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# What is "Ecological" in Local Ecological Knowledge? Lessons from Canada and Vietnam

KENNETH RUDDLE

Research Centre for Resources and Rural Development, Hanoi, Vietnam

ANTHONY DAVIS

Department of Sociology and Anthropology, Mount Saint Vincent University, Halifax, Nova Scotia, Canada

*Case studies from Canada and Vietnam demonstrate both the importance and content limitations of local ecological knowledge (LEK) acquired during collaborative research between local fishers and scientists. The Canadian research disproved fishers' contentions that white hake (*Urophycis tenuis*) was the main predator on juvenile lobster (*Homarus americanus*). In the Vietnam case, the LEK of 400 fishers was used to test a hypothesis about monsoon seasonality and the availability of fish for fermentation. Fishers' LEK was important in both confirming the basis of the hypothesis and highlighting anomalies. The cases demonstrate that although important, harvesters' local experiences and observations may not characterize accurately such ecosystem processes as predator–prey dynamics or seasonality. It is unrealistic to expect fishers' LEK and understanding of ecology to embody such attributes, since stomach contents of commercially important target species are rarely examined, and fishers interact with ecosystems primarily to earn a living.*

**Keywords** coastal fisheries, collaborative research, fermented fish, local ecological knowledge, monsoon seasonality, Nova Scotia, tropics, Vietnam

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Address correspondence to Anthony Davis, Department of Sociology and Anthropology, Mount Saint Vincent University, 166 Bedford Highway, Halifax, Nova Scotia, Canada, B3M 2J6. E-mail: anthony.davis@msvu.ca

From beginnings in the 1970s and 1980s (e.g., Johannes 1978a, 1978b, 1980, 1981a, 1981b; Ruddle and Johannes 1985), stimulated by the 1992 World Conference on Development and Environment held in Rio de Janeiro, and more sharply focused by the 2001 conference, "Putting Fishers Knowledge to Work" (Haggan et al. 2003), a large literature has accumulated documenting and debating the practical usefulness of fish harvesters' knowledge. As a consequence, the disparate worldwide community of fish harvesters is increasingly involved in collaborative arrangements with scientists, academics, government officers, and nongovernmental organizations (NGOs) to apply its counterpart knowledge effectively in fisheries science and management (Haggan et al. 2007). The coverage of research has become broad. Noteworthy among more recent studies of harvesters' local ecological knowledge (LEK) that have aided in marine conservation and helped explain trends in exploited fish populations, for example, are Aswani and Hamilton (2004), Drew (2005), Saénz-Arroyo et al. (2005a, 2005b), Silvano and Begossi (2005), and Silvano and Valbo-Jorgensen (2008). More specialized are Silvano et al. (2006), Gerhardinger et al. (2006), and Begossi and Silvano (2008), among others, which have focused on a detailed use of LEK to aid in the understanding of severely threatened species. Recent studies aimed at systematizing and integrating LEK include Anuchiracheeva et al. (2003), García-Allut et al. (2003), Aswani and Lauer (2006), García-Quijano (2007), and Barreiro et al. (2009).

Interest in the LEK of user groups has been stimulated also by the need to employ ecologically sensitive and sustainable approaches in policy design and to integrate local "voice" in policymaking and management (Ruddle 1995; Davis and Ruddle 2009). In this, collaboration between fishers and scientists is indispensable for at least four reasons. First, participation in collaboration empowers local "voices" by building an independent capacity to conduct and use research and then express their local understanding in ways not easily dismissed. Second, users experienced in conducting research and armed with evidence can compel scientists and resource managers to explain research and resultant management decisions. Third, collaboration gives natural resource and ecosystem scientists an unrivalled opportunity to study with people rich in local ecosystem experiences, those with whom scientists can often unwittingly share concerns about ecosystem and species sustainability. Finally, collaboration enables scientists to access and document new sorts of data and experiences required for more comprehensive understandings of ecosystems and to use innovative designs in microsystem research (e.g., Davis 2007; Neis et al. 1999).

