Current Anthropology Volume 43, Number 4, August–October 2002
 0011-3204/2002/4304-0001$3.00

Rousseau's Whale Hunt?

Coordination among Big-Game Hunters[1]

by Michael S. Alvard and David A. Nolin

In spite of its common use as a tool for examining cooperation, the prisoner's dilemma game does not conform to the reality of many socio-ecological contexts. Situations in which people engage in joint activities and maintain agreement in their preferences for outcomes are called "coordination games" by game theorists and "mutualism" by biologists. Coordination games are common, but cooperative outcomes are not always as easy to achieve as is generally believed. Data are presented from the village of Lamalera, Indonesia, where the economy revolves around traditional subsistence sperm-whale hunting, that indicate a situation consistent with a coordination game. Return rates from cooperative whale hunting are greater per capita than those from solitary fishing. Coordination is maintained through complex norms that reduce transaction costs and provide assurances of satisfactory payoffs to participants. We speculate that cultural transmission of norms provides the "pregame" communication shown to be crucial for actors whose preference is to cooperate and achieve the synergistic payoffs common to coordination games such as big-game hunting.

Michael S. Alvard is Assistant Professor of Anthropology at Texas A & M University (4352 TAMU, College Station, Tex. 77843-4352, U.S.A. [alvard@tamu.edu]). Born in 1959, he was educated at Colorado State University (B.A., 1984) and the University of New Mexico (Ph.D., 1993). His publications include "Evolutionary Ecology and Resource Conservation" (*Evolutionary Anthropology* 7:62–74), "The Potential for Sustainable Harvests by Traditional Wana Hunters in Morowali Nature Reserve, Central Sulawesi, Indonesia" (*Human Organization* 59:428–400), and (with L. Kuznar) "Deferred Harvests: The Transition from Hunting to Animal Husbandry" (*American Anthropologist* 103: 295–311).

David A. Nolin was born in 1973 and received a B.A. in anthropology from the University of New Orleans in 1995 and an M.A. from the State University of New York at Buffalo in 2000. His research interests are human behavioral ecology, the evolution of cooperation, and microeconomics and cooperative game theory. He plans to pursue an M.A. in economics before returning to anthropology to complete his Ph.D.

The present paper was submitted 16 I 01 and accepted 5 XI 01.

Cooperation is once again attracting interest in human evolutionary ecology. The ultimately competitive nature of selection has led to expectations of adaptive outcomes that are selfish (e.g., Dawkins 1989, Hamilton 1964, Williams 1966), and neoclassical economics and game theory also assume self-regarding behavior (Gintis 2000). This prediction does not, however, withstand ethological or ethnographic scrutiny (Dugatkin 1997). People commonly join together to produce goods that they can only obtain as part of a group (e.g., Hill 2002).

Kin selection and reciprocity are commonly invoked as solutions to cooperative dilemmas (Axelrod and Hamilton 1981, Hamilton 1964, Trivers 1971). Kin selection predicts cooperation among close genetic relatives because of the likelihood that they share the cooperative trait. While much evidence suggests that kinship is a strong predictor of cooperation among nonhuman animals (e.g., Dugatkin 1997, Hepper 1991) and humans as well (van den Berghe 1979, Voland 1998), humans commonly assort themselves into cooperative groups that are not based on kinship. While kinship is still important in complex societies, cooperative organizations such as religious groups, trade unions, firms, and political groups are often not primarily organized around kinship. Indeed, participants in modern markets are often described as anonymous (Bowles 1998, Kollock 1999).

Reciprocity, the nonsimultaneous exchange of goods between individuals, has been suggested as an explanation for the evolution of cooperation between unrelated individuals (Trivers 1971, Winterhalder 1996). The primary obstacle to cooperation in reciprocal systems is the conflict of interest that often exists between the individuals that make up a group and the group as a whole (Hardin 1968, Olson 1965). Such a system is vulnerable to free riders—individuals who reap the benefits of sharing but do not contribute themselves. As a result, reciprocity is often modeled with the game called the prisoner's dilemma (Axelrod and Hamilton 1981, Boyd 1987). The key feature of the prisoner's dilemma is that a cooperative[2] strategy is never a player's best response to an opponent in spite of the fact that cooperation is better than mutual defection (Poundstone 1992). Much of the work involving the prisoner's dilemma tries to reconcile this solution with the fact that cooperation is relatively common in nature (in anthropology, e.g., see Dwyer and Minnegal 1997, Jones 2000, Smith and Winterhalder 1992).

1. We thank Jatna Supriatna at the University of Indonesia for sponsoring our research, Wahyuni Sumarningrum and Ina Ihdiana at the Indonesian Institute of Science (LIPI), and two excellent fieldworkers, Eric Fink and L. Graydon Mull. We thank all the people of Lamalera but especially the families of Benjamin Dasion and Yosef Beda Blikololong for their hospitality and the *téna* crews for their tolerance and patience. The research was funded by the National Science Foundation (BCS-9805095) and the State University of New York at Buffalo (Equipment Challenge Grant). [Supplementary material appears in the electronic edition of this issue on the journal's web page (http://www.journals.achicago.edu/CA/home.html).]

2. Following Mesterton-Gibbons and Dugatkin (1997), we define "cooperating" as behaving cooperatively whether or not others do so as well.

Mutualism or Coordination

Recent work has suggested that the prisoner's dilemma and the payoff schedule that defines the game may not be the best paradigm for understanding many cases of cooperation because it does not conform to the reality of many socio-ecological contexts (Alvard 2001, Clements and Stephens 1995, Dugatkin 1997, Maynard Smith and Szathmary 1995). Ostrom (1990) has made the point that many collective-action problems are not prisoner's dilemmas (see also Hirshleifer 1999, Bardhan 2000, Runge 1984). Within anthropology, however, the differences between various types of cooperation and the implications of these differences are not well appreciated (but see McElreath, Boyd, and Richerson n.d., Hawkes 1992).

Where individuals have immediate common interest, joint activity is not readily understood as reciprocity and is best described as mutualism (Alvard 2001, Brown 1983, Clements and Stephens 1995, Conner 1986, Dugatkin, Mesterton-Gibbons, and Houston 1992, Dugatkin 1997, Mesterton-Gibbons and Dugatkin 1992, Winterhalder 1997). Maynard Smith and Szathmary (1995) have spoken of "synergistic mutualism," referring to economies of scale that make the combined effect of individuals' working together greater than the sum of their individual efforts provided that the other players cooperate too.[3] Game-theory-oriented economists and political scientists (Friedman 1994, Schelling 1960, Cooper 1999, Sugden 1986) call this mutualism "coordination." In coordination/mutualism benefits accrue to individuals through collective action and individuals are better off cooperating. In the prisoner's dilemma, in contrast, individuals are always better off defecting.

Mutualism, as understood by most evolutionary anthropologists (Hawkes 1992:275), is structurally a coordination game. Coordination games are characterized by common interest among players (Binmore 1998, Cooper 1999). The classic example is the pure coordination involved in choosing which side of the street to drive on. Driving on the right is as good as driving on the left as long as everyone drives on the same side. Both outcomes are Nash equilibria. A Nash equilibrium is a game-theoretical concept that describes a combination of players' strategies that are best against one another (Nash 1950). At a Nash equilibrium, no player can do better by changing his or her decision unilaterally (Colman 1995). In the above example, both solutions are equally "good" in terms of payoff, provided that players coordinate and all play the same move. Not all Nash equilibria are equally good, however. Coordination games often have multiple Pareto-ranked Nash equilibria. At a Pareto equilibrium, it is impossible for one player to increase his or her payoff without making the other player worse off (Buchanan 1962). A Pareto optimum can be conceived of as the set of strategies that maximizes group benefit. As we shall see below, coordination is preferred in many games, but some types of coordination are better than others.

Coordination games can be distinguished from the prisoner's dilemma and other similar games by comparing game matrices for a one-round, two-player normal-form game. Figure 1 presents such a matrix and the payoffs to each player for either cooperating or defecting in the context of one's partner's play. The prisoner's dilemma game is characterized by a payoff structure of T (temptation) > R (reward) > P (punishment) > S (sucker). In this case the Pareto optimum is for both players to cooperate (C, C), but this is not a Nash equilibrium. The Nash equilibrium is for both to defect, as each player does better by defecting no matter what the other does. Cooperation problems like that of the prisoner's dilemma arise characteristically when mutual cooperation is not a Nash equilibrium.[4]

In contrast, coordination problems exist when mutual cooperation is a Nash equilibrium but one among many (Binmore 1998). In an assurance game, R > T (cooperating with a cooperator is preferred to defecting), P > S (defecting with a defector is preferred to cooperating with a defector), and R > P (mutual cooperation is preferred to mutual defection). In this case, mutual cooperation and mutual defection are both Nash equilibria. They are Pareto-ranked because both players prefer mutual cooperation to mutual defection.[5] Thus, synergistic mutualism as described by the assurance game has two Nash equilibria (both cooperate or both defect) but only one Pareto optimum (both cooperate).[6]

In these sorts of games, while mutual cooperation is preferred, cooperating while a partner defects is worse than mutual defection. In other words, there exists a certain degree of risk to cooperation depending on the degree of trust between players (Harsanyi and Selten 1988). This is why these games are sometimes called "trust" or "assurance" games (Sugden 1986, Binmore 1994; also referred to as "the tender trap" by Hirshleifer

3. According to Brown (1983), "by-product mutualism" involves behaviors that Ego must accomplish whether others are present or not. Brown uses the term "by-product" because the benefits to others are an incidental result of Ego's behavior. In this case, Ego should act cooperatively regardless of what any partner does. Brown offers hunting as an example of by-product mutualism, but this will not be the case where successful hunting is impossible to do alone.

4. Another example of a game of this type is chicken, in which T > R > S > P. It is referred to by Trivers (1972) as the cruel bind and is one version of the hawk-dove game presented by Maynard Smith (1982).

5. Players need not share preferences for coordination problems to exist. One version of a coordination game is sometimes referred to as the battle of the sexes. In this game, coordination is preferred (R > T and P > S), but one player prefers mutual cooperation (R > P) and the other prefers mutual defection (R < P). The game is presented as a couple deciding where to go out for the evening. One prefers the ballet; the other prefers a hockey game. Each, however, prefers being together to going alone. There are two Nash equilibria, but in contrast to the situation in the assurance game, players do not share their preferences for which is best (Luce and Raiffa 1957: 90).

6. A symmetric by-product mutualism game has one solution—both cooperate—that is both a unique Nash equilibrium and a Pareto optimum (R > T, S > P, R > P). The problem of equilibrium selection or coordination is not an issue in a game of by-product mutualism. Cooperation is chosen regardless of what others do.

a

Player 1 \ Player 2	C	D
C	R_1,R_2	S_1,T_2
D	T_1,S_2	P_1,P_2

Prisoner's Dilemma b

3,3	0,5
5,0	1,1

Assurance c

5,5	0,1
1,0	3,3

Chicken d

3,3	1,5
5,1	0,0

Battle of the Sexes e

5,3	1,1
1,1	3,5

FIG. 1. *A generalized payoff matrix for a two-person game* (a) *and numerical examples for the prisoner's dilemma* (b), *assurance* (c), *chicken* (d), *and battle of the sexes* (e) *games. Rows and columns represent simultaneous choices by the two players. Each cell shows the payoffs from a combination of moves of player 1 and player 2; the first variable is the row player's payoff and the second variable is the column player's payoff.* C, *cooperate;* D, *defect;* P, *punishment;* R, *reward;* S, *sucker;* T, *temptation.*

[1999] and "the wolf's dilemma" by Hofstadter 1985, cited in Ridley 1998]). The best choice depends on what the other does, hence the need for players to coordinate to achieve the collective good. These outcomes exemplify a very important result of game theory: there can often be multiple stable solutions to a game. Understanding how people solve such problems ("equilibrium selection," according to the game theorists [Harsanyi and Selten 1998]) in order to achieve the benefits of collective action is a goal of much research.

Mutualism has been dismissed by many because of its apparently trivial solution (Crawford and Haller 1990, Hill 2001, Palameta and Brown 1999; see discussion by Colman 1995:34). Possibly this is because altruism and cooperation are often used as synonyms to mean behavior that is costly to an individual actor but benefits others

(Axelrod and Hamilton 1981). Anthropologists often look at cooperation strictly in terms of altruism (e.g., Hill 2002). In a mutualistic setting the Pareto optimum is also a Nash equilibrium, and thus it appears that cooperating is not an altruistic act. Since mutualistic cooperation is not costly, it is argued, its evolution does not require special explanation.

A definition of cooperation that is equivalent to altruism is unsatisfying because it excludes mutually beneficial collective action. We prefer Dugatkin's (1997:14) definition of cooperation as an activity requiring collective action by at least two individuals that results in a "good" outcome for the members of the group. "Goodness" is measured in terms of an appropriate proxy currency for fitness. Clements and Stephens (1995) define cooperation similarly, as joint action for mutual benefit.

While its distinction from altruistic cooperation is real, mutualistic cooperation should not be dismissed as unimportant. First, much human behavior viewed broadly as cooperation may be best classified as mutualism or coordination. For example, in a recent analysis of Ifaluk cooperative fishing, Sosis (2000*a*), following the work of Smith (1985), argues that a necessary condition for cooperative foraging is that the mean per capita foraging return rate in a group of size *N* be greater than the per capita return rate of foraging alone ($R_N > R_1$). Cooperating when this inequality holds is a case of mutualism, not altruism. Clearly, there is no conflict of interest among group members as long as the equation holds. Conflicts among group members do arise when the group becomes so large that $R_1 > R_N$ (a cooperatively acquired share is less than what is obtained from foraging alone) or $R_{N-1} > R_N > R_1$ (members receive no additional benefit from joiners but joining is better than going alone). Understanding how cooperation is maintained when these other conditions prevail is critically important (see Smith 1985), but these issues must not be allowed to eclipse the simplest case.

Second, experimental evidence shows that cooperative solutions to coordination problems are not as easy to obtain as one might think even when cooperation is obviously the best choice (Cooper 1999) and may require special solutions that are critical to overall human cognitive adaptation. To understand why this is the case, it is useful to examine mutualism from the perspective of game theory. Experimental evidence shows that even in coordination games where there is only one Pareto-dominant Nash equilibrium, players do not always converge; groups can get "stuck" at a nonoptimal equilibrium. For example, van Huyck, Battalio, and Beil (1990) did a number of experiments using a weak-link coordination game with groups of 14–16 players. The players were not allowed to communicate. Each player privately chose a number between 1 and 7, and the payoff to each player was a function of that choice and the minimum of all the others' choices (table 1). For example, if Ego chose 5 but the lowest number chosen by the group was 2, the payoff to Ego was 0.5 units. The highest payoff occurred when all chose 7—the Pareto optimum and also a Nash equilibrium because choosing a number different from

TABLE 1
Payoff Table for Coordination Experiment (van Huyck, Battalio, and Beil 1990)

Ego's Choice of *X*	Smallest Value of *X* Chosen						
	7	6	5	4	3	2	1
7	1.3	1.1	0.9	0.7	0.5	0.3	0.1
6	–	1.2	1.0	0.8	0.6	0.4	0.2
5	–	–	1.1	0.9	0.7	0.5	0.3
4	–	–	–	1.0	0.8	0.6	0.4
3	–	–	–	–	0.9	0.7	0.5
2	–	–	–	–	–	0.8	0.6
1	–	–	–	–	–	–	0.7

7 when all others chose 7 would result in a lower payoff. The trouble is that all other symmetric outcomes were also Nash equilibria. If all chose 4, for example, deviating and choosing 3 or 5 would only lower one's payoff. After each round of the experiment, the minimum was made public, the payoffs were made, and the game was repeated. Intuition would suggest that players should easily coordinate to choose the Pareto-optimal decision of 7, but van Huyck et al. found that this was not the case. In ten-round games, players found it difficult to coordinate; when coordination occurred it focused on the choice of 1, the least collectively desirable outcome. While players preferred the payoff associated with 7, a lack of confidence that all others would also choose 7 drove them away from the Pareto optimum.[7] Similar results of coordination failure have been reported elsewhere (e.g., Battalio, Samuelson, and van Huyck 2001; see review in Ochs 1995).

Even when cooperation is favorable, there is still the question of how the surplus generated through cooperative action will be divided.[8] The division must be agreeable enough to induce cooperative behavior among actors (Moulin 1995). Specifically, at the very least actors must be assured shares that are marginally better than their returns from solitary opportunities.

