COMMUNITY-BASED CONSERVATION OF THE *CALLO DEHACHA* FISHERY BY THE COMCÁAC INDIANS, SONORA, MEXICO

by

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El molino ya no está; pero el viento sigue, todavia.

Vincent van Gogh.

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ABSTRACT

In recent times, fishery management scholars have suggested the need to develop a better suited small-scale fisheries management approach for developing countries, than the one offered by conventional Western fishery science (Berkes et al. 2001). This alternative approach is based on the development of better resource access controls, community-based management, and an increased use of local traditional fishery knowledge (Berkes et al. 2001).

In response, this research aimed to understand what are the most important social and ecological elements that contribute to the successful community-based management of the Seri Indians' *callo de hacha* (pen shell scallops) fishery. Toward this end, Seri controls over access to the fishery, as well as the integration of traditional ecological knowledge into local fishing practices were documented and analyzed.

Results showed that the success of this locally managed fishery originate from a good fit between well-defined property rights, locally designed institutions, and the natural system.

Outside fishers are allowed to fish in Seri waters on a regular basis, in exchange for benefits to the Seri. The integration of Seri communal worldview, fishing norms and beliefs, into local management rules, allows them to achieve low-cost monitoring and successful exclusion from their fishing grounds when necessary. Therefore, this case study suggests that absolute exclusion is not necessary to avoid overexploitation and the attainment of successful local management of coastal fishing resources.

Some of the most important Seri fishing practices that might be responsible for promoting resilience and sustainable use of the *callo de hacha* fishery are: multi-species management, existence of no-take fishing areas, and rotation of fishing grounds.

INTRODUCTION TO THE PROJECT

JUSTIFICATION

Today approximately one billion people rely on fish as a major source of their food, income and/or livelihood. Over 99 percent of the world's 51 million fishers participate in small-scale fisheries and practically all of them pertain to developing countries. Together they produce 58 percent of the world's annual marine catch of 98 million tonnes and supply most of the fish consumed in the developing world. The importance of small-scale fisheries cannot be overemphasized (Berkes et al. 2001).

Current fishery science has largely been devoted to stock assessment with a geographical focus on industrialized countries and a disciplinary focus on biology and, to some extent, economics. Such approach has not suited the fishery-management needs of the developing world and overexploitation and habitat degradation scenarios continue to threat the livelihood of millions of people in coastal areas. The management and governance of small-scale fisheries is in urgent need of reform (Berkes et al. 2001).

Recent research focused in small-scale fisheries management in the developing world has shown that to improve coastal and fisheries resources conservation, managers need to be able to exert more control over access to their resources. Community-based management and an increased use of local traditional fishery knowledge have emerged as promising alternatives for fisheries, and resource management in general (Christy 1982; Cordell 1989; McGoodwin 1990; Ostrom 1990; Dyer and McGoodwin 1994; Pomeroy 1994; Berkes and Folke 1998; Kothari et al. 1998; Newell and Ommer 1999; National

Research Council 1999; Cudney-Bueno 2000; Durenberger and King 2000; Berkes et al. 2001; Bourillón 2002).

The Seri *callo de hacha*[1] (CDH) fishery provides an excellent opportunity to study these promising alternatives. This fishery is one of many Mexican small-scale fisheries unregulated by the Mexican Government. There is no federal or state mandate to regulate fishing effort in the form of season closures, restrictions on fishing gear, or minimum harvesting size. The Seri CDH fishery is managed entirely by local users.

In 1975 the Federal Government granted the Seri Indians a portion of their historic coastal territory and a fishing concession, as a way to guarantee the survival of the tribal culture and reduce conflicts with other local fishing communities. The CDH fishery is practiced entirely in the *Canal del Infiernillo* (Infiernillo Channel), a section of the Seri fishing concession where the Seri are able to control access to non-Seri fishermen. This area acts as an exclusive fishing zone (EFZ) for the Seri, and it is evident that within it, a Seri common property regime exists. This contrasts with the *de facto* open access regime that prevails in the rest of the fishing concession and in coastal waters nearby.

Locally and regionally it is *vox populi* among fishermen from nearby towns (i.e. *Bahia de Kino),* that the Seri fishing zone is rich in CDH beds, compared to the open access fishing grounds nearby. This belief is supported by the fact that the Seri CDH beds

[1] The *callos de hacha* are sessile bivalve mollusks pertaining to the order Pterioida (Brusca, 1980) (see Figure 1). They live buried mostly in sandy bottoms and are harvested by hookah diving. The meat is sold throughout the country at high prices and its shape and taste resembles those of bay scallops.

are able to sustain the fishery all year. Elsewhere the fishery only takes place part of the year, since is hard to find an abundant supply of CDH year around. Preliminary data suggests that the CDH fishery is almost 30 years old and for the last 15 has supported year around exploitation. Today most small-scale fisheries in the region do not reach that age or cannot support year around exploitation before they collapse. The productivity of the fishery fuels efforts by non-Seri fishermen to obtain access to the Seri fishing grounds.

The seemingly successful CDH community-based fishery allows us to look to the inner workings of the access control mechanisms and fishing practices based in traditional knowledge, that the Seri people have in place, and this way, contribute to the development of successful fisheries management approaches that are better suited for small-scale fisheries in developing countries.

GOALS AND OBJECTIVES

I suggest that the social and ecological mechanisms in place that might be accounting for the success of the *callo de hacha* fishery are: controlled access and fishing management practices based upon traditional ecological knowledge (TEK). Therefore, the purpose of this research is to answer the following question: Which are the most important social and ecological elements that contribute to the successful local management of the *callo de hacha* fishery?

To answer this question the following main objectives were accomplished:

1. To analyze how and why Seri control the access of outside fishers to their Channel.

2. To document and validate how traditional ecological knowledge has been integrated into local fishing practices.

3. To determine which fishing practices are important for the success of this community-based managed fishery.

Specific objectives were also developed as to complement and help accomplish these main objectives:

- Describe the Seri physical and historical background as it pertains to the CDH fishery.
- Revise the literature that addresses the theoretical foundations of common property resources and traditional ecological knowledge.
- Describe the historical and current Seri *callo de hacha* fishing practices.

GENERAL METHODOLOGY FOR THE PROJECT

Establish Rapport and Trust with the Seri Community

The existence of rapport with the subjects of study is necessary to be able to conduct participant observation, which in turn characterizes most ethnographic research and is crucial to effective fieldwork on this topic. The first efforts to establish rapport and trust with the Seri community and local fishermen started back in 1998 while living in the region and working with the Seri.

From 1998 to the summer of 1999, I lived in the area working as a field assistant for two Mexican Ph.D. students conducting research on Seri marine resource issues. They are well respected and trusted in the community so I gained entrance by association. My presence soon became familiar in the area, and I started to identify my own informants, contacts, and friends among the Seri. It is important to mention that the Seri, for various reasons, generally do not like the presence of wildlife researchers in their community and entrance is generally difficult.

In-depth Literature Research

A thorough literature review on the following subjects was conducted: The region's physical environment, history of the Seri Indians, history of early diving fisheries in the Gulf of California, biology and ecology of *callo de hacha,* common property theory and the intellectual roots of traditional ecological knowledge.

Presentation of Project Proposal to the Seri Government and Community

On June of 2000 I presented a formal proposal of my project to the main officials of the Seri traditional government. The presentation consisted in 4 posters using very concise, clear and simple language to describe the objectives and methods of my work, as well as the benefits that the project would bring to the Seri community. Once the project was accepted and supported by the Seri traditional government, I made the same presentation to community members in every opportunity I had: at the beach, inside their houses, at the local store, etc. I also physically showed them the actual equipment (data sheets, GPS unit, camera, measuring board, calipers, etc.) that I was using to collect data.

This was very useful to end gossip and speculation about my presence in the community at an early stage, as well as to provide first hand information to those community members who did not know me and were skeptical of my presence in the community.

Conduct Extensive Ethnographic and Ecological Field Research

To accomplish the goals of this project I conducted ethnographic and ecological research in the Seri village of *Punta Chueca* and at the Infiernillo Channel. Ninety-eight days were spent in the field between June of 2000 and June of 2001 (Table 1).

The ethnographic methods used in this study are the same for all the socio-cultural data presented in this thesis. A detailed explanation is presented at the beginning of Part II since that is where most of the ethnographic data is analyzed.

Table 1. Field work activities between June of 2000 and June of 2001.

Field work season	Duration	Activities conducted
Summer 2000	60 days (June-July)	• Setup camp in *Bahía de Kino* and *Punta Chueca* Village. • Presentation of the project to the Seri Government. • Reestablish contact with the Seri fishermen. • Revise methods to fit field circumstances. • Start biological monitoring.[a] • Start mapping of fishing areas.[a] • Start surveys of fishing boats.[a]
Summer 2000	2 days (August)	• Preliminary interviews. • Biological monitoring. • Surveys of fishing boats.
Fall 2000	3 days (September)	• Biological monitoring. • Mapping of fishing areas. • Surveys of fishing boats.
Winter 2000	15 days (December)	• Setup camp with a Seri family. • In-depth interviews. • Biological monitoring. • Mapping of fishing areas. • Surveys of fishing boats.
Spring 2001	15 days (March)	• Setup camp with a non-Seri family. • In-depth interviews. • Biological monitoring. • Mapping of fishing areas. • Surveys of fishing boats.
Summer 2001	3 days (June)	• Presentation of preliminary results to Seri community members. • Biological monitoring. • Mapping of fishing areas. • Surveys of fishing boats.

a. See Table 2 for details on the activities conducted during the fishing trips.

Sharing Results and Integration with Ongoing Conservation Efforts

During my stay among the Seri I shared with them the results of my preliminary assessments at every opportunity I had. It was a recurrent conversation theme among the fishermen and me, and a very useful way to learn and share our views and perspectives.

On June 6th, 2001, a formal presentation was conducted and preliminary results where presented to community members. An additional presentation is scheduled following the completion of this thesis.

Collaboration and preliminary results were shared regularly with a local Mexican organization that has ongoing projects with the Seri and has been working in the area since 1997. That organization, Comunidad y Biodiversidad (COBI), in turn provided logistic support during the field-work season.

Finally, the most important conservation information generated by this project will be included in an educational and training manual for a project that complements this thesis, and in collaboration with local and regional organizations working with the Seri, such as Comunidad y Biodiversidad A.C. (COBI), Northern Arizona University (NAU) and the Arizona-Sonora Desert Museum (ASDM). The general goal of this parallel project is to build local capacity among the Seri for the conservation of their natural resources, and the training manual will be aimed to provide basic guidelines for the Seri to develop their own biological monitoring protocols, for important natural resources such as the CDH fishery.

GENERAL ORGANIZATION OF THIS THESIS

This thesis is organized in three parts. Part I is divided in three chapters, each of them presents a literature review of the most relevant literature pertaining to the physical setting, the Comcáac people, common pool resources theory and the emergence of traditional ecological knowledge.

Part II aims to understand the community-based management regime in place for the exploitation of the CDH fishery, and it is divided in four chapters. Chapter 4 (History of diving fisheries in Comcáac territory) serves as an introductory chapter for the part. It briefly lays out the importance that diving fisheries have had for local populations in the Gulf of California (i.e. pearl fisheries), focusing in the development of Seri diving fisheries in the twentieth century. Chapter 5 (Natural history of the modern CDH fishery 2000-2001), provides an ethnographic account of CDH fishing practices as observed between 2000-2001. The remaining chapters build from this one and analyze the inner workings of the communal management regime of the CDH fishery. Chapter 6 (Social management mechanisms: understanding access controls), assesses how efficient the Seri exclusive fishing zone (EFZ) is for the management and conservation of the Seri CDH resources. Using the IAD framework as a roadmap, outcomes are identified by looking at the different social patterns of interaction that result from the array of rules and strategies that 'access seekers' and 'access controllers' have in place in the CDH fishery. In chapter 7 (ecological management practices), the aim is to identify some of the most important ecological and cultural elements that have contributed to the viability of the fishery in the

Infiernillo Channel, while documenting and validating how these elements have been integrated to local management through traditional ecological knowledge (TEK).

Finally, Part III presents the lessons learned from this project, which include social mechanisms for sustainable use of CDH resources, ecological practices for building resilience, and the role of fisheries authorities in community-based fisheries management.

PART I: THE SETTING

This part lays out the physical and historical basis necessary to understand current social and ecological dynamics of the CDH fishery, as well as the theoretical perspective under which communal management processes are interpreted, and the intellectual roots from which traditional ecological knowledge emerged.

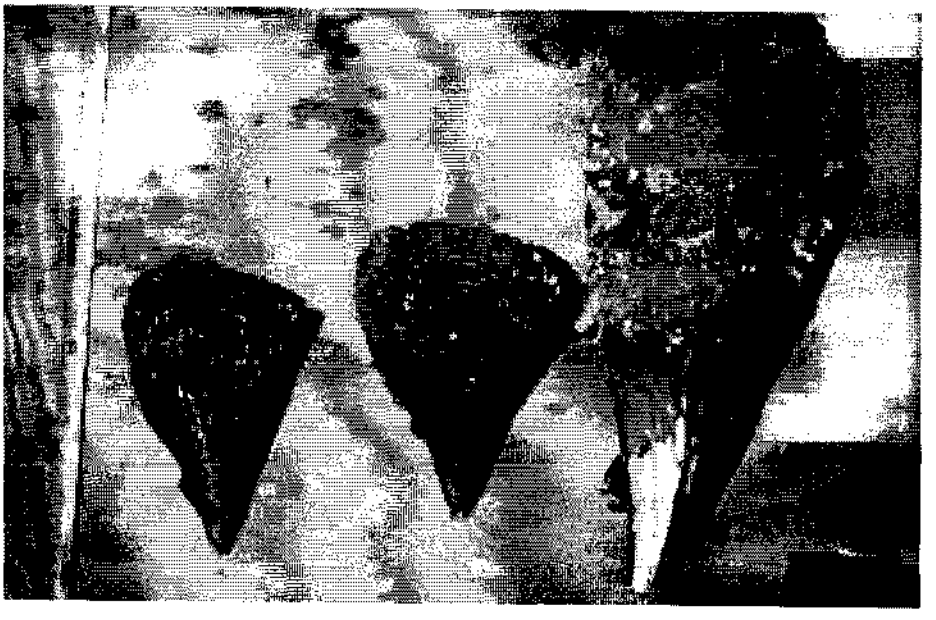

Figure 1. *Callos de hacha Atrina maura*, *Atrina tuberculosa*, and *Pinna rugosa*.

1 THE PHYSICAL ENVIRONMENT

1.1 WEATHER AND CLIMATE IN THE SERI REGION

The Seri or Comcáac ('the people') as they call themselves, inhabit a strip of coastal land in the central portion of the Gulf of California known as the Midriff Island Region (MIR) (See Figure 2).

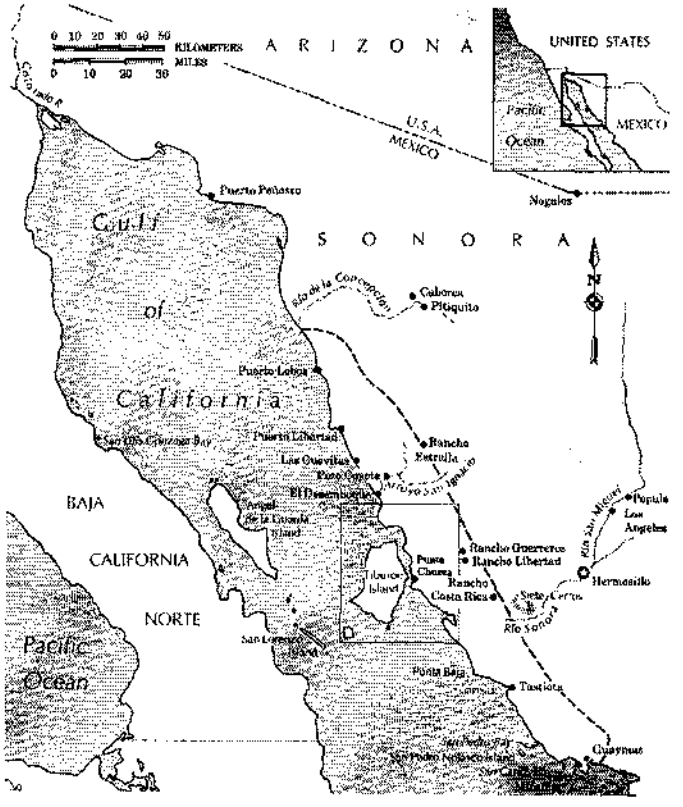

Figure 2. The Midriff Island Region of the Gulf of California.

The dashed line indicates the original area of Seri occupation. Note the location of the Seri villages of *Punta Chueca* y *El Desemboque.* Adapted from Map 1.1 from People of the Desert and Sea: Ethnobotany of the Seri Indians, by Richard Stephen Felger and Mary Beck Moser. Copyright © 1985 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

The Gulf of California is classified as a marginal sea (Kennish 2001). It is surrounded by continental and peninsular landmasses and is only connected to the Pacific Ocean at its southern end. The climatic conditions present in this region are produced mostly from inland Mexico.

The most recent climatic data sets available for the Seri region extend from 1974 to 1986.[2] The short period of time they describe and the recent climate variability, makes it impossible to create a precise description of the current climatology in the region. Nevertheless, a general description of weather and climate characteristics is offered by combining the existent published information with current local knowledge (Herring 2001).

1.1.1 Precipitation

Between 1974 and 1986 annual precipitation averaged 122 mm. The month with the highest average precipitation was August (30 mm) and the lowest was May (Herring 2001:55). This is one of the most arid and hottest regions of Mexico (type BW(h')hw(x')(e')), according to the modified Koppen climate classification (García 1988 cited in Torre-Cosío and Bourillón 2000). Between 1974 and 1986 there was no period longer than six months without measureable precipitation (Herring 2001:56). However, according to Seri informants a drought took place from 1996 to 1999 (Herring 2001:51), while the year 2000 was considered a wet year.

[2] These data sets can be purchased in CD-ROM format from the *Instituto Mexicano de Tecnología del Agua* (IMTA). See reference list for url address.

1.1.2 Temperature

In the summer, diurnal temperatures can raise above 40 °C, with August as the hottest month. In the winter, the influence of the predominant cold northwestern winds can lower temperatures to 10 °C, with January as the coldest month.

According to a Columbia University data set for the area between the years 1950-1979,[3] superficial sea water reached its highest temperature in August and its lowest in February (Herring 2001:55). In 2000 and 2001 the recorded surface seawater temperatures in the Infiernillo Channel ranged between 16.5°C and 19.0°C in the winter, and 30°C and 34°C in the summer (Basurto Unpublished Data). These temperatures are representative of the superficial temperature range throughout the Gulf of California (Robinson 1973:12).

1.1.3 Winds

Strong southerly winds dominate during the summer months while strong northerly winds dominate in the winter. In between are transition periods with more variable winds. March and October can be particularly calm. The strong summer winds are notable as being more consistent, often blowing day and night. In the winter, the northerlies are often strongest during the day, but during particularly windy periods the wind will persist at night (Herring 2001:57).

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[3] This data set is available through Columbia University on-line database retrieval system (see reference list for url address).

Local residents recognize two seasons throughout the year: *tiempo de color y tiempo de frio* (hot and cold seasons). The beginning of each season is highly variable due to year-to-year climate variability.

Kino fishermen generally agree that *tiempo de color* (hot season) starts after holy week takes place.[4] This does not necessarily mean that the weather is hot at that point in time, but it is when fishermen start shifting from winter to for summer fisheries. There are no specific dates for the beginning of *tiempo defrio* (cold season), but it is generally between October and November, when seawater temperature starts to drop noticeably (A.H. Weaver, Kino fisheries researcher, personal comm. 2001).

The Seri believe that seasons "settle in" when the predominant winds change direction and temperature. *Tiempo de color* (hot season) has arrived when the predominant cool southeast wind switches to blow hot and from the North. Similarly, *tiempo de frio* (cold season) settles in when the cold northerly winds arrive. In general, *tiempo de color* usually goes from May to November, while *tiempo de frio* from December to April.

1.2 OCEANOGRAPHY OF THE INFIERNILLO CHANNEL

The Infiernillo Channel (29,753 ha) is a long (41 km), narrow and shallow body of water that runs South to North. (Torre-Cosio and Bourillón 2000:9). The channel is flanked on the west by Tiburon Island, the biggest island in Mexico, and to the east by the continental coast of Sonora. The narrow southern mouth of the channel is 1.8 km wide,

[4] Holy week takes place 40 days after Ash Wednesday. Usually between March and April.

while *Bahia Sargento,* its northernmost portion is 10 km wide (Figure 3). White sandy beaches and occasional small salt grass meadows characterize both coasts of the Channel.

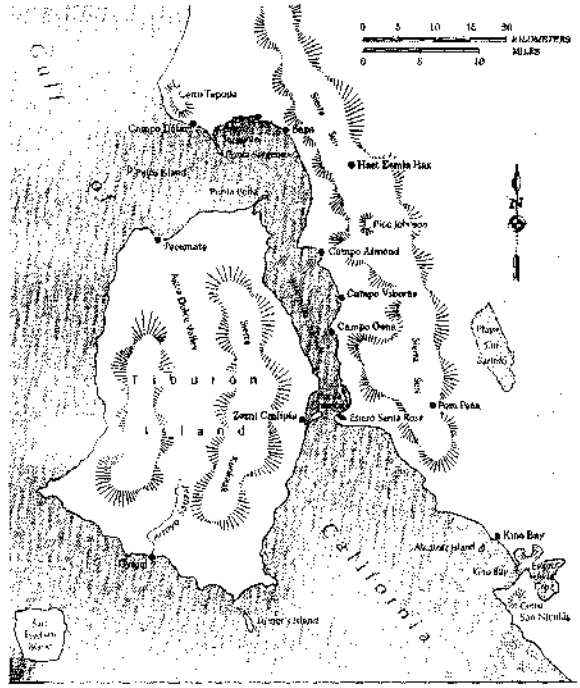

Figure 3. The Infiernillo Channel.

Taken from Felger and Moser (1985) with permission from the publisher. Adapted from Map 1.1 from People of the Desert and Sea: Ethnobotany of the Seri Indians, by Richard Stephen Felger and Mary Beck Moser. Copyright © 1985 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.

The bottom of the Channel is predominantly medium-sized granulated sand. However, there are occasional muddy areas, *tepetates* (rocky bottoms), and small soft coral reefs (ca. 10 x 2 x lm) (Torre-Cosío and Bourillón 2000:9). It is likely that the largest hard substrate surfaces are offered by the extensive aggregations of mussels (mainly *Modiolus capax).* These areas are locally known as *chorales* and constitute a very distinctive environment due to the habitats that are created by mussels and

associated organisms. In these areas it is possible to find aggregations of other benthic organisms such as bivalves, sponges, cnidarians, bryozoans, and echinoderms.

The Infiemillo strait has strong currents, due to its shallow (average depth of 5.5m) and narrow nature. The intricate current patterns favor continuous sediment transportation and the formation of sand bars, which are abundant. Some are completely exposed at extreme low tides. Scientific information about the current patterns of the Infiemillo Channel is practically nonexistent. Although the types of current cycles in the region vary, it seems that the semi-diurnal tidal cycles predominate. (Torre-Cosio and Bourillón 2000:9).

Seri fishermen believe that when tides are rising, water enters the Infiemillo Channel from both its South and North extremes. They refer to this event as *la subida del agua* (when the water goes up). The tidal currents meet at some point in the central portion of the Channel between *Punta Ona* and *Campo Almond* (Figure 3), generating whirlpool currents. When ebb tides form, water exits in the same fashion as it came in, from the center to each of its extremes at the same time. This is known as *la bajada del agua* (when the water goes down).

In the Gulf of California, salinity ranges mostly between 35% and 35.8%, and is l-2‰ higher than those of comparable latitudes outside the Gulf (Meling-López and Ibarra-Obando 1999:59). No superficial rivers or streams flow into the sea along the Infiemillo Channel (Felger and Moser 1985:20). Torre-Cosio and Bourillón (2000:9) state that the average salinity is of 35%.

13 MARINE PRODUCTIVITY AND BIODIVERSITY

The Infiernillo Channel is considered to be a very productive ecosystem for the following reasons: (1) Its borders include a high number (9 in total) of estuaries in a relatively small body of water. Estuaries act as nursery areas for marine organisms in their early development stages. (2) The presence of algae and eel grass beds that cover great extents of the bottom at different times of the year. Throughout their life cycle, algae and sea grass beds produce nutrients, food and offer protection and substrate to innumerable species of pelagic and benthic organisms. (3) There are important areas of upwellings and phytoplankton blooms near the northern portion of the Channel, as described by Molina and Manrique (1997). (4) There are continuous and changing currents, which bring nutrients and oxygen into the system.

The biological diversity of the Infiernillo Channel is illustrated by the work of Torre-Cosio and Bourillón (2000). In their biological inventory, they compiled records of more than 598 species of marine organisms. They registered more than 208 species of mollusks, 62 equinoderms, 214 sharks, rays and fish, 106 marine and shore birds, 8 species of marine mammals, and 5 species of marine turtles. No specific information is available in the literature on the abundance and diversity of the planktonic forms of life in the channel. However, its high productivity and rich macro fauna are indirect evidence of high primary productivity.

2 THE COMCÁAC

2.1 BRIEF EARLY HISTORY (1600-1900)

The origin of the Comcáac or Seri, is not well understood. They share more cultural traits with the people of Baja California than with Sonoran groups like the Yaquis, Opatas, Eudeves, and O'odham (Upper and Lower Pimas) (Sheridan 1999:7). The Seri bear the most resemblance to the Cochimí people of Baja California. Both groups inhabited extremely dry deserts, hunted and gathered in small groups, and navigated the waters of the Gulf of California (Sheridan 1999:7). The Cochimi people died out in the nineteenth century. It is known that their language belonged to the Hokan stock, which some scholars believe is also true for the Seri (though this is controversial) (Steve Marlett, Seri linguist, personal comm. 2001). There is some consensus that Seri ancestors might have migrated from Baja California to Tiburon Island using reed boats (Bowen 1976; Felger and Moser 1985; Sheridan and Parezo 1996; Sheridan 1999; Bourillon 2002).

Archeologists believe that the Seri have inhabited the Midriff Island Region of the Gulf of California (Figure 2) since the beginning of ceramic times, more than 2,000 years ago (Bowen 1983). There is also evidence that their coastal territory extended from north of Puerto Lobos to as far south as Guaymas, and that they had permanent populations in Tiburon and San Esteban Islands (Moser 1999:1).

Before the Spaniards arrived, the Seri were organized in bands. According to Moser (1999) and Sheridan (1999) there were six bands that spoke different, intelligible

dialects and had somewhat delimited territories. They were in constant warfare with other tribes. However, not all their relations with other natives were violent. The Band of the *Guaymas* and *Upanguaymas* had friendly relations with the Yaqui, and they traded with riverine communities of central Sonora such as the Ópata, Eudeve, and Lower Pima (Bourillón 2002). It is also believed that the Seri participated in the pre-Columbian shell trade. According to Sheridan (1999:13), this would have linked them with the Trincheras, Hohokam, and perhaps even Casas Grandes cultures.

The first Spanish written record of the Seri was made by Father Andrés Pérez de Ribas in the sixteenth century.[5] He made references to Seri livelihood on his classic *Historia de los triunfos de nuestra santa fe entre gentes las mas barbaras y fieras del nuevo orbe* (History of the triumphs of our holy faith amongst the most barbarous and fierce peoples of the new world) (Pérez Ribas 1994, 1999, cited in Sheridan 1999:17). However, Spanish missionaries or the military did not establish direct contact with the Seri until the seventeenth century. At the time, Jesuit missionaries were able to baptize a few Seri who were lured by the provision of food when wild resources were scarce. Most of them showed no interest in anything about the Spanish missions other than their livestock. It didn't take long for the Seri to make a way of life by raiding newly arrived settlers' livestock. Conflicts became more continual and violent as the number of Spanish settlers increased and retaliated. Mass assassination of Seri male adults and deportation of women to places as far away as Guatemala, were only some of the Spanish policies to control the Seri (Sheridan 1999). As conflicts escalated, Spanish forces in Sonora proved

[5] For an in-depth analysis of the Seri-Spanish interactions between 1645-1803 refer to Sheridan (1999).

insufficient to control Seri, Yaqui and Mayo revolts, and internal conflicts between the Spanish crown and the Jesuits crippled the Seri mission program. Spanish and Seri relations broke down by the eighteenth century (Sheridan 1999).