Since ecology is an inexact science, both "scientific ecology" and LEK have weaknesses. Some depictions of LEK may, for example, represent an incomplete understanding of ecosystem dynamics and complexities, or they may be completely inaccurate. At the same time, the limitations of scientific ecology provide an opportunity for LEK to contribute meaningfully to understanding ecosystems and their complexities. As a consequence, linking social research and management foci with scientific ecosystem studies has resulted in interdisciplinary collaboration employing the core tenets and methodologies of science to test local ecological knowledge (LEK) claims (e.g., Gadgil et al. 2000; Harkin and Lewis 2007; Huntington 2000; Stevenson 1996). Given its epistemological roots, science-based resource management practices anticipate that knowledge claims, before being accepted by "conventional science" and integrated into public policy, will be subject to evidence-referenced, reliable and replicable testing and proof, based on rigorous research (Davis and Wagner 2003) and sound theoretical substance (Davis and Ruddle 2009). The problems inherent in "fitting" LEK with science-referenced approaches to resource management have been discussed by Johannes et al. (2000), Holm (2003), and García-Quijano (2007), among others.

However, merely to suggest this often invites an intemperate response from those who simply contend that LEK is incontestably valid and should be accepted at face value (cf., Brook and McLachlan 2005; Dove 2006; Hames 2007; Ranco 2007; Sahlins 1993). We consider this wrong-headed and contend that not to query, test, and otherwise subject LEK claims to examination plays directly into the hands of those who would disparage it and further disempower its holders (Davis and Ruddle 2009). Equally, we argue that it is critical to examine and discuss the limitations of LEK that may emerge from field research, as well as to elaborate on cases of its usefulness in a complementary relationship with "scientific ecology." This is the purpose of the two case studies presented here.

Based on a case study from Nova Scotia, Canada, and another from Vietnam, in this article we examine some aspects of linking fishers' LEK with science-based research. In the Canadian case we consider the benefits and challenges of connecting LEK with natural resource management at the micro-level of fish predation. The study in Vietnam was conducted to test a hypothesis regarding the relationship between fishing behavior and seasonal hemispheric wind regimes. The LEK phase of the research in Vietnam was intended to overcome the major constraint that most hypotheses on the seasonal aspects of fish behavior had been developed and tested in the temperate waters of the Northern Hemisphere (Ruddle 1986). Both cases demonstrate the importance for understanding the usefulness of LEK in general; however, they also show that while harvesters' local experiences and observations are insightful, they may be insufficient to accurately characterizing key attributes of ecosystem processes. In all research it is fundamental to consider carefully the attributes and implications of the ecological content in natural resource users' LEK. Initially, such ecological content may arise and function directly from little more than the obvious need to learn and use whatever is necessary to secure a livelihood.

## Case Study I: White Hake Predation on Juvenile American Lobster[1]

Marine harvesters fishing the Nova Scotian St. Georges Bay area of the Southern Gulf of St. Lawrence (Figure 1) reported anecdotally in assessment and representative association meetings, research interviews, and personal communications that demersal fish, particularly white hake (*Urophycis tenuis*), prey on juvenile American lobster (*Homarus americanus*). They contended that small (juvenile) lobsters were observed frequently in white hake stomachs, which along with other demersal species commonly eat juvenile lobster, and that predation would increase as demersal fish populations recovered during the Atlantic Canadian groundfish fishing moratorium. This was expected to reduce recruitment of juvenile lobsters into the harvestable size classes, thereby jeopardizing the economic viability of the lobster fishery (Hanson and Lanteigne 2000).

Informed that recent seasonal feeding studies (e.g., Hanson and Lanteigne 2000; Hanson and Chouinard 2002) on Atlantic cod, white hake, and seven other common demersal species did not support these concerns, marine harvesters observed that the feeding studies on white hake, in particular, sampled the wrong places at the wrong seasons to capture predation on lobster. A research collaboration involving marine

