present in these areas are aquatic macrophytes, particularly dense beds of totora reeds. Communities with type I territories extend their boundaries far into these totora beds and usually, though not always, claim some open water space, not more than one or two hundred meters wide, on their outer edge. It is difficult to associate the outside boundaries of type I territories with any precise depth contour, although they rarely go beyond 3 meters and almost never beyond 5 meters. The presence of totora reeds in shallow waters greatly simplifies the problem of marking area boundaries within type I territories. The natural channels criss-crossing the totora beds can be used as lateral boundaries and, if necessary, artificially enlarged. In very shallow waters, local people use submerged human-made markers persisting from the times in which the lake level was lower, such as paths, ridges, and trenches.

In the second type of territory, a steeper bottom slope brings the outer edge of the totora reed beds to within a few hundred meters from shore. In such cases, local community members claim the totora beds in the shallow waters and an area of open and deeper water a few hundred meters wide, extending out to an area between the 10- and 20-meter depth contours. Natural features such as prominent rocks, hills, or promontories on shore, and small islands offshore are often used for lateral boundary identification. In a few instances, however, stone constructions on shore also delimit aquatic territories.

The very steep bottom slope in areas of type III territories makes the totora reed beds only a few meters wide. They may even be entirely absent, because of a rocky substrate or exposure to wave action. Alternative criteria of demarcation are used. Where gill-net fishing for demersal or bottom native species predominates, the 50-meter depth contour provides a good approximation of the outer edge; even though nets are rarely anchored deeper than 20 meters, this additional width offers a buffer against outsiders. Alternatively, where the trawl fishery for ispi predominates, no precise depth contour seems to correspond to the outer edge of type III territories; instead, the communities exclude outsiders from coming within 5 kilometers of the shore. Topographic features such as small valleys and outstanding rock formations, or human-made markers such as paths, walls, or houses are often used as lateral boundary markers for type III communal fishing territory areas, since a steep shore elevation makes them visible from a considerable distance.