It became clear to Spanish officials, that if they wanted to be able to confront the Apaches and expand the Northern frontier, they would first have to control and defeat internal Indian foes. Seri extermination became a priority for the Northern provinces of New Spain. Military campaigns were especially intense between the 1740s and 1771, and would last several decades into the eighteenth century (Sheridan 1999). Spanish military forces, old world diseases and the contraction of their territory seriously decimated Seri population. Seri managed to survive by taking refuge in their most formidable bastion: Tiburon Island. Presumably, distinctions among the different Seri bands slowly collapsed in this epoch (Sheridan, 1999:460). Needless to say, the loss of these distinct groups must have caused significant cultural losses.

The Spanish offensive against the Seri people, ceased at the end of the eighteenth century. Spain was at war with Britain (English ships entered the Gulf of California), and Mexican *Criollos* and *Mestizos* started the fight for independence from Spain.

After Mexican Independence (1810), inhabitants of the Republic settled along the borders of Seri territory. For the Seri, resources were available again and petty raiding of livestock resumed (Felger and Moser 1985:13).

Pascual Encinas, owner of the *Costa Rica* ranch, precipitated the bloodiest confrontation with the Seri of the nineteenth century. The conflicts, known as the

'Encinas Wars', lasted from 1855 to the late 1860s (Felger and Moser 1985:14). Encinas men killed about half of the Seri population (McGee 1898:113 cited in Felger and Moser 1985:14). Violence between the Mexican ranchers and the Seri continued until the 1920s (Bourillón 2002). Some thought it was a matter of time before the Comcáac people disappeared (Sheridan 1999:462).

2.2 RECENT HISTORY (1900-2000)[6]

Twentieth century Seri history is characterized by the adaptability and resilient capacity of the Comcáac. Their ability to cope with changing times and resources has continued to be their most successful survival strategy.

At the turn of the century, most of the Seri lived, hunted, and gathered on Tiburon Island and the nearby coast. Scholars agree that besides the reduction of their territory and the disappearance of their social subdivisions (bands), their livelihood was very similar to precolonial times (Felger and Moser 1985; Sheridan 1999; Bowen 2000; Bourillón 2002).

In the early twentieth century, two important events profoundly influenced the pattern of interactions between Seri and outsiders (Bourillón 2002): These were the establishment of the Kino Bay Sportsman's Club in 1926, and the beginning of Seri participation in commercial fishing in 1927.

The Club was popular among American businessmen, who found plenty of game and fish (and most likely drinking) opportunities at the time of Prohibition in the U.S.

(Felger and Moser 1985; Bourillón 2002). The Seri who had established their wintering fishing camps near *Bahia de Kino* started interacting with American tourists, who offered them food, clothing and all sorts of trinkets (Spicer 1962:115). Soon the Seri added this new resource to their wide range of subsistence strategies, and became frequent visitors of the outskirts of the Club (Bourillón 2002).

Seri participation in commercial fishing activities[7] began around 1927 as the result of the governmental support for fisheries development that started in 1920[8] (Villa Arce 1996) and was influenced by the boom of the Totoaba *(Totoaba macdonaldi)*[9] fishery in the Northern Gulf of California.[10]

According to Bourillón (2002), Roberto Thomson Encinas[11] was the first fish buyer to have contact with the Seri. Soon, the plentiful fish resources attracted other buyers and Mexican fishermen from Sonora and Sinaloa (Munro 1994 cited in Cudney-Bueno 2000:23). The Seri spent more time in Kino and semi-permanent fishing camps along the coast as their participation in the fishery increased. This was also the beginning

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[6] For a detailed account of general Seri historic events between 1990 and 2000 refer to Bourillón (2002).

[7] Most of the summary of this historic period is based on the dissertation work of Bourillón (2002), which in turn relied mostly in the field notes, booklets, and newspaper clips collected and written by the anthropologist William N. Smith II, on file at the Special Collections Library of the University of Arizona, Tucson.

[8] From 1920-1950 the Mexican government promoted fisheries development by enacting (socially conscious) fisheries legislation and supporting cooperative development (Villa Arce 1996:11).

[9] The totoaba is the largest member of the Sciaenidae (sea bass) family. It was exploited mainly for its swim bladder; a delicacy in Asiatic cultures. This fishery was responsible for the establishment of the northern gulf fishing villages of: Golfo de Santa Clara, Puerto Peñasco, and San Felipe (Berdegué 1955, cited in Flanagan and Hendrickson 1976).

[10] According to Bourillón (2002) the fishery started in the region South of Guaymas around 1910.

[11] Roberto Thomson Encinas was the nephew of Pascual Encinas, who years earlier almost exterminated the Seri people.

of an increasingly fast process of acculturation for the tribe. *Bahia de Kino* kept attracting Mexican fishermen and the Seri were rapidly outnumbered. Bourillón (2002) believes that the Seri would have disappeared as a cultural entity if the Seri fishing cooperative[12] had not been moved to *El Desemboque)*[3] Around 1940 most of the Seri left *Bahia de Kino* for *El Desemboque* and the first permanent Seri settlement was born. For several years *El Desemboque* continued to grow due to fishing activities, which may have peaked during the Second World War. During the war, fisheries of the Gulf of California played an important role in supplying fish to the US market, and fishing pressure skyrocketed like never before. The world demand to produce vitamin A from shark oil peaked during this time (Alcalá Moya 1999:61). At the end of the 1940s it became possible to synthesize vitamin A and the demand for shark liver ceased. The Seri economy had to rely, one more time, in the exchange of goods and clothing with outsiders, mainly American tourists.

The 1950s were characterized by the appearance of different religious groups trying to gain converts among the Seri people, and the cessation of the traditional Seri religion, based mostly on the vision quest and shamanism (Felger and Moser 1985:17).

Three religious groups were most important according to Bourillón (2002): (1) The Wycliffe Bible Translators operating in Mexico under the name of Summer Institute of Linguistics, (2)...the American Friends Service Committee (A.F.S.C.) operating in

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[12] The official name of the Seri fishing cooperative is "*Sociedad Cooperativa de Pescadores de la Tribu Seri, S.C.L.*". It started operations in 1938 in Kino Bay, before it was moved to *El Desemboque* a few years later (Bourillón 2002).

[13] *El Desemboque* or *Haxöl Ihoom* (Place of Clams) was an ancient Seri fishing Camp located more than 100 kilometers North of *Bahía de Kino* in the delta of the San Ignacio River.

Mexico as *Comité de la Sociedad de los* Amigos and (3) ... the Pentecostal Iglesia *Apostólica de la Fe en Jesus Cristo.* Although the activities of these groups were not directly related to Seri fisheries, they are significant in two ways. First, they permeated the Seri culture, surely influencing Seri worldview and their ancient relation with their environment in forms not yet understood. Second, they led to the establishment of the second permanent Seri village of *Punta Chueca.*[14] This occurred when a third of the Seri population, unhappy with the dominance of the Christian religious practices, decided to leave *El Desemboque* (Bourillón 2002). In the nineties, *Punta Chueca* would become the center of the tribe's economic and political activities.

The sixties saw the emergence of Seri artwork as a major source of income for the community. This economic development was triggered by the increase in American tourism[15] to the region and the decrease in fishing revenues. More than half of the adult population engaged in carving activities, and Seri artwork became highly regarded in international markets (Felger and Moser 1985).

In the 1970s, with the Mexican economic boom created by accelerated oil production, the federal government devoted considerable resources to develop small-scale fishing infrastructure. Many wharfs, jetties, roads, and ice plants were built in coastal communities to provide fishermen with means to increase their productivity, create regional development and a better quality of life (Lobato 1996). Unfortunately, the

[14] The village of Punta Chueca is located almost 90 kilometers South of *El Desemboque*, and 30 kilometers North of *Bahía de Kino.*

[15] American retirees started wintering in *Bahía de Kino* in the 1960s. Today 'snowbirds", constitute an important seasonal population of *Bahía de Kino* in terms of the number of people and resources that they bring to the area. They stay from October to March mainly living in RV motor homes.

government's paternalistic efforts failed to change the existing fishing practices, underdevelopment, and poverty. The failure was due to corruption, lack of governmental knowledge about small-scale fisheries and inefficient infrastructure design practices (Lobato 1996). However, most of the growth and development of small-scale fisheries in Mexico was achieved under this policy. Moreover, the State's strategy included a more holistic view of what fisheries development meant than the one imposed by the *neo-Hberalism* policies in the next decades (1980s -1990s) (Lobato, 1996).

The seventies are a paramount decade in Seri history, during this decade they obtained legal rights over: (1) a coastal portion of mainland, (2) Tiburon Island and (3) the fishing resources surrounding the Island. This legal recognition of their historic territorial rights brought great changes to the way they exploit their natural resources.

In 1970, the *ejido*[16] of *El Desemboque* and its annex of *Punta Chueca* were created by the Mexican President Luis Echeverria[17] who granted territorial rights to several of the smallest indigenous communities in Mexico, as a way to prevent their cultural extinction. In 1975 Tiburon Island was added to the Presidential decree. This added 120,756 hectares to the previous 91,322 hectares of communal land that the Seri already owned. Since 1963 Tiburon Island has been a Natural Reserve and Wildlife Refuge,[18] and in 1978 it was elevated to a Wildlife and Birds Migratory Refuge,[19] along with all the other islands of the Gulf of California. (Bourillón 2002).

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[16] *Ejido* is a form of communal land tenure

[17] The Presidential Decree was published in the *Diario Oficial de la Federación* (Federal Registrer) in November 28, 1970.

[18] Published on February 10, 1963 in the *Diario Oficial de la Federación* (Federal Register).

In 1975 exclusive fishing rights in the form of a fishing concession[20] were granted to the tribe. According to Bourillón (2002), the rationale to grant the Seri fishing rights was based on three points: (1) the dependence of Seri in fishing for their income, (2) the traditional use of marine areas adjacent to Tiburon Island and their mainland territory by Seri fishermen, and (3) the need to give preferential rights to Seri fishermen...to increase the possibilities for survival of the tribe, by minimizing competition with outside fishers. The fishing concession has provided the Seri with exclusion rights (Ostrom and Schlager 1996), which depending on the circumstances, they use to grant withdrawal rights (Ostrom and Schlager 1996) to non-Seri fishermen. As will be discussed later, this interaction pattern between Seri and non-Seri fishermen plays an important role in the local management of the *callo de hacha* (CDH) fishery.

According to several old Seri and non-Seri divers, the commercial exploitation of the Seri CDH fishery started in the Infiernillo Channel in the early 1970's. Fishermen from Sinaloa and southern Sonora were the first modern divers to fish in the Infiernillo Channel. Due to the relevance of the history of this fishery in this thesis, it is described in detail in Chapter 4.

The eighties and nineties were decades of economic, social and cultural transition for all of Mexican society including the Seri. Mexico followed the path dictated by structural adjustment programs of the World Bank (WB) and the International Monetary Fund (IMF). New federal policies required significant changes in the fishing industry in

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[19] Published on August 2, 1978 in the *Diario Oficial de la Federatión* (Federal Register).

[20] Published on February 11, 1975 in the *Diario Oficial de la Federatión* (Federal Register).

order to allow market forces to operate freely. Most of the state-owned enterprises were privatized, investment from the public sector was drastically reduced, and the cooperative's enabling legislation was modified (Lobato 1996).

At the beginning of the eighties, the public company *Productos Pesqueros Mexicanos* (Mexican Fishing Products), widely known as PROPEMEX, arrived at Seri territory. PROPEMEX activities invigorated Seri fisheries and they reemerged as an important source of income for the community.[21]

In the nineties, important changes in Seri small-scale fisheries took place. The beginning of the decade brought the prohibition of sea turtle hunting to the Seri community. The rapid depletion of global populations of sea turtles brought international attention to countries with sea turtle habitats (Cliffton et al. 1982). Mexico banned the pursuit, capture, and extraction of any species of sea turtle on beaches or federal waters.[22] This had serious repercussions in Seri culture. It is generally believed that sea turtle meat had been a major staple for the Seri people since ancestral times.[23] According to McGee (1898:214) it constituted the most important source of protein and probably accounted for 25% of the Seri diet.

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[21] PROPEMEX was created in 1971 by President Luis Echeverria (1970-1976). His successor Jose López Portillo (1976-1982), diversified its fishing fleet and used it to provide technical and infrastructure support to fishing cooperatives throughout the country, such as the Seri fishing cooperative. Today PROPEMEX has been almost entirely privatized (Lobato 1996:329).

[22] Published in the *Diario Oficial de la Federatión* (Federal Registrar) in May 31 of 1990 (cited in Nichols et al. 2000).

[23] This assertion is challenged by the archeologist Richard S. White, who believes that "Seri reliance on sea turtle as a major source of food is a historic rather than prehistoric phenomenon" (White 2000).

The Seri resorted to other fisheries throughout the nineties. Some were rapidly overexploited and only lasted a few seasons,[24] like the sea cucumber (*Isostichopus fuscus),* and murex snail *(Hexaplex spp.)* fisheries in the Infiemillo Channel. Others are practiced whenever a transient resource is available. These include fisheries for manta ray *(Dasyatis brevis, Gymnura marmorata, Mylobatis californica, Narcine entemedor, Rhinobatos productus, Urolophus* spp.), mullet *(Mugil cephalus, Mugil curema),* curvina *(Cynoscion* spp), shark *{Mustelus* spp., *Rhizoprionodon longuro, Squatina californica,)* and sierra *(Scomberomorus sierra* and *S. concolor).* Other marine resources such as clams *(Chione* spp, *Glycymeris* spp, *Laevicardium elatum),* mussels (*Modiolus capax)* and oysters (*Ostrea* spp) are only harvested occasionally for local consumption.

Today, the most important fisheries in the Infiemillo Channel are the *callo de hacha)* fishery *(Atrina tuberculosa* and *Pinna rugosa*[25]*)* and the *jaiba* (swimming crab) fishery (*Callinectes bellicosus* and *Callinectes arcuatus).* These fisheries provide employment to most Seri fishermen thoughout the year. In 1996 and 1997, most fishermen were involved in *jaiba* fishing activities (Bourillón 2002), but the number of fishermen involved in this fishery has been declining since then. At the time that this study was conducted (2000-2001), most of the fishermen in *Punta Chueca* were fishing for *callo.*

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[24] A season is a fishing period. It can be officially regulated or not, and its length varies depending on the fishing species. For example, the *jaiba* season is open 10 months per year.

[25] In total the Seri recognize 4 'ethnospecies' of *callo de hacha* in the Infiemillo Channel. *A. tuberculosa* and *P. rugosa* are the most common ones.

Two important events during the nineties helped the Seri to understand the importance of scientifically-based natural resources management: the legalization of bighorn sheep sport hunting in Tiburon Island and the emergence of the indigenous Zapatista movement promoting self-determination of Mexican ethnic communities. Bighorn sheep hunting generated revenue for the Seri community, giving the traditional (local) government financial independence from the Federal Government for the first time (Bourillón 2002). Continuous monitoring of the big horn sheep population to keep economic resources flowing towards the community became important to the Seri government. This control over a valuable resource plus the Zapatista movement reinvigorated the sense of pride and the importance of self-determination and natural resource ownership among the Seri. These events are indisputably influencing all aspects of Seri communal life, including their fisheries.

3 THEORETICAL FRAMEWORKS

3.1 COMMON PROPERTY RESOURCES

Throughout human history, resource users in general have designed and put into place a wide variety of property rights systems in order to secure their interests, organize production, and exploit their natural resources. Independently of the scale of interest (local, national or global), the nature and structure of property rights systems have a relevant role in the shape and evolution of cultures and human societies. Moreover, their study is providing useful analytical tools and theoretical bases to understand the outcomes of the interaction between man and their environment. For these and many other reasons this matter has been of interest to academics, policy-makers, and resource managers, among others.

Gordon (1954) and Scott (1955) are regarded as the precursors of the common vs. private property debate. As fishery economists, they were worried about rent dissipation in the fisheries. Not much later, Hardin (1968) argued for the need of social change to avoid resource depletion, overpopulation, and air and water pollution. His paper brought property rights systems to the limelight, by using a theoretical example of the overexploitation of commons grazing grounds. In it, each herder -acting in a rational fashion and looking after their own self interested benefits, added a few animals to their herds as a way to take advantage of the available-to-all-pasture until the resource was gone, and no more pasture was available to anybody. Since then, situations such as this one, where undesired outputs result from the absence of clearly defined property rights,

have been labeled as "the tragedy of the commons", in reference to the title of Hardin's famous article. This model had great resonance among scholars and policy-makers from all over the world, leading them to rationalize that solutions have to be imposed on users by external authorities, and that central government control or privatization of all common property resources was necessary to avoid their overexploitation. However, there is extensive evidence that not all natural resource exploitation cases fall into this category and a vast number of case studies on the study of self-crafted governance systems are available in the literature (McCay and Acheson 1987; Berkes 1989; Ostrom 1990; Bromley 1991; Blomquist 1992).

Today property rights regimes are divided into four basic analytic categories. As presented by Fenny et al. (1990), they consist of: (1) *open access regimes,* which refer to settings where there are no well-defined property rights in place, and the resource is open and unregulated for anyone's use. (2) *Private property regimes,* which exist where the right to exclude other users from extracting units from the resource, as to determine the degree of use or exploitation is determined by the holder of the right, either an individual, group or corporation. (3) *Common property regimes* are in place when a resource is held by an identifiable group of people, such as a community. Members of the community are able to exclude non-members from the extraction of the common pool resource (CPR), and usually regulate extraction of the CPR among them. Finally, (4) in *state property* or a state governance, rights to the resource and decisions on who, and how can the resource be exploited, are made by the government.

In light of these distinctions, it is clear that Hardin's example of the herders' common grazing grounds, was referring to an open access regime and not to a common property system, as some people are still mislead. Therefore, it is very unfortunate that he labeled his metaphor as "the tragedy of the commons". The point here, however, is that Hardin illustrated a very pessimistic and disempowering vision of humans as collective actors, where users are hopelessly trapped in a situation that they cannot change (Ostrom et al. 1999).

Although it is certain that overexploitation of CPR's has occurred, the surmounting body of research in the subject [see bibliographic compilations by Martin (1989, 1992) and Hess (1996, 1999[26])], had also shown that it is obvious that for thousands of years people have been able to self organize and achieve sustainable management of their CPR's. In other words, cases where self-organization has failed, and those where successful management has occurred do not constitute opposites but two halves of the same theoretical explanation.

In the last decade, there have been major advances in the analysis and understanding of the formation and evolution of property rights systems (Ostrom 2000, 2001). There is growing consensus that self-governed sustainable systems are characterized by most or all of the elements or conditions that allow them to adapt to new situations and manage their resources successfully over time. These so-called 'design principles' do not constitute a set of rules or blueprint that can be used to create effective local institutions as some analysts have come to believe. They are a set of conditions that

allow CPR appropriators to design, adapt and maintain rules to manage and exploit their resources in a sustainable manner, and according to Ostrom (2001) they are:

1. *Clearly defined boundaries and rightful users of the common pool resource.*
2. *Restrictions to time, place, technology, and quantity or resource units are related to local conditions.*
3. *Users can communicate and organize to create and modify their operational rules.*
4. *Monitors of the resource are the appropriators themselves.*
5. *Conflict resolution mechanisms exist.*
6. *There is minimal recognition [from outside authorities] of rights to organize.*
7. *Graduated sanctions to rules breakers are in place depending on the seriousness and context of the offense.*

Laboratory and field research continues to be conducted to test and better understand the applicability of the design principles, as to solve remaining 'theoretical puzzles.' However, it is clear that for successful sustainable self-governed systems to exist, appropriators need to be involved in the design of the regulations that affect their use of CPRs and ultimately of their livelihoods. To craft such rules, users will necessarily draw on their cultural endowment and knowledge of the resource and the physical environment in which they are embedded (Ostrom 2001).

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[26] In 1999 the data base contained more than 22,000 cases and it is being updated on a yearly basis.

3.2 TRADITIONAL ECOLOGICAL KNOWLEDGE[27]

As defined by Berkes (1999:8) traditional ecological knowledge (TEK) is *a cumulative body of knowledge, practice, and belief, evolving by adoptive processes and handled down through generations by cultural transmission and with their environment.* The intellectual roots of TEK are based in two different approaches: ethnoscience and human ecology.

Ethnoscience emerged from ethnologists' and linguists' interests in folk taxonomies, ethnobotanical and ethnozoological classifications, of plants and animals, as a way to be able to describe cultures from the inside. It is based in the assumption that the existence of a word to name a concept is the most reliable indication that the concept exists in that culture (Berkes 1999:37).

The study of systems of classification (folk taxonomies) (Murray 1982) provided insight to the long-standing debate in biosystematics about the concept of species. By studying non-western, indigenous systems of classification, it became possible to test whether species consisted in real units in nature or fictional mental constructs (Gould 1980). As studies have emerged and provided evidence of the similarities between folk systems and the Linnaean system of classification, the field has gained recognition and scientists began to accept the validity of folk science.

Human ecology (also known as cultural ecology) is mainly interested in the relationships between humans and natural processes, including animals, plants, and the

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[27] This section heavily relies in the work of Berkes (1999).

environment. The field had its origin in the work of Steward (1936) on the social organization of hunter-gatherer groups. Steward argued against environmental determinism, which regarded specific cultural characteristics as arising from environmental causes. Using band societies as examples, he showed that social organization itself corresponded to a kind of ecological adaptation of a human group to its environment. He defined cultural ecology as the study of adaptive processes by which the nature of society and an unpredictable number of features of culture are affected by the basic adjustment through which humans utilize a given environment (Steward 1936 cited in Berkes 1999:47).

Much work in classical human ecology was concerned with territoriality and land tenure systems in a diversity of cultural groups and geographic areas. Territoriality is considered a behavioral self-regulatory mechanism, and variations in resource control patterns have been explained by the use of economic and ecological models. However, since the 1980s, those emphasizing property rights and institutions have largely replaced territoriality-based analyses, as analysts have increasingly recognized the role that culture and society have in territoriality (Berkes 1999:51).

According to Berkes (1999:52) one of the major areas of study in human ecology of recent years is the integration of resource management and social systems. The book by Williams and Hunn (1982), dealing mainly with indigenous groups of the Pacific Northwest of the United States and Australia, is one of the earlier examples of the study of comparative cultural ecology and resource management. Over the past twenty years a large body of literature on traditional management has revealed deep and rich local

knowledge systems on which folk management is based, helping to revolutionize current management thinking (Johannes 1978; Klee 1980; Ruddle and Johannes 1990; Freeman et al. 1991; Ruddle 1994; Berkes and Folke 1998).

Such studies have spawned research for alternative resource management systems using more holistic, ecosystem based approaches, and adaptive systems based on local knowledge and practice. The rediscovery of ecosystem-like concepts among traditional cultures in many parts of the world was an important stepping-stone in the appreciation by ecologists of traditional holistic understandings of nature.

Today, one of the major lines of inquiry in TEK concerns cosmologies and worldviews. People's view of the universe and the world is structured through their own cosmology. According to Berkes (1999:53) some of the questions being raised today are: "Are traditional worldviews relevant to present-day resource stewardship, and to the reexamination of our current attitudes toward the environment?

The study of worldviews can be seen as the organizing concept behind the cultural ecology of a group. The logic of many traditional management systems would be difficult if this understanding is lacking. In other words context is key in the analysis of traditional ecological knowledge.

PART II: COMMUNITY BASED MANAGEMENT OF THE CDH FISHERY

Introduction

This part focuses in describing and analyzing the main ecological and social mechanisms of the community-based regime that manages the CDH fishery.

Chapter 4 provides important background information for the part. It reviews the first diving fisheries in the Gulf of California to put in context the importance of diving fisheries in the region. Most of this chapter however, describes the development of diving fisheries in Seri territory. The beginning stages of the commercial exploitation of the fishery are described, including names of pioneer fishers, first fishing sites and species, harvesting techniques, and the fishing process in general, as remembered by the fishermen interviewed.

Chapter 5 is a natural continuation of the previous chapter. It consists of an ethnographic account of the inner workings of the Seri CDH fishing process when at the sea and ashore as observed between 2000 and 2001. The last two sections of the chapter focus on the role that local market forces play in the fishery dynamics.

Chapter 6 looks at the social context and local institutions under which communal management of the CDH fishery exists. Since the CDH fishery takes place entirely in the Seri exclusive fishing zone, at the core of this chapter is the analysis of the mechanisms in place to control access. The Institutional Analysis and Development framework, developed by Ostrom and colleagues, aided the identification of different social patterns of interaction that result from the array of rules and norms under which local actors

behave. The results allowed the identification of a universe of strategies under which exclusion is achieved for the most part. The performance of the Seri exclusive fishing zone as a management strategy is therefore assessed.

Finally, Chapter 7 identifies and analyzes some the most important ecological elements that contribute to the viability of the fishery, while validating how these elements have been integrated to local management through ecologic traditional knowledge. Ecological and ethnographic methodologies are used to analyze the data. The results outline a well-endowed natural system. Linkages between the natural and social system provide important feedback loops between them, that influences decision making about the resource. At a systems level, a management regime embedded into the local ecological conditions is portrayed.

General Methodology

Data were recorded during 32 fishing trips conducted between June of 2000 and June of 2001. Socio-cultural, ecological, and biological data relevant to the CDH fishery were recorded, collected during each outing.

Table 2 shows the diverse information collected during each outing.

Table 2. Type of data collected during the fishing trips.

Type	Datum
Socio-economic	• Name & home town of all *pangas*[28] in the surroundings. • Number & home town of crewmembers on host *panga*. • Number & home town of crewmembers aboard all *pangas* in the surroundings. • Maximum number of *pangas* fishing in the area. • Ethnic origin of the owner of the *panga*.
CDH Ecology	• Species captured. • Sex. • Sexual maturity. • Maximum shell length. • Maximum diameter of the scallop meat (abductor muscle).
Geographic	• Fishing location (latitude and longitude coordinates using a GPS, and Seri and Mexican name).

The ethnographic methods used to collect the socio-economic data described below are relevant to all chapters of this section. The methods used to collect biologic and ecologic data are described only on Chapter 7.

Ethnographic Methods

Data collection was based on participant observation fieldwork using observation, informal interviewing and unstructured interviews involving 48-56 fishermen constituting -70-80% of all CDH fishers operating in the Infiernillo Channel at the time. The fishermen interviewed included: (1) Seri, (2) non-Seri living in the Seri community and (3) non-Seri fishermen visiting from nearby towns. In addition, twelve in-depth semi-structured interviews were conducted with key informants.

Participant observation combines involvement in the lives of the people under study while maintaining a professional distance that allows adequate observation and recording of data (Fetterman 1998). Informal interviewing is characterized by a lack of structure or control. The researcher just tries to remember conversations heard during the course of a day (Bernard 1995). Unstructured interviews are based on a clear plan that the researcher keeps constantly in mind, but with a minimum of controls over the informant's responses. It allows people to open up and express themselves in their own terms and at their own pace (Bernard 1995). Semi-structured interviews are based on a list of questions or topics that need to be covered in a particular order (Bernard 1995).

The documentation of the structure of the fishery was done by direct observation during fishing trips and interviews. The factors assessed were: length of the fishing season, size of the fishing fleet, use of fishing gear, conformation of fishing crew,

[28] A panga is a small fiberglass outboard motor boat typically used for small-scale fishing operations in the Gulf of California, Mexico.

selection of fishing times and diving locations, diving techniques, primary processing of the catch, and interactions with the local fish buyer.

Depending on the person and the suitability of the occasion, the informal interviews were conducted either during fishing trips, at the community, during community gatherings, celebrations, or at the fishermen's home. Whenever possible, non-Seri fishermen who came from towns nearby such as *Bahia de Kino,* were interviewed at their village, as they felt they could better express their opinions at home.

Once the most knowledgeable, experienced, and influential fishermen were identified, in-depth semi-structured interviews were conducted. All of these interviews were performed at the fishers' home, once all fishing operations had ended, generally at early evening. This time proved to be best as fishermen were willing to talk for long periods of time. These interviews were recorded (or not, at the interviewee's desire) and transcribed. The transcriptions were handed back to the interviewees for their revision and further clarification of important points. All conversations and interviews with Seri fishermen were conducted in Spanish.

An effort was made to take advantage of every available opportunity to gain trust, rapport, and a better understanding of the Comcáac way of life and daily fishing operations. Volunteering to work as part of the crew during fishing trips was very useful to learn the subtleties of the fishing operation and create social capital with the fishing community. Frequent participation in fishing activities included steering the boat, anchoring it, diving, helping with the primary processing of the catch, and cleaning the boat. For part of the summer fieldwork session and all of the winter and spring sessions,

residence was established at the Seri community. This allowed me to immerse myself in communal life. When not at sea, time was generally spent visiting Seri families, friends, and fishermen. Numerous evenings were spent sitting at home porches talking and drinking coffee. As a way to give back to the community and strengthen trust and reciprocity ties, as many favors as was reasonable to do were carried out. Purchases from the United States including clothing, kitchen supplies, diving gear, camping gear and wood-working tools were repeatedly brought to Seri families. Rides were commonly provided back and forth between *Punta Chueca* and *Bahia de Kino* to take someone to the doctor, or the fish market. Also, during times of scarcity of drinking water, propane gas, gasoline and medical supplies, fishermen and community members relied on my assistance to bring these items to the village. With most Seri fishermen I was able to establish an exchange relationship based in favors and services, rather than money, as is more typical between outsiders and the Seri.