Much of the discussion concerning how people solve coordination problems such as these revolves around the ideas first developed by Thomas Schelling in *The Strategy of Conflict* (1960). Schelling asked subjects to play a number of pure coordination games. His classic example involves a scenario in which two friends must meet in New York City but for some reason have separated and cannot communicate. There are many places to meet, all of which are equally satisfactory (they are all Nash equilibria) as long as both choose the same location. The idea of cheating is not relevant here, since it is in the best interest of both to cooperate. How can they decide where to meet? In Schelling's informal experiment, more than 50% of students from New Haven, Connecticut,

7. This effect is reduced in smaller groups; groups of two were more commonly able to reach the Pareto-dominant strategy.
8. In economic language this surplus is called the "core." How the core is divided is the main focus of cooperative (as opposed to noncooperative or competitive) game theory.

chose Grand Central Station as the meeting place. When asked to name a time, almost all chose noon. More formal experiments following a similar scenario were done with British subjects, who chose Trafalgar Square 38% of the time (Mehta, Starmer, and Sugden 1994*a*). Given the staggering range of possible meeting locations, these results are remarkable, and they have been repeated in a number of different contexts (see Mehta, Starmer, and Sugden 1994*b*).

Schelling called the points around which players coordinated "focal points" and argued that it was the salience or prominence of these points that drew players to them. What is considered salient is a difficult question to answer (see discussion in Sugden 1986:47–52; Colman 1995:37–40). Sugden (1986:49) suggests that people have *shared notions* of prominence and can use them to solve coordination problems. This seems reasonable to a point. Surely the results would not have been the same had the subjects been, say, Lamaleran whale hunters without knowledge of New York City. Obviously, not *all* people have shared notions of what is salient. Schelling (1960: 58) himself notes that what is prominent depends on the time and place and the players. Since the players in the games could not communicate, they must have drawn on shared information concerning locations in New York City.

Following the work of Lewis (1969), Sugden argues that these sorts of focal points can evolve into conventions or norms if interactions are repeated (see also Ullman-Margalit 1978). Norms are regularities of behavior that are maintained through shared ideas of right and wrong and fear of sanction (see McAdams 1997 for a review). Conformist cultural transmission, in which individuals have a preference for acquiring the traits that are the most common in a population, is one type of biased transmission that has been modeled as a mechanism for maintaining norms (Boyd and Richerson 1985, Henrich and Boyd 1998). The frequency of the trait provides individuals with information about its adaptiveness.

In economics and political science, coordination problems are often illustrated with reference to Jean-Jacques Rousseau, who, in his *Discourse on Inequality*, presented a parable involving stag hunting to illuminate the fragility of joint activity (Binmore 1998). Stag hunting in this situation is a cooperative effort that involves a group of hunters. No one can take a stag alone; group effort is required. Hares, however, can be taken alone. In the parable, it is implied that the per capita returns from stag hunting are greater than those from hare hunting, and, of course, killing a hare is better than obtaining nothing—which is what most will obtain if too many hunters opt for hares. In a prisoner's dilemma game it pays to cheat no matter what a partner does; in a coordination game like the stag hunt it pays to cooperate when partners cooperate. The whalers to be described below are a real-life example. While all should prefer to go whale hunting, unless eight men can coordinate to crew the boat no one goes to sea.

Whaling can be heuristically conceptualized as a two-person coordination game. Imagine that crews consist of only two members and assume that a man's decision is to hunt whale or not. Referring to figure 1, R can be understood as the payoff for cooperative hunting as a crew member. The T payoff is obtained when a player defects to engage in nonwhaling activity while his partner solitarily pursues whales for a payoff of S, assumed to be zero. P represents the payoff for nonwhaling activity by both players; P is equal to T because the payoff is for nonwhaling activity in both cases. If $R > T$ (cooperative hunting for whales provides greater returns than nonwhaling activity), men should share the preference to hunt whales, since it is a Pareto optimum, although both cooperative whaling and nonwhaling are Nash equilibria. While this model is useful, it is difficult to operationalize because the benefits of whaling and not whaling are not necessarily paid in the same currency.

Another way to conceptualize the problem is strictly in terms of meat acquisition. Here an individual's decision is either to hunt whale or to fish, and the benefits of the two alternatives are paid in equivalent and comparable units. Assuming that men can coordinate sufficiently to hunt whale, individuals are expected to switch to fishing if returns from whaling decline sufficiently (if $R < T$). As we will show, for a variety of reasons men do not treat whaling and fishing as strictly substitutable alternatives even when whaling returns drop to levels comparable to those of fishing.

We will argue that coordination is a particularly useful mechanism for explaining cooperative hunting or scavenging where the prey is an item that a solitary individual cannot kill or defend (Alvard 2001, Dugatkin 1997, Earl 1987, Packer and Ruttan 1988, Scheel and Packer 1991).[9] Our goal is to show, with a case study involving traditional whale hunters, that cooperative hunting is a game of coordination rather than a prisoner's dilemma. The implications of examining hunting as a coordination game will be discussed, and we will speculate as to why humans are so good at solving these sorts of problems.

Ethnographic Background

The village of Lamalera is located on the south side of the island of Lembata in the province of Nusa Tenggara Timur, Indonesia (fig. 2).[10] The economy of Lamalera revolves around subsistence hunting for whales, other ce-

9. Cooperative hunting was probably much more common in our evolutionary past than it is today. Hill (2002) notes that without projectile weaponry and poison it is difficult to imagine how many of the large game species present in hominid archeological assemblages were killed without cooperation (see also Washburn and Lancaster 1968).

10. Lembata had a population of 85,334 in 1994, much of it concentrated on the north side of the island (Barnes 1996:23).

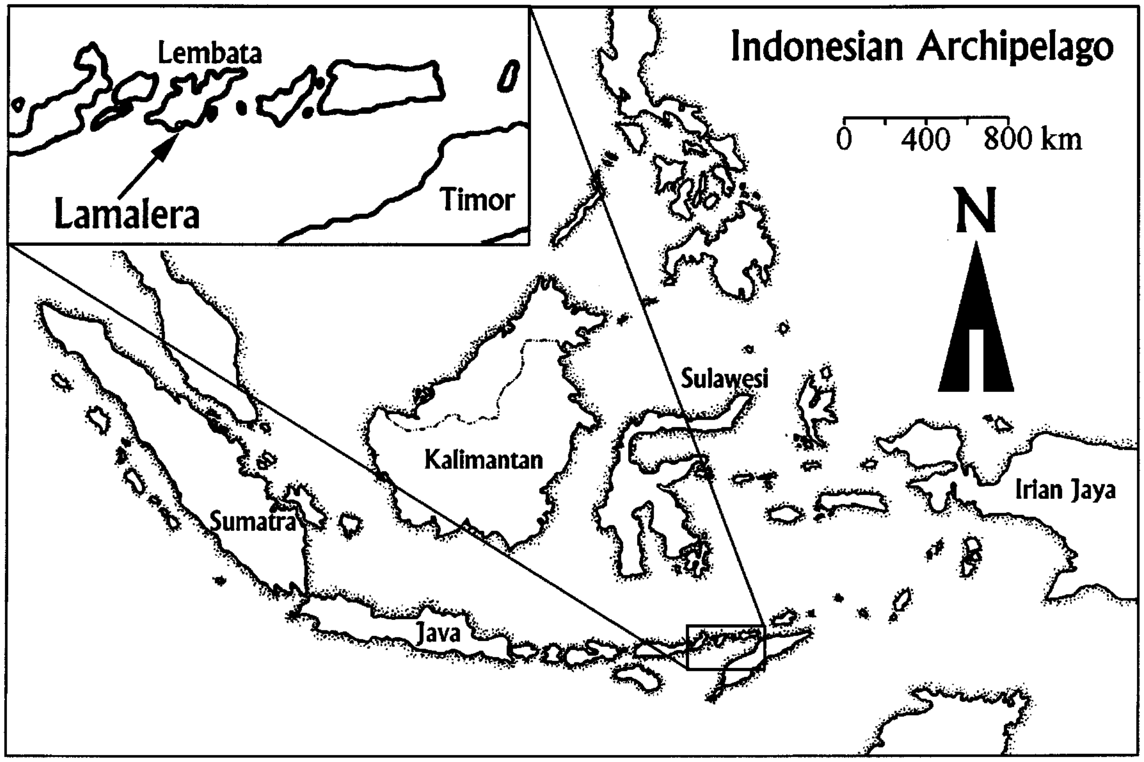

FIG. 2. *Location of the field site.*

taceans, and rays'.[11] The inhabitants of Lamalera speak Lamaholot;[12] all but the extremely young and old also speak Indonesian. The village is culturally similar to those of other Lamaholot-speakers (distributed from eastern Flores to central Lembata), sharing a system of patrilineal descent and asymmetric marriage alliance between descent groups. Its population is approximately 1,200, divided among 21 major patrilineal clans (*suku*), the larger of which are further divided into subclans (*lango béla*; see Barnes 1996 for detailed ethnography). In the recent past, Lamalera was subject to the Raja of Larantuka and was locally headed by a *kakang* or head man (Barnes 1996). There are three historically and politically important clans (referred to as *lika télo*, "hearthstone clans") that distinguish themselves from others in terms of their descent from the founding ancestor (Barnes 1996:62–80). Two others (referred to as *tana alep*, "lord of the land clans") are considered the only autochthonous clans of the village.

11. Indonesia is not a signatory to the International Convention for the Regulation of Whaling, though Lamalera would probably qualify for an aboriginal subsistence whaling exemption from the International Whaling Commission. As far we know, Lamalera is the only village in the Indonesian archipelago that currently practices subsistence whaling. Other villages on Lembata pursue fish using hook-and-line and nets but do not hunt whales. The only other site where subsistence whaling was common in the recent past is the village of Lamakera, approximately 30 km from Lamalera across the Solor Strait on the island of Solor (Barnes 1996).

12. We follow Barnes (1996) with respect to the spelling of Lamaholot words.

MARINE HUNTING

Although whaling occurs throughout the year, two seasons are recognized. *Léfa* is the primary whaling season, from May until September. This is the dry season and the period when sea conditions are best. During *léfa*, boats go out every day except Sunday, weather permitting. *Baléo* is a season of fewer resources, and in this period whaling boats are kept in their sheds and hunts occur only if prey are spotted from shore. Informants report that the rain that is common during *baléo* destroys the boats' woven-palm sails and makes control of the whaling vessels more difficult because of rough seas. Whether prey are also scarcer is unknown.

The primary prey for both seasons are sperm whale (*Physeter catadon*) and ray (*Mantis birostris*, *Mobula kuhlii*, and *M. diabolus*). Other toothed whales, including killer whale (*Orcinus orca*), pilot whale (*Globicephala macrorynchus*), several species of porpoise (*Peponocephala electra*, *Grampus griseus*, and others), shark, and sea turtle. Lamalera hunters taboo baleen whales (suborder Mysticeti) (Barnes 1996).[13] The mean

13. Hunters reported that baleen whales were too large and dangerous to pursue.

number of whales taken by Lamalera hunters per year from 1959 through 1995 was 21.4 (S.D. = 13.8, range 2–56 [Barnes 1996: table 15]; fig. 3). For the same period, the mean number of the two largest species of ray taken per year was 144.7 (S.D. = 95.7, range 10–360 [Barnes 1996: table 15]).[14] Daily returns can be thousands of kilograms (a typical sperm whale yields over 6,000 kg of edible produce), but variation from day to day is high.

Eighteen subclans maintain corporate whaling operations focused on whaling vessels called *téna*. Twenty boats were in operation in 1999 (one subclan maintained 3). These craft, which measure about 11 m in length and 2.5 m at the beam, are propelled by paddles and large rectangular woven-palm sails and steered with an oar (see Horridge 1982). Killing prey from a *téna* is a manifestly cooperative activity, impossible to accomplish alone. Each boat's activities are organized by a man called the *téna alep* (literally "*téna* owner"), whose role is in some ways similar to that of the *umialik* or whaling captain of the Inuit bowhead-whale hunters of northern Alaska (Spencer 1959). In spite of his name, the *téna alep* does not own the boat. Rather, he acts as a coach or manager and does not necessarily go out to sea. He serves as a nexus for the whaling operation, coordinating the three specialized and overlapping interest groups—crew members, corporate members, and craftsmen—that receive shares of the harvest.

Crew members are the active hunters. They tend to be clan members, but this is not a prerequisite. Within crews, the specialized roles are harpooner, harpooner's helper, bailer, and helmsman. While the crew tends to have a core set of members, its composition may vary from day to day. Corporate members are usually clan members who underwrite the construction and maintenance of the boat. They may or may not serve as crew. The craftsmen—carpenter, sailmaker, smith, and harpoon-bamboo provider (often the harpooner)—may or may not be clan members or crew.

Daily during the whaling season, a fleet leaves at sunrise, weather permitting, to search an area directly to the south at a distance of up to 13 km. When a whale is sighted, the sail is usually dropped and the crew rows furiously to catch up with the whale. Once the boat is in range, the harpooner leaps from a small platform on its bow to drive the harpoon into the back of the whale. The whale then dives or tows the boat along until it is exhausted. By almost any standard, whale hunting is dangerous. Boats may be towed out to sea and occasionally capsize (see Barnes 1974, 1996 and Severin 2000).

The boats travel in a diffuse group, and cooperation between boats is common. Large whales are difficult to catch, and more than one boat crew is often required to subdue one. Other crews will not assist unless they are asked to do so. A request for help is carefully calculated, because crews that participate in the kill have equivalent claims to the carcass. After help is requested, the helping crew may attempt to place additional harpoons or tie

14. These data include prey taken during both seasons.

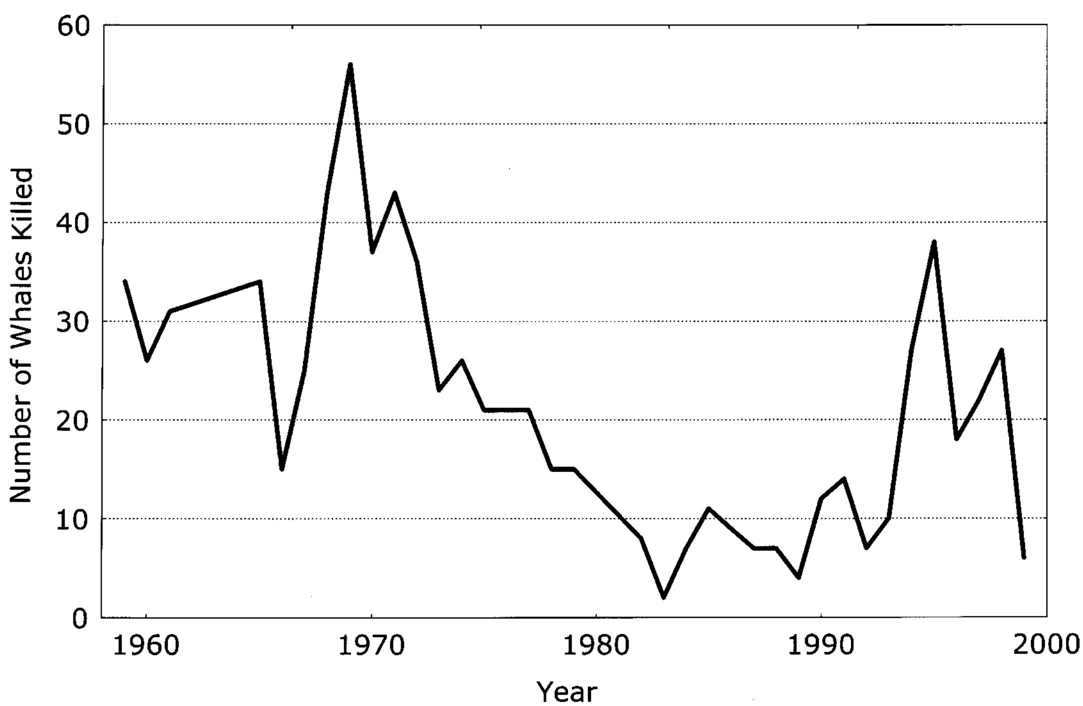

FIG. 3. *Number of sperm whales taken by Lamalera hunters per year from 1959 through 1995 (data from Barnes 1996: table 15).*

onto the first boat to help serve as a drogue. Crews also assist one another by recovering individuals who have been thrown overboard. Cooperation among crews is not required for smaller prey such as ray.

DISTRIBUTION OF THE CATCH

The systematic norm-based sharing of game found at Lamalera is not uncommon among hunters (Altman 1987, Cassell 1988, Gould 1967, Ichikawa 1983, Robbe 1975). In the Lamalera case, the primary distribution occurs as carcass pieces are given to shareholders on the primary village beach during and immediately following the butchering of the prey. Secondary distributions occur between households subsequent to the primary distribution. The primary distribution proceeds according to complex norms that are generally consistent among corporations but may vary in detail with prey species. The prey is divided into whole shares with names that correspond to anatomical parts of the prey (table 2). Each whole share has one or more shareholders who claim what we call individual shares.