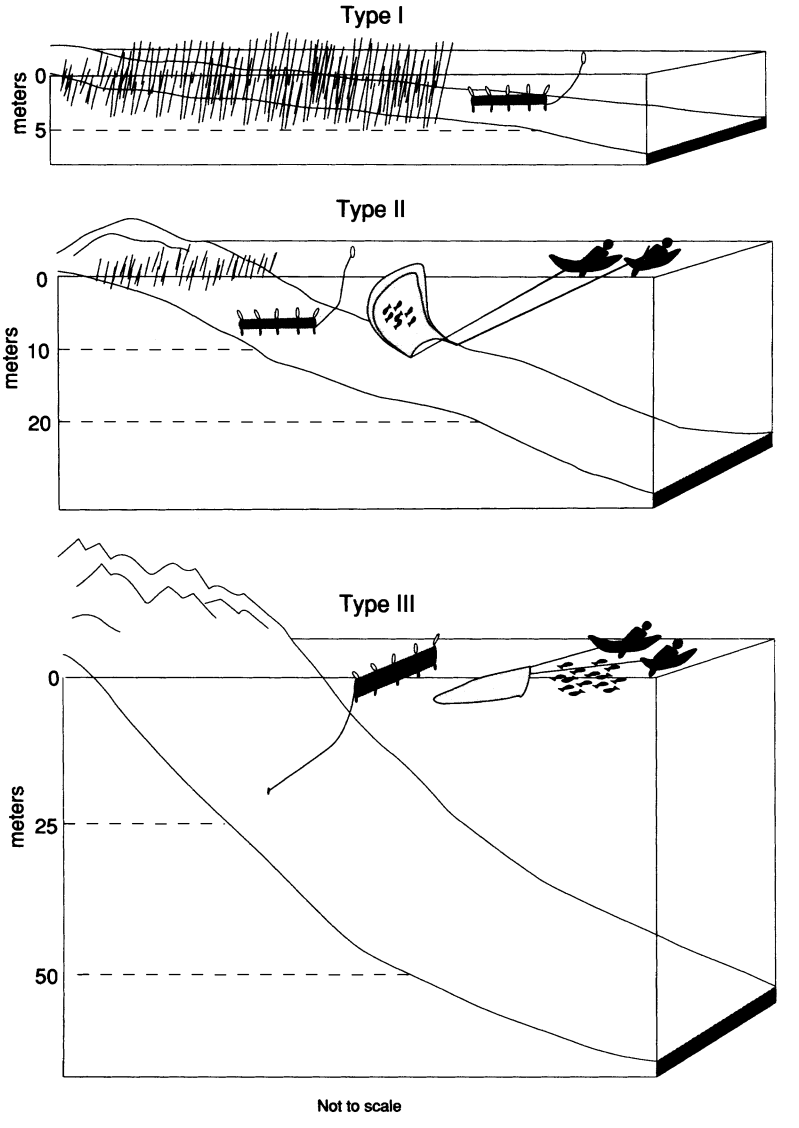

Figure 3
Types of communal fishing territories in Lake Titicaca, Peru.

There are some apparent exceptions to the location of offshore boundaries, in that the offshore boundary is not found at the distance or depth we have described. These types all reflect unusual shore characteristics in which communities are located on opposite sides of a narrow body of water, such as a river, bay, or strait. Whenever communities are located in such a configuration, the general practice is for these communities to divide the corresponding water space between themselves by drawing an intercommunal boundary approximately equidistant from both sides. However, natural features, such as channels in totora beds, are often used, even if they are closer to one community than to the other.