4 HISTORY OF DIVING FISHERIES IN SERI TERRITORY

4.1 THE FIRST DIVING FISHERIES IN THE GULF OF CALIFORNIA

"In the study of the economic phases of Spanish expansion in the Americas, one of the themes that has been passed over lightly is that of the pearl fisheries... they played an important role in the exploration of the new world" (Mosk, 1927:1).

After the conquest of the Aztec empire by Hernán Cortez, rumors and legends about the existence of richer empires, vaster lands, and infinite abundance of natural resources flourished. The legend of *Las Sergas de Esplandián* (The Exploits of Esplandián), described a great island of gold and pearls inhabited only by women known as "Amazons." The island was called "California", and was situated somewhere west of the North American continent (Bowen, 2000:34).

Between 1532 and 1535 Hernán Cortez launched 3 expeditions in search of the famous island of "California" and its enormous wealth of pearls. After two failed attempts, Cortez landed in Bahia La Paz in 1535 and named it *Santa Cruz*[29] However, he was unable to establish a permanent settlement due to the lack of provisions (water) and abundance of hostile natives. Very few pearls were found and the first expeditions were called a failure. However, the search for pearls fueled the exploration of the Gulf of California and the Northern frontier. By collecting one-fifth (the Royal Fifth) of the proceeds from pearl fishing licenses, the Spanish Crown was able to finance a big portion

[29] Located where the modern city of La Paz was later funded. La Paz is the capital city of the State of Baja California Sur.

of the colonization and occupation of northwest Mexico in the following centuries (Mosk, 1927; Cariño 1996:109).

In the 1600s, "Negroes" were brought from the Caribbean Islands and the Pearl Coast of Venezuela to harvest pearls in Baja California (Donkin 1998:331). It is not clear if they were Lucayan Indians[30] from the Bahamas or African slaves[31] (Romero et al. 1999). However it is known that later it was mainly Yaqui Indians who did the diving (Bowen 2000). The divers would harvest the pearl oysters by free diving in shallow areas. According to a report about the pearl fishery in Baja California, prepared by José Maria Esteva (1865), the *armadores* (petty entrepreneurs) diving forces ranged from 8 to 80 divers, depending on the size and operational capital of the enterprise. Each *armador* owned several canoes to do the fishing, and a couple of mother ships to transport food and the harvest between the fishing camps and the city port of *La Paz.* The fishery took place during the warmest months in the Gulf of California, from July to late September or early October. Daily activities would start at 7 or 8 AM to take advantage of clear and calm waters.[32] Once the canoes had found a pearl oyster bed divers would work intermittently until noon. According to Esteva (1865), divers could hold their breath for

[30] The Lucayan people were initially used for the exploitation of pearl fisheries because they were easily slaved and were great swimmers and divers. Since they were used to diving for conchs *(Strombus* spp), they could dive 30 meters or more (Romero et al 1999:62).

[31] In 1558 a Royal Decree prohibited the use of native people for the exploitation of pearl fisheries, stating that only Africans could be used. This Decree was prompted when the relationships between natives and Spaniards deteriorated to a point that missionary efforts were threatened (Galtsoff 1950 cited in Romero et al 1999:62).

[32] Masks were not available for everybody at the time.

as much as 2 minutes, reaching depths of 8 to 16 meters.[33] However, they would be able to reach up to 30 meters once they had ruptured their eardrums.[34]

The payment to the diver consisted of the pearls that he found in his share of the oysters he caught, after splitting the catch with the *armador.* Most of the time divers were in debt with the *armadores.* The money from selling their pearls was usually not enough to settle the cost of the food, which the *armador* had provided during the fishing season. In order to pay their debts divers had to work for the same *armador* the next season (Esteva 1865). It is surprising how similar this situation is to the way in which fishermen and fish buyers relate in present times.

By 1870 the most accessible (shallow) pearl oyster beds had been seriously depleted,[35] and it became necessary to use diving suits (Mosk 1927:228). In 1874 the first diving suits were introduced. An Italian diver named Bosi and an American named Clarte, were the first divers to exploit pearl oyster beds at 20 to 30 m depths. (Cariño 1996:116,117). This technological change allowed the systematic exploitation of shallow and deep pearl beds throughout the year. A fishing crew consisted of the diver, a *cabo de vida* (air hose caretaker), someone in charge of retrieving the shell bag, two responsible for pumping air and two for rowing the canoe.

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[33] According to Esteva (1865) the divers in Baja California didn't use any rocks as weights to reach the bottom, as the first pearl divers use to do it in Venezuela and the Caribbean (Romero et al. 1999).

[34] The English explorer, R.W.H. Hardy (1829), described his first diving experience as follows " …at the depth of six or seven fathoms, I felt a sensation in my ears like that produced by the explosion of a gun; at the same moment I lost all sense of pain, and afterwards reached the bottom…On the surface…I became sensible of what had happened to my ears, eyes, and mouth; I was literally bleeding from each of these, though wholly unconscious of it…"

The inability of fishers, state, and federal government to organize, regulate, and monitor the exploitation of the oyster pearl fisheries resulted in a generalized overexploitation of their populations in the Gulf of California. The fishery entered the twentieth century in evident decline and its exploitation came to a final end around 1940 (Cariño 1996:128).

4.2 COMCAAC DIVING FISHERIES

The first diving fisheries in Seri territory probably took place sometime in the 1720s. At that time, pearl beds[36] were discovered along the Sonoran coast extending northward from *Cabo Tepopa* to just north of Tiburon Island. These pearl oyster beds became known as the *San Xavier* or *Tepoca* placers (Stratford [1746] 1958:62 cited in Bowen 2000:74). By 1733, the *Tepoca* placers were abandoned mainly due to constant conflicts with the Seri. In fact Mosk (1931, cited in Bowen 2000:74), states that pearl oyster beds were found in the Infiernillo Channel but "Seri hostility prevented their exploitation". Perhaps, nobody would have imagined that almost 400 years later, "Seri hostility" would continue to be a successful strategy to regulate access to Seri fisheries in the Infiernillo Channel.

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[35] This is likely to have been the first human caused ecologic disaster in the Gulf of California (Cariño 1996).

[36] The pearl oyster beds found in the central portion of the Gulf were of a different species than the ones found in the Southern portion. Initially the Spanish were looking for the *madre perla* (mother of pearl, *Pinctada margaritifera*), which they found in the South. Later they discovered the smaller *concha nácar* or *callo de árbol* (*Pteria sterna*) in the central portion of the Gulf, when a severe storm washed to the shore hundreds of pearl oysters (Bowen 2000:73).

4.2.1 Free Diving for *Callo de Hacha*[37]

There is general consensus that commercial exploitation of *callo de hacha* began around 1973. It is difficult to establish who was the first CDH buyer in the Infiernillo Channel. It is likely that those already involved in the exploitation of more important fish products, such as sea turtles, groupers, sea bass or sierra started buying small quantities of CDH, and increasingly did so as markets developed and other fish products became scarce. According to some divers, the first fish buyers to show particular interest in CDH were Sergio Padres from Guaymas and Mr. Barol from Hermosillo.[38] They brought *pangas*[39] and fishing crews from Sinaloa, Guaymas and the South of Sonora to free dive for CDH. Therefore the first divers to exploit CDH in the Infiernillo Channel were non-Seri fishermen. At the beginning, only the *callo Redondo o de hacha* (round or rugose pen shell, *Pinna rugosa)* was harvested.[40] The first areas to be exploited were the sand bars in front of the fishing camp of *El Almo* in *Sargento* Bay and *Viboras* estuary. At the time most *pangas* were made of wood and most outboard motors were 18, 25 or 40 Hp. Each fishing crew had two divers and a boatman. The divers would free dive to the bottom, extract the round pen shells with a specially designed hook, and then deposit the catch into a floating mesh bag. The bag was made from two long segments of old gill nets sown together, tied to the inner circumference of a tube from a truck tire to form the

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[37] The information presented here was obtained from 9 in-depth interviews with the oldest and most experienced diving fishermen in the community.

[38] Other fish buyers of the time were Pancho Laguna and Fidel Calderón, both from Guaymas.

[39] *Pangas* are outboard boats commonly used in small-scale fishing activities in the Gulf of California.

[40] It is likely that fishermen were unaware of the presence of the more inconspicuous tuberculate pen shell (*Atrina tuberculosa*).

bag's "mouth". This way the divers could pull the bag to wherever they were diving. Once the bag was full, the *panga* would approach and retrieve the pen shells. Two or three full bags filled up & *panga,* which then headed back to shore (around 10-12 AM). Initially the fishing fleet consisted of 5 or *6pangas* (around 12 fishermen).

Once ashore, each diver had to open and extract the muscle from 300 to 600 organisms, yielding between 18 to 20 Kg of meat. The total catch per fishing crew averaged 50 to 60 Kg. The price ranged between 14-18 pesos per kilogram. One or two people received the scallops and acted as liaisons with the fish buyers in the field. Their main duties were to weigh and record the catch of each fisherman for later payment. The product was usually shipped back to town every other day, but this could vary depending on the volume of *callo de hacha* harvested and the availability of ice.

Around noon, fishermen had finished their duties and could start to prepare their food. Provisions and water allowed fishermen to camp for about 15 days. However, they typically were only able to dive 5 to 7 days due to weather and sea current conditions. The rest of the month (-15 days) was spent with their families back at their hometowns, after traveling in Hermosillo or Guaymas to collect their payment from the fish buyer. Fishing for pen shells in the Infiernillo Channel took place only during the winter. In the summer the divers would work in agricultural fields or participate in a different fishery somewhere else.

Around 1978 the first bed *of callo riñón* (kidney pen shell, *Atrina tuberculosa)* was discovered. The bank was located between *Punta Chueca* village and the *Santa Rosa* estuary, so the fishermen moved their camps to *Punta Chueca*. Word of the abundance of

pen shells quickly spread to their hometowns and soon more divers arrived in the Infiernillo Channel. An average of 20-25 non-Seri divers camped in *Punta Chueca.* One fish buyer of the time was Mr. Orta from Huatabampo Sinaloa. Some fishermen remember him fondly because he used to pay his divers on time with cash. He received between 400 and 600 Kg of CDH every day and the price ranged between 25 to 28 pesos per kilogram. Fishermen recall that:

... "habia tanto producto que los buzos podia sacar 20 kg y todavia tenian la energia para bucear otra vez y sacar 20 kg más!... El negocio era tan bueno que los compradores nos pagaban el pasaje y aun entonces si el precio del callo no era bueno no nos veniamos hasta que lo hubieran subido" ...

..." product *[callo de hacha]* was so abundant that divers would harvest 20 kg so fast and easily that they would still have the energy to dive back and bring up 20 Kg more!... The business was so profitable that fish buyers would pay for our transportation costs [to and from their hometowns in Sinaloa] and even then if the [CDH] price was not good we would not travel until they had raised it" (Interview # 3).

Today the CDH price ranges between 160-250 pesos per kilogram and a harvest of 20 Kg of CDH is considered a good catch. The catch of all fishers ranges between 100 to 500 Kg every day according to the fish buyer that receives 70-80% of the Infiernillo Channel's catch.

4.2.2 The Influence of PROPEMEX

In 1980 the Federal public fishing company *Productos Pesqueros Mexicanos* (PROPEMEX) arrived in Seri territory to reinvigorate its fishing activities. It built fish warehouses in *Punta Chueca* and *El Desemboque* and provided employment and new fishing gear (including more than 25 new fiberglass *pangas)* to the Seri and most of the fishermen from Sinaloa and Sonora already working in the area. Fishermen state that there was so much fish in the Infiemillo Channel that the *Punta Chueca* warehouse filled up with fish harvested exclusively there. Fishers recall that:

... *"no habia que salir lejosparapescar"*...

"there was no need to go out far to fish" (Interview #2).

During the presence of PROPEMEX in the Infiemillo Channel (1980-1984), CDH fishing activities practically came to a halt. Most CDH fishermen were working for PROPEMEX in one way or another. Nevertheless, PROPEMEX inadvertently shaped the future of the Seri CDH fishery in two ways, greatly determining its present structure. (1) When PROPEMEX stopped operations in the Infiemillo Channel, due to economic inefficiency and fish scarcity, PROPEMEX's *pangas* were handed to the Seri fishing cooperative to settle existing debts. This way many Seri fishermen, who had no means to buy a *panga,* were able to eventually participate in diving fisheries. (2) PROPEMEX attracted and provided steady employment to non-Seri fishermen, allowing some of them to become part of the Seri community (mostly through inter-ethnic marriage). Although throughout Seri history inter-ethnic marriages had always taken place, it is likely that

they became more common after PROPEMEX left Seri territory (See Table 3). Mexican fishermen were well aware of the richness of the Infiernillo Channel fishing grounds, and the potential personal benefits of the recognition of Seri territorial rights in the 1970s. Even Seri rejection, resentment and discrimination toward the *cocsar* (Seri for non-Indian Mexicans) living in *Punta Chueca,* was not enough to drive all of them away.[41]

This situation has been important in the emergence and design of the wide array of rights and rules under which the fishery operates today, as some rules only apply to non-Seri and *mestizos* (descendants of Seri and non-Seri parents) living in the Seri community.

Table 3. Non-Seri men living in *Punta Chueca* village

#	Town of origin	Prior occupation[a]	Current Occupation[b]	Relatinoship with Seri kinship
1	Kino, Sonora	Fisherman	CDH diver	Wife is Seri
2	Unknown	Army soldier	Storekeeper	Wife is Seri
3	Sinaloa	Student	CDH diver	Wife is Seri
4	Sinaloa	Student	CDH diver	Wife is Seri/ mestiza. Mother in law is Seri
5	Unknown	Army soldier	CDH diver	Wife is Seri
6	Unknown	Welder	Welder/fisherman	Wife is Seri
7	Monterrey, Nuevo Leon	Unknown	Fisherman	Wife is Seri
8	Kino, Sonora	Craftsman	Fisherman	Wife is Seri
9	Unknown	Building laborer	Building laborer/fisherman	Wife is Seri
10	Agiabampo, Sonora	Diver	CDH Diver	None
11	Kino, Sonora	Diver/Fisherman	CDH	Daughter married a Seri

[41] This situation does not hold true to the *cocsar* living at *El Desemboque* village.

			Diver/Fisherman	mestizo
12	*Punta Chueca*	NA	CDH Diver/Fisherman	Brothers married to Seri and mestizo women. Fluent in Seri language
13	Sinaloa	Diver/Fisherman	CDH Diver	Sons are married to Seri and mestizo women
14	Unknown	Unknown	Fisherman	None
15	Sinaloa	Peasant	CDH Diver	Brothers married to Seri and mestizo women
16	Kino Sonora	Diver/Fisherman	CDH Diver	Sister married to Seri mestizo
17	Kino Sonora	Diver/Fisherman	CDH Diver	Sister married to Seri mestizo

a. Occupation or trade before becoming part of the Seri community.

b. Occupation or trade after becoming part of the Seri community.

4.2.3 Use of Hookah Setups

Small-scale hookah diving fisheries, in which on board compressors provide air to divers underwater, began in the late 1960s and early 1970's, at the fishing town of *Bahia de Kino* (Cudney-Bueno 2000:41; A.H. Weaver, Kino fisheries researcher, personal comm. 2000). By the mid-seventies they were widely used in Sonora and Sinaloa. However, in Seri territory they were not used until the end of the 1970s.

Two Seri families, one in each Seri village, are regarded as the first to have dived using hookah setups. Members of the Morales Blanco family, Jesus Morales Colosio and his sons, Ramon, Arturo and Roberto, brought the first hookah rig to *Punta Chueca,* while the Astorga Flores brothers, Gonzalo, Santiago and Rosalio, were the first to own

one in *El Desemboque.* Alfredo Monroy* and Alfonso Mendes are also thought to have been among the first Seri hookah divers.

Ramon, Arturo, and Roberto Morales Blanco were taught to dive by their father, Jesus Morales Colosio, who was an accomplished free diver. He, in turn, learned to dive from working with the divers from Sinaloa and Guaymas, who were free diving in the Infiernillo Channel since 1973. In 1977 they bought a hookah setup[42] with the help of their uncle Efrain Estrella Romero, then President of the fishing cooperative. The hookah setup cost 25 pesos.[43] Although they mostly dived for round *callo de hacha {Pinna rugosa)* in the Channel, they also harvested *callo de escarlopa* (rock scallops, *Spondylus calcifer)* in an area locally known as El Jamoncillo, in the North mouth of the Infiernillo Channel.

About the same time, the Astorga Flores brothers also started to dive using an air compressor in *El Desemboque.* They had been recently taught to dive by Marco Antonio Luján, a fisheries technician from Hermosillo and friend of Santiago Astorga. They got the hookah setup from Fidel Calderon a fish buyer from *Bahia de Kino.* They paid him for the diving compressor with their diving catches. The Astorga Flores brothers mainly dived for rock scallops[44] and *pulpo* (octopus, *Octopus* spp). They mounted the hookah to the *panga Amalia* owned by Adolfo Burgos (who later became a diver too) and explored

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[42] The hookah rigs of the time were very similar to those that are used today (see following section for detailed description).

[43] It included the compressor, gasoline motor, 2 sets of hoses, 2 first stage breathers, 2 neoprene wetsuits and 2 pairs of fins (see Table 4 for a description of the CDH diving gear).

[44] As in *El Desemboque*, this species was the "initial catalyst" for the development of small-scale hookah fisheries in the Northern Gulf of California (Cudney-Bueno 2000).

and dived around Tiburon Island (mainly the South, West and North side) and Patos Island. They also frequently dived in front of *El Desemboque* village and in areas nearby known as *Las Estacas, Las Aguitas, Las Cuevitas* (North of *El Desemboque), El Mogote, Mancha Blanca, Piedra Colorada* and *Sargento* (South of *El Desemboque).*

As rock scallops became scarce and markets for benthic resources expanded in the region, the increasing number of divers diversified to other species such as *caracol de uña* (giant eastern Pacific conch, *Strombus* spp), *caracol chino* (black murex, *Hexaples* spp), *callo de arbol* or *concha nacar* (western wing pearl oyster, *Pteria sterna), langosta* (spiny lobster, *Panulirus* spp) and *callo redondo y riñón* (round and kidney sea pen shells, *Atrina tuberculosa, Pinna rugosa)* (Brusca 1980). On a regional scale, the availability of hookah setups in the 1980s led to the first boom of benthic resources exploitation in the Gulf of California during the 1980s since the zenith of the pearl fisheries in the 1870s.

Nevertheless, it was not until the mid-eighties that the use of hookah equipment became widespread among Seri fishermen (Chenaut 1985). The abundance of other more profitable fishing resources (or other sources of income in the community) for the Seri delayed their entrance into diving fisheries. Moreover this activity was widely regarded as dangerous and physically demanding, and required a sizable upfront investment to equip the boat. However, when PROPEMEX ended operations in the Infiernillo Channel in 1984, after 5 years of intense exploitation of the Channel's fish stocks, the Seri resorted to previously underexploited resources such as the benthic species. By the end

of the 1980s the wide array of Seri benthic fisheries started to narrow, and fishing pressure started to focus on the CDH.

Since the early 1990s the CDH fishery has been the most important benthic resource for the Seri. The decrease in the diversity of fish and benthic resources harvested by the Seri is not solely explained by the overexploitation crisis that is affecting most regional fisheries. It is also related to an increase in competition and conflicts with divers from nearby towns, which have effectively reduced their fishing grounds. Progressively, the Seri have limited their fishing activities to those areas of their fishing concession where they can control access (Bourillón 2002). The Infiernillo Channel is such an area, and since CDH are still very abundant (and the price and demand are high), it has proven economically viable for most fishermen to switch to this fishery.

5 NATURAL HISTORY OF THE MODERN CDH FISHERY (2000-2001)

The following is an ethnographic account of the current structure of the CDH fishery.

5.1 THE FISHING SEASON

There are no official openings and closures for the *callo de hacha* fishing season. This fishery does not figure among the few that are regulated by the Mexican law. Its length (and therefore the degree of fishing effort) is solely regulated by regional market forces, local economic alternatives, Seri communal rules, and the ecologic characteristics of the Infiernillo Channel. In the last few years CDH fishing activities occurred all year. This was possible due to a stable year-round national demand,[45] high market prices, and because of the Infiernillo Channel's abundance of CDH. Currently, the Infiernillo Channel is the only fishing ground able to supply CDH to fish buyers all year, as all other CDH banks in the Midriff Island Region have been overfished. Fishing effort and production output varies throughout the year. Generally, it is most intensive between October and June, while between June and October the fishing effort tends to decrease as other economic alternatives become available during that time (i.e. *Jaiba* and shrimp fishery).

[45] Along with oysters (*Ostrea* spp), CDH are the few shellfish products in Mexico for which there is reliable year-round domestic demand.

5.2 SIZE OF THE FISHING FLEET

During the outings performed in the season 2000 and 2001 (see Table 1), between 5 to 20 hookah setups were observed diving for CDH at all times. However, participant observation and informal interviews with fishermen showed that the number of CDH fishers varies considerably throughout the year. For instance, due to extreme circumstances up to 70 *pangas* were seen fishing in the Channel in January of 2001. Fishers said this was the highest number of *pangas* that Seri fishermen have seen in recent times. Since the Seri of *Punta Chueca* own at the most 20 hookah rigs, most fishermen were said to have came from *Bahia de Kino* due that they were experiencing a very bad harvesting season in their own fishing grounds.

During 2000 - 2001 there were up to 15 hookah rigs in working condition in *Punta Chueca* (8 to 12 in average). The total number of *pangas* owned by community members fluctuated between 20 and 30.

5.3 THE FISHING GEAR

As in most hookah diving small-scale fisheries of the region, the basic equipment consists of a *panga* with an outboard motor and a rudimentary hookah underwater breathing system (Cudney-Bueno 2000:48). Table 4 provides a complete list of the fishing gear used in the Infiernillo Channel CDH hookah fishery.

Hookah setups are built using the air compressor and engine of a paint-spraying machine. The compressor's outlet is connected to an air reserve tank to which one or two

sets of-100 m hoses are attached with air regulators on their ends. The length of the hose thus determines the diver's underwater action range.

A beer keg is modified to serve as the air reserve tank. Its function is to provide an emergency air supply to the diver in case the compressor would unexpectedly stop functioning. To adapt the beer keg for this function, a pressure gauge, and several valves (retention, check and outlet valve) need to be installed. Nevertheless, according to some fishermen, several accidents have happened because air leaked out the air tank through the compressor itself when the retention valve was not installed or working properly.

The hose fishermen buy is the same as that used for domestic propane gas connections. It does not meet the specifications generally demanded for diving operations, but is the most affordable. The most important differences between this and specially designed diving hoses are that the latter not constrict air flow when bent, are air pressure resistant and have been treated to resist damage from ultraviolet sunrays.

The attire of each diver is highly variable, depending on his preference, experience, creativity and economic situation, and the time of the year. However, the basic "standard" gear includes a diving mask, plastic boots, shoes or fins,[46] a weight belt and a custom made hook to extract the CDH from the bottom. Depending on the water temperature, the diver may need to use a wetsuit and a hood. Usually when the water is warm a short wetsuit is enough.[47] In the winter they wear as many wetsuits as they need

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[46] Walking or swimming over the bottom varies according to the divers preference (also see Cudney-Bueno 2000: 48).

[47] Fishermen have adopted the word "Surfin" when referring to a short-sleeved wetsuit.

to be warm.[48] Some fishermen even wear pantyhose under the wetsuit to be warmer. To protect the wetsuit from potential scratches from rocks, coral or CDH shells, some wear pants and a shirt outside their wetsuit.[49]

Pants and long sleeved shirts are also worn during the summer, to protect their skin from irritant hydroids such as *Plumularia* spp, *Porpita* sp. or *Physalia* sp. Cotton gloves are the most affordable and common, but I have seen divers using neoprene ones.[50]

The collecting bag where divers put the CDHs is made from two pieces of old shrimp trawl net sewn together, and attached to the inside wall of an old tire.

Some divers attach themselves to a long rope that a crewmember holds at the end, or that is tied to a floating buoy. This helps to locate the diver in the water, and serves as a communication system between the diver and the crew, through a system of pulling signals.

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[48] I saw a fisherman wearing 3 wetsuits during December of 2000. He needed 45 Lbs. of weights to go down.

[49] It is not cheap or easy to acquire a wetsuit in the region. Medium size, half-inch thick, wetsuits have been sold at more than $500 usd.

[50] Once a diver was seen using latex gloves below cotton ones for additional warmth.

Table 4. Description and cost of fishing gear used in the CDH fishery.

Fishing vessel Cost new $ 5,560.0 usd used $ 3,220.0 usd; Cost new $ 50,000.0 pesos used $ 29,000.0 pesos			
Gear (Spanish)	**Gear (English)**	**Brand or type**	**Specifications**
Panga	outboard motor boat	Preferred: Buggy	-
Motor	outboard motor	Honda, Evinrude, Mariner	45 Hp and up
Hookah rig Cost $ 1,110.0 usd; Cost $ 10,000.0 pesos			
Gear (Spanish)	**Gear (English)**	**Brand or type**	**Specifications**
Planta	gasoline motor	Preferred: Briggs & Stratton Co.	8 Hp gasoline motor
Compresor	air compressor	-	-
Manguera	hose	Used for propane gas connections	100 Mt. of crystalline hose
Boquilla	air regulator	No preference	-
Madrina	air receptacle	Beer keg	Capacity 60 lts (120 lbs)
Diver's personal gear Cost $ 500.0 usd; Cost $ 4,500.0 pesos			
Gear (Spanish)	**Gear (English)**	**Brand or type**	**Specifications**
Traje o surfing	Wetsuit	No preference	-
Pantalones y camisa	Pants & long-sleeved shirt	No preference	-
Pantimedias	Pantyhose	No preference	-
Gorro	Hood	No preference	-
Guantes	Gloves	Cotton.	Occasionally latex below the cotton
Mascara	Mask	Preferred: Pacific	-
Botas o aletas	Plastic boots or fins	No preference	-
Cinto	Diving belts	No preference	Preferred with metal buckle
Pastillas	Diving weights	-	Custom made
Gancho	Hook	-	Custom made
Other Cost $ 16.7 usd; Cost $ 150.0 pesos			
Gear (Spanish)	**Gear (English)**	**Brand or type**	**Specifications**
Bolsa callera	Collecting bag	-	Custom made
Cuchillo	Knife	Kitchen knife	Long and thick blade
Cubetas y taras	Buckets and containers	No preference	20 lt. buckets
Boya	Buoy	-	-
Cabo	Propylene rope	-	-
Total Cost (usd)	**$ 7,183 to 4,850**		
Total Cost (pesos)	**$ 64,650 to 43,650**		
1 usd= 9 pesos (year 2001)			

A fishing team can be formed of two, three or four crewmembers per boat. The number of crewmembers and the selection of individuals is determined by several interrelated factors: the partitioning of catch among crewmembers, the number of fishermen required to do the job, the amount of CDH expected to be harvested, CDH price, ethnic origin of the fishermen, ownership of *panga* and fishing gear, Seri communal fishing rules and family ties and kinship.

The number of members in a CDH fishing team ranges from 2 to 4, but most of them use three (Table 5).

Table 5. Crew size and inter-ethnic conformation of CDH fishing teams.

number of crewmembers*	number of *pangas*	*pangas* including at least one non-Seri** crewmember	*pangas* in which diver was non-Seri**
2	43	86%	65%
3	47	89%	64%
4	19	84%	74%
TOTAL	**109**	**87%**	**66%**

* Figures correspond to fishing boats surveyed during all outings conducted between June of 2000 and 2001 (see Table 1).
** Includes those non-Indian fishermen living in the Seri communities as well as those coming to fish from nearby fishing towns. Also includes those boats solely made up by non-Seri fishermen.

The line-up consists of a *buzo* (diver) or two if they are 4 members, a *popero* (sternman), and a *matador* (CDH meat preparer) (See Table 6). These team conformations differ from the findings of Cudney-Bueno (2000:49) for hookah fisheries in the Upper Gulf of California were fishing teams are usually conformed by one to three divers and a motorman. These differences may be related among other things, to the level of income that different fisheries are able to provide.

According to their origin, experience and position in the group, fishers share the different tasks involved in the CDH fishing process (Table 6).