Whole shares go, first, to the crew members of the boats involved in the capture of the prey. Second, certain corporate members receive corporate shares as part of their hereditary rights. Third, shares go to the craftsmen, who may or may not be clan members or crew. Fourth, shares go to the two clans known as *tana alep*; these shares are given only from sperm whale and represent a historical concession offered in exchange for use of the site on which the village now resides. Finally, small discretionary shares are usually given out by the boat master.

Within whole-share types, division becomes complex. Within a crew, for example, there are five positions—harpooner, harpooner's helper, bailer, helmsman, and crew—that may receive special individual shares depending on the species. The two bailers, for example, receive the *fai mata* share of a ray, a share similar to a standard crew share with portions from the head instead of the gill sections. Corporate shares vary considerably; for a whale there are six corporate whole-share types. Some are small, with many shareholders, and others larger, with few shareholders.

Finally, multiple shareholders receive all their due shares; a man who is a crew member, has a corporate share, and is the sailmaker for a boat that kills a whale receives all three shares.

TABLE 2
Types of Whole Shares of a Whale Carcass in Lamalera

Share Name	Type of Recipient	Number of Claimants
Méng (head)	Crew	8 or more
Kélik lama fa nãé	Crew (oldest male relative of harpooner)	1
Léfo tana	Rent (Lord of land clan)[a]	20 for Tufa Ona, 16 for Lango Fujon
Nupã	Craftsman (smith)	1
Laja	Craftsman (sailmaker)	1
Laba ketilo	Craftsman (carpenter)	1
Tenã kajo	Corporate (boat manager)	1
Kélik lango béla nãé	Corporate (keeper of clan house)	1
Nofek	Corporate	1
Mimã	Corporate	1–2
Kefoko seba	Corporate	5–14
Tenarap	Corporate	1–2
Kilã	Corporate	1–2
Befãnã béla	Corporate	1–5

[a]These shares are given only from sperm whale and represent a historical concession in exchange for use of the site on which the village now resides.

OTHER SUBSISTENCE ACTIVITIES

Besides marine hunting, there are few alternatives for acquiring meat or other forms of animal protein. Little animal husbandry is practiced. Some goats, chickens, and pigs are kept, but grazing is poor because the village is located on the lava flows of an extinct volcano. The common alternative to whaling is the relatively noncooperative hook-and-line or net fishing with small boats called *sapã*. Fishing occurs commonly during *baléo* but also during *léfa*. Some men specialize in fishing year-round. Fishing is done alone or in teams of two. While it can be accomplished alone, in practice it often involves cooperation among a small number of men. Fishers often cooperate with *sapã* and net owners. When this happens, each fisher and each owner claims a share. Share size is proportional to the number of claimants. Other, less common methods of obtaining marine resources include spear-gun fishing and fish trapping. Women also gather shellfish and seaweed.

Lamalera is located on the side of a collapsed volcanic caldera. The soil is extremely rocky and steep, and little agricultural land is available. A few villagers have obtained land outside the village (Barnes 1986) or attempt to grow a little produce in the rocky ground between houses (Barnes 1974). Villagers largely depend on trade to secure agricultural products. Women trade fish, whale meat and fat, and, to a lesser degree, salt, lime from coral, and dyed weavings with the agricultural communities of the interior. In exchange they receive maize, other carbohydrates such as rice and cassava, and other foodstuffs such as coconuts, coffee, sugarcane, citrus fruits, and green vegetables. This trade is generally on a barter basis (Barnes and Barnes 1989). During the study period, Lamalera was the site of a CARE International food-for-work project that supplied each household with 50 kg of rice each month in exchange for 30 hours of labor each week.[15] Nonagricultural goods such as pots and cloth are

15. This project required labor contributions from each household on a fixed schedule. Households could not increase or decrease the amount of rice they received by varying their labor contribution to

obtained in markets in the island's larger towns. Few people have a steady source of cash income, however. A primary source is remittances from villagers who have left to work for cash elsewhere. Tourism also provides a cash income for some villagers.

Methods

Project members lived in Lamalera from October 1998 through August 1999 and recorded the participation, duration, and outcome for hunts and fishing trips and the primary distributions of the meat and fish harvested from these activities. These two data sets were used to produce return rates (kg/hr.). Distribution norms were determined by interviews with boat masters and *ata molã* (master carpenters, who are also in charge of whale butchering). Master carpenters were given outline drawings of prey species and asked to sketch the division of a carcass into whole-share types. Boat masters were asked to name the shareholders with rights to individual shares in their boat. The result was a general normative set of rules for distributing cooperatively harvested prey. The rules agree in essence with Barnes (1996; see Alvard n.d.*a*).

All *téna* and almost all *sapã* leave from the primary beach. At least two observers were present on the beach for every potential foraging day during *léfa*. In the mornings, the departure times of boats were recorded. For *téna*, return times, harvests (number and kind of prey), and identity and crew position of men were recorded as they returned in the afternoon. Samples of share weights were collected. The same data were collected for *sapã*, except that here it was possible to weigh entire harvests immediately upon return (see Alvard n.d.*a*). After the catch was deposited on the beach and before butchering began, prey length and width were measured. As they were distributed to shareholders, a sample of individual shares for each whole-share type was weighed to the nearest 100 g. Large pieces were weighed using Vetek Weighingblock VB-200-10 flatbed digital scales. The scales were placed inside transparent plastic river bags to protect them from sand and carcass fluids. Smaller pieces, including shares from most rays, were weighed on Pesola spring scales. Each share was identified by share name and recipient.

In most cases, individual shareholders received $1/N$ of the whole share. The weight of each whole share for each prey item was estimated by first multiplying the average individual share weight by the number of shareholders from each boat and then summing across all the boats that participated in the kill. This procedure produced the estimated weight for each whole share. The natural log of the whole-share estimate was regressed against the natural log of length for cetaceans or length plus width for rays. This produced a least-square weight estimate for each whole-share type as a function of prey body size for each prey item caught (Alvard n.d.*a*).

Next, each individual share claimed was assigned an estimated weight based on prey body size. To do this, the estimated weight for each whole-share type was divided by the number of boats that participated in the kill and then by the number of claimants for that share type from the individual's boat. For example, if three crews killed a sperm whale that measured 8 m in length, we used the regression formula $\ln(\text{kg}) = 1.8229^{*}\ln(\text{ m}) + 1.1262$, constructed from the sample of 11 weighed individual *mimã* shares, to determine that the *mimã* whole share weighed approximately 148.4 kg. Since three boats participated in the kill, 148.4 kg was divided by three to estimate that 49.3 kg was due each boat. For the boat in question, there were two claimants to the *mimã* whole share, and therefore one individual's *mimã* share of this prey item was 24.7 kg.

To calculate the total amount of meat due particular hunters, all shares due each individual were summed on each day of hunting. Rates of return were calculated by dividing a hunter's total day's harvest by the number of hours at sea. This method produced a return rate estimate for each man for each day for each hunt.

A less complicated method was used to determine the return rates from fishing because the entire harvest from a particular trip could be weighed, the norms of distribution were not as complex, and the number of shareholders was far smaller. The entire harvest was simply divided into equal shares that went to the crew, the boat owner, and the net owner (if a net was used). As with hunting, one man could have more than one share if he contributed to the catch in more than one way; for example, a *sapã* owner who fished with a partner and used another man's net could claim two of the four shares or half of the catch, while one-quarter went to the partner and one-quarter to the net owner.

Results

HUNTING

A complete sample of hunts was obtained from the *léfa* period between May 3, 1999, and August 5, 1999. Boats went out every day except Sunday during this period. A total of 853 hunts were observed over the course of the 80 hunt days. The number of boats that went hunting each day (fig. 4) varied over the course of the season from 2 to 20 (mode = 9, $\bar{X}$ = 10.7). Some boats were able to hunt nearly every day; others had more difficulty (range = 17–69 hunts). Hunts started early in the morning, between 6:20 A.M. and 7:00 A.M. Hunt length ranged between 1.6 hr. and 9.4 hr. ($\bar{X}$ = 6.4 hr., N = 853 hunts). On an average day, 116 men went out hunting (range = 21–217). During the sample period, 290 individuals went hunting for a total of 9,041 man-hunts (N = 78

the project, nor could they choose when they contributed their time. In this light, we consider it a supplement to rather than a substitute for other subsistence activities.

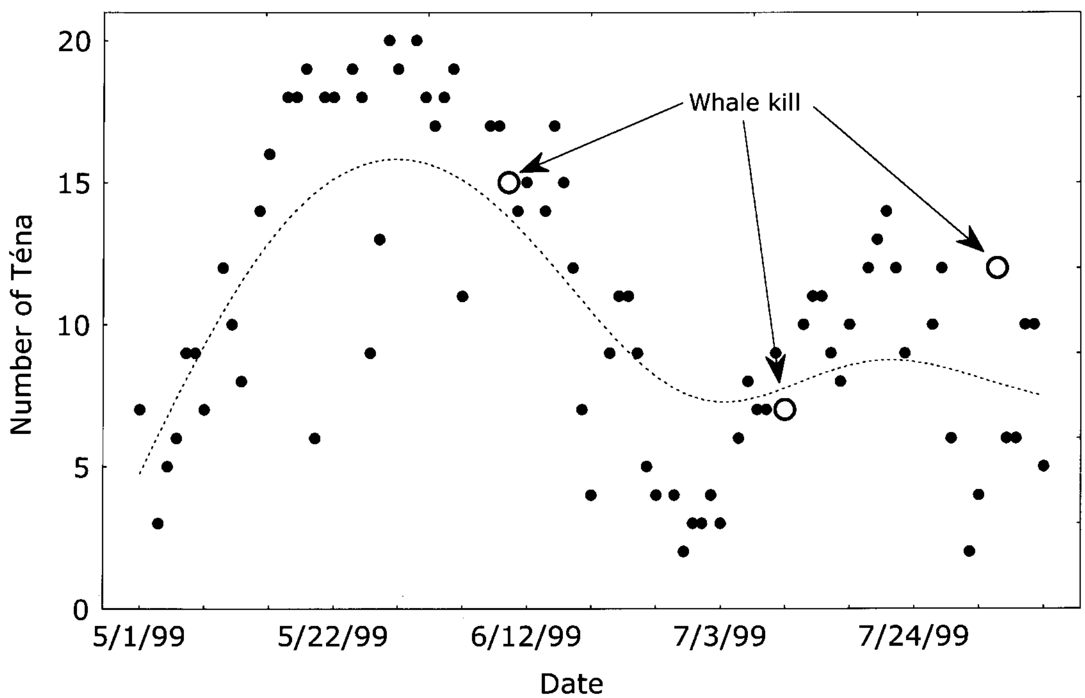

FIG. 4. *Number of* téna *that went to sea on each day of the* léfa *period May 3–August 5, 1999, and whale kills in that period.*

days).[16] The total number of hunter-hours was 57,722. There was wide variation in the number of hours individual men hunted, ranging from 2.4 hr. to 444.4 hr. ($\bar{X}$ = 195 hr.). Some individuals hunted regularly, others only occasionally. Crew size varied between 8 and 16 with a mean of 10.8 (N = 838).

During the sample period, 131 big-game items were harvested (table 3). The 1999 whaling season was one of the poorest in the past few decades. Only 6 sperm whales were killed in the 1999 calendar year and only 3 during the sample period. The number of rays taken during the 1999 field season was less deviant. The total estimated harvest for the sample period was 40,103 kg, of which 20,514 kg was sperm whale. The total harvest was divided as follows: 22,531 kg for crew shares, 10,887 kg for corporate shares, 4,031 kg for craftsmen, and 2,652 kg for the *tana alep*.

Each hunter participated in between 1 and 71 hunts (mean = 31.1 hunts). Hunters' return rates for individual hunts ranged from 0.0 kg/hr. to 48.9 kg/hr. ($\bar{X}$ = 0.36 kg/hr., S.D. = 1.75). The bulk of the man-hunts (85%) were associated with return rates of 0 kg/hr. (fig. 5). Alternatively, if we simply divide the total amount due crew members by the total hours hunted, the return rate is slightly higher (25,104 kg /57,722 hr. = 0.43 kg/hr.).[17] Return-rate estimates are tabulated in table 4. One might object that including the crews' corporate and craftsman shares along with their crew shares is inappropriate in that the men would receive these shares whether they hunted or not (provided that their boats went to sea). For present purposes we will call these additional shares "ancillary shares." Of the 25,104 kg due crew members, approximately 10% or 2,573 kg are ancillary shares, and if we remove them the return rate for crew members without any corporate or technical interest was 22,531 kg / 57,722 = 0.39 kg/hr.

As mentioned above, the 1999 season was atypical with respect to whale harvests. To estimate the harvest from a larger sample of years, we first went to the data from Barnes (1996:table 15) cited earlier, but because he does not distinguish *baléo* from *léfa* harvests it was impossible to know how many whales were normally taken during *léfa*. Data from written records obtained during our stay in Lamalera for the *léfa* seasons of 1995–98 showed that on 394 *léfa* days, 50 sperm whales were killed (Alvard n.d.*a*), yielding a rate of 0.127 whales per day. Our *léfa* sample in 1999 covers a period of 97 days

16. Crew counts were not done for 2 of the 80 observed hunt days. One man participating in one whale hunt is referred to as a "man-hunt." One man participating in one fishing trip is referred to as a "man-trip."

17. These two return rates differ because one is based on aggregate data and the other on ungrouped data. This is referred to as Simpson's paradox (Simpson 1951). This estimate also includes an additional 1,304 kg of meat of a rotating share whose owners were not identified.

TABLE 3
Harvest from Hunting May 1–August 7, 1999

Name	Species	Local Name	Number Killed
Manta ray	*Mantis birostris*	*belela*	52
Short-fin devil ray	*Mobula kuhlii*	*bou*	35
Whip-tail devil ray	*M. diabolus*	*moku*	22
Marlin	Istiophoridae	*feta*	4
Whale shark	*Rhinchodon typus*	*io kiko*	3
Sperm whale	*Physeter catadon*	*kotekelema*	3
Shark	many	*io*	3
Long-snouted spinner dolphin	*Stenella longirostris*	*temu kira*	3
Short-finned pilot whale	*Globicephala macrorhyncus*	*temu bela*	2
Melon-headed whale	*Peponocephala electra*	?	2
Risso's dolphin	*Grampus griseus*	*temu bura*	1
Bottlenose dolphin	*Tursops truncatus*	?	1

NOTE: These figures do not include game harvested by the two boats outfitted with outboard motors.

(including Sundays). Applying the average rate to our sampling period, we would expect 12.3 whales to have been taken. We added the estimated crew share of 9.3 additional whales to the total due the crew in 1999. Of the *léfa* harvest in 1999, the crew share alone consisted of 8,345 kg or 40.7% of the total harvest (Alvard n.d.*a*). The total share weights from the three whales in 1999 were 7,798 kg, 6,178 kg, and 6,536 kg ($\bar{X}$ = 6,838 kg). Assuming that each additional whale provided 6,838 kg of resource, the additional crew share from 9.3 whales was 25,882 kg, and adding it to the crew shares from 1999 (22,531 kg) produced a crew share of 48,413 kg for the estimated normative season. In 1999, crew members as a group received an additional 16% from whale kills as ancillary shares (Alvard n.d.*a*). This additional 4,141 kg (25,882 kg *0.16) raised the crew's share of the 9.3 whales from 25,882 kg to approximately 30,023 kg. Adding this amount to the 25,104 kg (the crews' total share in 1999) produced a total of 55,127 kg for the estimated total due the crews for a normative season.

To produce a normative return rate, we also need to estimate whaling effort. On average in 1999, 740 man-hours of effort were expended per day (range = 128–1,531, S.D. = 389). If we assume no additional effort for our normative estimate, the estimated mean return rate per man per hour during a year in which 12.3 whales were killed is approximately 55,127 kg /57,722 hr. = 0.95 kg/hr. It seems reasonable, however, to assume that more man-hours are expended hunting during a normal year. If we use the maximum man-hours expended on a single day (1,531) in 1999 as normative, our return-rate estimate drops to 55,127 kg /119,418 hr. = 0.46 kg/hr. Alternatively, we can estimate the effort expended during a normal *léfa* based on the mean daily 1999 effort plus one standard deviation. Thus, 740 hr. + 389 hr. = 1,129 man-hours per day; over the course of 78 days effort is 88,020 man-hours. In this case, the estimated mean return rate per man per hour during a year in which 12.3 whales were killed is approximately 55,127 kg /88,062 hr. = 0.63 kg/hr.

Finally, if we include *only* the crew shares due crew members and not any of their ancillary shares, the three estimates are 48,413 kg /57,722 hr. = 0.84 kg/hr. (1999 effort), 48,413 kg /119,418 hr. = 0.40 kg/hr. (maximum man-hours effort), and 48,413 kg /88,062 hr. = 0.55 kg/hr. (1999 effort plus one standard deviation).