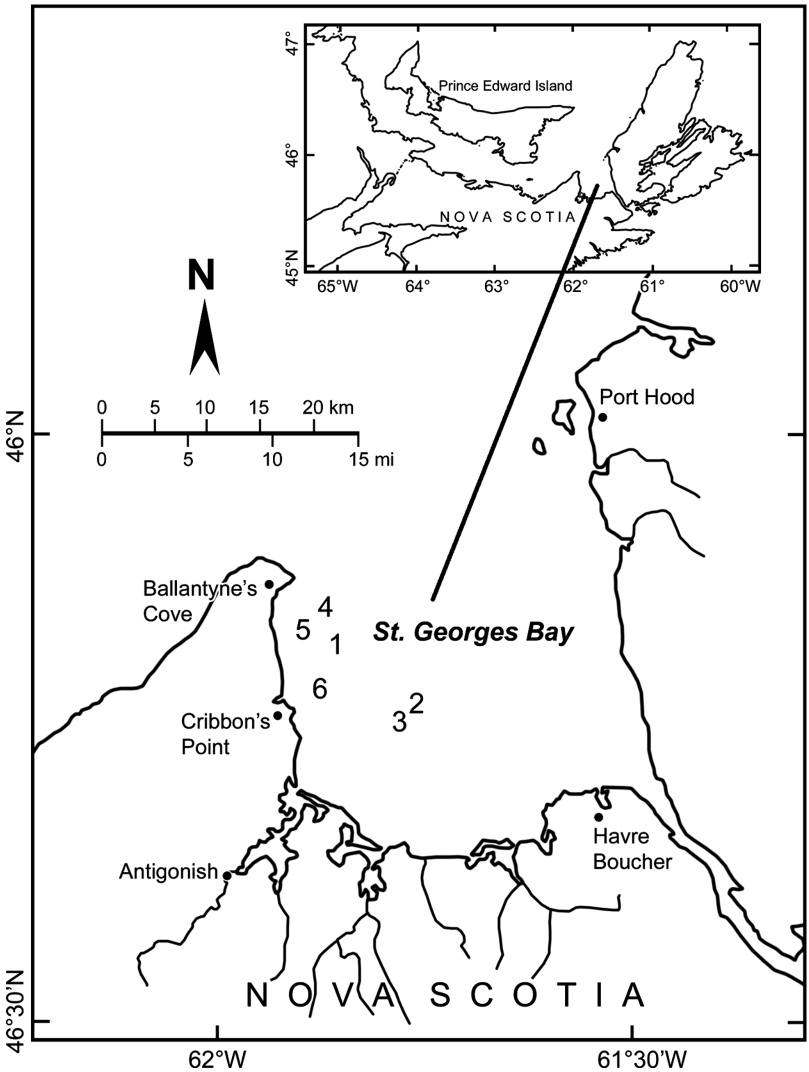


**Figure 1.** Map of St. Georges Bay, Nova Scotia, showing sites where groundfish were sampled in the three phases (1 = site 1, 2 = site 2, 3 = site 3, 4 = site 4, 5 = site 5, 6 = site 6). Redrawn from Davis et al. (2004).

harvesters, marine scientists, and social scientists was formed explicitly to examine these assertions.[2] The social science component documented St. Georges Bay harvesters' LEK to identify the sites and seasons for sampling. During the ensuing 2-year study, samples were drawn from six specified sites and the stomach contents of more than 3,500 fishes were analyzed.

A multiphase research design employing a stratified-random social survey followed by face-to-face interviews was used to identify harvesters reputed by their peers to be particularly knowledgeable. That ensured involvement of those considered most knowledgeable about fishing and fishing grounds. Further, such a design and methodology document marine harvester experiences and observations systematically, thereby establishing the core attributes of the LEK system while also providing a substantive research basis for harvesters and others to understand and assess LEK as something more than a suite of mere anecdotes (Davis and Wagner 2003). Employing this research design, the sample sites and seasons selected were indicated independently by three or more of the LEK experts as associated with finding hake feeding on juvenile lobster (referred to as "inside sites"). The LEK experts demonstrated a remarkable degree of unanimity regarding observations, experiences, opinions, and site/season recommendations. Interviews with additional harvesters employing opportunistic sampling identified an additional three sites (referred to as "outside sites") (see Figure 1). The harvesters were also asked to specify the direction for setting the sampling nets. Three of these sites (numbered 1, 2, and 3 in Figure 1) were located in waters 30–40 m deep (deep water "outside site" stations). These are the sites recommended by harvesters sampled opportunistically. The sites (numbered 4, 5, and 6; Figure 1) located in waters 15–30 m deep (shallow water "inside site" stations) were recommended by the nominated LEK experts. Phase I of the study was conducted between September 4 and 20, 2001, when white hake were captured in the three deep-water "outside" sites. In Phase II, July 14–30, 2002, white hake were sampled in the three shallower-water "inside" sites. Phase III was conducted September 3–11, 2002, and sampled white hake from all six sites, allowing concurrent collection of their stomachs within the two depth zones.