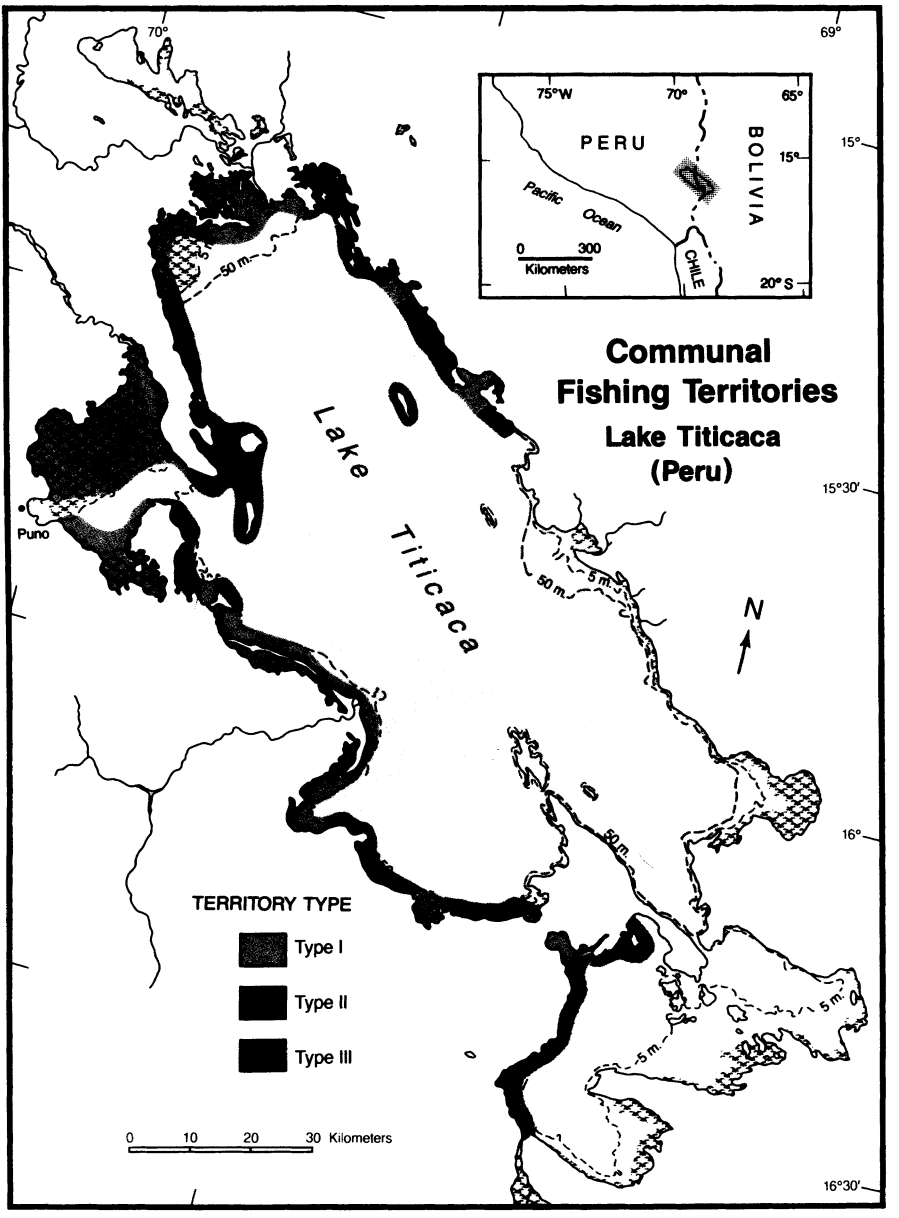

Figure 4
Distribution of communal fishing territories in Lake Titicaca, Peru.

Patterns of Fishing Territoriality

The distance from shore to which communal fishing territories extend varies with physical and ecological factors. The availability of natural features to delineate the boundaries of territories appears critical in this respect. Because totora beds are available for lateral boundary delineation of type I and II territories, but not for those of type III, the lateral boundaries of the first two types are better defined than those of the third. Similarly, because territories tend to include a larger proportion of open water as the width of their

totora beds decreases, the offshore boundaries are generally better defined in type I and II than in type III.

Most native fish species spend at least a portion of their life cycle within communal fishing territories. (This discussion is based on the relatively limited literature on Lake Titicaca fish biology and ecology [Everett 1973; Loubens, Osorio, and Sarmiento 1984; Loubens and Sarmiento 1985; Johannesson, Vilchez, and Bertone 1981; Alfaro et al. 1982; Richerson et al. 1986; Vaux et al. 1989; Wurtsbaugh, Bustamante, and Treviño 1989].) For pelagic native species, such times are the part of their cycle during which they are most vulnerable to fishing. Communal fishing territories thus include most of the range of the demersal native species of commercial interest, particularly the carachi, but they only include part of the range of the catfish and of both native and introduced pelagic species, such as ispi, boga, pejerrey, and trout (Levieil 1987). Territories of the first two types are thus more likely to include a larger proportion of carachi stocks because of the strong association of those species with lake plants and because most of their range is within the shallow littoral zone (less than 10–20 m deep). Territories of the third type are more likely to include ispi spawning and fishing grounds.

Boundary Permeability and Defense

A boundary may be precise inasmuch as its exact location is known to all to within a few meters. A channel or small trench within a totora bed is a good example of a precise boundary, since its location is obvious and cannot be disputed. A boundary may be also permeable (Pollnac 1984) in that some degree of overlap between neighboring territories may be allowed, or in that outsiders may be tolerated on the fringe of a territory, especially in the portions near the offshore boundary. However, one cannot speak of a permeable boundary if outsiders are required to provide compensation to the community member in whose area they operate. In acknowledging community members' right to receive indirect economic gains from the exploitation of the resources within their area, outsiders acknowledge the existence of territory boundaries.

The lateral boundaries of type I and II territories are precise and impermeable. They are precise because they are delineated by narrow channels or trenches in the macrophyte beds and they are impermeable because there is no overlap of territories. Members of neighboring communities are not tolerated within the territory of a community unless they make payments to the members of this community for their intrusion, or unless their kinship ties to parents, grandparents, or affines entitle them to do so.