FISHING

The number of fishing trips sampled between October 28, 1998, and August 2, 1999 was 1,020. The bulk (973 or 95%) of these employed either hook-and-line (545) or net (428) technology. Harpoons, traps, and parked nets were used on occasion. We do not have data on every fishing trip.

During the *léfa* period, 356 trips were observed; 338 of these trips used hook and line or net. A total of 135 men went fishing, for a total of 505 man-trips. These trips ranged from 2 to 9.5 hours in length. Crew size varied from 1 to 3 with a mean of 1.4 men for hook-and-line trips (N = 83 trips) and a mean of 1.7 men for net trips (N = 255 trips); the combined mean was 1.6 men. The mean return rate for individual men was 0.39 kg/hr. (N = 497 man-trips). Individual rates were 0.43 kg/hr. for net fishers (N = 396 man-trips) and 0.25 kg/hr. for hook-and-line fishers (N = 101 man-trips; fig. 6). Net fishing was marginally more productive ($t = -2.45$, p = 0.015). Return rate estimates are tabulated in table 5.

These estimates include all shares due fishers—crew shares and the ancillary shares that go to a fisher if he is also the net owner or *sapã* owner. The mean rates that count only the crew share are 0.32 kg/hr. for all trips combined, 0.34 kg/hr. for net fishers, and 0.22 kg/hr. for hook-and-line fishers.

Finally, if a man owns his own equipment and fishes alone, fishing can be done completely noncooperatively.

Such trips were rare (17/505 = 3% of all man-trips), but the mean return from them during the *léfa* season was 1.08 kg/hr. Gear owners were likely to allow others to use the equipment in exchange for a share while they themselves hunted for whales, thus accessing two sources of income. Whether this was the optimal choice for them remains to be seen. The bulk (31 of 46) of recorded *sapã* owners frequently went to sea, accounting for 1,170 man-hunts.

Discussion

IS WHALING MUTUALISM?

If Lamalera whale hunting is mutualism, then the payoff for cooperative whale hunting (R) should exceed the payoff for solitary nonwhaling activity (P and T), which should all exceed the returns for "solitary whaling" (S)—a failed attempt to hunt whales cooperatively. The obvious but not trivial result is that cooperative whale hunting clearly results in higher returns than solitary whaling. During the 1999 *léfa* season the return rate from whaling for an average crew member with all ancillary shares counted was approximately 0.43 kg/hr. Solitary whaling is presumably impossible, with a return rate of 0.0 kg/hr. To put it as Smith (1985) might, $R_8 > R_1$ for whaling—cooperative whaling in a group of eight or more has a higher per capita return than solitary whaling. In practical terms, S can be considered the payoff received by men who show up at the beach in the morning but whose boat does not go to sea and who otherwise fail to join another crew for that day. These men might still pursue fishing or some other nonwhaling activity, but they have at least suffered the cost of lost time if not lost opportunities.

We offer the return rate from fishing as an estimate of the payoff from solitary nonwhaling activity (P and T). Again, though other nonwhaling activities are possible, there are none that produce meat. In this sense whaling and fishing might be considered close substitutes. The overall fishing return rate with all ancillary shares

TABLE 4
Hunting Return Rate Estimates (kg/hr.)

	Effort[a]		
Harvest	Observed	Medium	High
Observed 1999			
Crew share and ancillary	0.43	n.a.	n.a.
Crew share only	0.39	n.a.	n.a.
Estimated normative			
Crew share and ancillary	0.95	0.63	0.46
Crew share only	0.84	0.55	0.40

[a]Observed effort is that observed in 1999; medium effort is the 1999 effort plus one standard deviation; high effort is based on the maximum daily effort observed in 1999.

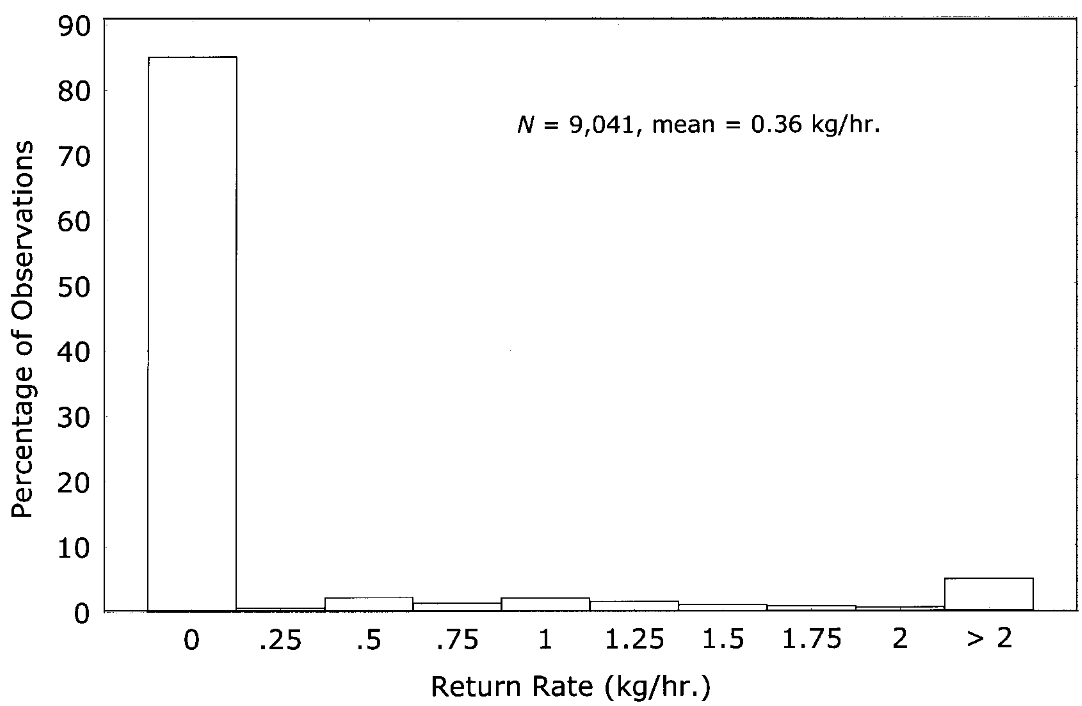

FIG. 5. *Frequency distribution of* téna *man-hunts.*

counted during the 1999 *léfa* season was 0.39 kg/hr. This mean return rate is not significantly different from 0.43 kg/hr., the return rate from whaling ($p = 0.1995$, $t = -1.285$, d.f. = 496). The mean return rate from the sample of net trips only ($p = 0.96$, $t = -0.045$, d.f. = 395) is also not significantly different from 0.43 kg/hr. Whaling, however, did provide a greater return than hook-and-line fishing, which yielded 0.25 kg/hr. ($p < 0.0001$, $t = -6.708$, d.f. = 100). If ancillary shares are not considered, the difference in return rate between whale hunting and net fishing is marginally significant (0.39 kg/hr. versus 0.32 kg/hr. respectively; $p = 0.048$, $t = -1.981$, d.f. = 395).

We conclude from these comparisons that in 1999 cooperative whale hunting was no more profitable or only marginally more profitable (depending on how the return rates are calculated) than fishing. This may provide a post-hoc explanation for the pattern of effort devoted to hunting over the course of the *léfa* season. Figure 4 showed that whaling effort, measured in terms of the number of boats that went to sea, increased until the end of May. At the start, hunters had only a probabilistic expectation of whaling productivity for the season. If they used previous years to predict the future, whaling was a good choice. At the end of May, all 20 boats were able to field crews. After this point, many boats began to experience what might be called coordination failure. The number of boats that were able to field crews dropped for the next month, and on July 3 only 2 boats went out. Whales were rarely sighted, and in spite of the killing of one whale on June 11 informants reported that many men were unwilling to go to sea because "luck was poor" (i.e., returns were low). It became difficult for a boat master to get eight men together.

TABLE 5
Fishing Return Rate Estimates (kg/hr.)

Harvest	Method: Net and Hook	Net	Hook
Crew share and ancillary	0.39	0.43	0.25
Crew share only	0.32	0.34	0.22

Another additional factor that may have contributed to cooperative instability was that, although $R_8 > R_1$, if whales are removed from consideration, crews larger than eight had lower per capita return rates ($R_8 > R_{8+n}$; fig. 7).[18] Larger crews are probably important in years when whales are more common, but in this particular year extra crew members meant smaller shares of rays and other small game.

While mutualism is not clearly supported for *léfa* 1999, this was an exceptionally poor year for whaling at Lamalera. The harvest data from the past 30 years in-

18. Including the three whales would bias the optimal crew size toward the crew sizes of the boats that caught the whales.

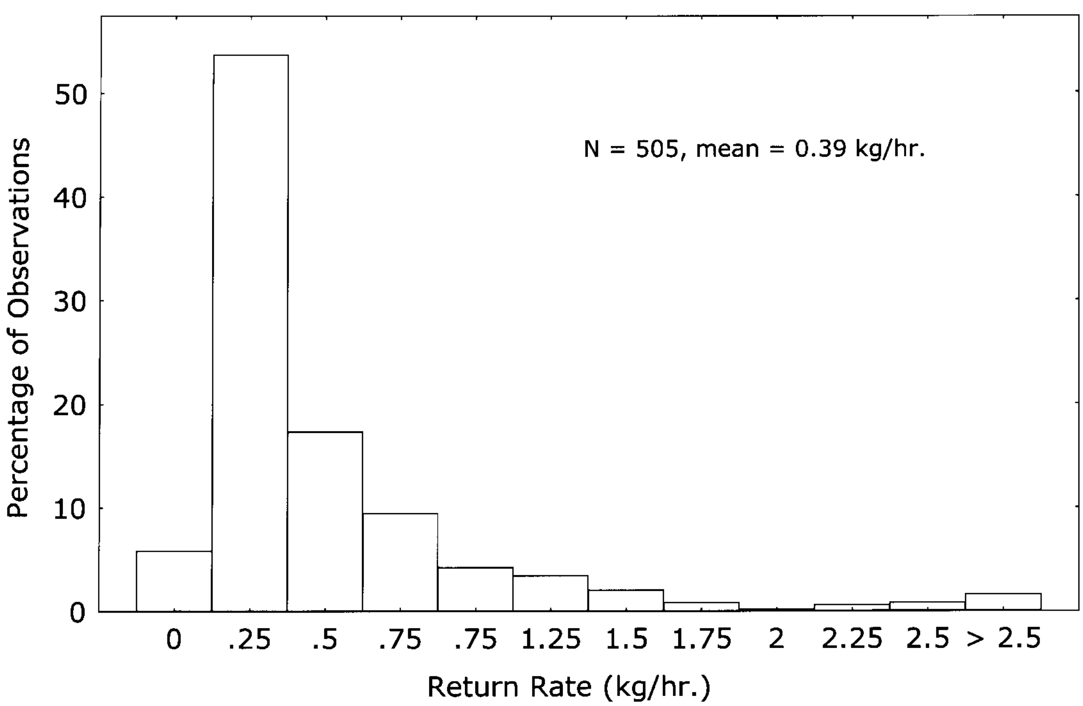

FIG. 6. *Frequency distribution of* sapã *man-trips.*

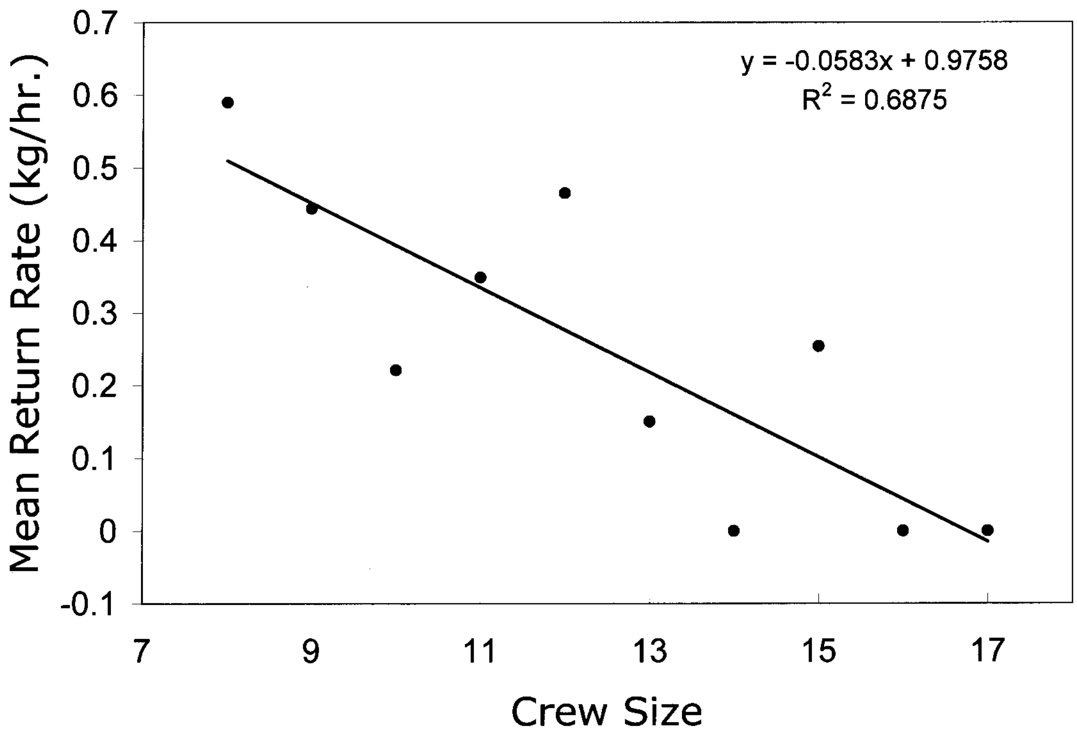

FIG. 7. *Return rates (excluding whales) of hunts as a function of crew size.*

dicate that cooperative whaling usually brings much higher gross returns than fishing. It is difficult to conclude, however, that the normal per capita return rate for individual whale hunters is greater than for individual fishers.[19] The key unknown variable is the amount of whaling effort (man-hours) characteristic of a normal *léfa* period. The observed and maximum return-rate estimates produced above are both unsatisfactory. An effort level of one additional standard deviation above the mean daily 1999 effort yields a mean per capita return rate during a normal year of 0.63 kg/hr. This rate is 62% higher than and significantly different from the rate for fishing ($p < 0.001$, $t = 7.96$, d.f. = 496). It is also significantly greater than that of net fishing ($p < 0.001$, $t = -5.49$, d.f. = 395). If we exclude ancillary shares, the mean whaling return rate drops to 0.55 kg/hr., but the rate also drops for fishing. Whaling still provides significantly greater returns (whaling versus fishing, $p < 0.0001$, $t = -12.39$, d.f. = 496; whaling versus net fishing, $p < 0.0001$, $t = -9.04$, d.f. = 395).

Assuming that whaling brings higher per capita returns over the long run, if hunters are using information gleaned from hunting experiences during previous years to generate expectations about future returns, cooperative whaling should be the preferred activity. The fact that all 20 boats were able to field crews in the initial part of the 1999 season suggests that enough men were motivated to coordinate sufficiently to achieve the presumed Pareto optimum. Coordination was maintained until it became apparent that expected return rates were not forthcoming, and this is consistent with the characterization of whaling at Lamalera as a coordination game. Cooperation is predicted only as long as the returns from whaling are sufficiently beneficial to individual participants.

One surprising result was that men did not shift to fishing when *téna* failed to go to sea in the 1999 season. The average number of men observed to go fishing per day during *léfa* was small—approximately 7 (range: 0–27)—in comparison with the 116 who went whaling. There was no relationship between the number of men fishing and the number of men hunting per day ($r = -0.15$, $p = 0.20$). We can only speculate as to the cause.

While we have characterized fishing as the less cooperative subsistence alternative to whaling, it still involves same coordination effort. Fishing takes a degree of commitment; not every man owns a *sapã*, for instance, and not every man owns a net. These are large, expensive, and complex pieces of technology that take capital to purchase, skill to manufacture, and/or social connections to obtain. This may make it difficult for men to switch from whaling to fishing in mid-*léfa*. While there were no other tasks that could bring meat into the household, men who did not go whale hunting could engage in a number of other tasks, such as limited gardening, house maintenance, ritual activity, rest, and communal

19. No comparable long-term data for *sapã* fishing are available.

village work.[20] It is apparent that at least some men valued the benefits from these other activities more than the benefits from either low-return whaling or fishing. From this point of view, a better characterization of the decision that crew members make is to hunt whales or not rather than to hunt whales or fish. The problem, of course, is that we can only presume the benefits of the alternative activities.

Another possible hypothesis to explain why men were reluctant to fish when whaling returns declined is related to kin selection (Hamilton 1964). Whaling provides large gross returns, and resources are often distributed to hundreds of people. Many of the benefactors are genetically related to crew members (Alvard 2000). Fishing provides much lower gross returns, and shares are distributed to far fewer people. Even with equivalent per capita return rates, fishing is not equivalently attractive to individuals because it does not provide the nepotistic benefit afforded by whale hunting.