Each site was sampled with a single string of gillnets, with each string composed of four nets 180 m long. These strings had alternating nets of 140 and 152 mm stretched mesh. For Phase III, an additional 114-mm mesh size net was added to each string in order to collect smaller fish. That increased the range of fish sizes sampled. The net with a smaller mesh was inserted randomly in each string. With only three strings of gillnets in use during Phase III sampling, two strings were rotated through the deep-water stations, whereas the remaining set was rotated through the shallow-water stations. The times of setting and recovery of each gillnet were recorded and the catch per unit effort (CPUE) was standardized to the number of hake captured per hour of soak time.

### *Sampling Results*

In total, 3,093 white hake were caught during sampling. The average CPUE in shallow water during July was much lower than that observed in September of either year. The average CPUE in September 2001 was significantly lower than in September 2002. The catch rate in the "outside" stations did not differ from that in the "inside" stations during September 2002. The very low catch rate observed during July 2002 was unexpected. Despite intensive fishing efforts, only 159 white hake were caught, indicating large numbers were not present in waters 15–30 m deep. The local experts had predicted that large numbers of white hake would be collected in waters 15 to 30 m deep during July, and that these fish were likely to prey on lobster. Neither prediction was supported by the field research. Of the white hake captured during July, 25% were females in spawning condition, which suggests that spawning activities may have affected their availability to the gear. A large increase in the number captured in shallow-water stations between the July 2002 and September 2002 phases, suggests a general movement of fish to the "inside grounds" between the two sampling periods.

Contrary to the harvesters' claims, lobster was not found in any of the 3,093 white hake stomach contents examined. This confirmed previous research in which white hake were found rarely to feed on lobster (Hanson and Lanteigne 2000; Garrison and Link 2000). Rather, various pelagic fishes were the dominant prey eaten by white hake greater than 45 cm total length in St. Georges Bay. However, four white hake had consumed the axiid shrimp (*Axius serratus*), a species that resembles a small lobster.

The occurrence of *Axius serratus* in the stomachs of four white hake may explain some of the reports by marine harvesters that white hake prey on juvenile lobster. A decapod crustacean, *Axius* looks similar to juvenile lobster (Squires 1990), especially when partially digested; hence, it is possible that some of the organisms in white hake that marine harvesters thought were lobster were actually *Axius.* At a meeting where the results were presented, many harvesters expressed surprise at and interest in these results. None expressed prior knowledge of either *Axius* or the taxonomic differences between *Axius* and juvenile lobster. Further, no harvester contested the observation that *Axius* in white hake stomachs may have been misinterpreted as juvenile lobster.

Although sometimes attributable to the misidentification of *Axius serratus*, some harvesters probably had observed lobster in the stomachs of white hake, as Hanson and Lanteigne (2000) found that about 1 in every 1,000 white hake captured in autumn had eaten a small lobster. Although the consumption rate is low, a marine harvester daily gutting thousands of white hake might see at least one lobster per day, making it a "daily occurrence."

This mistake may be explained further by the "availability heuristic" (Tversky and Kahneman 1973), where what people recall seeing is influenced by the personal meaning attached to what is being seen. For example, things potentially important to livelihoods are remembered with greater clarity than other observations, since the personal meaning of observations influences their sense of the frequency, with meaningful observations estimated to occur more often.

The stomach contents of all other fish sampled were also analyzed. This included 175 Atlantic cod (*Gadus morhua*), 73 shorthorn sculpin (*Myoxocephalus scorpius*), 73 sea raven (*Hemitripterus americanus*), and 38 spiny dogfish (*Squalus acanthias*). Juvenile lobsters with carapace lengths of 30–50 mm were found in the stomachs of 13 shorthorn sculpin, which was clearly the most important predator of lobster in the St. Georges Bay study area. This is consistent with the results of an earlier study that examined 322 Gulf of St. Lawrence shorthorn sculpin and found that more than 12% contained juvenile lobster (Hanson and Lantiegne 2000). The marine harvesters were surprised by this information. They were unaware that sculpin ate juvenile lobsters in large numbers. Sculpin are commercially valueless, and usually considered a pest. Difficult to handle because they are covered in spines, landed sculpin are either discarded or occasionally used as lobster bait. Since harvesters have no reason to gut sculpin, they are unaware of its stomach contents.