The offshore boundaries of type I territories are also precise and impermeable; however, their defense is problematic because of their great width. Holders of type I territories have difficulty in spotting trespassers hiding among totora reeds, which grow up to 3 m above the water surface (Collot 1980) from a low shoreline. To solve this problem, the inhabitants of the floating islands in the Bahía de Puno build small platforms, one or two meters high, from which they can watch over their territory. It is common, however, for members of communities with large type I territories to take advantage of their rights of indirect economic gain. Residents allow outsiders to cut totora within their large communal plots in exchange for some agricultural products or a small sum of money; the community members say that they rent (*arrendar* [Spanish]; *arint'asiña* [Aymara]) their totora beds, to indicate that this exchange implies temporary use rights rather than prolonged use rights or transfer of ownership. Less frequently, the residents of these communities allow certain outsiders to fish on the outer fringe of their communal fishing territory areas in exchange for a small portion of their catch; some agricultural products; or some coca leaves, alcohol, or tobacco. Fishermen often refer to this as "making friends" *(hacerse amigos)*.

When taking advantage of their rights of indirect economic gain, community members do not forsake their other rights. This was demonstrated during the drought of 1983, when the members of the communities of Ramis and Requeña prevented members of neighboring communities from harvesting totora reeds on the grounds that they did not

have enough to feed their own cattle. Similarly, when the fishing is poor, only those outside fishermen with relations of kinship and coparenthood *(compadrazgo)* may still be allowed to fish on the outer fringe of type I territories.

Enforcement is not quite as difficult for holders of type II territories as it is for the holders of the wide type I territories. Because of a greater shore relief, holders of type II territories can watch over their territory more easily. Outsiders who trespass under the cover of darkness have a chance of slipping away before being caught, but they are very likely to be spotted and make arrangements with local community members, if they do not want to lose their gill nets or to be roughed up.

Defense against trespassing trawl fishermen, who tow their gear between two craft each manned by two fishermen, is much more difficult. Since they do not set their nets overnight, gear molestation is not a solution to repel them. As for physical abuse of the fishermen themselves, it requires coordination between communal fishing territory holders simply to outnumber trespassers. For these reasons, compensation by trawl fishermen is a common practice along the western shore of the Lago Pequeño, where most trawl fishing takes place.

The defense of the boundaries of type III territories differs substantially from that of the other two types because it depends on the presence of elusive schools of ispi rather than on that of totora beds. These boundaries are imprecise and permeable for most species except for ispi, for only when ispi schools are detected do holders of type III territories bother to repel outsiders. Holders of type III territories allow gill-net fishermen from neighboring communities to fish for carachi within their area. However, they do expect in return to be allowed to trawl for ispi in the open waters of the territories of those communities that do not practice ispi fishing.

Analysis of the Patterning of Communal Fishing Territory Boundaries

In previous sections, we have presented the results of our research and noted that each particular type of communal fishing territory is restricted to the areas where the lake bottom and aquatic vegetation have certain characteristics. In this section, we explain this patterning in terms of cost-benefit analysis. Our argument rests on the claim that the patterning of communal fishing territories is consistent with calculations of the costs and returns of the defense of these territories. In general, we note that the benefits (as reflected in yields of fish and totora, which are greater than they would be if noncommunity members had open access to these areas) are higher close to shore, where the totora beds are located and where fish populations are denser. The costs, however, are higher far from shore, because of the greater difficulty of policing distant areas rather than near ones.

In all cases it is worthwhile defending a communal fishing territory out to a depth of 5 meters, to protect the highly valued totora and to keep outsiders from landing their craft on the shores of the community. The additional width that will be defended reflects the particular costs of defense, which vary with the width of the totora beds, and the benefits, which depend on the particular resources that are present.

We have chosen to offer a qualitative comparison of total costs and benefits, rather than to adopt what might seem the next logical step of the quantitative calculation of marginal costs and benefits. Our decision is based partly on the difficulties of the latter and partly on the merits of the former. The assessment of marginal costs and benefits faces three major problems in the case of the Lake Titicaca fishermen. First, since they have strong commitments both to the home production of their food and to the purchase of some industrial goods, they aim neither to satisfy a fixed set of subsistence needs nor to maximize profits or revenues, making it tricky to weigh marginal costs and benefits realistically (Orlove and Rutz 1989). Second, the low degree of monetarization of the Altiplano impedes the assigning of value to some benefits (because staples are often unavailable for purchase by peasants in local markets, the cash value of food used for home consumption is hard to establish [Chibnik 1978]) and to some costs (since regional labor markets are

poorly developed, the opportunity cost of time is difficult to define). Third, because fishing households engage in a variety of economic activities, an analysis of a change in the size of a communal fishing territory would not only entail an examination of the allocation of resources to fishing and the returns from fishing, but would also require a study of the impact of this change on agriculture and other cash-generating activities.