Finally, the small number of men who regularly fished may have been more risk-averse. The variance in daily returns for fishing trips was significantly less (S.D. = 0.67 compared with S.D. = 1.7 for hunts [see above]). While 85% of man-hunts returned nothing, only 6% of fishing trips returned nothing. A test for homogeneity of variances for return rates indicates a significant difference (Levene $F = 11.01$, d.f. = 9626, $p = 0.0009$). Hunting is the riskier activity; fishing is the way to harvest resources on a day-to-day basis. Fishing during *léfa* was a specialization practiced by a few men as part of a *mixed strategy*. Most of the regular fishers both fished and hunted. (Why these men and not others fished is beyond the scope of this paper.)

What does this mean for our characterization of whale hunting as coordination? There are a number of interpretations, but none of them lead to rejecting the hypothesis that whale hunting in Lamalera is a coordination game. What preserves the argument of whaling as mutualism is that whaling returns 0.0 kg/hr. if attempted alone; men in Lamalera must coordinate in order to achieve the collective good obtained through whaling. We have presented data to show that whaling provides high returns to individuals that would be unavailable if not for cooperative activity. Presuming that whaling gives higher returns on average than fishing and alternative activities, the resulting payoff structure is different from a prisoner's dilemma and consistent with a game of coordination. That is, there should be agreement among hunters with respect to their preferences to cooperate. Hunters should also prefer that others hunt. For Lamalera whalers in a normal year and, by extension, for many big-game hunters, it pays less to "cheat" by not cooperating than to hunt. There is no incentive not to cooperate. These conclusions are the same that were obtained from a much smaller sample of data collected during the *baléo* period of 1998 (Alvard 2001).

20. Data were not collected to quantify the activities of men who did not hunt whales or fish.

"CHEAP TALK," NORMS, AND CULTURE

Substantial coordination is required to subsist on cooperatively acquired resources. Behaviors must be synchronized, rules must be agreed to (even if tacitly), and assurance, trust, and commitment must be generated among participants for the collective benefits of cooperative hunting to be realized. How does viewing big-game hunting as coordination rather than a prisoner's dilemma help us understand it and cooperative behavior in general? Just as the focus on the prisoner's dilemma led to a wealth of studies on reciprocity (e.g., Axelrod and Hamilton 1981), framing cooperative hunting as coordination will focus research on areas that will illuminate adaptations to coordination problems.

Norms have increasingly been viewed as facilitating coordination (Boyd and Richerson 2001, Ellickson 1991, Ostrom 1990, Lewis 1969, Sugden 1986). According to Ensminger and Knight (1997:2), "Social norms are informal rules that structure behavior in ways that allow individuals to gain the benefits of collective action. By collective action we mean not just the usual large-scale interactions implied by the term but any activity in which two or more people gain benefits, otherwise unrealizable, from acting together."[21] In situations of pure coordination, following the convention—driving on the right side of the road in the U.S.A., for example—is in an individual's best interest. It is also in an individual's best interest that others follow the norm as well (Sugden 1986).

Beyond the basic coordination problem described in this paper, coordination problems abound in the whaling complex at Lamalera, and one of them is reliance on norms to coordinate behavior among various actors. For example, as we have seen, coordination may fail if participants are not assured a sufficient share of the surplus generated by collective action. Payoffs to hunting are described by distribution norms that produce a payoff schedule acceptable to participants and are presumably maintained by the threat of punishment.[22] The distribution norms seem designed to facilitate a partitioning of resources in a way that is satisfactory to the hunt participants—if satisfaction can be assumed from their participation.

It is easy to view the distribution norms as a solution to this sort of coordination problem. For prey that requires more than one crew to subdue, hunters on differ-

21. We do not want to sound Panglossian. Norms need not result in convergence to the Pareto optimum. They may lead to coordinated behavior that is better than no coordination at all but not the most socially beneficial outcome.

22. Barnes (1996:79) anecdotally describes what might be described as a "cheater" clan named Lefo Sefo that existed in Lamalera until the turn of the 19th century. Its boat, the *Fao Puka*, was very successful but restricted to clan members as crew. Instead of returning its harvest to the normal beach spot where all the other crews butchered and distributed prey it would butcher at a spot called Lodo Ika. The clan was eventually punished; other crews failed to offer assistance when the *Fao Puka* capsized during a hunt, and as a result many of its crew drowned. It was ostracized afterward, and its last member died in the 1920s.

ent boats must have assurance that each boat uses the same distribution rules. While there is some variation in the way shares are distributed *within* boats, these differences do not affect the way prey are distributed *among* boats. Except for a token bonus for the crew that harpoons first, division of prey among boats is equal. Men cooperating in a crew must also have assurance that fellow crew members will not lay claim to shares that they themselves believe they own. It is difficult to know if the distribution norms at Lamalera are equitable if an equitable distribution is one in which the share quantities are proportional to the share owners' contributions to the hunt's success (see Chan et al. 1997). It is true, however, that among individuals whose contribution is of the same type, division of their whole share is equal.[23] It is among *classes* of individuals whose contributions vary (crew, corporation members, and craftsmen) that there is variation in whole-share size.

The entire system is based on an assumption by participants that they will receive the payoff prescribed by the norm. While the solution may not be socially the most efficient, it is surely more efficient than no norms at all. Ellickson (1991) argues that norms function in this regard to reduce the transaction costs of cooperative outcomes. Transaction costs are the costs of establishing and maintaining property rights and include such activities as inspection, enforcing, policing, and measurement (Allen 1991). For the whale that was killed on June 11, 1999, three boats participated, and at least 99 individuals were due and received shares according to the norms of the primary distribution. It seems unlikely that these individuals would have participated in such an activity if transaction costs could not be minimized and payoffs ensured.

What is interesting for anthropologists is that these coordination solutions require a cultural mechanism of information transfer to provide players the shared expectations crucial for coordinating behavior. Indeed, both the idea of norms and the idea of focal points revolve around "shared information." Distribution norms in Lamalera are socially transmitted and learned (Boyd and Richerson 2001). Schelling's focal points have salience because players share socially transmitted information.

In contrast to mutualistic contexts, in competitive situations where people's preferences are opposed, socially transmitted information is suspect because there is no motivation for individuals to transmit the truth. In game theory, outcomes in such contexts are sometimes referred to as "babbling equilibria" (Crawford 1998), in which receivers are expected to ignore uninformative signals from senders. Biologists come to the same conclusion—if organisms are tempted to misinform, others are expected to pay little heed to what they signal (Dawkins and Krebs 1978). In a world dominated by prisoner's dilemmas, this somewhat cynical view is justified. Although the anecdote that accompanies the prisoner's dilemma has the two prisoners held in separate cells so that they cannot speak to one another, this should make no difference to the outcome. A statement of intent to cooperate on the part of one player should always be ignored and met with defection by the other (Farrell and Rabin 1996).

For many of the coordination games described above players are assumed not to communicate before they make their decisions. This is presumably because such communication would provide an uninteresting solution to the problem (see, e.g., van Huyck, Battalio, and Beil 1990:235). As Crawford (1998:287) points out, in a pure coordination game it is plainly consistent with equilibrium for the sender to reveal his private information truthfully and for the receiver to believe him. This makes sense because, as stressed above, in coordination games there is no conflict over the desired outcome—cheating simply does not pay. Game theorists sometimes refer to pregame communication as "cheap talk" if the messages do not have any direct effect on payoffs.

That such solutions are uninteresting is a matter of perspective; there *is* a substantial literature that shows how pregame communication can lead to a socially efficient or Pareto equilibrium (e.g., Anderlini 1999, Banerjee and Weibull 2000, Farrell and Rabin 1996, Robson 1990, Silk, Kaldor, and Boyd 2000, Wärneryd 1993). Lab-based experimental coordination games show that simple pregame communication, in which one or both players can indicate their intent, dramatically changes the outcomes compared with control games in which no communication is allowed. In one case reported by Cooper et al. (1989), the Pareto optimum was observed in less than 5% of cases when no communication occurred. With pregame communication the Pareto optimum was observed in more than 67% of the cases. Farrell and Rabin (1996) argue convincingly that in contexts like the rendezvous game discussed by Schelling (1960) above, pregame communication can lead not only to coordination but to the Pareto optimum. In these cases, statements of intent concerning destination should be honest. If one of a pair declares she will go to the Empire State Building, there is good reason for her to want her partner to believe she is in fact going there, for her partner to believe her, and for them both to go there. Kim and Sobel (1995) apply an evolutionary approach and come to same conclusion—that communication leads to evolutionary stable, socially efficient outcomes provided that players' interests coincide sufficiently. The key here is that honest communication of intent provides the trust or assurance required for coordination at the mutually desired outcome.

In Lamalera, assertions involving coordination issues are made in a number of contexts. Boat masters begin recruiting crews in the spring, especially in the relatively dead months of January and February, when few people are at sea. They visit potential crew members individually to assemble a crew for the upcoming season. Thus, assurances of cooperation are made prior to the whaling season. In fact, the centralization of this activity in the

23. This tendency toward an equal division was reflected in the results of an ultimatum-game experiment conducted in Lamalera (Alvard n.d.*a*). The results showed a modal offer of 50% and a mean of 58%—6 out of 19 offers were "hyperfair" (above 50%).

office of the boat master may itself be seen as a normative solution to the coordination problem of eight or more men all trying to obtain assurances of cooperation from each other. There is also an annual ceremony called Tobo Namã Fata that precedes the whaling season. The boat owners, harpooners, and master carpenters of each boat are required to be present, and so are the heads of the three hearthstone clans and the two *tana alep* clans. In 1999 it occurred on April 30 and involved about 100 people. Its purpose is to discuss any mishaps, accidents, slights, and problems from the previous whaling season, clear the air of any ill will, and suggest solutions for the upcoming year. In this regard, it is a formal forum for the discussion and establishment of norms. For example, in 1999 one topic of discussion was which boats could be called to help in the capture of a whale. In the previous year one crew had preferentially requested help from a particular crew even though another was better positioned to provide aid; the better-positioned boat had responded to the call for help, and afterward some individuals from the first boat had sought to deny the second boat its share because it had not been specifically invited to help. Discussion resulted in the decision that if a boat wanted help with a whale, it had to call the closest boat. Essentially, a new norm was established to ensure a participating boat of its share of the surplus realized through collective action and thus promote coordination among boats.

Conclusion

While both theory and empirical work suggest that communication provides solutions to problems where individuals have common interest, solutions that include pregame negotiations are often considered trivial by economists because all humans can easily communicate in this way (van Huyck, Battalio, and Beil 1990:235). From a comparative evolutionary perspective, however, such a solution is far from trivial. The adaptive value of being able to communicate honest cooperative intent with such a statement as "I will hunt whales tomorrow with you if you hunt whales tomorrow with me" is hard to overestimate. We speculate that the pregame communication so crucial to the solution of coordination games such as the cooperative hunting described above may have been one selective pressure favoring the evolution of language and culture. The benefits of being able to solve mutualistic collective-action problems like those modeled by coordination games would have provided individuals a tremendous selective advantage.

While the idea that language and culture evolved in order to facilitate the planning involved in hunting is not new (e.g., Montagu 1976, Washburn and Lancaster 1968), framing the issue in terms of game theory is. Coordination problems are common and not limited to hunting. For example, depending on the ecological and social contexts and the degree of conflict of interest, marriage could be viewed as a coordination problem in which the members of the pair share an interest in producing offspring (Hadfield 1999, but see Bird 1999). Predictably, in many societies public assertions of assurance and commitment are offered to initiate such relationships.

A broader example of how culturally transmitted information can work to resolve coordination issues is described by McElreath, Boyd, and Richerson (n.d.). They suggest that ethnic markers enhance the ability of people to solve certain very common and important coordination problems. They show that "if people preferentially interact in coordination games with people who have the same marker as they do, and if they acquire their markers and coordination behaviors by imitating successful individuals, groups distinguished by both norm and marker differences may emerge and remain stable despite significant mixing between them." This assumes that identity is a reliable predictor of behavior—that identity covaries with the way in which the player will "play." Culture is often described as a complex, internally consistent whole (Tylor 1871), suggesting a set of covarying traits. "Playing" with someone who shares markers increases the probability that ideas of saliency will be shared. Clan totems, language, costumes, scarification, tattoos, rituals, and other identifiers indicate group association, decrease anonymity, and provide assurance that all are playing by the same rules (see Barth 1969). While anthropologists have long studied such cultural markers, understanding them in terms of solutions to coordination problems is an important theoretical insight.

There is growing consensus that 40,000–50,000 years ago humans developed the ability to transmit large volumes of information culturally. Subsequently, there was a dramatic increase in what could be called cultural diversity in the archeological record (Klein 1999, Mellars 1998). The Upper Paleolithic transition represents a quantum change from everything that went before. What were the selective forces that favored the development of the traits implicit in such complexity? One such force may have been the adaptive advantages of being able to solve coordination problems. Such problems are among the most basic of social problems: cooperation is the best route, but whom do you trust to play by the same rules? It is increasingly clear that being able to communicate and establish behavioral norms is crucial for solving coordination problems and gaining access to synergistic payoffs.

Comments

PETER BROSIUS
Department of Anthropology, University of Georgia, Athens, Ga. 30602, U.S.A. (*pbrosius@arches.uga.edn*).
10 V 02

The relationship between individual and collective life—between self-regarding behavior and altruism—has been a perennial issue in social and political theory. A central concern to Enlightenment *philosophes*, 19th-century evolutionists, and 20th-century anthropologists, it has reemerged in recent decades in Darwinian guise. Though problematic in many respects, this perspective has stimulated a florescence of research on the evolutionary significance of human behavior. Alvard and Nolin's treatment of Lamaleran whaling and fishing is a valuable extension of this research trajectory. The authors have taken on an interesting subject, laid out their argument clearly, and provided an impressive set of data to support it. However, their argument is ultimately unconvincing; this is primarily a function of data *not* provided.

The shortcomings lie in the authors' overemphasis on normative rules and behavior. While there is a clear set of rules governing whale hunting and the distribution of game, it is hard to imagine that Lamalerans *always* adhere to norms. Anthropologists have long stressed the distinction between "structure" and "event" (see, for instance, Kelly 1974), but the authors appear uninterested in the possibility of practices that depart from normative expectations.

Equally problematic is their reluctance to provide data that cannot be quantified. This is unfortunate, as much would be gained from an attempt to integrate their quantitatively based observations with a fuller account of the cultural context in which those observations were made. For instance, in a comparison of whaling and fishing we are told that, on the basis of returns, "cooperative whaling should be the preferred activity." Perhaps. But is potential yield the only factor that makes whaling preferred? What role might the cultural salience of whaling in Lamalera have in determining preferences?

This points to a troubling contradiction in Alvard and Nolin's presentation of data. While they are explicit about their methods for collecting data on whaling and fishing, down to the brand of scale used, they are silent about how ethnographic data other than numbers were collected. In what language were interviews carried out? Did they do interviews themselves or use translators? These questions are critical for assessing the quality of the information and interpretations provided.

The questions they raise but for which they have no answers are striking. They mention that "Some boats were able to hunt nearly every day; others had more difficulty." Why? They state that "one surprising result was that men did not shift to fishing when *téna* failed to go to sea. . . . We can only speculate as to the cause." Why not ask? They note that fishers are more risk-averse. Why? Are there any predictors, such as age, marital status, relative wealth, or clan affiliation? They suggest that game distribution norms are "presumed maintained through threat of punishment." Why presumed? Could they not have explored this with informants? They mention the difficulty of obtaining nets for fishing because nets "take capital to purchase, skill to manufacture, and/or social connections to obtain." This one sentence suggests several lines of inquiry that would have enriched their analysis. Elsewhere they state that "it is difficult to know if the distribution norms at Lamalera are equitable." While equitability, like political legitimacy, can be subjective, it is not "difficult to know": Lamalerans could certainly have provided perspective.

Much of their argument rests on the question of trust, which they recognize but treat in an empirically inadequate manner. Their account would have been much enhanced if they had considered the cultural and political dimensions of trust and reputation in Lamalera. What are the processes by which trust is established, and what are the implications of trust violated? Do certain individuals have reputations as slackers or cheaters, and how did they come to be regarded this way? Are other individuals renowned for their trustworthiness, and do *téna alep* compete to recruit them?

The shortcomings of the authors' argument all come down to an impoverished notion of culture. At times explicitly Tylorian, at other times reduced to "pre-play communication," "culturally transmitted information," or markers of identity that serve as reliable predictors of behavior, the notion of culture they employ is not up to the task of providing the sort of nuanced ethnographic data that would have strengthened both their argument and their conclusions. We need to know more about the social history and cultural salience of whaling, the micropolitics of crew recruitment and game distribution, the ways in which clan affiliation might be strategically manipulated by key actors, and what happens to whom when rules are broken. A reliance on normative statements is never enough.