Table 6. Description of tasks and duties of CDH fishermen when at sea.

Role* (Spanish)	Tasks and duties*	Who performs it
Capitan (Captain)	1. Usually motors the boat. 2. Makes decisions that involve navigation of the boat or fishing gear, especially when the diver is underwater. 3. When the diver is non-Seri he makes decisions that usually correspond to him. 4. Deals with the fish buyer.	The owner or manager of the boat and fishing gear.
Buzo (Diver)	1. Collect CDH. 2. Make decisions regarding where to dive, when to go out and when to quit for the day.	Diver
Motorista o Popero (Motorman or Sternman)	1. Motors the boat. 2. Follows the diver so he has always enough hose to move freely underwater. 3. Is responsible of all aspects of the outboard motor.	A crewmember. Can be the Captain.
Matador (CDH meat preparer)	1. Pull up the bag of CDH and send a new one. 2. Separate the meat from the shell (primary processing). 3. He is usually in charged of all aspects concerning the diving compressor. 4. In responsible of the anchor.	A crewmember. Usually is not the owner or responsible of the boat and fishing gear.
Cabo de vida (Life line)	1. Monitor signals that the diver could send through the hose or through a separate rope attached to his weight belt or to a buoy. 2. Pull up the bag of CDH and send a new one.	A crewmember. Usually is not the owner or responsible of the boat and fishing gear.

*Roles, tasks and duties are distributed among the number of crewmembers (2, 3 or 4) depending on their experience, origin and position in the group. They frequently overlap.

Participation of non-Seri fishermen in this fishery is high (Table 5). 87% of the fishing teams include crewmembers of an ethnic origin other than Seri. It can be only one member, two, three or all of them. The estimates presented in Table 5 include those fishermen who come from a nearby town to fish and those who are already living in the Seri community. Some of the non-Seri fishermen that come from elsewhere bring their own *panga* and fishing gear. Many times these fishermen have to negotiate their access to the fishery. One of many requisites that the Seri Traditional Government imposes on

them is that non-Seri boats have to hire a Seri as part of the fishing crew, therefore influencing crew size and conformation.

Also interesting is that most Seri fishermen who participate in the fishery are not divers (Table 5). As in any other hookah diving fishery, diving is the most exhausting and dangerous task of the fishing process (Table 6). Most Seri prefer to hire outside divers, who, facing scarcity in their own fishing grounds, are attracted to the relative abundance of the Infiernillo Channel. The shallow Infiernillo Channel also offers them a safer place to dive in comparison to the depths they must attain to harvest CDH back home.

Paradoxically, this inter-ethnic integrated fishery takes place in the only area where the Seri can control access to their fishing grounds. This illustrates the existence of incentives and trade offs that the Seri face when granting access to non-Seri fishermen.

5.5 SELECTION OF FISHING TIMES

Owing to the shallow and narrow nature of the Infiernillo Channel, tidal currents can be very strong. Therefore, the best times to dive are in low amplitude tides (neap tides). Fishermen consider neap tides to take place 2-3 days before, during, and 2-3 days after quarter moon. Since this takes place twice a month (during waxing and waning) thus divers have roughly 15 days of good diving per month. The other 15 days when spring tides occur,[51] currents are strong and diving is very strenuous. In some areas of the Channel, the currents cover CDHs with sand. In other underwater visibility improves and CDHs are easier to find. While there are tradeoffs for diving in either tide period, divers

prefer to dive during neap tides and rest during spring tides (Figure 4). However during my fieldwork season this was not frequently observed due to the innumerable unexpected events with which divers are confronted everyday.

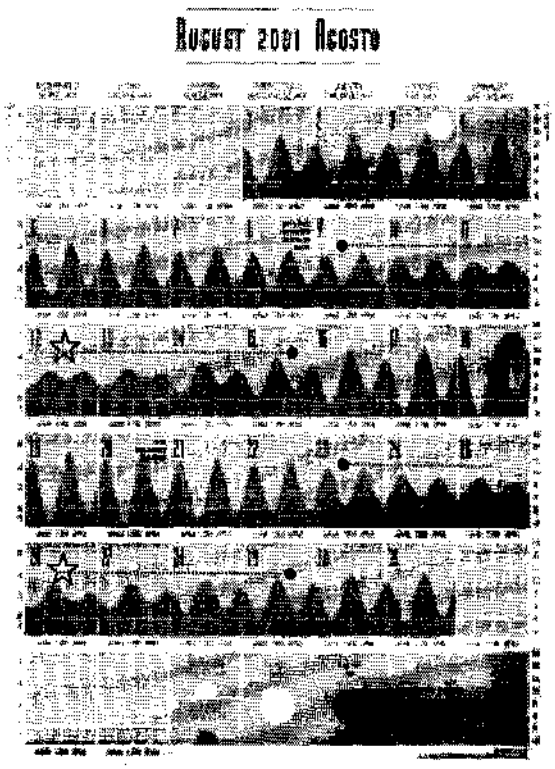

Figure 4. Preferred diving times in the Infiernillo Channel.

Star indicates day of quarter moon. Dotted line indicates best diving times as stated by the fishermen. Figure does not represent tidal patterns of the Infiernillo Channel. Modified from Tide Calendar 2001 for the Northern Gulf of California with permission from the editor Dr. Donald A. Thomson.

As customary in other hookah fisheries of the region (Cudney-Bueno 2000:50), the diver is in charge of deciding when and where to go fishing (Table 6). Nevertheless

[51] Regionally, neap tide periods are known as *mareas muertas* (dead tides), while spring tides are *mareas vivas* (alive tides). Occurrence varies depending on the place and time of the year.

in the CDH fishery when the diver is an outsider this does not apply. Then, the decision is usually reached jointly with the owner of the gear or by consensus with the rest of the crew.

5.6 SELECTING DIVING LOCATION

Selecting a diving location usually requires balancing profit and risk. An ideal situation of maximum profit is when the diver discovers a new CDH bank and no other divers are around to compete for the harvest. However, probing for new CDH banks is a risky endeavor, and the odds of finding a new CDH bank are variable, potentially resulting in little harvest and economic loss that day. A fishing team therefore often chooses a minimum risk strategy, deciding to fish in an area where other teams are already harvesting CDH. This is the most common scenario in the Infiernillo Channel. Fishermen prefer this strategy because the high productivity of CDH banks in the Channel and the low number of *pangas* (due to Seri access control), generally guarantees an acceptable harvest for all divers. When the area becomes unproductive, fishing teams move to other productive areas that have not been worked recently. Fishing effort is deployed flexibly and opportunistically, therefore in some cases the initial success of one group seems to encourage others to converge upon an area. In other cases, fishing teams change to the new area at roughly the same time. Here, the tradeoff is that finding the richest CDH beds within a known fishing area is more successful when several fishing teams are present.[52] The costs of searching are spread among the group reducing the

[52] To navigate and position themselves in a fishing area, fishermen rely on land features triangulation. In Mexico, GPS units are not affordable to small-scale fishermen.

individual risk and uncertainty of not finding a good CDH stock. By maintaining visual contact with other fishers, it is possible to determine where and how much CDH is being harvested and relocate accordingly.

These general patterns of costs, risk perception, and incentives vary depending on the particular circumstances of the fishing team, their knowledge, ethnic origin, etc. A team of non-Seri fishermen who "sneak into" the Infiernillo Channel to dive (see Chapter 6) will behave very differently from a Seri-only fishing team.

5.7 DIVING TECHNIQUES

Important ecological characteristics of the CDH shape the technique used in diving. The most important commercial species of CDH in the Infiernillo Channel is the sessile *Callo riñón* (kidney shaped pen shell, *Atrina tuberculosa).* It lives completely buried in the sand, therefore the only portion visible to the diver is the small aperture of the two valves, through which the animal filters planktonic organisms and breathes. When there is any disturbance in its surroundings the CDH closes its valves, making them extremely difficult to find.[53] In this context, a good diver must (1) know how to move underwater to find CDH, (2) how to extract them from the bottom, (3) and have a good underwater communication system with crewmates at the surface.

Based on personal preference, divers choose to swim or walk over the bottom. Either way the diver hangs the collection bag from his neck so he has both hands free to work. Swimming divers claimed that they could see CDH easier since they were closer to

the bottom. For me, the most noticeable difference between the two techniques was that walking divers could carry around bigger bags.

Either way, in times of tidal currents (which occur most of the time in the Infiernillo Channel), divers prefer to approach a CDH bank from downstream. This way, the sediment that they stir as they pass by, goes behind them and does not block their view or disturb the CDH further upstream. Once one CDH has been located there are usually more around. Therefore, before moving forward to pick up that individual, the diver looks around making a mental plan of the location of all CDH that cross his sight. Next, he starts approaching all of them in an orderly fashion, from downstream to upstream.

To extract them from the bottom, the diver introduces the hook between their two valves, which close at contact. The diver then twists the hook to lock it, and pulls the animal out. In the event that the CDH closed its valves before the diver introduced the hook, the diver breaks through one side of the shell with the hook and then pulls it out. In both cases, the important thing is to avoid damaging the meat with the hook, meaning that the diver needs to know where the scallop meat is located.

When the bag is full, the diver either surfaces with the bag (increasing the risk of injury)[54] or asks the crew to pull it up and send down a new bag. This is communicated to

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[53] The second species commercially important is the Callo Redondo (round pen shells, *Pinna rugosa*), which usually exposes a third of their body size off the bottom, making them easier to spot and pull out.

[54] The chances of suffering a diving injury increase with diving time, effort and depth. However, because the Infiernillo Channel is very shallow (Average depth is 5.5 meters), few diving accidents have occurred. The National Association of Underwater Instructors (NAUI) considers it safe to dive for unlimited time in depths of less than 10 meters (1 atmosphere of pressure).

the crewmates through a series of pulls to the hose, or to an alternative line that the diver has attached to him and that the other end is held by a crewmember[55] or attached to a buoy at the surface. This proves to be a better practice, since it decreases diving time and allows the diver to keep working in the same area without interruption.

5.8 PRIMARY PROCESSING

Once the animals are pulled out of the bag, the *matador* (Table 6) starts the process of extracting the meat from the animal. There are basically two ways to do this: (1) By separating the shells without breaking them, and cutting the scallop meat (adductor muscle) that holds the shells together with a knife. (2) By breaking the shell using the unsharpened side of the knife's blade and then reaching with the knife to remove the scallop meat. Fewer fishermen practice the former technique because it's harder to learn, even though it is more efficient. It is faster and less messy, and those who perform it, consider it an essential skill of a "true" CDH fishermen.

In any case, once the shell is opened and the organism set apart in a container, the shells are discarded in the ocean. Then the *matador* starts separating the scallop meat from the guts, mantle and gonads. The guts are always discarded, but fishermen sometimes keep the mantle to take home for their consumption. If time and other duties allow, the separation of meat from guts and mantle is done aboard, if not, this can be done back at the village. When conducted ashore it is not uncommon for family or other community members to gather to help, usually with the intention of keeping the mantle as

[55] Whoever is carrying out the role of *cabo de vida* (see Table 6).

a compensation for their work. This is also a good opportunity for community members to check out fellow fishermen's catch of the day.

Finally, the catch is usually stored in seawater or ice at the captain's home, until the fish buyer arrives in the evening. Then the product is weighed and put in 5 Kg bags. Any debts or credits in favor of the fish buyer are discounted from the value of the catch before payment to the fishermen is done. Credits can be in the form of cash, gasoline, motor parts, or any piece of fishing gear that the buyer acquired for the fishermen. Depending on the nature of the arrangement with each fisherman, payment is done daily, weekly, or whenever possible.

A typical fishing day ends when transactions with the fish buyer are concluded and every crewmember gets his monetary share. If gasoline is available, the weather forecast is good, and spirits are high among the crew, the process will start all over the next day at sunrise.

5.9 CONDUCTING BUSINESS IN SERI TERRITORY: A DIFFERENT STORY

There is no doubt that to some extent, the CDH buyer has an important influence in how the Seri determine which fishing areas to exploit, and the level of exploitation to which they are subjected. However, the Seri CDH fishery does not appear to be completely at the mercy of the market yet as other fisheries of the Gulf of California seem to be (Greenberg 1999). The unique characteristics of the Seri setting help to counteract some of the bargaining power that the CDH buyers have gained.

The ability of the Seri to produce a year round supply of CDH, in comparison to other open access areas nearby where supply is less reliable and uncertainty is higher, attracts fish buyers to the Seri fishing commons, and motivates them to establish long term relationships with the Seri. Moreover, Seri ownership of the land that surrounds their CDH fishing grounds gives them more voice in regard to who they consider acceptable to conduct business with and who is not welcomed. This successfully brings bargaining forces to a closer equilibrium, and further provides incentives for the fish buyers to be in good terms with their business counterparts.

The Seri are certainly aware of these factors, and take advantage of it by imposing rules on individuals who want to conduct business in Seri territory. One of the main rules is the monetary payment of a quota, that grants fish buyers with the right to buy products from the Seri territory (see Chapter 6 for an in-depth discussion).

Some Seri fishermen say that *los compradores no duran aqui* (fish buyers do not last here), meaning that most fish buyers fail to establish long lasting relationships with the Seri, and decide to stop doing business with them. There seems to be a high turnover of fish buyers in the Seri CDH fishery.

In general, fish buyers and non-Seri fishermen believe that the Seri are difficult people to work with. Besides the historic distrust between both cultures, it seems that it is difficult to build social capital with them because the Seri do not reciprocate according to Mexican social conventions, either because they do not understand them, do not care, or both. This reinforces the belief that the Seri are not trustworthy people. For example, when a Seri fisherman and a fish buyer agree to engage in a business relationship, usually

the fish buyer loans the Seri gasoline so he can go fishing,[56] the fish buyer expects some kind of moral commitment in reward or loyalty from the Seri fisherman. However, this frequently does not happen. If for any reason the Seri used it for something else (i.e. make an errand to town), or did go fishing but sold the product to someone else who offered a better price, the only way for the fish buyer to recover that money is to keep lending the Seri or take the loss. It is understood by both sides that if the fish buyer stops the loans of gas, the Seri would also break the agreement to pay him back. One fish buyer stated that he was still doing business with the Seri not to make a profit, but in the hope to recover the more than $5,000 U.S. that he had lent to them.

Other factors such as tough competition among fish buyers, few ways in which they can control the fishery (since they do not own the fishing gear that the Seri use) and the relative homogeneity of the Seri community, further help to balance the bargaining power between both parts. This situation contrasts with the strong bargaining power that fish buyers hold in other open access fishing areas in the coast of Mexico (Lobato 1996:329).

[56] There are no gas stations in the Seri village of Punta Chueca. The closest gas station is at 30 Km in the fishing village of *Bahía de Kino*.

6 SOCIAL MANAGEMENT MECHANISMS: UNDERSTANDING ACCESS CONTROLS

6.1 BACKGROUND

Throughout history, fishers have tried to limit access to their fishing grounds. Today, western fisheries managers believe that exclusive, transferable and well-defined property rights are an essential step to reduce fisheries overexploitation and the habitat degradation that threatens the Earth's coastal and marine environments (NRC 1999).

Recent social and technological advances in industrialized countries have allowed the successful implementation of territorial use rights in fisheries, also known as exclusive fishing zones (EFZ). The influence of western thought, policy, and the expansion of global markets, has made privatization the policy of choice for the conservation of coastal fisheries in many countries. Nevertheless, if worldwide fisheries overexploitation is to be reduced, the management of small-scale fisheries in developing countries must change. Small-scale fisheries employ 50 of the world's 51 million fishers, practically all of whom are from developing countries. Together, they produce more than half of the world's annual marine fish catch of 98 million tons, supplying most of the fish consumed in the developing world (Berkes et al. 2001).

It is difficult to find cases where local holders of territorial coastal rights have achieved successful exclusion without the intervention or regulation of outside enforcement institutions. In small-scale fisheries, the development of successful mechanisms of access control often face unsolvable technological, legal, social,

geographic, ecological or demographic constraints. This is specially true in developing countries.

The above constraints limit the opportunities to assess the inner workings and performance of EFZs in small-scale fisheries. The Seri Indians' *callo de hacha* fishery (CDH), however, provides such an opportunity.

For cultural and economic reasons, the Seri community has been granted legal rights over their fishing grounds and coastal land by the Mexican federal government. After this decisive but one time intervention, the federal government has not been involved in the monitoring and enforcement of such rights. Local users are the sole recipients, regulators and designers of the strategies under which they manage their common property. Fortunately for the Seri, most of the typical constraints to control access to their fishing areas are absent or have combined in their favor. Allowing a close look at the inner workings of the access controlling strategies in use by a community-based fisheries management regime.

The geographic location of the village and fishing areas facilitates the monitoring of the entrance and exit of users. The CDH are a sessile resource and the fishing technology is relatively homogeneous among users. Moreover, the Seri find it acceptable to grant withdrawal rights to outsiders if they comply to a determined set of rules.

To assess the performance of the Seri community based EFZ, I relied on the Institutional Analysis and Development (IAD) framework developed by Ostrom et al. (1994) (Figure 5). The IAD framework looks at the different patterns of interaction that

emerge in a given action arena, once physical conditions, communal attributes, and rules-in-use have been taken into account.

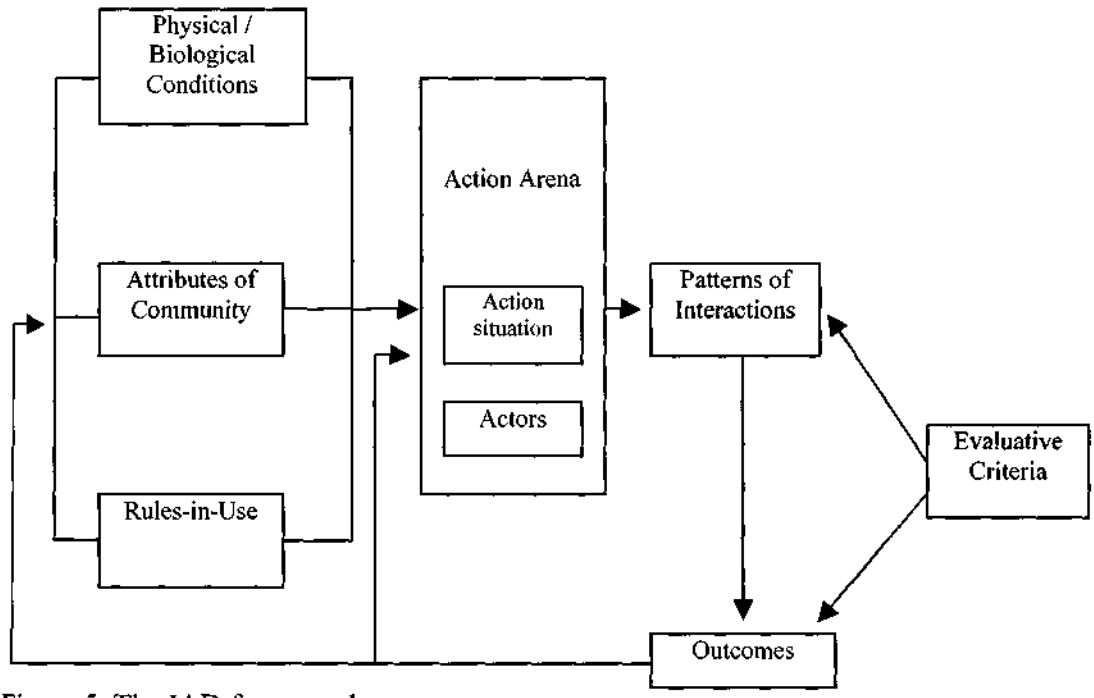

Figure 5. The IAD framework.

This chapter starts by describing Seri local institutions, communal attributes and the role the Seri government and community have in granting access to their CDH fishing grounds. By looking at the patterns that resulted from the array of rules and strategies that 'access seekers' and 'access controllers' used, I evaluated how and why the Seri control access to their EFZ.

6.2 SERI GOVERNANCE INSTITUTIONS

Seri social organization is centered in an extended family structure with complex kinship relations (Felger and Moser 1985; Burckhalter 1999). When the Mexican government granted the Seri with terrestrial and marine ownership rights in the 1970s, it also designated the *ejido* system and the fishing concession as their governing structure.

The norms and rules-in-use of today's Seri governance structures are the result of the integration of their complex social and kinship traditions to their interpretation of the laws and statues of the *ejido* system.

Seri political power orbits around four different structures: the Tiburon Island Comunal Property (TICP), *Ejido El Desemboque* and its' annex *Punta Chueca*, the Seri Fishing Cooperative and the Elderly Council (Figure 6), with the traditional governor as the prevalent authority.

Each structure has its own members and leaders. It is not rare for their activities to overlap and for one structure to overtake the responsibilities, tasks, and resources of the other, depending on the personal ability and capabilities of the elected officials for each governing structure.

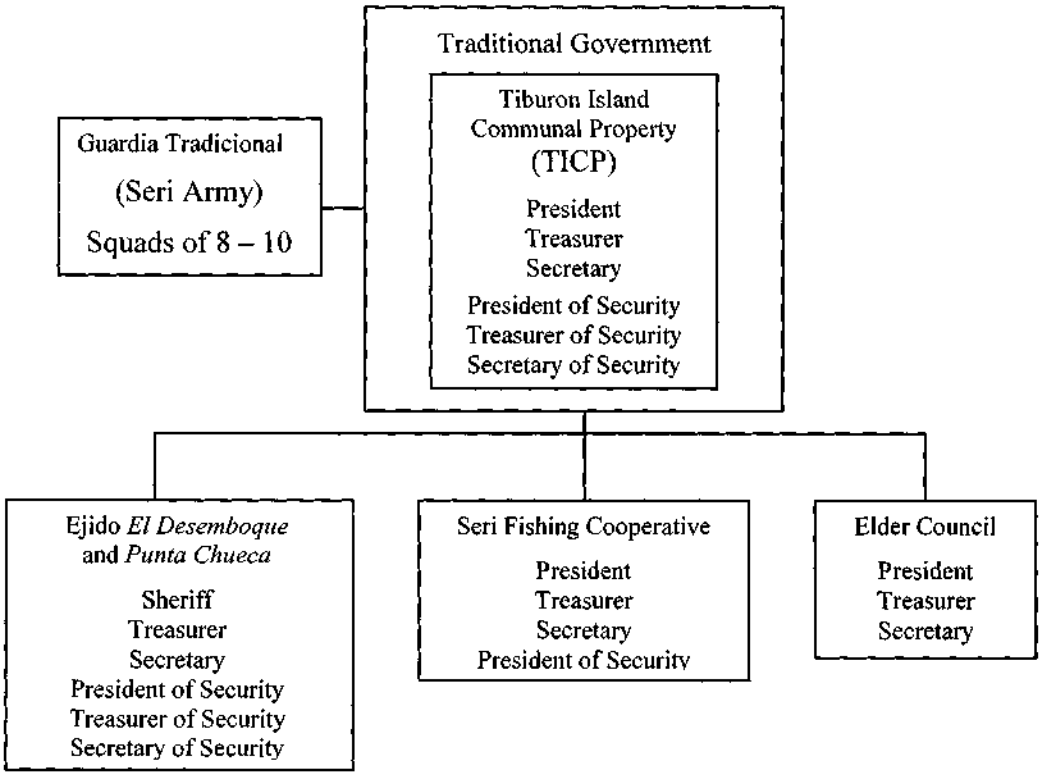

Figure 6. Modern Seri governing structures

Political power fluctuates among these structures depending on (1) the amount of social capital and influence that the leader and his family have in the community, and (2) their ability to acquire economic resources and distribute them among other community members. The following sections describe the four political structures:

6.2.1 Tiburon Island Communal Property

The presidential decree of 1975, mandated Seri to adopt a federally recognized form of communal land tenure for Tiburon Island. The Agrarian Reform Secretariat

(SRA) enforces the bundle of rules of this form of land tenure. The responsibilities of the Tiburon Island Communal Property (TICP) elected officials (6 in total, Figure 6) are to govern and resolve any issue concerning the island commoners' interests.

Elected officials serve for 3 years. The election for public positions is held in a public meeting. Members of the Federal Agrarian Reform Secretariat (SRA) certify the election process. Only *comuneros* (communal members) can vote and occupy public positions.

Recently, TICP became synonymous with the Seri Traditional Government. Since Mexican law does not grant legal status to any ethnic form of Traditional Government,[57] this post was combined with the presidency of TICP in order to give the Traditional Governor legal authority (and the ability to write checks) (Figure 6). The same members elected for the TICP are therefore cabinet members of the Traditional Government.

The *Guardia Tradicional* (Seri Traditional Army) is the enforcement body of the Traditonal Government or TICP. It is an informal and non disciplinary group, made up of squads of 8 to 10 young Seri commanded by a squad chief, which responds to the President of Security of the TICP (See Figure 6). Their main task is to police illegal poachers on Tiburon Island and Seri waters. However, they will conduct any "ethnic law" enforcement procedure that they are assigned to by the Traditional Government. For instance, sometimes they are ordered to visit CDH fishing camps and force all non-Seri fishers to leave or confiscate their fishing gear.

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[57] This could soon change if the Mexican Congress signs the Ethnic law as proposed by the members of the National Indigenous Congress (CM) and the National Zapatista Liberation Army (EZLN).

Tax collection is not practiced among the Seri. The Traditional Government functions from the moneys it receives from: (1) government subsidies (almost non existent today), (2) sale of hunting permits on the island (rapidly diminishing in price), and (3) the sale of fishing permits (rapidly increasing in number as more non- Seri fishermen seek access to Seri waters). Since the money that enters the government's chests does not need to be accounted for,[58] the Traditional Governor has absolute discretion in spending it. It seems to be communally understood that anybody is entitled to ask for a personal loan from the Traditional Governor (or any other governing structure if the money comes from the exploitation of Seri common resources). Personal loans are rarely (if ever) paid back. This is likely to be how most of the Traditional Government's money is spent, and the main reason why the Traditional Government is always broke. It is likely that this practice results from a combination of cultural, political and economical elements, such as the complex Seri family and social norms, mimicry of the Mexican government's paternalistic policies for the recruitment of political clientele, and the precedents set by the Seri fishing cooperative administrative laxness in times of fishing abundance (1970s).

6.2.2 *Ejido* of *El Desemboque* and *Punta Chueca*

The administrative structure of the *Ejido* is similar to that of TICP, except that elected officials' tenure lasts only 2 years. As in the TICP structure, only registered *ejidatarios* can participate in the elections. The main duties of elected officials are to

[58] As an effort to provide more information on the activities of the Seri government, in 1999 the Seri Governor (Moises Mendes) offered an annual activities report to the community. This was the first time a

manage their common land (mainland) in accordance with the national *ejido* statutes regulated by the Agrarian Reform Secretariat (SRA). Among other duties, the *comisario ejidal* (communal sheriff) is in charge of overseeing land assignments to new *ejidatarios* (communal owners) and their married descendants.

Some sources of income for this governing structure between 2000-2001 were: (1) The sale of hunting permits within the *ejido* (mainly for waterfowl and mule deer). (2) Proceeds from fees to grant *derecho de servidumbre* (right of access)[59] to merchants that wished to conduct business in the Seri *ejido* including fish buyers. (3) Proceeds from fees to grant *derecho de piso* (right for the use of land) to *non-ejidatarios* (non-Seri) that request to temporarily use *ejido* land. *Derechos de piso* are granted mainly to non-Seri fishermen or fish buyers that establish fishing camps in mainland Seri territory (*ejido).* The Seri army is used to monitor the presence of unauthorized personnel in the *ejido,* such as fishermen camping illegally, and to enforce the payment of fees when necessary.

6.2.3 The Seri Fishing Cooperative

The rules under which the cooperative operates are stipulated in the Cooperative Societies' General Law (Villa Arce 1996:16). The responsibilities of the publicly elected officials (4 in total, see Figure 6) are to manage and administer the activities of the Seri Fishing Cooperative. Their public appointments last 5 years with the possibility of

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Seri government had done such thing.

[59] Such right of access fee is not featured in the statutes of the *ejido* common property system. It could be that it resulted from the Seri interpretation of the *derecho de via* (right of way), which stipulates that *ejido* members have the right to charge a fee to grant the right of way for people using *ejido* owned roads. However, in the Seri case, none of the roads are owned by the *ejido* (personal communication with personnel of the attorney's office of the Agrarian Reform Secretariat (SRA) 2001).

multiple re-elections. The Presidential Decree of 1975 identified the Seri Cooperative as the only entity authorized to harvest fishing resources from concession waters.