The choice of the language of total, rather than marginal, costs and benefits has several positive justifications. We note (1) that communities change their types of territory very infrequently and (2) that communities with a particular type of territory tend to be clustered, because of the concentration of particular shore types in certain regions. Most communities, therefore, maintain the type of territory they have had for a number of years and that neighboring communities also have; in short, they are not making new decisions, but continuing old ones. Furthermore, part of the ideology underlying the system of communal fishing territories is the notion of community as a corporate group, linked to specific lands, which persists over generations. The members of a community are strongly committed to the defense of all of its terrestrial and aquatic space, and think of their possession of this space as a right, not as a benefit. The broad-based and vehement participation of community members in the defense of communal fishing territories rests on their unwillingness to negotiate over their domain. They would no more willingly trade a portion of their communal fishing territory in exchange for some agricultural fields of a neighboring community than a modern nation would arrange a swap of states or provinces with a neighboring nation.

Benefits

Members of communities with communal fishing territories derive two types of benefits from the defense of the boundaries of their territories: direct economic gains from their exclusive use rights over the resources found within their territories, particularly higher fish and totora yields, and indirect economic gains derived from allowing outsiders to harvest these resources. The former is typically far greater than the latter. Fishermen recognize that their personal levels of capture would be lower if individuals from outside their community could enter their territory to fish. Many nonfishermen receive fish as gifts from kin or neighbors who are fishermen, thus sharing in the higher yields. In addition to this direct economic benefit, community members challenge outsiders within their territory because such incursions are serious offenses against their pride and the integrity of their communities. In some instances, most importantly in the communities with the largest totora beds, each community member has the additional incentive to defend the communal boundaries because he may be able to receive some fish, some agricultural products, or some other gifts from outsiders in compensation for their harvesting activities and keep it for himself.

The benefit of defending an area of water varies with the abundance and predictability of the resources within the area considered. Since only fish, rather than both fish and totora, are available in the open area adjacent to the totora beds, the benefits are correspondingly lower. They drop off from the somewhat richer fishing grounds closer to the totora to the less abundant resources farther away. In the region of open water far beyond the totora beds, the contribution of the pelagic fish species is relatively small because the fish are more mobile and their densities are low. This benefit is much larger, though, when the presence of ispi schools is detected within the area.

Costs

Enforcement costs include the allocation of time and effort to surveillance, defense, and retaliation. Surveillance costs are quite small for the first few kilometers of width for the holders of type II and III territories, because they can easily watch over their areas from their fields, although these costs increase with distance from shore. They may be higher for the holders of type I territories who cannot watch over their areas as easily. Community members face defense costs when they row their craft to where trespassers have

set their gear to confront them or to molest their gear. Retaliation costs may result from the actions of a group of outsiders who take revenge on gear of community members or on totora. The Coast Guard may also impose such costs when they confiscate nets as punishment for the extra-legal exclusion of outsiders from communal fishing territories. Such costs are higher for type II and III territories than for type I, because the greater slope of the lake bottom and the relative scarcity of totora facilitate access for the boats of the Coast Guard. Much as the fishermen in a community receive higher benefits than the nonfishermen, they also pay higher costs in the form of surveillance, defense, and risk of retaliation.

For any given community, the surveillance becomes more difficult as the distance offshore increases, so that its costs rise. Defense costs also increase with the longer time needed to travel the greater distance from shore. The retaliation costs are harder to evaluate, because the likelihood of retaliation by trespassers seems greatest for type I, while that of retaliation by the Coast Guard seems least; the reverse is true for type III. In any case, the retaliation costs would not decrease with distance, but would either remain constant or increase, so that the sum of the surveillance, defense, and retaliation costs increases with distance.