My comments should not be taken to suggest that Alvard and Nolin's theoretical perspective is untenable, that they should adopt an interpretive approach, or that they should have undertaken a research project they never intended. Just as economists have been faulted for relegating data they prefer not to deal with to the realm of "externalities," so these authors have consigned much nonquantifiable ethnographic material to the realm of the anecdotal and irrelevant. It appears that they have so constrained themselves as to what they count as data that some of the potentially most interesting avenues of inquiry were never pursued. The effect is to weaken their argument. The evolutionary perspective that guides their research would have been much enriched had they provided readers with a more fully developed set of observations.

LAWRENCE A. KUZNAR
Department of Sociology–Anthropology, Indiana University–Purdue University at Fort Wayne, Fort Wayne, Ind. 46805, U.S.A. (*kuznar@ipfw.edu*). 4 IV 02

Alvard and Nolin's article is a very welcome addition to the empirical record of forager behavior and to the body of anthropological theory. The authors provide one of the better anthropological applications of game theory since Barth's (1959) pioneering study. Their work has applications ranging from the mutualistic human interactions they describe to interactions between humans and the biotic environment. I will comment on the importance of payoffs in human behavior, other areas in which their approach may be fruitful, and the role of differential risk sensitivity in individual men's whaling.

Alvard and Nolin quite correctly point out that the prisoner's dilemma, while useful for wholly competitive scenarios, does not reasonably model many other human interactions. They provide alternatives whose payoff structures would lead to mutualistic coordination, and their data mainly support these models. They also point to the conditions under which coordination may break down. Finally, they demonstrate that knowing the payoffs to individuals is essential for predicting mutualistic behavior and understanding the development of seemingly arbitrary cultural norms. More important, they demonstrate that when these payoffs fail the norms weaken, indicating the generally adaptive nature of culture. This is an important point, since, while norms may be culturally transmitted through learning, they can also, as the data presented indicate, be unlearned.

The authors suggest several applications of their general model beyond Indonesian whale hunting, and I would suggest other obvious ones such as the hunting of megafauna during the Upper Pleistocene (beyond the general hunting hypothesis they suggest) and cooperative hunting among West African chimpanzees. Their approach may also be fruitful for analyzing the development of intergroup warfare, since individual interests in defense may coincide as in the assurance game. Also, there are few areas of human behavior more laden with norms than warfare (Keeley 1996).

Alvard and Nolin note that differences in risk sensitivity may explain variation among men in their hunting. The risk of failure is great in whale hunting, and examining what makes some men engage these risks while others opt out could be most illuminating, especially since there is much variability in individual men's whaling. I would predict that frequent whalers will be men who stand to gain much in status from winning (helping to kill a whale) but lose comparatively little status from losing (failure in the hunt) (see Kuznar 2002). This hypothesis could be tested against provisioning, nepotism, prestige, and tolerated-theft possibilities. Finally, individual returns from whaling decrease with increasing crew size, indicating that the minimal crew (8) is optimal. However, the average is greater (10.8). Given that many in a boat's crew are clan kin, nepotism and behaviors that enhance inclusive fitness may be operative in explaining this.

In recent years, human behavioral ecologists have focused and coordinated their efforts (perhaps to realize greater individual benefits?) on examining fundamental aspects of human behavior (division of labor, sharing, prestige, reproductive strategies) (Bliege Bird, Smith, and Bird 2001, Hawkes, O'Connell, and Blurton-Jones 2001, Henrich et al. n.d.). They have done this with well-designed empirical studies and advanced theoretical tools in the natural and social sciences. Alvard and Nolin's work among the Lamalera is part of this emergent research program, and it helps to clarify our understanding of the evolution of human economic and reproductive behavior and the development of human behavioral, social, and even ideological norms.

JÉRÔME ROUSSEAU
Department of Anthropology, McGill University, 855 Sherbrooke West, Montreal, Quebec, Canada H3A 2T7 (jrouss5@po-box.mcgill.ca). 9 IV 02

Formal approaches to decision making (game theory, prisoner's dilemma, coordination games, decision-making under risk, decision-making under uncertainty, Bayesian strategies, and other forms of optimization analysis) are useful thought-experiments which help us seek the most parsimonious explanations of decisions. The value of these approaches is in proposing testable algorithms. In some cases, these frameworks are sufficient to explain actors' choices for a single activity (see White 1973:385–402). This is the case here: I have no difficulty in recognizing Lamalera whale hunting as a coordination game.

In many settings, some of these forms of optimization analysis do not provide an evident answer because of their initial assumptions. As Alvard and Nolin point out, some models assume an absence of prior communication between players because this is more "interesting" from a mathematical viewpoint. This is of course unrealistic. In real social settings, prisoner's dilemmas are radically transformed by prior communication and shared expectations.

All forms of optimization analysis are easier to compute if one can isolate the context (i.e., "All other things being equal, we can expect X"). In practice, several games go on at once and in sequence. Social actors seek to optimize several outcomes; their priorities can change according to circumstances. Because of this, it is often difficult to demonstrate that specific outcomes are a consequence of optimal decisions. This is indeed what complexity theory leads us to expect: a limited number of easily comprehensible initial conditions can lead to unpredictable outcomes. In such cases, simulations can help generate a variety of outcomes which can be compared with ethnographic realities.

A common limitation of optimization analyses is the assumption that actors make a detailed evaluation at each game. In fact, norms and habits reduce the likelihood of reevaluating game parameters. For instance, when moving to a new city, we initially spend time optimizing shopping strategies on the basis of relevant parameters (price, availability, accessibility, etc.). Once we have done so, we tend to go on shopping at the same places without checking to see whether the initial conditions still apply. It is unrealistic to expect optimal choices. Decisions are often made on the basis of satisfactory rather than optimal outcome.

Finally, power differentials radically skew optimization. As Alvard and Nolin state, "It is difficult to know if the distribution norms at Lamalera are equitable." There is no reason to assume that they necessarily are equitable. If choices are limited, outcomes are more likely not to be equitable. In Lamalera, some social actors receive whale shares on the basis of ownership and hereditary rights. These differential rights are there at the outset of any optimization computation ("Given that all other things are *not* equal, we share as follows . . . ").

On another topic, the authors mention the suggestion that "ethnic markers enhance the ability of people to solve . . . coordination problems." This notion accords with an anthropological myth according to which ethnicity is the "most general identity" (Barth 1969:13). It isn't. Shared norms certainly help regulate coordination games, but there is no reason to expect them to be marked ethnically. Counterexamples abound (e.g., Rousseau 1990).

LORE M. RUTTAN
Department of Environmental Studies, Emory University, 300 Dowman St., Atlanta, Ga. 30322, U.S.A. (*lruttan@emory.edu*). 15 IV 02

Alvard and Nolin's paper is an important contribution not only to the body of work on cooperative hunting but, more generally, to the study of cooperative behavior. Using data from their studies of Lamaleran whalers, they make a strong case that the problem of assembling whaling crews is frequently one of the coordination rather than a prisoner's dilemma and, moreover, that many writers are rash in dismissing coordination problems as uninteresting. As they note, in many situations pecuniary payoffs to cooperation are structured not as in a prisoner's dilemma but as in an assurance game, a type of coordination problem. Furthermore, as they make abundantly clear in their case, coordination problems can involve multiple equilibria with no dominant strategy, and thus the solution to these problems is not trivial. In addition, I would note that experimental research indicates that individuals frequently behave as if social dilemma problems were assurance games; something like 30–50% of subjects cooperate in one-shot and repeated prisoner's dilemma games (Ahn et al. 2001). In other words, people seem to think that they are solving assurance games, perhaps because their utilities (as opposed to the pecuniary payoffs from the game) reflect such a structure (Hayashi et al. 1999). Given the extent to which anthropologists and many others view the world solely through the lens of the prisoner's dilemma, these are points well worth emphasizing.

Having supported Alvard and Nolin's case for the prevalence and relevance of coordination problems, I am not convinced that Lamaleran whaling is *always* a coordination problem. They present strong inferential evidence and argument that in 1999 hunters began the season with high expected returns from whaling and thus found themselves faced with a coordination problem. However, I have a minor disagreement with their conclusion that the fact that coordination failures increased as it became apparent to hunters that normal benefits were not forthcoming is consistent with the characterization of whaling at Lamalera as a coordination game. Although hunters began the season expecting that the rewards from hunting would be greater than the reward from defection ($R > T$), they soon found otherwise ($T > R$), particularly when the rewards of defecting are broadly construed as coming not just from fishing but also from completing household chores. Thus I would argue that coordination failures and the measurably low rates of return in 1999 indicate that the perceived payoff structure changed over the course of the season from a coordination game to one in which mutual defection was the dominant, equilibrium strategy. My point in making this subtle distinction is that we have a tendency to assume that payoff structures are static rather than exploring how they change with temporal variation in ecological and social conditions.

Turning to the very rich details of the case, there are two issues that I would like to see explored further. First, I was struck by the fact that the few individuals who own fishing equipment tend to "rent" out their equipment while they themselves go whale hunting. This creates an interesting asymmetry among those who crew the whaling boats. Owners of fishing gear are almost certain to bring home some form of protein at the end of the day, because they will receive auxiliary shares from the fisher renting their equipment, while other crew members do not have this same security. Might these two different groups have different risk-related thresholds for wishing to participate in the whale hunt, with those receiving auxiliary shares from fishers being more willing to commit to whaling? An early commitment to the team by these individuals might make commitment less costly for later joiners and thus facilitate the solution of the coordination problem.

A second point that struck me is that the authors explicitly discuss several possibilities for defection (e.g., going fishing, going home and doing chores) but only briefly touch on another possibility that is just as interesting—that defection may be an issue not only of whether to join one's crew on a given day but also of which crew to join for the season. The impression given in the paper is that crew membership is fluid in the months preceding the start of the *léfa* season. One wonders whether defection can also be construed as changing crew membership at the last minute; presumably defectors join a more skilled and more committed crew, leaving their former crew with fewer, less skilled, less committed members. In years when the rewards from whaling are larger than the temptation to defect and not whale, might this not be the biggest coordination problem of all?

ERIC ALDEN SMITH
Department of Anthropology, University of Washington, Box 353100, Seattle, Wash. 98195–3100, U.S.A. (*easmith@n.washington.edu*). 21 III 02

I applaud Alvard and Nolin for bringing together many strands of current theory that have a bearing on understanding the evolution of human cooperation: game theory, behavioral ecology, communication and enforcement of norms, transaction costs, and the like. Their emphasis on various kinds of mutualism and on alternatives to the prisoner's-dilemma/conditional-reciprocity paradigm that has so dominated work on this topic is refreshing. The application of these ideas to the Lamalera whaling case needs further work before it can be considered compelling, so I will concentrate my comments on the broader conceptual issues.

Alvard and Nolin are right to stress that linguistic communication dramatically enhances the potential for solving coordination problems, but the impact of language on collective action is surely broader than that. Symbolic communication greatly lowers the cost of monitoring free-riding and other forms of defection and perhaps of punishing it as well (employing gossip as a low-cost form of punishment and allowing coordination of cooperative high-cost punishment). Language also increases the benefits to be gained from signaling and reputation building, thus enhancing the selective incentives for unilateral contribution to the solution of collective-action problems (e.g., Gintis, Smith, and Bowles 2001). Language also expands the possibilities for disseminating (and monitoring) commitments, a class of social interactions that greatly expands the possibilities for cooperation beyond standard game-theoretical treatments (Nesse 2001).

Current approaches to the evolution of human cooperation remain quite divided regarding the degree to which we must abandon the individual-payoff focus that has dominated the field. Some insist that altruism (in the evolutionary sense) is prevalent and must be explained in terms of multilevel genetic selection (e.g., Boehm 1997, Sober and Wilson 1998, Bowles and Gintis 1998) or cultural group selection (e.g., Richerson and Boyd 1999, Henrich and Boyd 1998). Others, including Alvard and Nolin, remain wedded to the individual-benefit framework. It will be some time before these issues are sorted out theoretically and especially empirically. It is important that, while we debate these issues, we at least keep our terminology as clear and logical as possible. Alvard and Nolin generally do a fine job of this, but there are occasional lapses, as when they cite the observation that people "commonly join together to produce goods that they can only obtain as part of a group" as evidence against the game-theoretical assumption of self-regarding preferences. Particularly in cases of mutualism, there is surely no contradiction between cooperation and self-interest! Even in cases where individuals provide public goods (including enforcement of group-beneficial norms) at personal cost, there are explanations built on self-interest that can in principle apply (e.g., Gintis, Smith, and Bowles 2001).

The interesting though very brief discussion of ethnic markers, identity, and coordination of collective action raises some fascinating issues. Alvard and Nolin (citing the work of McElreath, Boyd, and Richerson n.d.) suggest that this provides insight into why stable ethnic groups with internally consistent cultures can persist despite interaction with neighboring groups. This seems plausible but perhaps a little anachronistic in the postmodern world of fluid identities, decentered selves, and destabilized essentialisms. However, if contemporary socioeconomic conditions involving the global flow of goods, information, capital, and labor mean that individuals are increasingly involved in playing multiple games with different sets of players (some defined by occupation, others by religion, others by political movement, still others by ethnic enclave in a multiethnic state, etc.), then we can extend this game-theoretic insight to postmodern contexts. In simple terms, multiple games with context-specific norms and markers both produce and require multiple identities. (Of course, in cases of collective competition that escalate to violent political conflict, individuals may be forced by social pressures to affiliate with a single collective entity—defined by political, ethnic, or religious markers, as the case may be—in opposition to the opposed collectivity, as we have seen occur repeatedly and with often horrific consequences in modern multiethnic states.)

In sum, Alvard and Nolin have exposed the CA readership to a rich set of theoretical tools and compelling issues in the study of human cooperation. As their discussion and analysis illustrate, game theory is a powerful tool for analysis of behavior involving interdependencies and interactions. Though there have been surprisingly few anthropological applications to date (Hawkes 1990, 1992; Rushforth and Chisholm 1991; Smith and Boyd 1990; Ruttan and Borgerhoff Mulder 1999), we can hope that this paper is not just one more isolated instance but rather marks a growing trend.

RICHARD SOSIS
Department of Anthropology, University of Connecticut, Storrs, Conn. 06269-2176, U.S.A. (*richard.sosis@uconn.edu*). 17 IV 02

Alvard and Nolin make a valuable contribution to the theoretical issues surrounding the study of cooperation and provide much-needed empirical data on behavioral decisions under conditions that offer potential gains from collective action. Since Boone (1992) and Hawkes (1992) introduced the games discussed here into the anthropological literature, fieldwork has empirically documented various types of cooperation across diverse communities (e.g., McMillan 2001, Ruttan 1998, Ruttan and Borgerhoff Mulder 1999, Smith 1991, Sosis 1997), and some of this work suggests that when cooperation emerges individuals face mutualistic, not altruistic, payoffs. Although Alvard and Nolin may ultimately demonstrate that this is true among Lamalera foragers, the analyses presented here do not support this conclusion.

They correctly point out that the prisoner's dilemma does not accurately describe conditions of cooperative resource acquisition. However, some of the shortcomings of the prisoner's dilemma—for example, its inability to distinguish between individual differences in utility for a resource or to model conditions in which foragers are able to cooperate at various levels of effort—are also inherent in the coordination games that they claim describe Lamalera whale hunting, and thus we may need to look elsewhere for a model of cooperative foraging decisions. I have used bargaining-theoretical models derived from behavioral ecology and economics (e.g., Noe, Van Schaik, and Van Hoof 1991) to generate qualitative predictions of cooperative fishing participation among Ifaluk men (Sosis, Feldstein, and Hill 1998), and others have developed and tested sophisticated evolutionarily-stable-strategy models (e.g., McMillan 2001, Ruttan and Borgerhoff Mulder 1999).

The use of two-player games to model Lamalera foraging decisions has significantly constrained the option set and thus limited the alternative decisions that can be evaluated. Alvard and Nolin provide us only with mean return rates for crew members, yet it is critical that we also know the payoffs for not hunting or fishing. If at least eight men hunt successfully, corporate members and craftsmen can acquire shares without hunting, and many men may have the opportunity to receive shares of a whale harvest from a secondary distribution. If some men can acquire meat through secondary distributions (which seems likely), then free-riding is a potential strategy and men with this opportunity may be facing a social dilemma (Dawes 1980) or a collective-action problem (Olson 1965) rather than a coordination problem. In other words, they may be able to achieve their highest payoffs by defecting when others hunt. This strategy seems especially likely since mean per capita return rates decrease with increasing crew size over eight.