The Seri cooperative does not operate as a production and commercialization entity, and does not actively represent Seri fishermen's interests. Lack of functional infrastructure, operation capital, technical support, internal organization, and good management practices were some of the causes for its disintegration. Today, its' main role is to legalize the fish products harvested in Seri waters. The fishing cooperative charges a couple of pesos per kilogram of product to grant a receipt to the fish buyers. This mimics the commercialization of the product through the cooperative and legalizes the product into the market (Bourillón 2002). This is the main source of income for the fishing cooperative. It seems to be enough to support the three or four families that occupy the administrative positions of the cooperative.

6.2.4 The Seri Elder Council

Three members of the elder council are appointed by the Seri Traditional Government and occupy lifetime positions. When the President dies, the Secretary takes his position (see Figure 6). Only knowledgeable elders can belong to the council. Their role, as described by a Seri, is "to answer questions regarding traditional names, uses or location of plants or animals to any member of the community." From an outsider point of view it seems that the political influence of the council is limited to internal issues, and even so it appears to be non-significant. Sporadically, the council receives money to organize traditional *fiestas.* This money usually comes from the *Instituto Nacional*

Indigenista (National Native Peoples Institute) or from *Dirección General de Culturas Populares, Unidad Regional de Sonora* (General Management of Popular Cultures, Regional Unit of Sonora).

6.3 COMMUNITY ATTRIBUTES

6.3.1 Heterogeneity of Interests

Three different groups of CDH fishers or appropriators exist for the Seri EFZ. Their cultural and ethnic differences, heterogeneity of preferences, discount rates and norms of behavior distinguish them.

(1) Full-blooded Seri fishermen or 'access controllers'. The Infiernillo Channel fishing grounds have been part of their ecosystem and cultural continuum for more than 2000 years. The discount rate towards their fishing resources is expected to be low, since they value them not only as a source of economic income but as an integral part of their world view and heritage.

(2) The non-Seri fishermen or 'access seekers' from fishing towns nearby. They usually have a much higher discount rate and utilitarian perception of the resource.

(3) Non-Seri fishermen married to Seri women and living in the Seri community of *Punta Chueca*. This group acts as 'access controller' when confronting outside access pressures that would lower their net benefits as usufructors of Seri fishing resources. However, most of them do not consider the Seri community as their permanent home and it is assumed that they value the future differently.

The access of non-Seri fishermen to the Seri EFZ is a constant source of conflict between Seri and Mexicans. Every new conflict between both groups rapidly reinstates each other's historic conviction that their counterparts are untrustworthy and agreements are broken. Conflicts with outsiders frequently backlash to the non-Seri fishermen living in the community. In various occasions non-Seri fishermen have had to temporarily leave the community until hostility against outsiders has ceased. It is clear that access control to the Seri fishing grounds is not only seen as a fundamental way to conserve their fishing resources, but it is also a way to maintain Seri sovereignty, and cultural and ethnic viability.

6.3.2 Seri Norms of Behavior: The Seri Community

The Seri are considered highly opportunistic and individualistic people. This behavior has represented a successful survival strategy since their nomadic hunter and gatherer times, and has found a natural niche in their present lifestyle, since fishing is often an individualistic endeavor. Cooperation between members of different kin or with outsiders requires a material incentive, usually in the form of money.

Nevertheless, when external conflicts arise the Seri act as a compact group. It is believed that this trait played an important role for Seri survival in the extermination wars that the Spanish and Mexican held against the Seri in the eighteenth, nineteenth and early twentieth century. As a consequence the Seri do not like nor trust Mexicans. In fact, Mexicans are seen with distrust in the Seri community. Seri that engage in relations with

Mexicans only do it if they have a lot to benefit from and little to compromise. Even in these cases, the Seri do not feel obligated to honor their agreements with outsiders. Those that establish long lasting friendships with Mexicans are looked at with suspicion by the rest of the community.

On the other hand, the Seri community's internal cohesion is limited and fragmented by kinship. Mutual cooperation between the Seri is mostly restricted to members of their immediate kin[60]. Conflicts between individuals of different immediate kin easily escalate to include all members of the extended family. Interfamily conflicts are considered a serious matter and can continue for a long time after the incident has been solved. As a consequence, the degree of accountability that members of the Seri Government can exert over internal rule-breakers is diminished. Their actions against community members are taken to a personal level and retaliation against the government official or his family can be expected. Therefore, Seri authorities prefer to not get involved in such issues.

6.3.3 Seri Norms of Behavior: The CDH Fishing Grounds

Seri fisher's norms of behavior have played an important role in maintaining the abundance of CDH in the EFZ after almost 30 years of continuous exploitation. Through time, Seri CDH fishing norms have intertwined with the CDH fishing ecological and social system (see Chapter 7).

[60] The immediate kin includes parents, brothers and sisters.

There are fishing areas inside the EFZ where the Seri avoid diving and that therefore constitute a natural refuge for the CDH. Other fishing areas are restricted from diving exploitation but open for the use of the rest of the Seri community (mainly women, elders, and children). When the CDH of a fishing area are too small (for Seri standards), fishermen move to one where nobody has worked recently, allowing the CDH to grow and be harvested in the next rotation cycle.

Some of these norms have become part of the Seri government's requirements to grant withdrawal rights to outsiders, as I will describe later on.

6.3.4 Non-Seri Fishermen Norms of Behavior

If outsiders are to obtain withdrawal rights from the Seri, they must be willing to adhere to the accepted fishing norms inside the Seri EFZ. It is expected that the degree of compliance is the result of a compromise with their discount rate towards the EFZ and the enforcement that the Seri are able to exert. For instance, in one occasion, the Seri traditional government ordered the immediate cease of all CDH fishing activities in the EFZ, as a way to force a rise in the local CDH price. The order came after several days of bad weather and fishers needed income desperately. The day the order was given only one of four outside non-Seri fishing teams violated the government's order, the second day all outside non-Seri fishing teams fished, including a Seri community's non-Seri fishing team. The third day everybody fished, including the Seri fishing teams. Of all non-Seri fishermen who gain access to the Seri EFZ, those living in the Seri community usually have the highest compliance to Seri norms of behavior.

6.3.5 'Official' Mechanisms to Grant Access

Although the Seri fishing concession stipulates that only members of the Seri community or fishing cooperative are allowed to fish in its waters, in practice withdrawal rights are granted to outsiders who comply with Seri requirements. When an outsider chooses to camp in Seri territory, to avoid the costs of going back and forth to their village every day, the Seri believe that they have the right to collect royalties for the use of their land. Therefore, depending on the case, outside fishers are granted only *derechos de agua* (water rights) or also *derechos depiso* (land rights). The award of each right and the collection of its royalties may be coordinated by different structures of the Seri government. Although the collection of royalties for water rights is only the jurisdiction of the fishing cooperative, land rights can be the jurisdiction of the *Ejido* or the TICP, depending if the outsider is using a mainland (common case) or Tiburon Island fishing camp (rarely happens).

Seri requirements to grant withdrawal rights are widely known among non-Seri fishermen from nearby towns, and are accepted as the "official" procedure to gain access to the Seri EFZ. Access requests are made to members of the Seri government. If access is granted, a written permit is issued and payment is made including all royalties for water and land rights.

The written permit stipulates the following rules:

1) *Payment of a fishing permit.*

The amount to be paid is determined by the Seri government officials in turn. During the tenure of the Seri Governor Moises Mendes (1999-2001) the price of a fishing permit was

determined as the value of one kg of CDH per day. The cost of a weekly (7 days) permit fluctuated between 2,000-3,000 pesos ($210-$310 US usd).[61]

2) *A Seri fisherman must be hired as part of the non-Seri fishing crew.*

The Seri fisher is generally paid the same share as that of the rest of the crew. This way those Seri that typically have no access to the fishery are able to participate. Monitoring and enforcement of norms and rules is conducted at a low cost for the community by the Seri crewmember. However, depending on the situation, the Seri might be deterred from denouncing unacceptable activities of their employers, since their employer's expulsion from the EFZ would imply the loss of their job.

3) *Fishing quota.*

No more than 20 Kg. of CDH can be harvested per day by non-Seri fishers. This is based in the average catch that Seri fishers harvest in a good day of fishing. This rule does not apply to Seri fishers.

4) *Restricted fishing areas.*

Regardless of their ethnic identity, divers are not allowed to exploit CDH in traditional sandbar harvesting areas at any time. These areas are reserved for the use of non-fishing members of the community (children, adults, and elders). The definition of sand bar harvesting areas is quite loose among the Seri. However, these areas are typically partial or completely exposed at low tide and at high tide the maximum depth does not surpass the waist length.

[61] 1 usd= 9.5 pesos

Seri official rules-in-use are directly aimed at providing a wide array of economic benefits to the Seri, and protecting their ecologic and cultural patrimony (Table 7).

Table 7. Benefits that rules-in-use bring to the Comcáac community.

RULES	BENEFITS TO THE COMCÁAC COMMUNITY
Payment of fishing permit	♦ Economic revenue to the Seri government
Hiring a Seri as part of the crew	♦ Employment (fisher's economic benefit) ♦ Higher participation of Seri fishers in the fishery ♦ Low cost monitoring of compliance of Seri fishing norms
Fishing quota	♦ Avoid overexploitation of CDH stocks
Restricted fishing areas	♦ Avoid overexploitation of CDH stocks ♦ Protection of culturally important fishing sites

On the other hand, these rules also try to diminish outsiders' seeking access by reducing the economic benefits that they are able to obtain from fishing in the Seri EFZ. For instance, for many outside fishermen the upfront costs of accessing the Seri EFZ, plus the limit on the amount of CDH that can be harvested, makes the benefits of fishing in Seri waters to be equal to those obtained at any open access fishing grounds. As stated by non-Seri fishers:

"...afuera del Canal se hace menos marea, pero no tenemos que pagar por el permiso ni tenemos que subir al Seri asi que la ganancia es mejor. "

"...outside the [Infiernillo] Channel the catch is less, but we do not need to pay for the permit, neither we have to employ a Seri, therefore the profit is better." (field notes 7/20/2000).

On the other hand, some 'access seekers' find enough incentives to develop alternative strategies to obtain access, depending on how the Seri honor, apply and enforce their own "official" rules. The factors that originate and maintain alternative access seeking strategies, are the subject of the following sections.

6.4 RULES-IN-USE TO GRANT ACCESS

6.4.1 The Role of the Seri Government

Due to the Seri government's limited sources of income, it is common practice that the Seri government official who receives the payment of the fishing permit will keep it. Often the monetary amount of a fishing permit corresponds to the joint payment of royalties of water rights and land rights, each of which are under different jurisdictions of the Seri government. Therefore, it is not rare for members of the different jurisdictions to find themselves competing to grant and keep the monetary payment of the permit.

When acting in a self-interested fashion, Seri officials grant withdrawal rights as long as they foresee that they will benefit from the monetary transaction that will take place. Seri government's dependence on outside income can be significant and sometimes it is not clear which constituency they serve, as illustrated by the comment of a Seri fishing cooperative official:

"...Anteayer unos conocidos de Kino me pidieron un permiso pero les tuve que decir que sepasaran pues la comunidad no quiere que se vendan mas permisos. "

"...One day before yesterday some acquaintances from Kino asked me [to sell them] a fishing permit but I had to tell them to sneak in [to the Infiernillo Channel] because the community does not wan me to sell any more permits." (field notes 12/13/2000).

The constant visits that different members of the Seri government make to non-Seri fishermen to collect their royalty fees, allows them to oversee the compliance of outsiders with Seri rules. Since it is not uncommon to find that somebody else already collected their fees, they are likely to ask for more money if given the slimmest excuse. Outsiders generally comply with new monetary requests in order to avoid conflict or risk being expelled before they can recuperate the upfront costs already incurred. However, this inequitable relationship is a cause of the perpetuation of the perception by outsiders that the Seri do not honor their agreements and are not trustworthy.

In one occasion, the Seri discovered a very rich CDH bed in their EFZ, the word rapidly spread to non-Seri fishermen, who were facing one of the worst fishing seasons in recent years, and were badly in need of income. Outsiders requested the Seri governor to grant them fishing permits. In the agreement, only 3 boats were to receive withdrawal rights (which included water and land rights) for one week. The price of the permit was unusually elevated since it included all the royalties corresponding to all the structures of the government involved. In return the governor guaranteed that no other sum had to be paid to anybody during their stay in Seri territory. The agreement fell apart when some Seri harassed the outside fishers to give them money. This triggered the illegal entrance of many other non-Seri fishers to the EFZ, convinced that it was useless to invest in a

fishing permit. Given their circumstances it was worthwhile for them to engage in conflict with the Seri in exchange of one or two days of good fishing. The Seri Army expelled all foreigners after a few days of, according to the Seri, unprecedented fishing pressure to the CDH fishing grounds.

6.4.2 The Role of the Seri Community

Most members of the Seri community are not compensated and do not benefit in any way from granting access to non-Seri fishermen. Only those temporarily employed by non-Seri fishermen enjoy a short-term benefit (see rules-in-use). This creates incentives to some members of the community to seek their own alternative ways to grant outsiders with withdrawal rights, as a way to obtain a personal benefit of sharing their resources with outsiders.

Social pressure and internal isolation are the most effective coercion mechanisms to control self-interested behavior at the individual level. It is also the only mechanism with which the individuals that compose the Seri government can be held accountable for its actions. No external authority is in place in charge of overseeing the actions of the Seri government. The involvement of Mexican local or Federal government in Seri internal issues is limited to certification of the election process for Seri government officials (see Seri Governance Structures Section). From the outsider's perception Seri territory is a lawless place, as illustrated by the fact that Mexican car thieve mafias chose it as a preferred place to sell their stolen items.

Communal pressure is the driving force that prompts direct action against illegal fishers in the EFZ, once communal transaction costs of expelling them are surpassed. The degree of communal tolerance towards a specific type of access pressure varies according to current economic, political, and social circumstances. For those individuals (in the Seri government or the community) who are in the position to grant access to outsiders, these factors influence the mental calculation of costs and benefits (social capital, discount rate) that their self-interested actions will bring to them.

Typically, when the Seri community exceeds the maximum level of tolerance towards non-Seri fishermen, the Seri government will issue an order to all non-Seri fishermen, mandating them to abandon Seri territory within a 72 hour period before the Seri Army proceeds to confiscate all foreign fishing gear and catch. In situations of extreme tension no notice is given before the Seri Army takes action.[62]

6.5 ALTERNATIVE STRATEGIES TO GAIN INCLUSION

Most of the alternative strategies to grant withdrawal rights to 'access seekers' (Table 8) originate from community members' self-interested behavior, especially at the level of the Seri government.

Five major groups of alternative strategies were identified in the Seri CDH fishery between 2000-2001 (Table 8). Differences in preferences, benefits, incentives, and social capital between the potential beneficiaries of obtaining or granting access to the EFZ, define the different alternative strategies that are in use. Whether the beneficiary is a non-

Seri fishermen, a group of them, or a member of the Seri community; most strategies aim to simulate compliance with the "official" Seri rules-in-use in one way or another.

Table 8. Access strategies observed for the Seri EFZ.

Strategy	Times strategy was used by foreign fishing boats inside the Seri fishing grounds [a]
Seri government's procedure (*official*):	
Agreement to (a) pay for a permit, (b) hire a Seri fisher, (c) limit catch, (d) avoid diving in communal areas.	11[b]
Alternative procedures (*unofficial*):	
• Hiring a Seri crewmember	26[c]
• Non-Seri fishing team contracting with a Seri patron	13
• Non-Seri diver contracting with Seri patron	21
• Becoming part of the Seri kin	34
• Sneaking in	9[d]

a. Data recorded during 32 fishing trips conducted between June of 2000 and June of 2001 (See Table 2). Also see Table 1 for a detailed description of length of field season.
b. Number is possibly underestimated due to the lack of reliability of the information provided by Seri government officials.
c. Number may be overestimated because of the inclusion of official cases as alternative strategies.
d. Number is likely to be highly underestimated due to the evasive nature of this strategy.

A description of each of the observed strategies between 2000-2001 follows. Some of the alternative strategies have one or more characteristics in common. Characteristics are described in those strategies where they are most significant or illustrate best the mechanism of the given strategy.

[62] As an outsider, it is difficult to distinguish when the expulsion of outsiders is caused by communal

6.5.1 Hiring a Seri Crewmember

One of the most common strategies to enter the EFZ without paying a fishing permit is to directly hire a Seri fisherman (Table 8).

In most cases the Seri fishermen recruit outside fishers to come to the EFZ in exchange of employment. For Seri fishermen who do not own a boat nor have CDH diving gear, this is a way to gain access to the fishery. They are able to benefit from it without making a monetary commitment or expose themselves to the inherent risks of diving (Table 9). However, they earn as much as the rest of the fishing team, since the catch is divided equally between all crewmembers and owner of the boat.[63,64]

Table 9. Position of Seri fishers in non-Seri fishing teams.

Crew Position	Times Seri fisher was observed occupying position [a]	Nature of the Job
Diver	0	Very technically and physically demanding
Crewmember	26[b]	Least technically and physically demanding

a. Data recorded during 32 fishing trips conducted between June of 2000 and June of 2001 (See Table 2). Also see Table 1 for a detailed description of length of field season.

b. Includes fishing teams of non-Seri living in the Seri community.

In turn, outsiders consider that the presence of a Seri on their boat reduces the level of economic uncertainty and risk of fishing in unknown waters. For his own short-

pressure or by the initiative of an individual of the Seri government.

[63] There are exceptional cases where the Seri fisherman is paid a fixed amount for his labor.

[64] Customarily, when it comes to dividing the catch, the boat is considered part of the crew, and the owner receives compensation for the use of his equipment.

term benefit the Seri is likely to provide them with information on current productive fishing areas and potential upcoming raids by the Seri Army. For the benefit of the long-term productivity of the EFZ, he also may caution them about prohibited fishing areas and Seri acceptable fishing techniques.

Social repercussions for the Seri that engage in this activity vary extensively. The fewer economic alternatives available for Seri fishermen, the more tolerant the community is to fishers who find employment by becoming part of an outside fishing crew. However, there is usually less tolerance towards those individuals who, motivated by internal conflicts, prefer to fish with outsiders than with their own people. One interviewed Seri fisher said that to avoid to be "yelled at" by members of the community he frequently traveled 30 Km by land to a neighbor non-Seri town just to board and unboard the outsider's boat and then travel by water to fish inside the Seri EFZ.[65]

Most interviewed Seri fishers expressed that they would rather not have to work for outsiders if other economic alternatives were available. In fact, when other economic alternatives were at hand, they readily switched activity voiding their agreement with the outside fishers.

Communal disapproval of Seri and non-Seri relationships seems to control individual incentives to grant access at the individual level. It is also the driving force that

[65] Other Seri fisherman (although for reasons non related to fishing) moved to the non-Seri village and utilized the same strategy to gain access to his own EFZ.

prompts action against outsiders, once communal transaction costs for expelling them are surpassed.

Between 2000-2001, direct Seri cooperative behavior (in the form of coordinated actions by the Seri army to expel outsiders), was always recorded whenever the number of CDH fishing boats (Seri and non-Seri included) surpassed 15 in the same fishing area of the EFZ.

Finally, a third measure to control access is the reduction on economic profitability that hiring a Seri brings to the non-Seri fishing team. The profit margin of a fishing team varies in relation to the productivity of the CDH EFZ, which in turn, varies throughout the year according to the stage in the ecosystem cycle of the EFZ and CDH biology. When the EFZ's productivity reduces the profit margin to the point where incentives to keep fishing in the Channel are nullified non-Seri fisher's decide to leave the Seri EFZ on their own.

6.5.2 Non-Seri Fishing Teams Contracting with a Seri Fishing Patron

In Mexican small-scale fisheries, fishing patrons make a living from marketing fish. To guarantee a constant supply of product, they provide all the necessary fishing means (boat, motor, diving compressor, gasoline) to a pool of fishers who work for them.

Seri fishing patrons operate in a different manner. They are not necessarily economically powerful individuals as their counterparts elsewhere. However, they are in the position to provide different levels of support (and hold significant amounts of bargaining power) to non-Seri fishers inside EFZ. The profit Seri obtain from granting

withdrawal rights to outsiders consists of receiving an equal share of the catch, or double that, if they are also the owners of the boat and fishing means that outside fishers are using. Others also profit from acting as middlemen in the regional CDH market.

Since fishing patrons do not participate in the operations at sea, they can manage more than one outside fishing team and multiply their income. Their tasks are usually bound to provide fishers with provisions (food, gasoline, etc.) and take the catch to sell. A Seri patron's support is essential for non-Seri fishing teams to camp inside Seri territory for various days, without suffering active communal pressure against their presence. Eventually, Seri fishers identify them at sea, and news about their presence spread once they are back in the Seri community. Whether the Seri take action to expel these outside fishers or not, depends on the level of communal tolerance towards outsiders that prevails at the time.

The significant amounts of bargaining power that the Seri patron enjoys originate from the total dependence that outsiders have on his continued support to fish in the Seri EFZ.[66] The result is that the Seri patron is able to coerce alien fishers to comply with Seri EFZ fishing practices, indirectly benefiting the long-term viability of the fishery.

This was one of the least observed alternatives used to gain access to the EFZ between 2000-2001 (Table 8), suggesting the presence of extremely high transaction costs that decreased its popularity. In several interviews some Seri mentioned that those

[66] The disproportionate difference on bargaining power between Seri and outsiders is illustrated by extreme cases where non-Seri fishermen accept food as payment for their work.

who engage in this activity are traitors, because they prefer to employ outsiders than fishers from their own village.

Seri *mestizos* (the progeny of Seri and non-Seri parents), were seen engaged in granting this form of access more frequently than full-blooded Seri (Table 10), illustrating that they hold lower social capital inside the Seri community than full-blooded Seri. It is likely that the racial discrimination they face as a "non-pure" Seri reduces the transaction costs of engaging in conflict when there is the opportunity of obtaining personal profit.

Table 10. Ethnic profile of fishing patrons and their non-Seri fishing teams.

Ethnic profile of fishing patron	Times non-Seri boats contracted with Seri patron [a]
Full blooded Seri	3
Seri *mestizo* [b]	10
Non-Seri living in the Seri community	0

a. Data recorded during 32 fishing trips conducted between June of 2000 and June of 2001 (See Table 2). Also see Table 1 for a detailed description of length of field season.

b. Seri *mestizos* is the name with which community members that descend from a full blooded Seri and a non-Seri marriage are called.

The same three access control mechanisms observed for the prior strategy were observed in this case: (1) Communal pressure at the individual level, (2) communal pressure to prompt Seri army action, and (3) reduced non-Seri fishers' economic profitability.

6.5.3 Non-Seri Divers Contracting with a Seri Fishing Patron

Contracting in an individual basis with a Seri fishing patron was much more popular than as a fishing team between 2000-2001 (Table 8). Many Seri expressed that, "for good reasons", they almost always hire outside fishers who are divers (Table 11). Diving is regarded as a hazardous and exhausting task and Seri prefer not to perform it. Also, the diver's personal outfit and fishing gear (wetsuit, mask, fins, hook) can be expensive ($500) and difficult to get. Since the beginning of the fishery (1970s), outsiders have done most of the diving in the Seri EFZ. Therefore, their presence is less problematic and noticeable in the Seri community than that of other non-Seri fishermen.

Table 11. Division of labor in Seri fishing teams.

Position in the fishing team [a]	Seri	Non Seri
Captain	57	0
Diver	19	38

a. Data recorded during 32 fishing trips conducted between June of 2000 and June of 2001 (See Table 2). Also see Table 1 for a detailed description of length of field season.

There is a constant influx of non-Seri divers to the Seri village in search of work. If a Seri patron is interested in a diver's services, he will provide a place for him to stay and will lobby in his favor as long as they have a working relationship. Interviewed non-Seri fishers said that only the very best divers are able to establish long-lasting relationships with Seri patrons, and some of them return to dive every year.

Non-Seri divers are attracted to the profitability and safety of diving in the Seri EFZ. The shallow depth of the Channel (average 5.5 m) allows them to stay underwater for extended periods of time without the risk of suffering a diving disease. It is likely that no other CDH fishing ground offers such characteristics in the Gulf of California.

Outside the Seri EFZ, it is customary that the diver is in charge of deciding time and place to dive. He is usually the most experienced and therefore authoritative member of the team. There is a sense of pride in being a diver, and they consider themselves as a separate group of fishermen. Their traditional role changes when a Seri fishing patron hires them. Their sole role is to harvest CDH underwater and have no other say or authority in any other aspect of the fishing operation. Most divers tolerate this, at times, humiliating situation because diving is safe and profitable. However, if not careful, the profit can be rapidly lost on the expenses of staying in the Seri village for a period of time. As expressed by a non-Seri diver:

"...la paga no es tan buena como parece, el mandado y la renta son muy caros and nosotros estamos solos, no hay nadie que nos haga el paro... "

"...the pay is not as good as it seems, goods and services [in the Seri community] are very expensive, and we are alone here, nobody would give us a break..." (field notes 9/29/2000).

Most outside divers cannot and do not want to stay long in the Seri village. Those who do are practically invisible. After diving they stay indoors until the next morning when they go out again. Nevertheless everybody knows that they are in the community,

and they are expelled in times when the Seri Army takes action against aliens inside their territory.

6.5.4 Becoming Part of the Seri Kinship

Mexicans married to a Seri obtain immediate rights to all Seri common resources. Seri territory continuously attracts Mexicans for various reasons including the abundance of fishing resources. Most males become fishers after establishing residence in the Seri village. The Mexicans married to Seri account for one of every three active fishers in the Seri community (Table 12).

Table 12. Seri fishermen demographics for *Punta Chueca* between 1997-2001.

Adult Seri male population [a]	124
Adult non-Seri male population	18
Non-Seri married to a Seri or *mestizo* woman	17
Active fishermen	62
Active Seri fishermen [b]	46 (65%[c])
Active non-Seri fishermen (% of active fishermen)	16 (35%[c])
Non-Seri that were already fishermen before living in *Punta Chueca*	6 (33%)
Non-Seri that became fishermen since living in *Punta Chueca*	12 (67%)

Source: This work except for a & b (Bourillón 2002).
c. Percentage of active fishermen.

In several interviews Seri and non-Seri members of the community indicated that many non-Seri fishers have tried to establish residence in the Seri community, but only those that became part of Seri kin were able to stay (Table 12). Seri social pressure and

Seri exclusive legal ownership over their land, make it very difficult for outsiders to permanently establish in the Seri village without being part of the Seri kin.

Under the *ejido* communal ownership system, only commoners can own and build a house in *ejido* land. Since the Presidential decree established that only Seri can be commoners, unless a Seri family has an extra parcel of land to lend to a foreigner, he cannot establish in Seri territory.[67] Some families are in the position to lend an unused lot when their unmarried adult descendants have claimed their property but are still living with their parents.[68]

Once a non-Seri is established in the Seri community his or her extended family can become part of his fishing team, therefore gaining access to the fishery. Some non-Seri extended family members have made fishing in the Seri EFZ a seasonal job. They arrive to the village and live with their relatives at times when there is no work elsewhere. If social pressure mounts, they leave.

From the Seri perspective, alien residents bring sociocultural, economic, and political problems to the community and many Seri do not welcome inter-ethnic marriages. This sentiment reflects hundreds of years of exploitation and extermination wars by the Spaniards and Mexican.

The presence of outsiders in Seri territory is seen as a new form of invasion and loss of sovereignty. Many full-blooded Seri are very hostile and outspoken against

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[67] Under the ejido system, the state still holds alienation rights to the land, therefore land users cannot sell or lease it.

[68] This is the case of the only non-Seri couple that has been able to establish residence in the Seri community. Both families are related through their married son (non-Seri) and daughter (Seri).

foreign presence. Most Seri elders worry that if the inter-ethnic marriages are to continue, soon there will be no full-bloodied Seri left and all Seri resources in their territory will be lost to the *mestizos* (the progeny of Seri and non-Seri parents). The Seri government has made several attempts in the past to divide communal benefits on the basis of ethnic origin.

Recently (April of 2000), the Seri government issued a resolution[69] that laid out the basis under which it intends to monitor and control future alien residents' activities in Seri territory. The resolution aimed to limit (a) communal rights of inter-ethnic marriages, (b) foreigner's rights to participate in economic activities inside the community, and (c) their ability to grant access to their extended families (Table 13).

Table 13. Seri government's official resolution to monitor and control foreigner's activities in the Seri community (literal translation).