Comparison of Costs and Benefits

In type I territories with wide totora beds, the cost of enforcement does not become greater than the corresponding benefits until the outer edge of the totora beds is reached, particularly because community members can receive the indirect economic gains that result from the harvesting activities of outsiders. Holders of type I territories include some open water space on the outer edge of their totora beds in their territory, to obtain more fish and to make it easier to spot and to expel potential trespassers.

The benefits of controlling open water beyond the totora beds are quite similar for type I and type II territories. However, the costs are lower for type II territories, because of the greater ease of surveillance and the lesser travel time to the outer edge. It is thus worthwhile for members of communities with type II territories to extend their control farther out than in type I cases. This band is more permeable in the type II case. Trespassing trawl fishermen are tolerated because they are difficult to police and because they compensate community members. However, most of their trespassing takes place in areas where community members would not fish themselves and where the enforcement of exclusive fishing rights would be prohibitive because of distance from shore and retaliation by outsiders.

As for type III territories, there is not much point for their holders to defend their boundaries strictly, except for their scanty totora beds, because of the exclusiveness of the ispi. For the few communities with significant numbers of fishermen who specialize in this species, it is worthwhile to defend the large schools of this fish during the irregularly occurring periods when they come onshore. The spatial concentration both of the schools and of the fishermen pursuing them reduces the costs of policing the large type III territories.

Conclusions

In spite of their informal status and the opposition of government officials, communal fishing territories are widely enforced around Lake Titicaca. Members of shore communities repel trespassers by threatening them physically or by destroying their gear. Although Lake Titicaca fishing territories are communally held, individual community members are willing to bear their share of the costs of enforcement because they are committed to the spatial integrity of the community and because they fear that their individual access to plants and fish would decrease if outsiders could also use them. In addition, members of certain communities also receive some of the benefits of their defense activities as indirect economic gains.

Our study of communal fishing territories in Lake Titicaca may contribute to the more general study of resource allocation and territoriality in several ways. We have examined a number of examples of group-based control of resource use from one region and demonstrated regularities in the spatial and social dimensions of this control. These regularities are directly influenced by environmental variables. We have also discussed some previously unstudied features of such control that merit examination elsewhere, particularly the distinctions between lateral and offshore boundaries and between the precision of the delineation of boundaries and the stringency of their enforcement.

More generally, we apply a very broad approach, cost-benefit analysis, which has allowed us to incorporate the concerns that fishermen and other lakeshore peasants have voiced into a model that accounts for the regular patterning of variability of these territories. Like other recent researchers (McCay and Acheson 1987) in common property systems, we also recognize the importance of specifying many features of the context of communal fishing territories, such as the possibility of multiple aquatic resources, the relation between terrestrial and aquatic socioeconomic activity, and the influence of governmental institutions (Durrenberger and Pálsson 1988). The details of these features vary from case to case. In the instance we discuss, they include the economic importance of aquatic plants, the scale and organization of peasant communities, the fishermen's experience with common property institutions in other economic contexts, and the weak enforcement of national legislation.

This explanation of variation among communal fishing territories is different from an explanation of the existence of such territories. We do not claim to offer here an analysis of the origins of these territories along the shores of Lake Titicaca, a topic that would require a detailed historical examination of economic, political, and cultural factors; instead, we have merely sought to explain the distribution of different types of territories. We encourage other researchers to pay close attention to the variability in definition, precision, and permeability of communal fishing territories and to the interactions of fish, other aquatic and terrestrial resources, and institutions in the patterning of these territories. The ability of our research to uncover systematic variation in communal fishing territories, and to account for this variation through cost-benefit analysis, suggests that other such regional comparisons and analyses might be fruitfully undertaken.

Notes

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[1]These figures correspond to the period 1979–80. Current proportions may have changed somewhat, due to a series of years of unusually low and high lake levels, to shifts in fishing effort, and to population dynamics within the biological fish communities.

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