Ignoring the energetic costs of Lamalera foraging compounds this problem. Crew members have specialized roles with energetic requirements that are likely to vary and to differ from the energetic costs of fishing. Thus, if the energetic costs of hunting and fishing were incorporated into the payoffs the payoff structure for some men might be altruistic. Indeed, if the caloric gains that Lamalera men can acquire through not hunting (via secondary distributions or entitlements as a corporate member or craftsman) are greater than the caloric costs of hunting, men are facing an altruistic payoff schedule and not the mutualistic payoffs proposed in the article.

The payoffs to Lamalera hunters and free-riders are frequency-dependent, and this makes it difficult if not impossible to categorize them in terms of two-player games. For example, since the payoffs for fishing or not fishing on Ifaluk are a function of the number of men who fish (which impacts the harvest size and consequently the distribution pattern), the type of game men play varies with the number of men who are expected to fish. When I calculated net caloric expected payoff curves for all men as a function of the number of men who fished and then evaluated whether observed fishing decisions matched the behavior predicted by the payoff curves (Sosis 2000*a*), it became apparent that it was inaccurate to categorize Ifaluk fishing as either mutualistic or altruistic. Similarly, such a categorization of Lamalera whale hunting would also be mistaken. Payoffs need to be calculated for each *potential* cooperator, and if payoffs vary as a function of some variable they need to be calculated for each potential variable state. Expected net caloric payoff curves of Ifaluk men indicated that some men always faced mutualistic payoffs, some men always faced altruistic payoffs, and others, depending on the number of expected fishers, faced either mutualistic or altruistic payoffs. On any given morning men who faced mutualistic payoffs were much more likely to fish than those who faced altruistic payoffs. However, some men who faced altruistic payoffs regularly fished, and some men who faced mutualistic payoffs never fished. Cooperators (i.e., those who fished) often responded to very different payoff schedules, not all of which were mutualistic. Calculating payoffs in this manner enabled me to capture individual variation and evaluate alternative hypotheses (such as costly signaling [Sosis 2000*b*]) to explain it. Individual payoff curves for Lamalera men would probably demonstrate that crew members, corporate members, and craftsmen face very different payoff schedules and that there is variation within each of these interest groups (due to differential energy expenditure and differential access to secondary distributions). Some of these payoffs are likely not to be mutualistic because of opportunities to gain meat without hunting.

I have one additional concern. It seems unlikely that distribution patterns are "designed to facilitate a partitioning of resources in a way that is satisfactory to the hunt participants." Distribution patterns are not necessarily fair, nor do they necessarily maximize group benefit (although, unless there are unconsumed ritual sacrifices, they have likely reached a Pareto equilibrium). It seems more likely that those with greater power (bargaining advantage) are better able to manipulate the distribution patterns in ways that allow them to gain relative advantage. For example, on Ifaluk members of low-ranking clans and men without canoes consistently received a smaller percentage of the catch. Notwithstanding their small share of the distribution, they continued to fish, but they were clearly making the best of a bad situation (Sosis, Feldstein, and Hill 1998).

Despite these concerns, Alvard and Nolin's work is a welcome and valuable contribution to the literature on human cooperation. I look forward to their future efforts in this area of research.

Reply

MICHAEL S. ALVARD AND DAVID A. NOLIN
College Station, Tex., U.S.A. 5 v 02

We thank all the commentators for their insightful remarks on our work.

Field anthropologists usually do not have the confidence that comes with experimental settings. The world is a messy place, and this is perhaps why game theoreticians rarely venture out of their offices or labs. To create simple models like the prisoner's dilemma or the assurance game, game structures are abstracted from a wide variety of real-world phenomena. Predictions from these models are usually tested in laboratory settings in which the conditions are rigorously specified to match the game under study. We have taken a bit of a risk in using rigorously specified games and attempting to show that a real-world situation is better described in terms of one game than in terms of another. By doing so, we have exposed ourselves to the criticism that the models do not match the complexity of the real-world phenomena. In spite of this difficulty, most of the comments are sympathetic to our main thesis. We argue that many cooperative instances are structurally coordination rather than prisoner's dilemmas. Ideally, awareness of this distinction will compel researchers interested in cooperation to think outside the prisoner's-dilemma "box" and give more attention to the way people construct solutions to coordination problems.

A number of the commentators are not convinced that the analysis provides a sufficiently compelling argument for coordination in the particular case of Lamalera; others feel that the story is much more complex than simply a coordination game. Sosis and Ruttan offer the most thoughtful critiques. Both of them support our notion that coordination problems are more common and more interesting than is commonly appreciated among anthropologists, and along with a number of the other commentators they argue that the social interactions among hunters are more complex than a simple coordination game.

The complexity is evident in a number of areas. Ruttan correctly points out that the structure of interactions and the payoffs should not be assumed to remain static over time. She calls attention to our observation that crews had more difficulty forming as the summer progressed; we argued that this had to do with the realization by hunters that the normal return rates were not forthcoming. She suggests that one interpretation is that the structure of the game changed during the course of the summer. Both she and Sosis argue that there is more variability among men in terms of payoff structure than is admitted by the model. She points out, for example, that *sapã* owners begin their payoff calculus from a different space than others and may be more likely to commit to whaling because they have a ready source of meat. The fact that some men fish using *sapã* at all, given the usually greater return rates from whaling, suggests that some men are making decisions with a different payoff structure.

Sosis argues that determining men's individual payoff schedules would likely reveal structures that are not mutualistic. While he suggests that the energetic costs of alternative activities might make the difference, it is likely that other factors are more important. Harpooners, for example, seem to be at much greater risk of injury and death. Barnes (1996:307–309) describes the dangers at sea for Lamalera whalers, the preponderance of which seem to fall upon harpooners. Being struck by the tail of the whale and becoming entangled in the ropes are two commonly mentioned hazards. Unpublished data on meat distributions show that harpooners differentially benefit during primary distributions. While they give away some of the shares they receive by virtue of their roles, they also receive additional shares because they are more likely than the average crew member to own corporate shares. It is hard to know if the increased payoff that harpooners receive is balanced by the increased mortality risk. If not, then the crew is free-riding on the courage of the harpooner. If, however, the increased mortality risk is not very great, the harpooner may be free-riding on the crew.

Sosis is generally convinced that there are more ways to free-ride in Lamalera than are presented in the model. Granted, the model limits the payoffs to primary distributions, in which nonparticipating free-riders do not receive shares. The data on primary carcass distributions, however, do show that successful boats do not share the carcass with unsuccessful boats. This contrasts with the situation of some Inuit groups, in which all the boats that go out receive a share of a captured whale whether they participate in the pursuit and kill or not (van Stone 1962). The secondary sharing that occurs at Lamalera is a key but missing piece of the puzzle. If secondary, nonreciprocal transfers occur and men do free-ride, Sosis argues, the system begins to resemble a prisoner's dilemma. This is not necessarily the case, however. Most recent models of food transfer postulate that transfers occur because of benefits that accrue to the resource acquirer. In addition to the meat he obtains, costly-signaling theory, for example, hypothesizes that the hunter also enjoys the largesse of others who learn about his qualities and consequently behave in ways that benefit him (Hawkes 1991, Bliege Bird, Smith, and Bird 2001). If this is true, then free-riders may be able to acquire meat, but it is impossible for them to acquire the less tangible benefits of whale hunting if they stay at home.

Brosius's methodological criticisms are a bit contradictory. First, he notes our reliance on normative rules. This is noteworthy because we have been critical of anthropologists who rely on an informant's verbal utterances rather than observations of behavior to provide support for hypotheses (Alvard 1995). While we could have included additional information about how the data were collected, we were not quite as silent about the methodology as Brosius suggests. The distribution norms we described were collected in Indonesian via interviews with boat masters and master carpenters using outline drawings of the prey. The methods are discussed in more detail in Alvard (n.d.*b*). Our choice of methodology in the Lamalera case had much do with expediency and the nature of the data. Identifying the norms solely on the basis of observations would have taken an extraordinary amount of time. We were careful to determine that the observed distributions were made according to the norms as described. Individuals who were approached to have their shares weighed were always in possession of the expected shares. On the beach during the butchering there was occasional grumbling about the size of shares, but a person always received the share to which he or she was entitled.

Brosius is curious to know "what happens to whom when rules are broken." While we did mention the anecdotal evidence of the "cheater" clan whose members were ostracized, rule breaking was difficult to detect, presumably because the system works so well. In spite of the perception that big-game hunters suffer "formidable accounting problems" and "ever changing scores in different currencies" (see Hawkes 2001:132), the Lamalerans are able to perform what appears to be choreographed butchering and distribution with little observable contention.

Oddly, after faulting us for relying on normative responses, Brosius criticizes us for not having asked questions in a way that is vulnerable to the same criticism. For example, he notes that we state that is difficult to know if the distribution norms at Lamalera are equitable and suggests that we should have asked the Lamalerans about their views on the distribution. It is much more difficult to learn whether answers to questions concerning equitability are simply normative statements or are true in the way that we were able to determine the meat distribution was. Brosius does, however, make a valid point. We were trained in an environment in which the informant's verbal utterances were suspect to the point that asking "why" questions was discouraged. We are willing to concede that behavioral ecologists could benefit from a greater willingness to adopt a more cultural approach. Brosius argues "that we have consigned much nonquantifiable ethnographic material to the realm of the anecdotal and irrelevant." It seems to us unlikely that most behavior ecologists will be willing to abandon a strict quantitative approach, but there are ways to include more information provided by informants while remaining faithful to a quantitative methodology. The cultural consensus models (Romney, Weller, and Batchelder 1986) are an excellent approach. It is time that we admitted the usefulness of cultural information, although we need to be more careful about the way we validate such information than cultural anthropologists have in the past.

Finally, Brosius makes a statement that we presume is a criticism but consider more of a compliment. He says that the number of questions we raise for which we have no answers is striking. While answering questions is surely the primary goal of research, we are never discouraged when more questions are raised during the course of a research project than are answered.

Both Smith and Rousseau add some interesting speculation about how markers might be useful for solving coordination games. Smith notes that "multiple games with context-specific norms and markers both produce and require multiple identities." Ruttan implies that social reality consists of a great number of embedded, overlapping and changing games. We have no quibble with these ideas; the usefulness of a specific identity is context-specific. In Lamalera, where everyone is a Catholic, a religious identity offers little for resolving differences that might be useful within the village; such an identity might be very useful as individuals traveled to Jakarta. At the same time, Lamalera contains a number of clans, and knowing about clan identities is useful for individuals making decisions and forming coalitions (Alvard n.d.*b*).

Rousseau comments on our citation of McElreath, Boyd, and Richerson's (n.d.) suggestion that ethnic markers enhance the ability to solve coordination problems. He is concerned that ethnicity is incorrectly viewed as the "most general identity" and points out that there are many other ways in which social norms can be marked. We certainly do not see why markers must be limited to ethnic identity (and presumably neither do McElreath, Boyd, and Richerson). Markers may, for example, be religious, political, or national. Recent analysis shows that lineage identity predicts affiliation among Lamalera hunters to a much greater degree than does strict kinship (Alvard n.d.*b*). Lineage identity provides unambiguous group membership. Preferring to affiliate with someone with whom one shares lineage identity reduces anonymity, increases the probability of the sharing of norms, and provides assurance that fellows play by the same rules.

Finally, Smith views our statement that "people commonly join together to produce goods that they can only obtain as part of a group" as evidence against "selfishness." Wedded to the individual-benefit framework himself, he says that there are many explanations for collective action built on self-interest. Our reasoning follows that of Gintis (2000:244), who criticizes the idea that rationality implies self-interest. He argues that self-interested people, defined as those who act without regard to the interests of others, are sociopaths exemplified by cannibals, sexual predators, and professional killers. We make the point that we need to move beyond the argument that people are strictly self-interested. Individuals employ strategies that subordinate their interests to those of their group in exchange for goods that can be obtained only via collective action. By limiting one's analytic framework to individual benefits one is at risk of losing an understanding of the benefits obtained by virtue of being part of a group.

References Cited

AHN, T. K., E. OSTROM, D. SCHMIDT, R. SHUPP, AND J. WALKER. 2001. Cooperation in PD games: Fear, greed, and history of play. *Public Choice* 106:137–55. [LMR]

ALLEN, D. W. 1991. What are transaction costs? *Research in Law and Economics* 14:1–18.

ALTMAN, J. 1987. Hunter-gatherers today: An aboriginal economy of north Australia. *American Institute of Aboriginal Studies* 35:701–9.

ALVARD, M. 1995. Intraspecific prey choice by Amazonian hunters. CURRENT ANTHROPOLOGY 36:789–818.

———. 2000. Kin composition of cooperative whale hunts. Paper presented at the 99th meeting of the American Anthropological Association, San Francisco, Calif., November 15–19.

———. 2001. "Mutualistic hunting," in *The early human diet: The role of meat*. Edited by C. Stanford and H. Bunn, pp. 261–78. New York: Oxford University Press.

———. n.d.*a* Carcass ownership and meat distribution by big-game cooperative hunters. *Research in Economic Anthropology.* In press.

———. n.d.*b*. Kinship, culture, and an evolutionary perspective on the structure of cooperative big game hunting groups in Indonesia. MS.

ANDERLINI, L. 1999. Communication, computability, and common interest games. *Games and Economic Behavior* 27: 1–37.

AXELROD, R., AND W. HAMILTON. 1981. The evolution of cooperation. *Science* 211:1390–96.

BANERJEE, A., AND J. WEIBULL. 2000. Neutrally stable outcomes in cheap-talk coordination games. *Games and Economic Behavior* 32:1–24.

BARDHAN, P. 2000. Irrigation and cooperation: An empirical analysis of 48 irrigation communities in South India. *Economic Development and Cultural Change* 48:847–65.

BARNES, R. 1974. Lamalera: A whaling village in eastern Indonesia. *Indonesia* 17:136–59.

———. 1986. Educated fishermen: Social consequences of development in an Indonesian whaling community. *Bulletin de l'École Française d'Extrême-Orient* 75:295–314.

———. 1996. *Sea hunters of Indonesia*. Oxford: Clarendon Press.

BARNES, R., AND R. BARNES. 1989. Barter and money in an Indonesian village economy. *Man* 24:399–418.

BARTH, F. 1959. Segmentary opposition and the theory of games: A study of Pathan organization. *Journal of the Royal Anthropological Society* 89:5–21. [LAK]

———. 1969. "Introduction," in *Ethnic groups and boundaries*. Edited by F. Barth, pp. 9–38. Boston: Little, Brown.

———. Editor. 1969. *Ethnic groups and boundaries: The social organization of culture differences*. Boston: Little, Brown. [JR]

BATTALIO, R., L. SAMUELSON, AND J. VAN HUYCK. 2001. Optimization incentives and coordination failure in laboratory stag hunt games. *Econometrica* 69:749–64.

BINMORE, K. 1994. *Game theory and the social contract*. Cambridge: MIT Press.

BIRD, R. 1999. Cooperation and conflict: The behavioral ecology of the sexual division of labor. *Evolutionary Anthropology* 8:65–75.

BLIEGE BIRD, R., E. A. SMITH, AND D. W. BIRD. 2001. The hunting handicap: Costly signaling in human foraging strategies. *Behavioral Ecology and Sociobiology* 50:9–19. [LAK]

BOEHM, CHRISTOPHER. 1997. Impact of the human egalitarian syndrome on Darwinian selection mechanisms. *American Naturalist* 150(suppl.):S100–S121. [EAS]

BOONE, J. 1992. "Competition, conflict, and the development of hierarchies," in *Evolutionary ecology and human behavior*. Edited by E. Smith and B. Winterhalder, pp. 301–37. New York: Aldine de Gruyter. [RS]

BOWLES, S. 1998. Endogenous preferences: The cultural consequences of markets and other economic institutions. *Journal of Economic Literature* 36:75–111.

BOWLES, SAMUEL, AND HERBERT GINTIS. 1998. The moral economy of communities: Structured populations and the evolution of pro-social norms. *Evolution and Human Behavior* 19(1):3–25. [EAS]

BOYD, R., 1987. Is the prisoner's dilemma a good model of reciprocal altruism? *Ethology and Sociobiology* 9:211–22.

BOYD, R., AND P. RICHERSON. 1985. *Culture and the evolutionary process*. Chicago: University of Chicago Press.

———. 2001. "Norms and bounded rationality," in *The adaptive tool box*. Edited by G. Gigerenzer and R. Selten, pp. 281–96. Cambridge: MIT Press.

BROWN, J. 1983. Cooperation: A biologist's dilemma. *Advances in the Study of Behavior* 13:1–37.

BUCHANAN, J. 1962. The relevance of Pareto optimality. *Journal of Conflict Resolution* 6:341–54.

CASSELL, M. 1988. Farmers of the northern ice: Relations of production in the traditional North Alaskan Inupiat whale hunt. *Research in Economic Anthropology* 10:89–116.