1. All alien residents must request an official authorization to continue living in the Seri community.
2. Foreigners that do not have an official authorization to establish residence in the Seri community must leave our territory within a 72 hour period. After which the Seri Army will assure the curse of this resolution.
3. Seri men or women that marry a non-Seri person lose their rights to Seri communal benefits and could be expelled from our territory.
4. Aliens to our community and blood have no right to establish any kind of commercial established business (corner store, food stand).
5. Aliens to our community will not enjoy open access to our territorial rights.
6. Foreigners engaged in any illicit activities will be immediately expelled from our community.
7. Any vehicle without legal documentation and in the possession of foreigners will be

[69] The resolution was legally based on the Seri interpretation of the Mexican Constitution (Art. 4), the International Labor Organization (Agreement 169 for Native Indian Nations, Art. 133), and the presidential resolutions of 1970 and 1975 that granted them territorial rights.

confiscated.
8. Only foreigners married to a Seri will be allowed to continue living in the community. 2nd degree non-Seri relatives (extended family) are not allowed to establish in Seri community.
Note: The Seri governor, his secretary and treasurer signed the resolution. It also carried the official stamp of the ITCP and of the Elder's Council.

Since the resolution was issued, no married non-Seri fishermen have fled the community. They say that previous resolutions such as that one had been issued before, after which they would leave the community and come back later. Now they don't take those resolutions seriously anymore. They believe that they are mostly intended to frighten potential newcomers, but not them.

A close look at the non-Seri norms of behavior inside of the community reveals the practice of strategic actions to keep a low profile so that they do not loose access to the Seri EFZ. In several interviews non-Seri expressed that when a non Seri boat goes out fishing, non-Seri teams also try to avoid having to go out to fish. They always try to avoid being the first boat to go out or the last one to return. Even in times when they haven't fished enough to make a profit. When they bring home a really good catch, they never brag about it in the presence of fellow Seri fishermen, as fishermen customarily do.

Jointly, these strategies show conformity to Seri norms and are a way to avoid unwanted attention from Seri fishers. Giving the Seri any reason to believe that they might be fishing more than what they consider appropriate, could potentially result in their expulsion from the village.

In general, non-Seri fishermen married to Seri women have very limited participation in communal activities. However, they are always well informed of the current political situation in the community, especially of any internal tension that could be building up against their presence.

Seri communal rejection, government pressure, and the existence of Seri *ejido* property rights around their EFZ, create enough barriers to deter the permanent establishment of most outside fishers who try to establish residence in the Seri community.

6.5.5 Sneaking into the Seri EFZ

The secretive entrance of non-Seri fishers to the EFZ is an event difficult to document (Table 8). However people frequently talk about outside fishers or *pirates* entering the EFZ. Some of them only enter the Seri fishing grounds to fish for the day. Others camp inside for one or two days and then leave.

Since the closest non-Seri town is more than 30Km south, entering and leaving the Seri EFZ in a daily basis increases gas costs and reduces the fisher's profit margin considerably. Furthermore, the appeal to travel to fish in the Seri EFZ is influenced by the availability of other fishing alternatives elsewhere, regional market price of CDH, Seri internal tolerance towards outsiders, and the non-Seri fisher's own risk tolerance.

Knowing that the reaction of the Seri community to expel outsiders is generally slow (taking one day or two to react), *some pirates* camp in Seri territory for one night or two to increase their profit margin. Some fishers have been known to sleep aboard their

little outboard boats as a safety precaution. In times when communal uprising against outsider's presence has raised to unusual levels, the Seri Army has posted a boat to patrol the physical entrance of boats to the Channel. If a *pirate* is caught, their catch is generally seized and sold by the Seri government for its own profit.

6.6 PERFORMANCE OF ACCESS CONTROL MECHANISMS

6.6.1 Mechanisms to Control Access

Throughout this chapter I have described and discussed the different mechanisms that are in place to control access to the Seri EFZ (Figure 7).

The first 3 mechanisms: (1) the existence of Seri exclusive property rights, (2) rules-in-use to grant withdrawal rights, and (3) environmental stochasticity + reduced profit margin, function by decreasing outside fishers' incentives to fish in the EFZ. In one way or another they decrease the profit margin of the fishing venture, while increasing the transaction costs of seeking access. Seri fishermen do not have to constantly invest in the implementation of these controls and I have called them passive mechanisms.

These passive controls are at work when non-Seri fisher's "try their luck" for a few days, and decide to leave the EFZ long before communal pressure builds up against their presence. Outside fishers generally leave in a friendly manner as a way to maintain the possibility of gaining access again in the future.

Outside fishermen who find it worthwhile to surpass passive control mechanisms, then face access controls originated at a community level. Such mechanisms are (4)

communal pressure and (5) deployment of the Seri Army (Figure 7). These are considered active mechanisms since the community has to invest social capital and material resources to implement them.

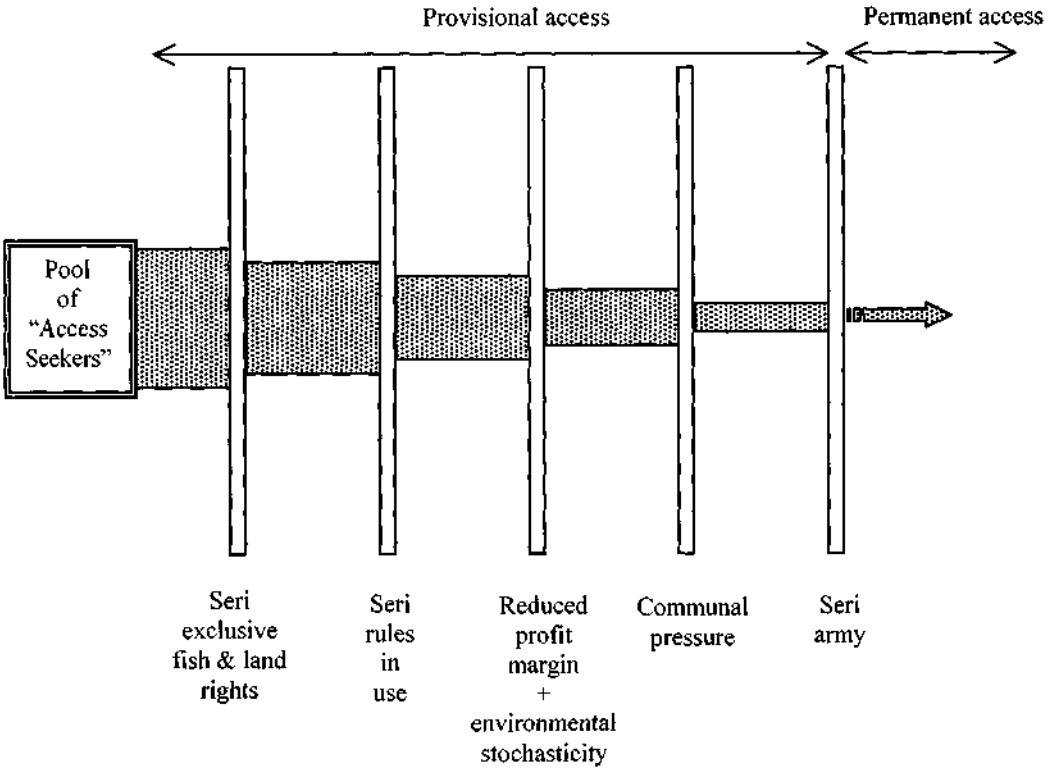

Figure 7. Mechanisms to Control Access to the Seri Exclusive Fishing Zone

Active control mechanisms are responsible for controlling access in most of the strategies that *access seekers* use and that have been analyzed in this chapter (Table 14).

Communal pressure is the primary force to control self-interested behavior of potential beneficiaries from granting access to outsiders. It is also the mechanism that

prompts to action the Seri Army when communal tolerance to the presence of outsiders has been surpassed, and physical enforcement is required. Only those outsiders who are able to become part of the community through inter-ethnic marriage can surpass these controls in a permanent basis.

6.6.2 Graduated Inclusion Mechanisms

The award of fishing property rights and the physical characteristics of the Seri CDH fishing setting has put the community in a favorable position to exclude fishing competitors for the most part. The Seri community however, has chosen to offer CDH withdrawal rights to outsiders when members perceive they can obtain economic benefits (Table 14).

In times of economic hardship, the grant of withdrawal rights is a handy alternative that the Seri use to create employment for themselves and increase communal participation in the fishery. The pairing of withdrawal rights with self-employment of Seri fishers favors the Seri community since it provides low cost monitoring of outsider's activities while in Seri fishing grounds. As a result a high compliance of Seri fishing rules and norms by outsiders seems to be achieved (Table 14).

Table 14 shows that the communal benefits that the Seri government aims to achieve when granting withdrawal rights to outsiders (Table 7) are also obtained when withdrawal rights are granted to outsiders by alternative mechanisms. These similarities in the performance are likely due to a shared world view or cultural homogeneity among the Seri community. The differences between official and alternative access mechanisms

resides in the allocation of benefits that granting access brings to the Seri community. While in practice the official rules mostly only benefit governmental members, the use of alternative strategies shifts benefits to the community.

Table 14. Characteristics of the strategies to obtain access to the Seri EFZ.

STRATEGY	Who initiates the interaction?	Who benefits economically?	Effect in local participation?	Are local norms and rules monitored?	Forms of access regulation
Seri government procedure (*official*)	Non-Seri	Members of the Seri government	Increase	Yes	Economic profitability, Communal pressure, Seri Army.
Hiring a Seri crewmember	Seri	Individuals in the Seri community	Increase	Yes	Economic profitability, Communal pressure, Seri Army.
Non-Seri fishing team contracting with a Seri patron	Non-Seri/ Seri	Individuals in the Seri community	Increase	Yes	Economic profitability, Communal pressure, Seri army.
Non-Seri diver contracting with Seri patron	Non-Seri / Seri	Individuals in the Seri community	No change	Yes	Seri Army
Becoming part of the Seri kin	Non-Seri / Seri	Individuals in the Seri community	Increase	Yes	Seri exclusive property rights over their land, Communal pressure, Government pressure.
Sneaking in	Non-Seri	Non-Seri	No change	No	Seri army

6.6.3 Equity Issues

The high bargaining power with which the Seri control their arrangements with outsiders is based for the most part in their capability to revoke their agreements with outsiders without legal repercussions to their actions. Threatening to expel outsiders or confiscate their fishing equipment if local norms are not followed (or for no apparent reason) is readily used by the Seri to control outsiders' actions inside their fishing grounds. Although highly inequitable, this scheme achieves a high degree of enforcement of local rules-in-use from outsiders.

However, the ease with which Seri fishers decide not to honor or cancel their agreements, reinforces outsiders' beliefs that the Seri are unreliable partners. Through time, the nature of these interactions has resulted in a stable equilibrium of distrust between both parties from which it is difficult to break free. Reciprocal initiatives have a very limited life in the Seri EFZ and social capital hardly accumulates between the Seri and outsiders. If this scheme is perpetuated, it is expected that sneaking to the Seri fishing grounds will become a more prevalent access strategy in the future. The primary reason this illegal entry is not more common today might have to do with the geographic location of non-Seri fishing villages with relation to the Infiernillo Channel. For outside fishers coming from *Bahia de Kino,* it is still too costly to sneak into the Infiernillo Channel from the North, since it would take them more than two hours to circumnavigate Tiburon Island, Mexico's biggest Island. However, this might change as the populations grow in the region.

6.7 FINAL REMARKS

It is clear that property rights play a significant role in the universe of strategies that users are able to devise when dealing with exclusion issues. However, the presence of ownership rights does not *per se* achieve access control. Owners frequently choose to grant access to outsiders as in the Seri CDH fishery. The lack of democratic mechanisms within the Seri community contribute to the existence of alternative sources of access of non-Seri fishers. Nevertheless, it is the presence of a culturally homogeneous community, and shared world view, norms, beliefs and ethics, which achieve most of the access control when it is needed. To the degree that current cultural values keep providing Seri with a low discount rate for the use of their fishing resources, individual monitoring and enforcement will be adequate to maintain external pressures in check and offset strategic self-interested behavior in favor of the Comcáac's common good.

The declaration of property rights has proved crucial nevertheless, for the Seri to preserve a significant geographic, cultural, and demographic isolation from the rest of the local fishing communities. While nearby fishing communities keep growing as fishers seeking good fishing arrive, emigration and immigration to Seri territory remains low.

The existence of Seri ownership rights to the land surrounding their fishing grounds allows the Seri to control access to fish buyers and fishers in general influencing and leveling the bargaining power created by external forces such as regional markets and population growth. Under a higher population pressure from outsiders, the Seri would face a wider range of incentives and tradeoffs for granting access while monitoring and enforcing outsiders' activities would become much more challenging. It is certain

that physical isolation has provided the Seri with the ideal setting for preserving spaces for renewal and validation of communal patterns of behavior, which are based in their ancestral common cultural values, ethics, and worldview.

7 ECOLOGICAL MANAGEMENT PRACTICES

7.1 BACKGROUND

Mollusks have always been an integral part of Seri livelihood. The Comcáac names of several fishing camps along the coast are indicative of their knowledge and connection with these organisms. Probably the most famous one is *Haxol Ihoom* (Place of Clams), now known as *El Desemboque,* the first permanent Seri village. Malkin (1962), provided the first western science account of the mollusks used in Seri livelihood. According to his work, the Comcáac used 27 mollusk species for food,[70] 13 for trade,[71] 13 for decoration, 1 for bait, and an uncounted number as utensils.

Since time immemorial, the Seri have harvested bivalves from sand flats exposed by the tides in the Infiernillo Channel, estuaries, and shallow waters along the coast. In 1973 fish buyers started the commercial exploitation of scallops from CDH in the Infiernillo Channel. They brought their own fishing crews from Sinaloa and South of Sonora to free dive for them. It is likely that at this time the Seri started to commercialize part of their subsistence catch from the sandbars. Soon they acquired their own hookah underwater breathing apparatus and joined the commercial activities, incorporating their traditional ecological knowledge (TEK) to the new fishing practices.

Twenty-eight years later, the CDH fishery still remains active and profitable. In fact, the Comcáac CDH fishing grounds seem to be the most productive in the Midriff

[70] According to McGee (1898), the importance of mollusks in Seri diet ranked third, only behind sea turtle meat and fish.

[71] The Seri traded rock scallops *(Spondylus* spp), during the pre-Columbian shell trade (Sheridan 1999:13).

Island Region, as they are the only grounds able to sustain a relatively constant fishing effort year around (A.H. Weaver, Kino fisheries researcher, personal comm. 2000).

The goals of this chapter are to identify, document, and validate how TEK has been integrated into local fishing practices, and to determine which fishing practices are important for the success of this community-based managed fishery.

To accomplish this I used the framework developed by Berkes and Folke (1998) (Figure 8) to analyze the link between social and ecological systems for resilience and sustainability.[72] They hold the view that "the delineation between social and natural systems is artificial and arbitrary." They refer to a social system as those that "deal with property rights, land and resource tenure systems, and world views and ethics concerning environment and resources. Ecological system (ecosystem) is used in the conventional ecological sense to refer to the natural environment."

The information presented in this chapter was obtained from interviews, underwater censuses, fishing trips, and literature review. The methods used to gather the ethnographic information have already been described at the beginning of Part II of this thesis. The next section describes the methods used to collect the ecological information. Results have been organized in three general sections: (1) Documentation of traditional sand bar harvesting sites, (2) use patterns of hookah fishing areas, and (3) fishing biology and ecological factors that influence local management. Based on this information various components of the ecological and social CDH fishing system were identified,

their role in local management was analyzed, and their contribution to the viability of the system is the focus of the discussion.

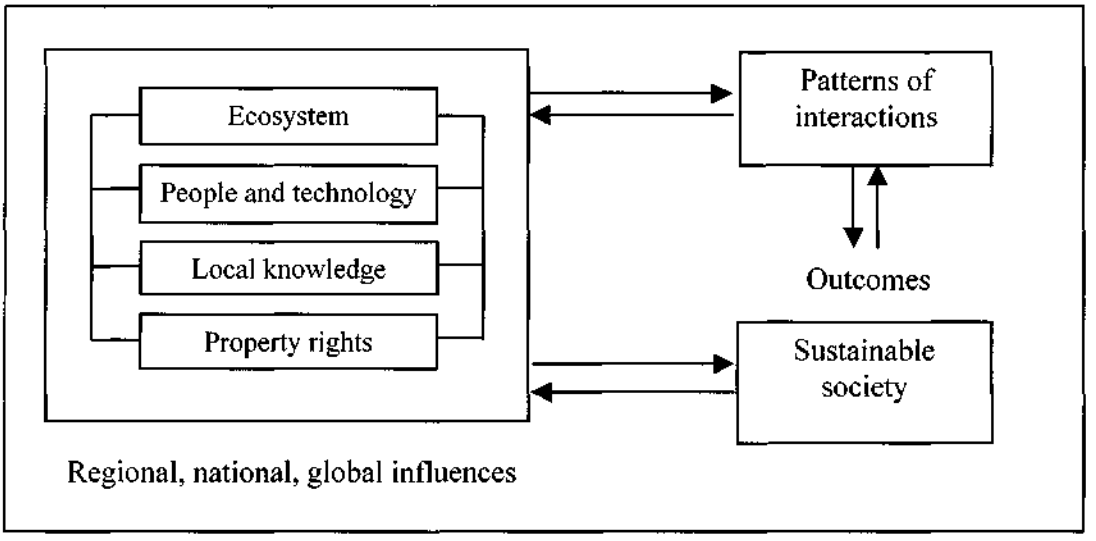

Figure 8. Framework used by Berkes and Floke (1998).

7.2 METHODS

7.2.1 Traditional CDH Sand Bar Harvesting Sites

Traditional CDH sand bar harvesting sites consist of those areas where the Comcáac people have harvested CDH, and other bivalve mollusks, for subsistence purposes for thousands of years.

[72] The definition of sustainability used here is the one provided by Folke et al. (1998) witch they in turn borrowed from the WCED (1987). Sustainability is a developmental process where the needs of the present are met without compromising the ability of future generations to meet their own needs.

To document the location of the main traditional sand bar harvesting sites, 4 Seri elders and 6 experienced fishermen were interviewed using a semi-structured format. An in-depth explanation of the ethnographic methods used to document fishers' traditional knowledge is included at the beginning of Part II of this thesis.

The survey of fishing locations only included those sites lying between *Punta Perla* and *Punta San Miguel* in Tiburon Island, and from *Dos Amigos* fishing camp and *Santa Rosa* estuary in main land Sonora (Figure 9). I created an account of the number of traditional sand bar harvesting sites, and their ecological significance.

7.2.2 Hookah Fishing Areas: Use, Differentiation, and Site Selection

The identification of modern CDH fishing areas in use by hookah diving teams was done using several data gathering methods: (1) I conducted unstructured and semi-structured mapping interviews with experienced fishermen; (2) I recorded the area's geographic position using a GPS Garmin XL; (3) I reviewed 2 fishermen's fishing journals, and; (4) I recompiled scattered and scarce GPS data gathered prior this study.

To determine the most important CDH fishing areas and their frequency of use, fishermen were asked to name and identify on a map of the Infiernillo Channel, the locations of fishing areas used for the longest periods of time by most of the fishing fleet during the years 1999, 2000 and 2001 (Jan-Jun). Fishing areas were grouped in three categories: (1) Alternatively used throughout the year; (2) used at least once a year, and (3) used once every few years.

During the interviews, fishers were asked to list the factors that influence their choice of fishing areas. To specifically assess the influence of scallop size and abundance in their selection of fishing areas, fishermen ranked several fishing areas according to their level of preference. Fishermen's choices were compared to the CDH scallop meat sizes obtained. The categories and definitions under which the fishing areas were ranked were (1) preferred: CDH abundance and large to average scallop size; (2) average: CDH variable abundance and average to small scallop meat size; and (3) avoided: highly variable abundance as scallop meat size. Fishing areas for which fishermen had no preference were not included in the survey. Surveys included important areas for the two most commonly harvested CDH (the kidney and the round shaped pen shell). For most of the fishing areas mentioned by the fishermen in the surveys a sample was obtained either through the catch or by doing an underwater census. Geographic positions of these sites were recorded using a hand held geographic positioning system (GPS).

Data from various sources were used to corroborate the information obtained through interviews and in the field and consisted of: (1) Fishing journals kept by two CDH fishermen, (one from July 2000 to March of 2001 and another from July 2000 to June 2001), and (2) a few GPS polygons and positions of CDH fishing boats mapped by fellow researchers in years prior to this study (1998 and 1999).[73]

[73] For details of mapping methodology see Bourillón (2002) and Torre-Cosío n.d.

7.2.3 Eelgrass Meadows

The presence of CDH beds in areas where algae, eelgrass, or seagrass meadows occur was assessed by direct observation, interviews with fishermen, and overlaying hookah diving GPS positions (gathered in this study), and eelgrass meadow areas available from other studies (see Torre-Cosio n.d.).

7.2.4 Underwater Survey

The goal of the underwater survey was to compare the species and shell size composition of the CDH obtained on the fishermen's catch against that available to them on the fishing areas were the catch was obtained, as to determine if divers had the ability to select among CDH species and if they were shaping species composition of their catches.

Once fishing areas relevant to the CDH fishery had been identified, underwater surveys were conducted on two of the most important CDH fishing areas. Two were conducted in the fishing area known as the *Paredones* and three for *Hona iyat.* More underwater surveys were conducted in *Hona iyat* due that an initial assessment showed that this area contained more bottom habitat types than *Paredones.*

In each survey a transect of 300 m^2 were censused. Shell size (cm), scallop size (mm), sex ratio, and stage of sexual development were assessed in the same way and by the same person as it was done for the fishermen's catch. This operation required the assistance of a fisherman on the surface to act as guide, motorman, meat preparer, and lifeline keeper (Table 6), while an assistant and myself conducted the survey.

The guide was asked to motor to a fishing location used within the past 3 days by the fishing fleet and which catch had been censused for this study. Once the boat had been anchored, a "a guide line" was submerged making sure it was extended in a straight line over the bottom. The "guide line" consisted of a 30 m long rope with one weight (~0.3kg) tied up every meter, and two dead weights (-5.0 kg each) and a buoy attached at each end. This line served as a guide to census an area of 300 m^2. The diver harvested all CDH he encountered in the area of up to 5.0 m from each side of the line. To make sure the diver kept himself within the 5.0 m limit, one extreme of a 5.0 m long measuring tape was held by a diver positioned always above the line, while the other worked his way perpendicularly to the line, harvesting all CDH (of every size) that he encountered. Every time a CDH was found, the species, position, and distance from the line were recorded. The total amount of CDH obtained in the survey was later added to the total amount of CDH obtained by fishers in a previous fishing trip to the same location, and conducted within a 30 day period to the underwater census. This way the total species and shell size composition for the location was obtained, allowing us to differentiate the selection made by the fishermen and that obtained during the underwater census.

Two important assumptions were made, (1) no significant growth or mortality took place between the time of the last harvest and when the census took place (30 day period); and (2) on average divers covered an area of 2,400 m^2 per fishing trip.

After a pilot trial, and taking into account that the diver's endurance was negatively affected by current strength and visibility, it was determined that 300 m^2 was the largest area that could be safely and technically surveyed in one session of 3 to 4.5

hours by two hookah divers. This area comprised 12.5% of the area covered by a commercial diver.

7.2.5 Fishery Biology

Thirty-two fishing trips were performed between June of 2000 and June of 2001 as shown in Table 15.

The number of sampling events for each of the biological factors assessed varied, because not all of them could be measured or assessed in all fishing trips. This was due to environmental factors and the high variability of working conditions, such as available space on the boat and the need to adapt to the different working styles of each of the many different fishing crews with which the sampling was conducted.

Table 15. Times each factor, fishing area, or underwater survey were measured or conducted during the fieldwork season.

Seasons	Fishery Biology factors					
	Shell size	Scallop meat size	Reproductive Cycle	Sex	Fishing Areas	Underwater Survey
Summer 2000 (June & July)	15	7	15	0	20	5
Summer 2000 (August)	0	0	1	1	0	0
Fall 2000 (September)	2	1	2	0	2	0
Winter 2000 (December)	5	3	5	0	5	0
Spring 2001 (March)	4	4	4	4	4	0
Summer 2001 (June)	1	1	1	1	1	0
TOTAL	27	16	27	6	32	5

To assess the CDH fishery biology I surveyed several characteristics of the catch during the fishing trips (Table 15): (1) Species composition, (2) shell and scallop size composition, (3) Sex ratio, sexual dimorphism and type of reproductive strategy (continuous Vs seasonal).

7.2.5.1 Species Characteristics and Composition

Species identification was done visually (Keen 1971). *Callo de hacha* species that inhabit the Infiernillo Channel are recognized by shell and scallop meat shape, as well as differences in the mantle's color. Fishermen were always consulted whenever I was uncertain about the species of a specimen.

7.2.5.2 Shell and Scallop Meat Size Composition

Shell size was determined as the maximum length (L) of one of the two shells of each animal. Measurements were done using an ichtyometer scaled in centimeters (0.1).

Since the scallop meat of the most frequently exploited CDH (*callo rinon* or kidney pen shell) is shaped in the form of a kidney, size was determined as the maximum diameter of the scallop. Measurements were done using a micrometric caliper (0.1 mm).

Shells and scallop meats were measured once the crewmate acting as meat preparer had emptied the bag of CDH inside the *panga*, opened the shell, and removed the internal organs of the CDH. Before he discarded the shell he placed it in a plastic container from where it was recovered, measured, and then discarded to the ocean. Scallop meats were measured after all shells of that load were measured.

7.2.5.3 Sexual Dimorphism and Sex Ratio

To assess if the CDH were sexually dimorphic, t-tests were performed to the shell and scallop size distributions of both sexes. Sex ratio was determined by conducting a chi square test of the average sexual ratio of 4 different fishing areas during the same climatic season.

Sex determination of adult individuals was done visually by observing the highly conspicuous gonads of each specimen. In CDH, as in other gonochoristic bivalves species (separate sexes), mature female gonadic tissue is bright orange colored and the male's is usually white to ivory colored (Strathmann 1987: 310).

7.2.5.4 Reproductive Strategy Determination

According to Ceballos-Vázquez et al (2000), there are two basic types of reproductive patterns exhibited by marine bivalves in the Gulf of California waters: those that have no seasonal reproductive cycle and continuously spawn and those that exhibit distinct seasonal reproductive cycles. To determine which reproductive pattern fits CDH, the gonadic condition of a sample of each catch was assessed visually by looking at coloration and size characteristics.

I determined two different stages for the condition of the sample tissue: (1) Presence of sexual activity. Individuals included in this category ranged from those that were ripe (gonad was brightly colored and swollen, bursting open at minimal contact), to partially spawned or still under a developing stage (their gonads seemed brightly colored

but not completely full). (2) Absence of sexual activity. Individuals included in this category presented an unidentifiable gonadic tissue.

7.2.5.5 Scallop Size Temporal Variability

Samples of scallop meats from the same fishing areas were obtained in each of the seasons of the year and measured to assess temporal size variability.

7.3 RESULTS

The results are organized as follows: (1) Documentation of traditional sandbar harvesting sites, (2) documentation of use patterns of modern fishing areas, and (3) fishing biology and ecological factors that indirectly influence local management. In each section, fisher's beliefs (as determined from the interviews) are presented first followed by the quantitative data that supports or contradicts their claims.

7.3.1 Traditional Sand Bar Harvesting Sites

The interviews with Seri elders and experienced fishers revealed a wealth of knowledge about the location and tidal influence on the sand bars along the Infiernillo Channel, as well as their relationship with other marine species such as sea turtles, and the bivalve species that could be found in them.

Seventeen sandbars were identified with Comcáac names and nine indicate an ecological characteristic of the place (Table 16). The informants also named 69 traditional campsites used when harvesting bivalves. In these accounts sacred campsites were not included (Figure 9).

Table 16. Type of names the Comcáac have assigned to traditional sand bar harvesting sites.

Names that indicate an ecological relationship	• Indicate a relationship between the tides and the sand bar	4
	• Indicate a relationship between sea turtles and the sand bar	3
	• Indicate a relationship between mollusks and the sand bar	1
	• Indicate the presence of crustaceans (swimming crabs)	1
Names similar to those of the fishing camps nearby		4
Names without an apparent meaning (likely to be proper names)		2
Names that describe the physical shape of the sandbar		1
Unknown meaning (but not recognized as proper name)		1
TOTAL number of sand bars identified by name		**17**

According to fishermen accounts and personal observation, sand bar harvesting in the Infiernillo Channel takes place from late spring to early fall depending the water temperature and when the biggest spring tides take place. Therefore, it is usually during summer that the greatest number of members of the two Seri villages gathers in the Infiernillo Channel to harvest bivalves.

Informants said that traditional sandbar harvesting sites are banned for hookah divers. Accordingly, none of the hookah fishing areas that were mapped during the fishing trips corresponded to traditional sandbar harvesting sites.

Figure 9. Traditional sandbar harvesting sites in the Infiernillo Channel.

Table 17. Key to sandbar names of map in Figure 9.

#	**Names in Comcáac**
1	Axl Quipc
2	Cöcootij Iizcam
3	Zozni Iyat
4	Caayam Lip
5	Coniic Iyat
6	Xepe Limac Lime
7	Xla Quita
8	Hant Ctapjö
9	Hant Quisil
10	Hataam Caaol
11	Inóohcö Imáitom
12	Hant Quitij Caacoj
13	Yaiij Yeen
14	Iifa Hamóiij Quih Iti Ihíij Iyat
15	Zamt Iime Inóohcö
16	Moosni Oofija
17	Hona Yaiij

7.3.2 Hookah Fishing Areas

7.3.2.1 Use Patterns

Eight different hooka fishing areas were mentioned by interviewed fishers as most important for the fishery. During fishing trips seven of them were mapped (Figure 10).

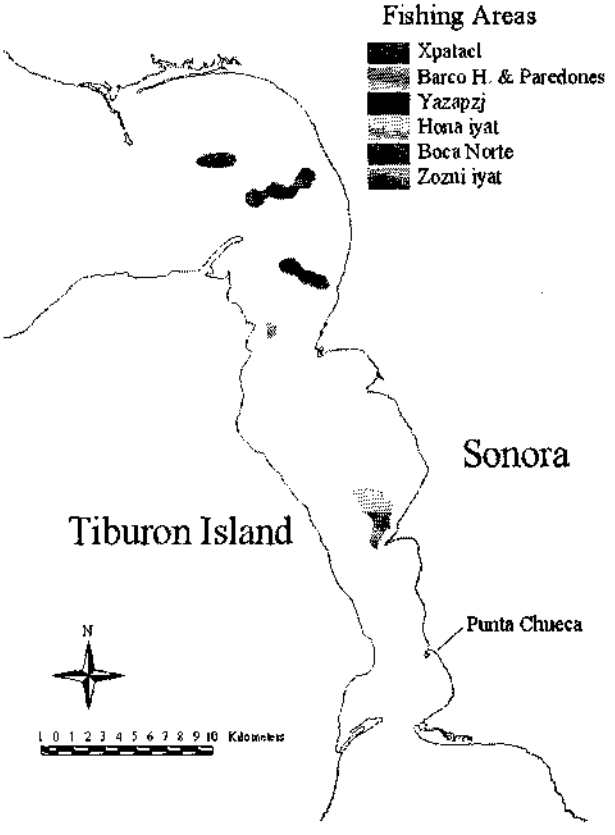

Figure 10. Hookah fishing areas used between the summer of 2000 and 2001.

According to their frequency of use, rotation patterns were identified at three different time scales: (1) Usage throughout the year, (2) areas visited generally only once a year, and (3) fishing areas visited generally only once every few years areas (Table 18). Fishers alternate among fishing areas and among time scales as shown in Figure 11.

As described in Chapter 5, the hookah fishing fleet generally works in groups, concentrating their effort in one fishing area and as the catch per unit of effort decreases (CPUE[74]) they move together to the new site. Length of time that each of the fishing areas was used per occasion was not surveyed.

Table 18. Use patterns of hookah fishing areas.

Pattern of use	Sym	Name of fishing area
Visited several times within a year	A	*Xpatacl (=Almo)*
	B	*Barco H. & Paredones*
	C	*Yazapzj*
Visited generally only once a year	D	*Hona iyat*
	E	*Quipcö Coospoj (=Campo Víboras)*
	F	*Boca Norte*
Visited generally only once every few years	G	*Zozni iyat*
	H	*Sacpátix (=Punta PaloFierro)*

Notes:
1. Names are presented in Comcáac, Spanish or both, as they use it.
2. Only fishing areas mentioned by >20 (83%) of the fishermen (n=24) were included.
3. See methods section for definitions.

Source: GPS waypoints during fishing trips between June of 2000 and June of 2001, mapping interviews, fishermen journals, and data available form other sources.

[74] CPUE was defined as it is perceived by the Seri fishermen: the harvest (in Kg) of a *panga* per day.

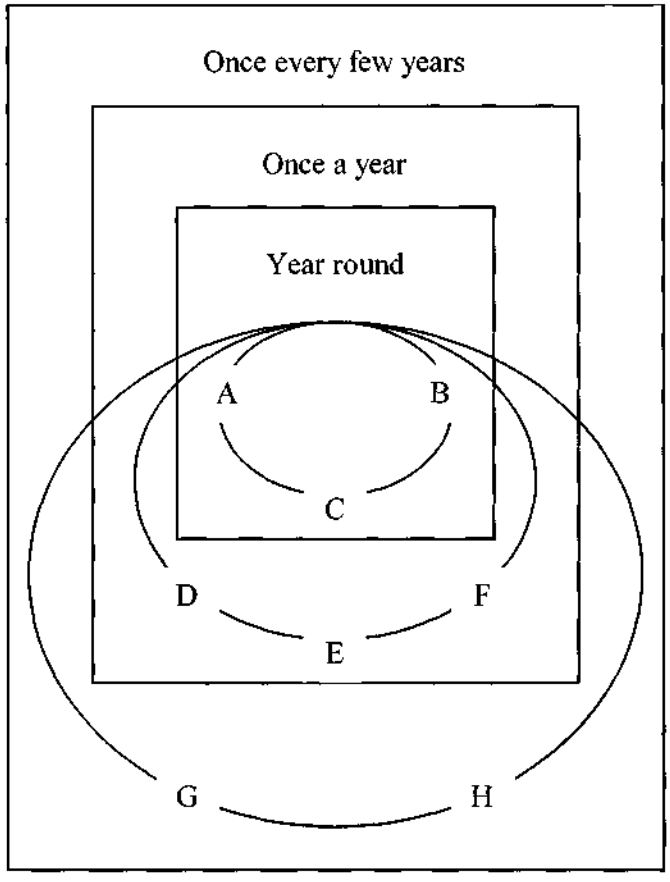

Figure 11. Rotation patterns of the most important hookah fishing areas.

7.3.2.2 Differentiation Between Fishing Areas According to Scallop Meat Size

Hookah fishermen said that there are scallop meat size differences between fishing areas (A, B, D, G). They also mentioned that large CDH shells do not always contain large scallops, and that there are scallop meat and shell size differences among fishing areas (ANOVA, $F_{3,\ 2736}=141.70$, $p<0.05$) (ANOVA, $F_{3,\ 945}=511.16$, $p<0.05$) respectively. Area D is readily identified by the fishermen as a site where average shell sizes can be found, but their scallop size is generally the smallest (Figure 12).

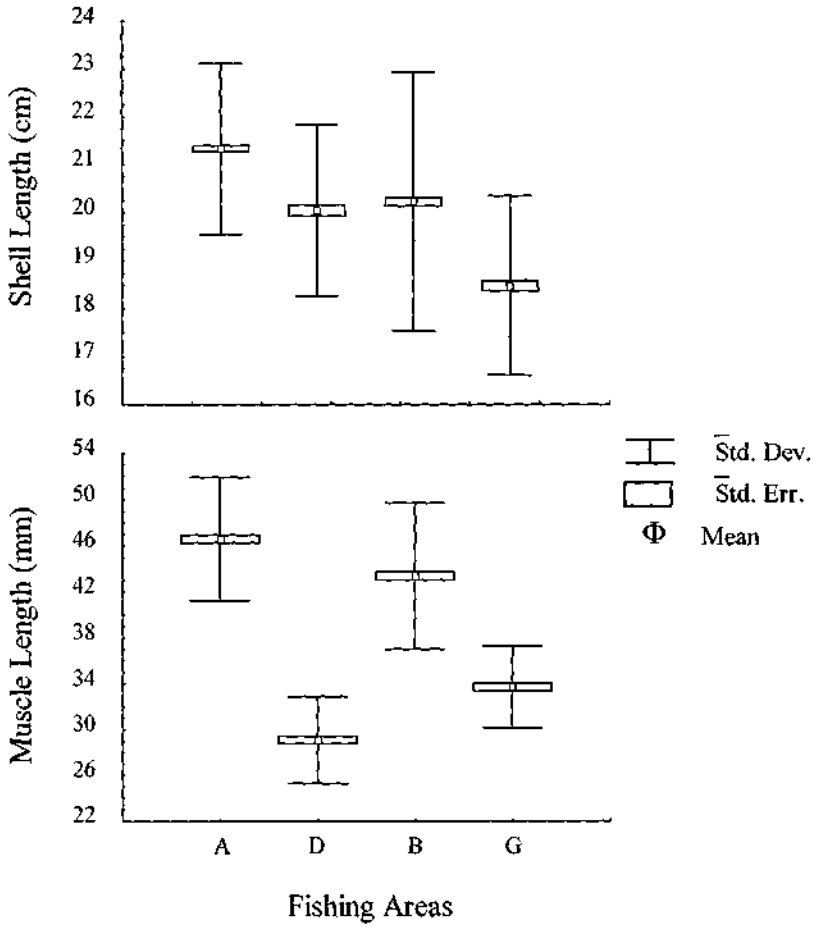

Figure 12. Shell and scallop meat size differences among fishing areas.

7.3.2.3 Criteria for Site Selection

Fishermen mentioned that the most important factors that influence their selection of fishing areas are the scallop meat size and abundance. Other ecological characteristics that also influence site selection are depth, current strength, lunar cycle, cloud cover, and underwater visibility. Fishers' preference was tested for scallop meat size. It was showed that scallop meat size has an influence in fishers' preference of hookah fishing areas

when targeting either kidney or round pen shells (ANOVA $F_{2,104}$=10.97, $p<0.05$; ANOVA $F_{2,146}$= 20.47, $p<0.05$). Fishing areas with large scallop sizes were not the same for both species of pen shells. Fishermen categorized the hookah fishing area *Chorales Hona* (Sym=I) as an area to be avoided when fishing for kidney pen shells, but as a preferred one when fishing for round pen shells (Table 19 and Figure 13).

Table 19. Categorization of fishing areas by preference level and species.

Category	Sym	Kidney pen shell	Sym	Round pen shell
Preferred	A B C	*Xpatacl* *Barco H. & Paredones* *Yazapzj*	A B C I	*Xpatacl* *Yazapzj* *Barco H. & Paredones* *Chorales Hona*
Average	D E F G H	*Hona iyat* *Quipcö Coospoj* *Boca Norte* *Zozni iyat* *Sacpátix*	D E F H	*Hona iyat* *Quipcö Coospoj* *Boca Norte* *Sacpátix*
Avoided	I	*Chorales Hona*		

Notes:
Only those fishing areas selected by ≥ 20 (83%) fishermen (n= 24) were included in each category.
Categories definitions: *Preferred*: high CDH abundance and large to average scallop size. *Average*: CDH variable abundance and average to small scallop size. *Avoided*: highly variable abundance and scallop size.
Source: Mapping interviews, GPS waypoints during fishing trips between June of 2000 and June of 2001, fishermen journals, and available data form other sources.

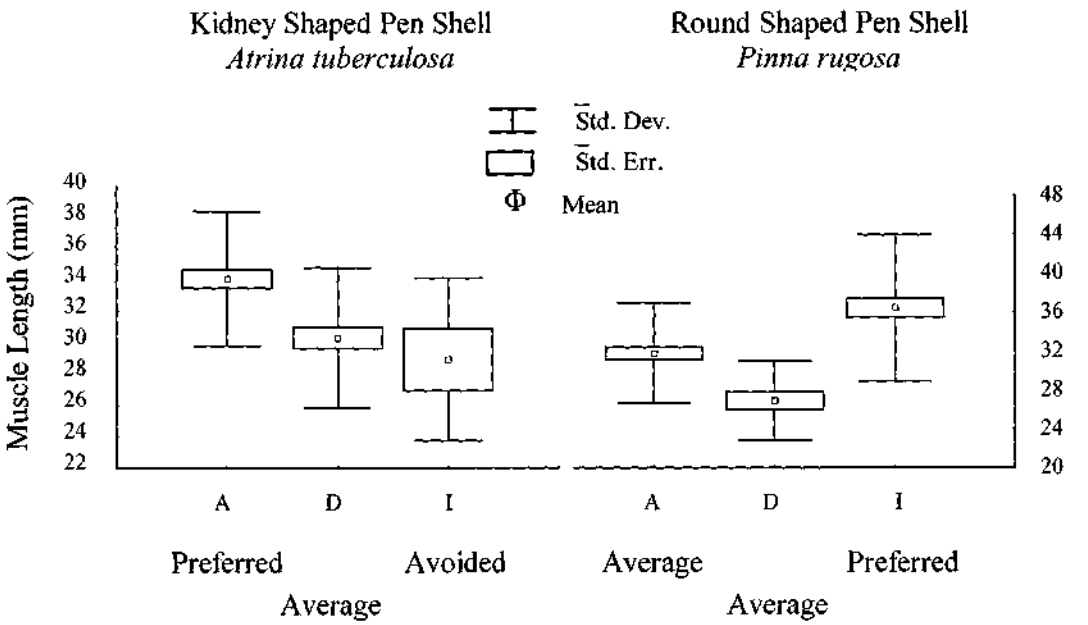

Figure 13. Fishers' stated preferences and statistical differences among hookah fishing areas according to scallop meat size.

7.3.2.4 Eelgrass Meadows

Fishermen said that CDH are found on sandy bottoms all over the Infiernillo Channel including places where eelgrass *(Zostera marina)* and algae *(Caulerpa Sp)* meadows appear seasonally. The appearance of these meadows prevents the harvest of CDH that get covered until the plants die-off.

A literature search showed that the presence of Pinnidaes (and other bivalves) living in areas where seagrasses, eelgrasses, or algae grow has been widely reported (see Butler and Keough 1981; Roberts 1984; Zavodnik et al. 1991; Kuhlmann 1998; Richardson et al. 1999).

The seasonal patterns of marine plant species present in the Infiernillo Channel and relevant to the fishery were documented and are presented in Table 20.

Table 20. Seasonal patterns of marine meadows in the Infiernillo Channel.

Marine plants	Hot Season						Cold Season					
	J	J	A	S	O	N	D	J	F	M	A	M
Algae* *Caulerpa* Spp.												
Eelgrass*§ *Zostera marina*												
Seagrass§ *Halodule wrightii*												
Ditch-grass§ *Ruppia maritima*												

Notes:
Caulpera Spp. and *Zostera marina* are of most importance to the fishery.
*Sources: *This work, ‡Felger and Moser (1985), §Torre-Cosio (n.d.).*

Direct observation showed that fishermen tried to avoid diving in eelgrass *(Zostera marina)* and algae *(Caulerpa* Spp.) meadows, restricting themselves to sandy areas or clean patches in between the meadows. Some of the reasons that were mentioned for avoiding these areas were the difficulty of finding CDH, the risks of getting tangled, stepping on sting rays or swimming crabs, and the possibility of encountering sharks, sea lions or other marine mammals.

The overlap of fishing and eelgrass areas was also verified using a geographic information system (GIS), which provided a temporal perspective of the use of eelgrass areas by the CDH fishery. The map showed that fishing overlaps eelgrass meadows only during the times that the eelgrass is not present. The eelgrass coverage areas are part of the dissertation research of Torre-Cosio (n.d.).

7.3.3 Fishery Biology

7.3.3.1 Species Characteristics

Fishermen recognize four different ethno-species[75] of CDH in the Infiernillo Channel. In contrast, only two species have been reported by biologists for this area (Torre-Cosío and Bourillón 2000:47) (Table 21).

Table 21. Species and ethno-species of CDH in the Infiernillo Channel.

ntific name	**Ethno-species**		**Scientific records (previous to this study)**
	Seri name	**Spanish/*English* name**	
a tuberculosa	Ceten cmaam	Callo riñón (*kidney or tuberculose pen shell*)	Yes
Pinna rugosa	Ceten ctaam	Callo redondo (*round or rugose pen shell*)	Yes
Atrina maura	Ceten iizax coocp	*Callo media luna* (*half moon pen shell*)	No
Atrina Spp.	Ceten cöquimá hjö	Callo rosado (*pink pen shell*)	No

According to the fishermen the two most abundant species are the kidney and **the** round pen shell. Fishermen use the scallop meat, shell shape, and mantle's color as the main identifying characteristics. They claim that the half moon and pink pen shell are new to the Infiernillo Channel (Table 22). Some fishers said that half moon pen shell became the pink pen shell once it grew older. While half moon pen shells where clearly identified as *Atrina maura* (Keen, 1971: 75), it was not possible to clearly identify the pink pen shells due to the lack of enough samples in the fishermen's catch.

[75] As a subset of ethnoscience (folk science), ethno-species refers to the names used by any given culture to classify a determined animal or plant that belongs in their universe (Hardesty 1977).

Table 22. *Callo de hacha* (CDH) identifying characteristics as described by fishermen.

CDH	Status	Fishermen identifying characteristics
Callo riñón (*kidney pen shell*)	Abundant	Scallop shape resembles a kidney. Shell doesn't protrude above the bottom. Shell is "fat" (shell is not much longer than wide). Scallop "gets skinny" in the summer.
Callo redondo (*round pen shell*)	Abundant	Scallop shape is round. Shell does protrude above the bottom. Shell grows the largest of all and can be relatively thin.
Callo media luna (*half moon pen shell*)	Common Recent appearance in the Channel	Scallop is similar to that of a kidney pen shell, but bigger. Scallop doesn't "get skinny" in the summer. It does during the winter. Shell has a similar size of kidney pen shell but not as fat. Resembles a half moon.
Callo rosado (*pink pen shell*)	Scarce Recent appearance in the Channel	Scallop shape resembles a kidney. Shell is similar to a kidney pen shell. Scallop is always fat and has a pinkish coloration. Mantle has a unique pink coloration.

Due to the relevance that the kidney pen shell has for the CDH fishery, the survey of the catch focused mostly on this species. For the remainder of this chapter kidney pen shells are referred to as CDH unless otherwise specified.

7.3.3.2 Species Composition of the Catch and Underwater Survey

Fishermen asserted that they are able to distinguish between CDH ethno-species prior to harvesting them from the sand.

A Pearsons x^2 test showed that significant differences (a =0.05) existed between the natural species composition of CDH, and that obtained by the fishermen in their catch of the two surveyed fishing areas (see Table 23). In the *Paredones* (Sym=B) fishing area the natural composition ratio between *callo riñón* (kidney shape, *Atrina tuberculosa)* and *callo redondo* (round shape, *Pinna rugosa)* was 5:1. However, the ratio obtained by the

fishermen was 15:1. For *Hona iyat* (Sym=D) the natural composition ratio between *callo riñón* and *callo redondo* was 2:1, while the fishers' catch yielded a ratio of 18:1.

Table 23. Species composition of the catch and natural abundance.

Fishing area	Paredones (Sym=B) *			Hona iyat (Sym=D) **		
Species	*callo riñón*	*callo redondo*	Abundance Ratio	*callo riñón*	*callo redondo* & other Sp.	Abundance Ratio
Natural composition	82.19%	17.81%	**5:1**	70.13	29.86	**2:1**
Fishers' catch composition	93.72%	6.28%	**15:1**	94.74	5.26	**18:1**

* χ^2=5.95, p=0.014. ** χ^2=20.4, p<0.001.

7.3.3.3 Shell Size Composition of the Catch and the Census

Fishers claimed that they are able to distinguish shell size differences prior extracting CDH from the sand. Of the totality of the CDH catch that was sampled during this research (n= 4,673), the average size was 20.8 cm (Std. Dev.=2.53) with a size range of 12.1 to 29.9 cm.

The average size of CDH was significantly bigger (a= 0.01) for the fishermen's catch than for the census in the two fishing areas sampled: A and D (tu5=16.30, p<0.01; t246=15.09, p<0.01 respectively; Figure 14).

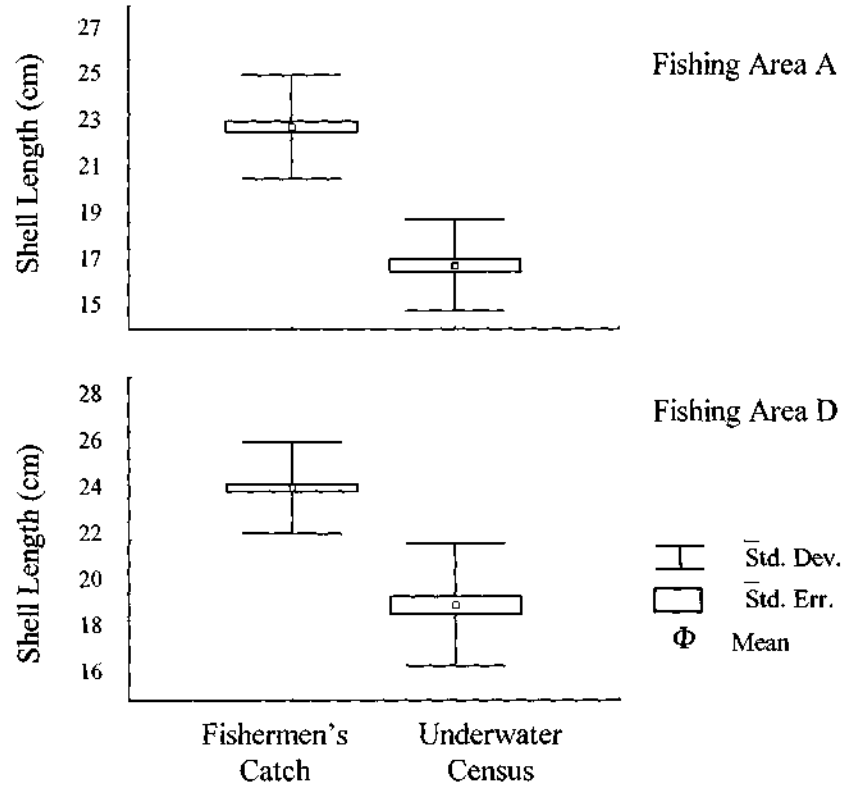

Figure 14. Diver's size selection of CDH.

7.3.3.4 Sexual Dimorphism and Sex Ratio

Fishers mentioned that it is not possible to determine the CDH' sex by looking at the shell or scallop meat alone. The fishing catch was analyzed to assess if shell or scallop differences could be related to sexual dimorphism. In both assessments differences were not significant at an alpha of 0.05 (t_{312} = -0.10, p=0.92; t_{93}=-1.24, p=0.22).

The sex ratio of the catch of four different fishing areas was an average of 53% females and 47% males (SE = 2.9).

7.3.3.5 Reproductive Strategy Determination

Both sexes presented gonadic activity in the same period of time. The result of gonad examination showed no clearly defined seasonal reproductive cycle for the kidney pen shell *(Atrina tuberculosa)* in the Infiemillo Channel. Mature gonadic tissue was observed during all sampling events with the highest frequency during the warmest seasons of the year (summer and fall) (Figure 15).

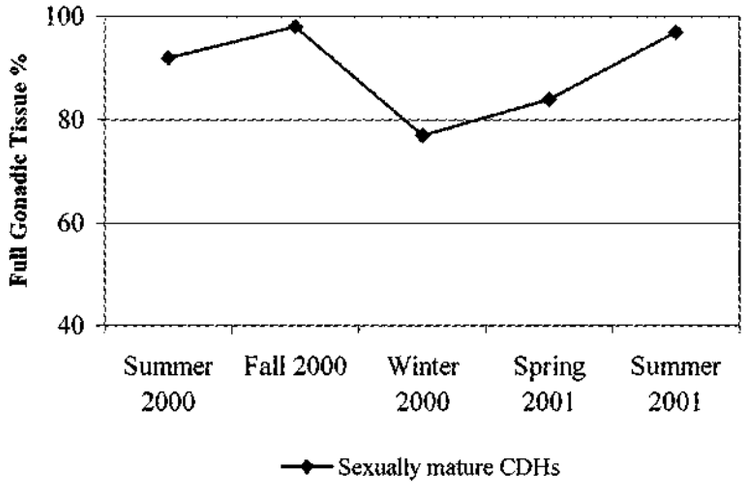

Figure 15. Percentage of sexually mature CDH.

7.3.3.6 Scallop Size Temporal Variability

Fishers claimed that scallop meat 'fattens' in the cold season (winter-spring) and 'thins' in the hot season (summer and fall). The analysis showed that meat size changes throughout the year being the smallest during the fall and the biggest during the winter and spring (ANOVA $F_{4,1284}$=148.28, $p<0.05$; Figure 16).

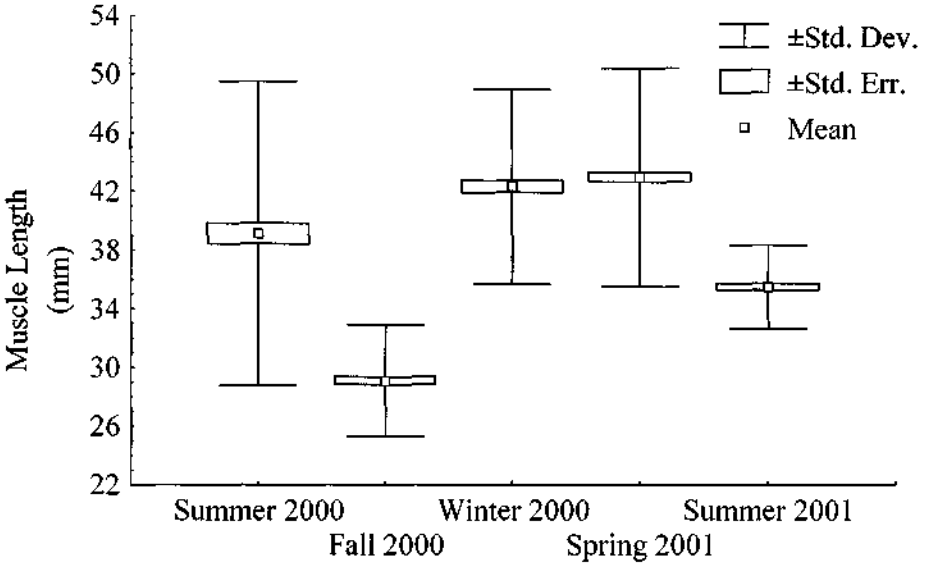

Figure 16. Scallop meat size variation throughout the year.

7.4 DISCUSSION

The results of this study allowed the identification of several ecological characteristics and management strategies of the CDH fishing system that might explain the ability to maintain such sustained CDH output for almost 30 years. They are: (1) Multi-species management, (2) harvesting and (3) fishing areas selectivity, (4) characteristics of the reproductive cycle, (5) no-take areas and natural refuges, (6) rotation of fishing areas, (7) and annual communal assessments of the resource.

7.4.1 Multi-species Management

The collective decision to harvest mainly *callo riñón* (kidney pen shells) is primarily related to the constant demand for the meat and the fact that this species usually commands the highest price of all CDHs in the regional market.

Nevertheless, fishermen's ability to recognize species diversity presents a range of management possibilities for their fishery. The selections that they make are often a blend of a variety of external (political, economical, ecological) conditions and their own self- interested calculations. For instance, when the price of kidney pen shell decreases due to market saturation (CDH are mainly marketed fresh), the fishers' strategy is to reduce the kidney pen shells offering on the market by switching to harvest round pen shells, and threatening the fish buyer with landing their catch to anyone that offers them a better price. Although their income is reduced, it allows fishers to remain economically active as they exert pressure on the fish buyer to raise back the price once market saturation has ceased.[76] Pressure also often comes in the form of increased competition among fish buyers to gain fishers trust and secure supply from a year round source such as the Infiernillo Channel.

On the other hand, fishers' ecological knowledge can also be used to "please the market." This occurs when the fish buyer prices CDH according to their scallop size, influencing fishers to exploit fishing areas where they know they can find bigger sizes.

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[76] It is fish buyers' common strategy to maintain low prices as long as possible once market saturation has cleared. Fishermen in other localities usually have no way to counteract this, and abide with the new circumstances until a better fishing option becomes available or price rises again.

Multi-species management is best exemplified by the fishermen's belief that when seasonal closure to the fishery was desired, "switching" between species would be the best way to proceed, allowing one species to rest while the other is harvested. Many societies that have developed a long-standing ability to maintain the productivity of the ecosystems in which they depend are known to practice multi-species and integrated management (Alcorn and Toledo 1998; Jodha 1998; Warren and Pinkston 1998).

7.4.2 Harvest Selectivity

The degree of selectivity that the CDH fishery can achieve depends on the divers' ability to distinguish among species, shell, and scallop meat sizes. The differences in species composition between the fishermen's catch and the underwater census, suggest that divers are able to distinguish between CDH species (kidney and round), and among CDH size differences, usually selecting the biggest pen shells available. Since the censuses were conducted recently after fishers used the area, the size range of the CDH captured, indicate the CDH size range that divers decided not to harvest. Therefore, the censuses had few of the large sized CDH.