CHAN, K., R. GODBY, S. MESTELMAN, AND R. MULLER. 1997. Equity theory and the voluntary provision of public goods. *Journal of Economic Behavior and Organization* 32: 349–64.

CLEMENTS, K., AND D. STEPHENS. 1995. Testing models of non-kin cooperation: Mutualism and the prisoner's dilemma. *Animal Behavior* 50:527–35.

COLMAN, A. 1995. *Game theory and its applications*. New York: Butterworth-Heinemann.

CONNER, R. 1986. Pseudoreciprocity: Investing in mutualism. *Animal Behavior* 34:1562–84.

COOPER, R. 1999. *Coordination games: Complementarities and macroeconomics*. New York: Cambridge University Press.

COOPER, R., D. DE JONG, R. FORSYTHE, AND T. ROSS. 1989. Communication in the battle of the sexes game: Some experimental results. *Rand Journal of Economics* 20:568–87.

CRAWFORD, V. 1998. A survey of experiments on communication via cheap talk. *Journal of Economic Theory* 78:286–98.

CRAWFORD, V., AND H. HALLER. 1990. Learning how to cooperate: Optimal play in repeated coordination games. *Econometrica* 58:571–95.

DAWES, R. 1980. Social dilemmas. *Annual Review of Psychology* 31:169–93. [RS]

DAWKINS, R. 1989. 2d edition. *The selfish gene*. New York: Oxford University Press.

DAWKINS, R., AND J. KREBS. 1978. "Animal signals: Information or manipulation?," in *Behavioural ecology: An evolutionary approach*. Edited by J. Krebs and N. Davies, pp. 282–309. Oxford: Blackwell Scientific Publications.

DUGATKIN, L. 1997. *Cooperation among animals: An evolutionary perspective*. Oxford: Oxford University Press.

DUGATKIN, L., M. MESTERTON-GIBBONS, AND A. HOUSTON. 1992. Beyond the prisoner's dilemma: Towards models to discriminate among mechanisms of cooperation in nature. *Trends in Ecology and Evolution* 7:202–5.

DWYER, P., AND M. MINNEGAL. 1997. Sago games: Cooperation and change among sago producers of Papua New Guinea. *Evolution and Human Behavior* 18:89–108.

EARL, M. 1987. A flexible body mass in social carnivores. *American Naturalist* 129:755–60.

ELLICKSON, R. 1991. *Order without law: How neighbors settle disputes*. Cambridge: Harvard University Press.

ENSMINGER, J., AND J. KNIGHT. 1997. Changing social norms: Common property, bridewealth, and clan exogamy. CURRENT ANTHROPOLOGY 38:1–24.

FARRELL, J., AND M. RABIN. 1996. Cheap talk. *Journal of Economic Perspectives* 10:110–18.

FRIEDMAN, J. Editor. 1994. *Problems of coordination in economic activity*. New York: Kluwer Academic Publishers.

GINTIS, H. 2000. *Game theory evolving*. Princeton: Princeton University Press.

GINTIS, HERBERT, ERIC ALDEN SMITH, AND SAMUEL L. BOWLES. 2001. Cooperation and costly signaling. *Journal of Theoretical Biology* 213:103–19. [EAS]

GOULD, R. 1967. Notes on hunting, butchering, and sharing of game among the Ngatatjara and their neighbors in the West Australian Desert. *Kroeber Anthropology* 36:41–66.

HADFIELD, G. 1999. A coordination model of the sexual division of labor. *Journal of Economic Behavior and Organization* 40:125–53.

HAMILTON, W. 1964. The genetical evolution of social behavior. *Journal of Theoretical Biology* 7:1–16.

HARDIN, G. 1968. The tragedy of the commons. *Science* 162: 1243–48.

HARSANYI, J., AND R. SELTEN. 1998. *A general theory of equilibrium selection in games*. Cambridge: MIT Press.

HAWKES, KRISTEN. 1990. "Why do men hunt? Some benefits for risky strategies," in *Risk and uncertainty in tribal and peasant economies*. Edited by E. Cashdan, pp. 145–66. Boulder: Westview Press. [EAS]

———. 1991. Showing off: Tests of a hypothesis about men's foraging goals. *Ethology and Sociobiology* 12:29–54.

———. 1992. "Sharing and collective action," in *Evolutionary ecology and human behavior*. Edited by E. Smith and B. Winterhalder, pp. 269–300. New York: Aldine de Gruyter.

———. 2001. "Is meat the hunter's property? Big-game, ownership, and explanations of hunting and sharing," in *Meat-eating*

and human evolution. Edited by C. Stanford and H. Bunn, pp. 219–36. Oxford: Oxford University Press.
HAWKES, K., J. F. O'CONNELL, AND N. G. BLURTON-JONES. 2001. Hunting and nuclear families: Some lessons from the Hadza about men's work. CURRENT ANTHROPOLOGY 42:681–709. [LAK]
HAYASHI, N., E. OSTROM, J. M. WALKER, AND T. YAMAGISHI. 1999. Reciprocity, trust, and the sense of control: A cross-societal study. *Rationality and Society* 11(1):27–46. [LMR]
HENRICH, J., AND R. BOYD. 1998. The evolution of conformist transmission and the emergence of between-group differences. *Evolution and Human Behavior* 19:215–42.
HENRICH, J., R. BOYD, S. BOWLES, C. CAMERER, E. FEHR, H. GINTIS, R. MCELREATH, M. S. ALVARD, A. BARR, J. ENSMINGER, K. HILL, F. GIL-WHITE, M. GURVEN, F. W. MARLOWE, J. Q. PATTON, N. SMITH, AND D. TRACER. n.d. "Economic man" in cross-cultural perspective: Behavioral experiments in 15 small-scale societies. MS. [LAK]
HEPPER, P. Editor. 1991. *Kin recognition*. Cambridge: Cambridge University Press.
HILL, K. 2002. Cooperative food acquisition by Ache foragers. *Human Nature* 13:105–28.
HIRSHLEIFER, J. 1999. There are many evolutionary pathways to cooperation. *Journal of Bioeconomics* 1:73–93.
HOFSTADTER, D. 1985. *Metamagical themas: Questing for the essence of mind and pattern*. New York: Basic Books.
HORRIDGE, G. 1982. *The lashed-lug boats of the eastern archipelagoes*. Monographs and Reports, National Maritime Museum, 52.
ICHIKAWA, M. 1983. An examination of the hunting-dependent life of the Mbuti Pygmies, Eastern Zaire. *African Study Monographs* 4:55–76.
JONES, D. 2000. Group nepotism and human kinship. CURRENT ANTHROPOLOGY 41:779–809.
KEELEY, L. H. 1996. *War before civilization: The myth of the peaceful savage*. Oxford: Oxford University Press. [LAK]
KELLY, RAYMOND. 1974. *Etoro social structure: A study in structural contradiction*. Ann Arbor: University of Michigan Press. [PB]
KIM YONG-GWAN AND J. SOBEL. 1995. An evolutionary approach to pre-play communication. *Econometrica* 63: 1181–93.
KLEIN, R. 1999. *The human career*. Chicago: University of Chicago Press.
KOLLOCK, P. 1999. "The economies of online cooperation: Gifts and public goods in cyberspace," in *Communities in cyberspace*. Edited by M. Smith and P. Kollock, pp. 220–39. London: Routledge.
KUZNAR, L. A. 2002. Evolutionary applications of risk sensitivity models to socially stratified species: Comparison of sigmoid, concave, and linear functions. *Evolution and Human Behavior* 23:1–16. [LAK]
LEWIS, D. 1969. *Convention: A philosophical study*. Cambridge: Harvard University Press.
LUCE, R., AND H. RAIFFA. 1957. *Games and decisions*. New York: Wiley.
MC ADAMS, R. 1997. The origin, development, and regulation of norms. *Michigan Law Review* 96:338–433.
MC ELREATH, R., R. BOYD, AND P. RICHERSON. n.d. Shared norms and the evolution of ethnic markers. CURRENT ANTHROPOLOGY. In press.
MC MILLAN, G. 2001. Ache residential grouping and social foraging. Ph.D. diss., University of New Mexico, Albuquerque, N.M. [RS]
MAYNARD SMITH, J. 1982. *Evolution and the theory of games*. Cambridge: Cambridge University Press.
MAYNARD SMITH, J., AND E. SZATHMARY. 1995. *The major transitions in evolution*. Oxford: W. H. Freeman.
MEHTA, J., C. STARMER, AND R. SUGDEN. 1994*a*. Focal points in pure coordination games: An experimental investigation. *Theory and Decision* 36:163–85.
———. 1994*b*. The nature of salience: An experimental investigation of pure coordination games. *American Economic Review* 84:658–74.
MELLARS, P. 1998. Modern humans, language, and the "symbolic" explosion. *Cambridge Archaeological Journal* 8:88–94.
MESTERTON-GIBBONS, M., AND L. DUGATKIN. 1992. Cooperation among unrelated individuals: Evolutionary factors. *Quarterly Review of Biology* 67:276–81.
MONTAGU, A. 1976. Toolmaking, hunting, and origin of language. *Annals of the New York Academy of Sciences* 280: 266–74.
MOULIN, H. 1995. *Cooperative microeconomics: A game-theoretic introduction*. Princeton: Princeton University Press.
NASH, J. 1950. Equilibrium points in *N*-person games. *Proceedings of the National Academy of Sciences, U.S.A.* 36:48–49.
NESSE, RANDOLPH M. Editor. 2001. *Evolution and the capacity for commitment*. New York: Russell Sage Foundation. [EAS]
NOE, R., C. VAN SCHAIK, AND J. VAN HOOF. 1991. The market effect: An explanation for payoff-asymmetries among collaborating animals. *Ethology* 87:97–118. [RS]
OCHS, J. 1995. "Coordination problems," in *Handbook of experimental economics*. Edited by J. Kagel and A. Roth, pp. 195–249. Princeton: Princeton University Press.
OLSON, M. 1965. *The logic of collective action: Public goods and the theory of groups*. Cambridge: Harvard University Press.
OSTROM, E. 1990. *Governing the commons: The evolution of institutions for collective action*. New York: Cambridge University Press.
PACKER, C., AND L. RUTTAN. 1988. The evolution of cooperative hunting. *American Naturalist* 132:159–98.
PALAMETA, B., AND W. BROWN. 1999. Human cooperation is more than byproduct mutualism. *Animal Behaviour* 57: F1–F3.
POUNDSTONE, W. 1992. *Prisoner's dilemma: John Von Neumann, game theory, and the puzzle of the bomb.* New York: Anchor.
RICHERSON, PETER J., AND ROBERT BOYD. 1999. Complex societies: The evolutionary origins of a crude superorganism. *Human Nature* 10:253–89. [EAS]
RIDLEY, M. 1998. *The origins of virtue: Human instincts and the evolution of behavior.* New York: Penguin.
ROBBE, P. 1975. Partage du gibier chez les Ammassalimiut observé en 1972 dans un village de Tileqilaq. *Objets et Monde* 15:209–22.
ROBSON, A. 1990. Efficiency in evolutionary games: Darwin, Nash, and the secret handshake. *Journal of Theoretical Biology* 144:379–96.
ROMNEY, A. K., S. WELLER, AND W. BATCHELDER. 1986. Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist* 88:313–38.
ROUSSEAU, JÉRÔME. 1990. *Central Borneo: Ethnic identity and social life in a stratified society*. Oxford: Clarendon Press. [JR]
RUNGE, C. 1984. Institutions and the free rider: The assurance problem in collective action. *Journal of Politics* 46:154–81.
RUSHFORTH, SCOTT, AND JAMES S. CHISHOLM. 1991. "Game theory and historically stable strategies," in *Cultural persistence: Continuity in meaning and moral responsibility among the Bearlake Athapaskans*. Edited by S. Rushforth and J. S. Chisholm, pp. 84–89. Tucson: University of Arizona Press. [EAS]
RUTTAN, L. 1998. Closing the commons: Cooperation for gain or restraint? *Human Ecology* 26:43–66. [RS]
RUTTAN, L., AND M. BORGERHOFF MULDER. 1999. Are East African pastoralists truly conservationists? CURRENT ANTHROPOLOGY 40:621–52. [EAS, RS]
SCHEEL, D., AND C. PACKER. 1991. Group hunting behaviour of lions: A search for cooperation. *Animal Behavior* 41: 697–709.
SCHELLING, T. 1960. *The strategy of conflict*. Cambridge: Harvard University Press.

SEVERIN, T. 2000. *In search of Moby Dick: The quest for the white whale.* New York: Basic Books.
SILK, J., E. KALDOR, AND R. BOYD. 2000. Cheap talk when there are conflicts of interest. *Animal Behaviour* 59: 423–32.
SIMPSON, E. 1951. The interpretation of interaction in contingency tables. *Journal of the Royal Statistical Society B* 13: 238–41.
SMITH, E. 1985. Inuit hunting groups: Some simple models incorporating conflicts of interest, relatedness, and central-place sharing. *Ethology and Sociobiology* 6:27–47.
———. 1991. *Inujjuamiut foraging strategies*. New York: Aldine. [RS]
SMITH, ERIC ALDEN, AND ROBERT BOYD. 1990. "Risk and reciprocity: Hunter-gatherer socioecology and the problem of collective action," in *Risk and uncertainty in tribal and peasant economies*. Edited by E. Cashdan, pp. 167–91. Boulder: Westview Press. [EAS]
SMITH, E., AND B. WINTERHALDER. 1992. "Natural selection and decision making: Some fundamental principles," in *Evolutionary ecology and human behavior*. Edited by E. Smith and B. Winterhalder, pp. 25–60. New York: Aldine de Gruyter.
SOBER, ELLIOTT, AND DAVID SLOAN WILSON. Editors. 1998. *Unto others: The evolution and psychology of unselfish behavior*. Cambridge: Harvard University Press. [EAS]
SOSIS, R. 1997. The collective action problem of male cooperative labor on Ifaluk Atoll. Ph.D. diss., University of New Mexico, Albuquerque, N.M. [RS]
———. 2000*a*. "The emergence and stability of cooperative fishing on Ifaluk," in *Adaptation and human behavior: An anthropological perspective*. Edited by L. Cronk, N. Chagnon, and W. Irons, pp. 437–72. New York: Aldine.
———. 2000*b*. Costly signaling and torch fishing on Ifaluk Atoll. *Evolution and Human Behavior* 21:223–44. [RS]
SOSIS, R., S. FELDSTEIN, AND K. HILL. 1998. Bargaining theory and cooperative fishing participation on Ifaluk Atoll. *Human Nature* 9:163–203. [RS]
SPENCER, R. 1959. *The North Alaskan Eskimo.* Bureau of American Ethnology Bulletin 171.
SUGDEN, R. 1986. *The economics of rights, co-operation, and welfare.* Oxford: Blackwell.
TRIVERS, R. 1971. The evolution of reciprocal altruism. *Quarterly Review of Biology* 46:35–57.
———. 1972. "Parental investment and sexual selection," in *Sexual selection and the descent of man*. Edited by B. Campbell, pp. 136–79. Chicago: University of Chicago Press.
TYLOR, E. 1871. *Primitive culture.* London: J. Murray.
ULLMAN-MARGALIT, E. 1978. *The emergence of norms.* Oxford: Oxford University Press.
VAN DEN BERGHE, P. 1979. *Human family systems: An evolutionary view.* New York: Elsevier.
VAN HUYCK, J., R. BATTALIO, AND R. BEIL. 1990. Tacit coordination games, strategic uncertainty, and coordination failure. *American Economic Review* 80:234–48.
VAN STONE, J. 1962. *Point Hope: An Eskimo village in transition.* Seattle: University of Washington Press.
VOLAND, E. 1998. Evolutionary ecology of human reproduction. *Annual Review of Anthropology* 27:347–74.
WÄRNERYD, K. 1993. Cheap talk, coordination, and evolutionary stability. *Games and Economic Behaviour* 5:532–46.
WASHBURN, S., AND C. LANCASTER. 1968. "The evolution of hunting," in *Man the hunter*. Edited by R. Lee and I. DeVore, pp. 293–303. Chicago: Aldine.
WHITE, DOUGLAS R. 1973. "Mathematical anthropology," in *Handbook of social and cultural anthropology*. Edited by J. J. Honigmann, pp. 369–446. Chicago: Rand McNally. [JR]
WILLIAMS, G. 1966. *Adaptation and natural selection.* Princeton: Princeton University Press.
WINTERHALDER, B. 1996. Social foraging and the behavioral ecology of intragroup resource transfers. *Evolutionary Anthropology: Issues, News, and Reviews* 5:46–57.
———. 1997. Gifts given, gifts taken: The behavioral ecology of nonmarket, intragroup exchange. *Journal of Archaeological Research* 5:121–68.