To determine the ecological significance of divers' size selectivity, the size composition of the catch was compared to the results of age determination studies. These studies were conducted, in nearby areas to the Infiernillo Channel, with half moon pen shells by Serrano and Ahumada (n.d.). They determined that half moon pen shells reach one year of age at shell length of 12 to 14 cm. Kidney pen shells (closely related to half moon pen shells) are likely to present similar shell growth rates when inhabiting the same

areas (S. Serrano, *callo de hacha* expert, personal comm. 2000). If correct, 99.4% (n=4,645) of the CDH that the divers harvested were at least one year old. Moreover, the great majority (70.2% n=3,261) were much bigger (20 cm or longer: average size =20.8, Std. Dev. 2.53), and likely to be two years of age or more. It is common for bivalves of the Gulf of California to reach sexual maturity at their first year of age (E. Arizmendi, pearl oyster specialist, personal comm. 2000). This has also been documented for other Pinnidaes from other latitudes, such as *Pinna bicolor* in Australia (Butler 1987:764), and *P. nobilis* in the Mediterranean Sea (de Gaulejac 1993). Following this scenario, it can be assumed that almost all of the catch of CDH had the opportunity to spawn at least once before being harvested.

Nevertheless, the diver's ability to select their harvests could also pose detrimental effects to the CDH population. For instance, harvesters could chose to make sexually selected catches due to the influence of market commodification forces (Greenberg in press).[77] However, the analysis of shell and scallop meat size differences was not significant between sexes, suggesting that there is no incentive for divers to make sexually selective catches even if they could. Sexual dimorphism is very rare in pelecypods (Sastry 1979), and none of the studies conducted with Pinnidaes suggest otherwise. Moreover, dioecious species such as the CDH, present similar sex ratios within their population, since for successful external fertilization they depend on the synchronized liberation of gametes to the environment (Newell et al. 1982). As long as

[77] As defined by Greenberg (in press), commodification takes place when arbitrary values are placed over selected parts of the ecosystem while devaluing others (Greenberg 1999).

the current fishing technology remains the same, CDH catches will continue to reflect the sex ratio of the CDH population.

7.4.3 Fishing Areas Selectivity

Preferred fishing areas are those with the largest and most abundant scallops. However, divers cannot assess the size of the scallop unless they harvest and open it. My results showed that divers could not assume a correlation between shell and scallop size. The only way they have been able to gain knowledge about these differences is by the collective, and accumulated experience of trial and error attempts of all fishermen. This is the most tangible piece of evidence of the use of TEK in the management of the CDH fishery. Fishers' ability to distinguish differences in scallop size among fishing areas is important to understanding how those areas are used through time.

Fish buyers price CDH by weight (kilogram), and sometimes place a differential value on scallops according to their size, color and overall quality. Fishers maximize their catch per unit of effort (CPUE) accordingly.

From an ecological perspective, two main factors could be responsible for differences in scallop size among fishing areas. One is biological and the other environmental. At the individual level, scallop size might change as it transfers energetic material to the gonad as the individual prepares to spawn. This phenomenon has been well documented for various species of bivalves (Taylor and Venn 1979; Barber and Blake 1981; Laurén 1981). At the population level, different CDH banks might spawn at

different times in what is known as asynchronous spawning (Sastry 1979). The CDH reproductive cycle is discussed further in the next section.

As for environmental reasons, the specific characteristics of the site where a CDH larvae settle for life have a direct effect on their resultant growth and development. Factors such as food flow, food quality, presence of predators, sediment type, temperature, and anthropogenic impacts, are some of the most important characteristics that will determine the habitat quality and therefore growth differences within sessile bivalves of the same or different species.

7.4.4 Contribution of the Reproductive Cycle

The presence of mature gonadic tissue during all seasons of the year on at least 75% of the catch, suggests that this species presents asynchronous spawning. In such cases, the gametogenic cycles within the individuals of the population are out of phase. Thus, a proportion of the population may breed at any time, giving way to the presence of a variety of size classes among different fishing areas. It's common that in populations exhibiting an asynchronous breeding period, individuals go through successive gametogenic cycles throughout the year (Sastry 1979).

This reproductive strategy is common of tropical species of bivalves (Keen 1971:75), some of which inhabit in the Gulf of California, like *Megapitaria aurantiaca* (Garcia-Dominguez et al. 1994), and *Pinctada mazatlanica* (Garcfa-Dominguez et al. 1996). The advantage of releasing gametes in short spawning events is that it spreads out the risk of larvae encountering unfavorable conditions (Parson et al. 1992).

The external factors influencing gametogenesis were not assessed in this work. In consideration of the highly dynamic and complex tidal system in the Infiernillo Channel (see Chapter 1), it might be that spawning depends on environmental cues correlated to the tides. Such cues include physical (e.g. temperature, pressure, or currents), biological (e.g. food levels), and chemical factors (e.g. pheromones or exudates in the water column) (Parsons et al. 1992). Lunar and tidally related spawning events have been reported for other bivalves such as *Pecten maximus, Chlamys (Pecten) opercularis, Yoldia sapotilla* and *Ostrea edulis* (Parsons et al. 1992).

Occurrence of meat size difference throughout the reproductive cycle has been assessed for several different bivalve species (Taylor and Venn 1979; Barber and Blake 1981; Laurén 1981). These researchers believe that an inverse size relationship exists between the adductor muscle and gonad size, since nutrients (glycogen and protein) are transferred from the muscle to the developing ovary in times of reproductive activity. Barber and Blake (1981), report that the adductor muscle of the bivalve *Argopecten irradians concentricus,* shrinks to less than half its maximum weight as its reserves are depleted and transferred to the oocytes. According to Parsons et al. (1992), other bivalves for which this condition has been studied are: *Chlamys opercularis, C. islandica, Amusium japonicum balloti, Pecten alba,* and P. *maximus.*

7.4.5 No-take Areas and Natural Refuges

According to Felger and Moser (1985:207) there are about 200 marine plant species in the Seri region. Several major seaweed species inhabit the Infiernillo Channel.

The meadows that these species form cover distinct CDH beds in various degrees throughout the year (their life cycles are alternated). These natural dynamic no-fishing areas assure that a portion of the CDH stock remains off-limits to the fishery for several months, including the peak season of the CDH reproductive cycle (summer-fall).

These meadows also may provide predator protection for the CDH larvae and substrate to the young (Vicente 1990). The tradeoff though, is that the meadows may reduce the nutrient and food supply, by decreasing water flow and changing rates of particle deposition (Coen and Heck 1991). Although it is not known how these factors affect CDH reproductive output, there is no doubt that the meadows are an influential component on the temporal and spatial use patterns of the CDH fishery. It is in the fishers best interest to have a spatial and temporal "mental map" of the meadows' dynamics to be able to use their fishing areas in the most efficient way and maintain a suitable CPUE throughout the year.

A similar situation has been documented by Cudney-Bueno (2000:125) for the rock scallop fishery in the Upper Gulf of California. Cudney-Bueno reported that in 1999 due to oceanographic and biologic factors alone divers were unable to fish almost 70% of the year. These factors included the presence of marine meadows, which acted as natural no-take areas during the summer months that they covered rock scallop fishing areas.

In relation to the CDH fishery, two seasonal species are most relevant: (1) the algae *Caulerpa* Sp., and (2) the eelgrass *Zostera marina*. The latter may be of most importance as it forms the largest meadows in the Infiernillo Channel, covering 12% of the channel floor at the time of maximum coverage (Torre-Cosio n.d.). But probably it is

at a regional scale that eelgrass meadows are most significant for the CDH fishery. *According to Torre-Cosio (eelgrass researcher, personal comm. 2001), the* eelgrass population of the Gulf of California might constitute a *relict* population since the last glaciation. Before this event, eelgrass meadows might have been distributed throughout the Gulf of California. Thereafter, only few "population pockets" survived the global increase in temperature. Genetically isolated populations are scattered in coastal bays throughout the Gulf of California, and the largest meadows in Western Mexico are found in the Infiernillo Channel (Felger and Moser 1985:22). Therefore, the eelgrass population of the Infiernillo Channel could have a significant role in maintaining the exceptional productivity of the Seri CDH fishery. It could also be a "source" area for the Seri and other nearby CDH fisheries, playing a key role in maintaining their productivity, and repopulating local and regional fishing areas, from which other fishing communities rely upon.

Eelgrass and algae meadows constitute important examples of CDH beds that are not exploited and constitute natural refugia for the CDH. Fishers have no physical access to these areas given their current harvesting technology. A different example follows in which no-exploitation is motivated by some of the factors that influence fishers' selection of harvesting areas, such as the market. The market's influence is reflected in the fishermen's preference for areas with large scallop size and high abundance. One particular area that fishers say to avoid when targeting kidney pen shells is locally known as *Chorales Hona*. This area is left alone because although the shell size is similar to those of other areas, their scallop size is significantly smaller, and their color sometimes

presents a blackish appearance. It is likely that this area constitutes a low quality habitat for the CDH. Nevertheless, an underwater census in this area showed that sexually mature CDH were present, and therefore it is assumed that there is no impediment for them to successfully contribute their gametes to repopulate fishing areas that are favored by the market's demand.

7.4.6 Rotation of Fishing Areas

The different interrelated factors that influence fishers' choice of a fishing area result in regular rotation of CDH fishing areas. This study was able to assess rotation in three different time scales: (1) Areas that are intensively used throughout the year, (2) areas that are used intensively once a year, and (3) areas that are used intensively every few years. These use patterns can be implicitly signaling the productivity of each area, as fishers try to maintain a constant catch per unit of effort (CPUE) throughout the year. When the CPUE starts to decrease in one bank, fishers move to areas that offer them a better CPUE. Since productivity of each area determines the frequency in which they can be used, and it is known to vary across time and space; mapping those areas reveals a multi-scale cyclical pattern.

Some areas can support constant use throughout the year while maximizing fishers' CPUE (i.e. *Xpatacl, Barco H. & Paredones,* and *Yazapzj).* These areas must provide an excellent habitat quality to the CDH, as their scallop meat is generally big and

their abundance keeps fishers returning to these areas year after year.[78] These are the farthest from the Seri village of *Punta Chueca* (see Figure 10). In the fishers' own benefit-cost analysis, the resultant ratio of fishing in these areas must surpass those of fishing elsewhere, for most of the time.

When areas that are not as productive as *Xpatacl, Barco H. & Paredones or Yazapzj* reach an abundance that yields fishers with a similar or better CPUE while reducing their costs (i.e. same amount of catch but less gas expenditure), they readily switch to these areas. For instance, the fishing banks *of Hona iyat,* are significantly closer to *Punta Chueca* (see Figure 10), but present a smaller scallop size than other areas. Nevertheless, in a yearly cycle their abundance provides a CPUE that surpasses the benefits of fishing at the more productive sites while incurring in lower gasoline expenditures.[79]

As the productivity and benefit-cost ratio of an area decrease, the area is used less frequently and the cycle of use becomes wider. Given an infinite demand, and all related factors being equal; this exercise can also be used to explain why at other localities and fishing communities the CDH fishery only takes place during a few months of the year (i.e. *Bahia de Kino* village).

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[78] Although productivity patterns have not been studied in the Infiernillo Channel, the vicinity of important up-welling areas, dynamic tidal currents, and eelgrass meadows, are likely to be influencing these fishing areas.

[79] The number of rotation patterns presented here are a reflection of the resolution level at which this study was conducted. By no means they aim to be an index of the diversity of scales or a comprehensive account of the use patterns, undoubtedly they must be richer and far more complex.

Within the Seri community there is no collective decision-making involved in determining which fishing areas are to be used, except for sand bar traditional areas, which are off limits for hookah divers all year. Fishing effort is deployed flexibly and opportunistically therefore; fishers use the decline of catch per unit of effort (CPUE) as the feedback that informs decision-making and the state of the stock. Small-scale fishers cannot afford to waste time and effort if they are not catching enough product. If the return from one fishing area is poor they move to a different one where a catch can be easier to make (Berkes 1999:120).

These patterns could not be created if fishers were not able to learn from past individual and collective experiences, as documented in other systems and cultures such as nomadic herders in semi-arid Africa (Niamir-Fuller 1998), agricultural societies the Himalayas (Jodha 1998) and small-scale fisheries such as the Chisasibi Cree fishery in subartic Canada (Berkes 1999:111).

7.4.7 Annual Communal Assessments

Comcáac communal gatherings at traditional sandbar sites allow the non-fishing community members to make annual assessments of the state of their CDH resources. The monitoring of fishing effort and use patterns of the CDH hookah fishing fleet, is an important feedback loop between the ecological and social system at an annual scale.

Year after year during the lowest spring tides of the summer, Comcáac children, adults, and the elderly from both villages travel to their old fishing camps along side the Infiernillo Channel, camping and harvesting CDH together. Although most of the Seri

have relatives in both towns and frequently visit each other, this is the only occasion when most Seri families gather outside their villages. This annual event[80] remains as a silent testimony to a nomadic subsistence practice, thousands of years old, which has slowly turned into a modern Seri tradition.

To successfully harvest buried bivalves from a sandbar, it is necessary to know the tides and their interaction with the sandbars. In the Infiernillo Channel the tidal currents uncover the sand bars to varying degrees throughout the year, depending on the amplitude of the tide. Some sand bars are partially or totally exposed. Accordingly, depending on their location, shape, height and tidal amplitude, they can be exposed from a few minutes to several hours per occasion. Therefore, the knowledge of when, where, and which sand bars are going to be exposed has to be very precise, if successful harvesting of buried mollusks is to be accomplished before the water has covered them again.

This event provides important services to the Seri community. In times of economic hardship it provides food and monetary resources to the Comcáac people. However, the most valuable service is of a holistic nature. By providing the appropriate setting for the exchange of experiences and information among the elderly, women, children, and adults, it helps the Comcáac to perpetuate communal ecological knowledge of their traditional CDH harvesting sites. It also reinforces family bonds, and their collective connection to the sea. According to Ruddle (1994), acquiring, using, and

[80] This event is locally known as *el callo de bajamar* (intertidal pen shell), *callo parado* ('standing pen shell) or *el callo de mujeres y ninos* (pen shell for women and children).

transmitting such knowledge is extremely relevant for local peoples' livelihoods, especially in settings where marine resources are still relatively abundant.

Moreover, these communal harvesting events allow non-fishing community members to do an annual assessment of the CDH fishery (and other natural resources). For instance, communal uprising against the hookah diving fleet may develop, if annual sand bar harvesters discover smaller or less abundance of CDH than expected indicating that it has been worked recently. On one occasion, the incident resulted in a community meeting where it was determined to reduce the fishing pressure for some time to allow the banks to recuperate (i.e. expulsion of all non-Seri fishing teams).

Communal Seri norms and the abundance of CDH in other areas usually keep hookah-fishing teams away from the traditional sandbar harvesting sites. Nevertheless, when the benefits offset the costs of facing social punishment, rule breaking occurs. This might happen when hookah fishing teams do not find CDH in their usual grounds and are in the desperate need to make a profit. This "rule breaking", is detected when the community gathers to do their annual sand bar harvest. The community then issues a graduated sanction which frequently aims to allow the resource to restore its prior condition.

As it is, the CDH fishing system allows over-exploitation to be detected before it does major damage to the resource. The annual communal gatherings assure that the exploitation does not reach a level causing a large-scale crisis (i.e. depletion of CDH banks), which would threaten the existence of the whole CDH social-ecological system.

Such systems allow for internal renewal while maintaining overall structure (Holling et al. 1998).

This tradition provides one of the most important ecological and feedback loops of the CDH fishing system. Therefore it is worth investigating what keeps this tradition alive. As usual, the explanation involves a combination of social and ecological factors. The demand and price of CDH are high during summer, which is when supply languishes elsewhere and the biggest spring tides of the year take place in the Infiernillo Channel. Also, summer is when economic hardship is greatest for the Seri. It is the off-season for other important fisheries (i.e. the *Jaiba* fishery closed from April to mid July). Usually no hunting or research activities (which also bring monetary resources to the community) take place, and tourism and handcraft sales are very low (the American tourists who are important costumers of the Seri, are usually gone from April to October). As a result, the Comcáac readily resort to old subsistence fishing practices, interweaving a cash and subsistence economy in the mean time.

7.4.8 Resilience

CDH fishermen believe that their fishery is healthy and will continue to be productive. For the most part, the results of this study seem to support this claim. Nevertheless, the degree to which it will hold true may be determined by the resilience that the system achieves overtime. Resilience is the magnitude of disturbance that can be absorbed before the system changes (Berkes and Folke 1998). The loss of resilience

could move the system closer to its threshold, and ultimately cause it to flip from one equilibrium state to another (Holling et al. *1998).*

The level of resolution at which this study was conducted allowed the identification of several factors that might be providing resilience to the CDH system: the marine vegetation and the meadows they form (that function as CDH refugia), the continuous and asynchronic reproductive cycle of the CDH, and the ecological-social feedback loops provided by communal assessments and CPUE readings. It is likely that the eelgrass meadows play the most important role, however. In addition of providing protection to young and adult CDH, at an ecosystem level, the eelgrass, sea grass, and algae meadows may provide important modification to the CDH population by influencing water flow, food, and deposition rates. By doing so, these meadows may facilitate CDH reproduction and renewal of populations throughout the Infiernillo Channel. At the level of the social system, they influence CDH fishing patterns. If the marine meadows of the Infiernillo Channel were to disappear, the CDH fishing system would undoubtedly be influenced dramatically.

To assess the robustness of the CDH system, a study of the role of the four functions of the ecosystem (exploitation, conservation, release, and renewal) would be very useful, especially if focused on other important factors that act as sources of primary productivity in the Infiernillo Channel (i.e. sea current patterns).

7.5 FINAL REMARKS

From his work with the Cree fishers in Subartic Canada, Berkes (1999) asserted that the apparent productivity and sustainability of their fisheries could not be explained simply on the basis of small population and 'primitive' technology. "If fisheries management is defined as controlling how much fish is harvested, where, when, of what species, and of what sizes (Gulland 1974:1), then the Chisasibi fishers were managing their fishery" (Berkes 1999:117). The same can be concluded about the Seri CDH fishing system. These cases are not isolated. Other authors that have extensively documented functional community-based fishery management regimes have arrived at similar conclusions (Johannes 1978; Cordell 1989; McGoodwin 1990; and Dyer and McGoodwin 1994).

The Seri CDH fishery however, provides a good example of how culture, fishing practices, and biological characteristics of the resource, have come together to nurture strong ecological-social linkages and feedback loops into both systems.

As was shown throughout the chapter, marine vegetation meadows play a significant role in determining physical temporal and spatial availability of hookah fishing areas, provide resilience to the system, and constitute dynamic no-take areas for the fishery. From the universe of available hookah fishing areas, fishers choose according to a variety of ecological and social factors that influence their fishing benefit and cost analyses. Currently the most influential factors are CDH abundance and scallop meat size. Fisher's temporal and spatial knowledge of areas that meet these requisites results from the accumulation and dissemination of collective fishing experiences.

Once fishers are at the chosen harvesting area, divers select the largest sizes available of the targeted species according to their individual skills an experience. As the CPUE diminishes in the harvesting area, they move to a different one in which they can expect to maximize their CPUE. In the event that the level of fishing effort of the fishing fleet surpasses the given productivity of their hookah fishing areas, it is likely that some fishing teams will resort to harvesting CDH from traditional harvesting sandbars, and upset Seri communal rules. If these violations are significant enough, these areas will show a lower than expected CDHs' abundance and size at the time of the community's annual gathering. This discovery launches social rejection against the hookah fishing fleet and the fishers respond by diminishing the fishing pressure and allowing the recovery of these areas.

In the CDH Seri fishery, human and natural systems cycles seem to have converged through collective learning, mechanisms for the accumulation of knowledge, communal norms that keep in check self-interested strategic behavior (see Chapter 6), homogeneous use of technology, ecological stochasticity, and biological circumstance. The result is a fluid management framework that appears to result in a productive and sustainable fishery. The future of this fishery will depend on the degree to which these human and natural elements continue to interweave (Holling and Sanderson 1996).

PART III: CONCLUSIONS

7.6 LESSONS LEARNED

This study demonstrated that community-based management and an increased use of fishers' local knowledge are approaches likely to be better suited for small-scale fisheries management in developing countries, than current fisheries science as applied in the developed world.

The access control mechanisms and fishing practices that are responsible for the conservation and sustainability of the *callo de hacha* fishery were explored. A close look at the access control mechanisms in place showed a wealth of strategies developed to exclude outsiders from using Seri fishing resources, or to allow outsider's inclusion when this is convenient for the Seri. This case has also provided evidence that it is not necessary to obtain absolute exclusion of outside users to attain sustainable resource use. Graduated access control mechanisms seem to be an integral component of the system.

Fishing practices based in traditional ecological knowledge nurture strong ecological-social linkages, some of which provide important feedback loops between them and are likely to be conductive to sustainability.

The biggest threats that the CDH fishing system faces are conflicts that result in part, from the lack of internal democratic mechanisms, which could result in communal disintegration and loss of similar cultural norms. Any disruption of the relationships and traditions within the Seri community could lead to a loss of the system's resilience, flexibility, and the Seri ability to control exclusion to their fishing grounds.

It is clear that there is no single set of rules, strategies, or management regime that can solve the myriad of dilemmas to which users are confronted every day, as other fishery studies in the region (Cudney-Bueno 2000), and elsewhere (McGoodwin 1990) have demonstrated. However, there is growing consensus that sustainable systems are characterized by some elements that provide them with the ability to adapt to new situations and manage their resources successfully over time (Ostrom 1990, Berkes and Folke 1998). Although it is not possible to ensure the long-term future of the *callo de hacha* fishing system, and therefore a precautionary approach is recommended towards its exploitation, this system shares some of the elements or characteristics observed in other sustainable and resilient systems.

7.6.1 Social Mechanisms for Sustainable Use of CDH Resources

From the social perspective, several of the design principles (see Chapter 3) that are believed to characterize sustainable systems were identified in the CDH fishing system (Ostrom 2001):

1) *Clearly defined boundaries of the fishing grounds.* The CDH fishery takes place entirely in the Infiernillo Channel. There is fair consensus among local and outside fishers about its boundaries and Seri ownership (Chapter 1, 5 and 6).

2) *Congruence. Restrictions to time, place, technology, and quantity or fishing units are related to local conditions.* As shown in Chapter 6, there are explicit rules regarding the use of harvesting technology (i.e. traditional sandbar harvesting sites are off-limits to the hookah divers), and quantity of CDH that can be harvested (i.e. 20 kg harvest

quota per boat). There are no explicit rules that limit fishing times and place. However, there is a natural season closure of the fishery that results when the eelgrass meadows cover parts of the CDH fishing areas (Chapter 7).

3) *Seri community members can communicate and organize to create and modify the rules with which they manage the fishery,*

4) *Monitors of the resource are the Seri fishers themselves,*

5) *Conflict resolution mechanisms exist within the Seri community,*

6) *There is recognition [from outside authorities] of the Seri communal ownership rights that the Seri have over their Infiernillo Channel fishing grounds.*

7) *Graduated sanctions to rule breakers are in place depending on the seriousness and context of the offense.*

The last point is the weakest link in the Seri CDH fishing system and the one of most concern. As discussed in Chapter 6, the nature of the Seri cultural and social structure, and the lack of democratic mechanisms to exercise power, undermines the authority of Seri government officials and sanctions to internal rule breakers are rarely applied. On the other hand, sanctions to non-Seri fishers are usually disproportionate, and sometimes arrogant. This behavior is fueled by the historic mistrust that exists towards outsiders in general (Chapter 2 and 6). Internal conflicts that result in communal disintegration and loss of cultural norms are the biggest threat to the Seri ability to control exclusion to their exclusive fishing zone.

7.6.2 Ecological Practices for Building Resilience in the CDH Fishing System

To analyze the ecological practices that contribute for building resilience into the management of the Seri CDH fishery, the framework proposed by Berkes and Folke (1998) (Figure 8) was very useful. Berkes and Folke (1998:21), hypothesize that 'successful knowledge and resource management systems allow disturbance to enter at a scale that does not disrupt the structure and functional performance of the ecosystem and the services it provides.' They believe that such adaptations have been made possible through management practices based on ecological understanding, and generated through a trial-and-error learning process. Needless to say, this is still an alternative approach to 'main stream' resource management. According to Folke et al. (1998:415) conventional management is predisposed to block out disturbance, which may be efficient in the short term, but in the long run 'tends to increase the potential for larger-scale disturbances with devastating effects' (i.e. the northern cod fishery in Newfoundland).

The CDH fishing practices based on local ecological knowledge that seem to be conductive to building resilience and sustainability are:

(1) *Practices that allow the Seri to monitor change in ecosystem and in resource abundance.* In the CDH fishing system, this is achieved at all levels of the harvesting process since the diver has visual contact and manually selects each CDH at the time of harvest. The non-fishing members of the community also monitor resource abundance during annual gatherings in traditional sandbar harvesting sites.

(2) *Practices for the protection of vulnerable stages in the life-history of the species.* As shown in chapter 6, divers ability and 'cultural practice' of harvesting the biggest sizes of CDH available, spares the young CDH that are not sexually mature.

(3) *Multiple species management,* and (4) *temporal restrictions on harvest* are management practices mostly regulated by regional markets, Seri communal rules, and the presence of eelgrass meadows over fishing areas (i.e. *Zoostera marina* and *Caulerpa* spp).

(5) *Resource rotation* of fishing grounds is catalyzed by productivity differences among fishing areas and the presence of eelgrass meadows in the Infiernillo Channel.

(6) *Cultural practices for the transmission of knowledge.* Locally devised fishing norms that provide users with the necessary feedback loops with the natural system enable them to tune local management with current productivity and assume a sustainable output. It is no accident that Seri fishing norms shape exploitation and management of their EFZ and contribute to the conservation of their CDH resources.

Other useful management practices that were not included in the framework of Berkes and Folke (1998), but that also play an important role in the CDH system are: (1) the continuous and asynchronic reproductive cycle of the CDH, (2) the sessile nature of the resource, and (3) their communal ability to control access to the CDH fishing grounds.

7.6.3 Role of Fisheries Authorities in Community-Based Settings

It is clear that in order for small-scale fisheries management policies to be successful, they need to take into account the physical and cultural environment in which they will be imbedded, and no one knows these conditions better than local fishers themselves (Ostrom 1990). Moreover, resource management institutions need to be built on ecological dynamism, and designed to flex with natural variability in order to have a positive impact over the resource (Holling and Sanderson 1996).

Therefore, an increasing number of researchers and natural resource managers advocate new state and federal roles in small-scale fisheries management in developing countries (Berkes et al. 2001 among others). Fisheries management institutions' duties should include facilitating local self-organization by providing fisheries information, providing arenas in which participants can engage in conflict resolution processes, and providing mechanisms to back up monitoring and sanctioning efforts (Ostrom and Schlager 1996).

When fishers are involved in the design and adaptation of rules to manage their fisheries, the probability of achieving an effective and efficient outcome is higher than when governing regimes ignore local input or presume, that the state or federal government must make all decisions about governance and management (Ostrom and Schlager 1996).

This is not a call for state and federal management agencies to take a *laissez faire* stance in community-based fishing settings. To the contrary, it is a proposal to

incorporate institution-building into fisheries management to enhance the capability of fishing communities for resource management. Regional small-scale fishing settings are in urgent need of official support to nurture, validate, and protect the indigenous management mechanisms that they have designed over time as demonstrated by the work of Cudney-Bueno (2000).

Clearly, there are scores of problems which local communities are confronted with and that cannot be solved at a local-level. For instance, even though fishing communities may have devised property rights and rules to govern the access and harvesting activities of their own grounds, the source of their harvest stock may be away from their fishing grounds and thereby out of their control. In this case, the participation of a higher-level institution could facilitate distant communities to communicate, organize, and manage their shared fish stock appropriately. Ostrom and Schlager (1996) propose that to achieve better success in locally-based resource management regimes, these organizations should be nested in a federal not hierarchical structure. This way each local organization retains exclusive jurisdiction over its own local issues and the larger regime serves as a mechanism to enhance their viability, provide collective benefits, and exercise authority when any member organization exceeds its functions.

Decentralization of management, and devolution of authority in fisheries is not an easy endeavor. It can be accomplished only if both government managers and users are willing and have the capability. It is extremely difficult to create a role for fishing communities in resource management if there is no cultural tradition of self-regulation and no stewardship ethic. Even with such a background, community-based fisheries

management will likely fail if there are major problems with exclusion, subtractability, and boundaries (Berkes 1994). Fortunately, and based in the results of this study, this does not seem to be the case for the *callo de hacha* community-based fishing system.

Therefore, if research is to be conducted to further explore these promising small-scale management alternatives to current fisheries science, such as the incorporation of fisher's local knowledge or community-based management, it would make sense not to loose sight of the Seri *callo de hacha* fishing system which to date, at least, appears to be a sustainable system for harvesting a valuable renewable natural resource, and from which there is still a lot left to learn.

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