## Case Study II: The Monsoon Seasonality of Fish in Vietnam

In a study of fermented fish products in East Asia (Ishige and Ruddle 1987, 1990), Ruddle (1986) examined the physical and biological reasons for seasonality in the availability of the marine species used and for the locations fished. The main species used are round herring (*Spratelloides* spp.), sardine (*Sardinella* spp.), and various anchovies (*Coilia* spp., *Setipinnia* spp., and *Stolephorus* sp.). Indo-Pacific mackerel

(*Rastrelliger* sp.), gizzard scads (*Anodontostoma chacunda* and *Nematolosa nasus*), and round scad (*Decapterus* sp.) are also used (Ruddle 1986). Fish availability depends on the cycle of the northeast monsoon, from about mid-October until March, and the southwest monsoon, from mid-May until September, separated by two transitional inter-monsoonals.

Persistent off-shore winds are crucial to fish production, because they create an upwelling (or vertical water movement) that restores depleted fertility in the upper layers of the sea. The "burst" of plankton growth that occurs when nutrient-laden waters are thus restored to the surface results in an increased population of planktivorous fish, the spawning and feeding patterns of which are adapted to this seasonal loss and restoration of nutrient levels (Figure 2). In Southeast Asia this process is triggered mainly by the offshore monsoon wind. Thus, the location of coastal upwelling, and therefore of fishing activities, changes seasonally, according to the prevailing wind direction.

However, the broad patterns of wind-induced coastal upwelling are distorted by currents, by the influx of nutrients and freshwater from river discharge and rain, and by the interruption of winds and currents by highly indented or island-studded

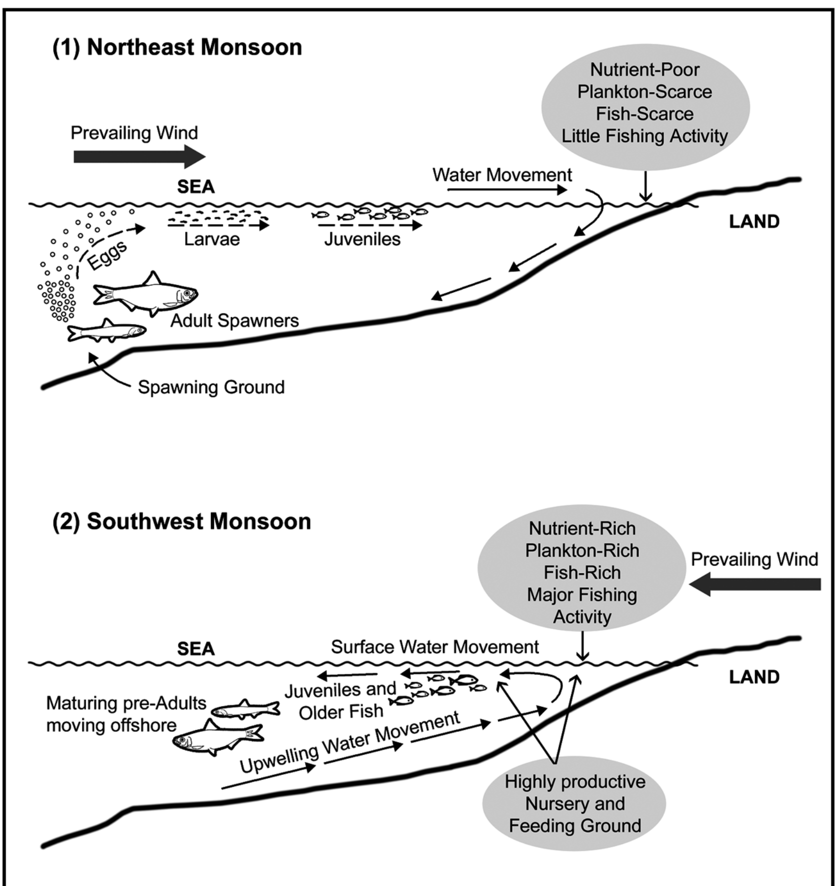


**Figure 2.** Hypothesis on fish behavior and the monsoons.

coastlines. In many places monsoon-induced upwelling may be reinforced, masked, or totally negated by such local factors.

In Vietnam the main factors include the role of the north to south flowing current, and the effect of both island-studded sections of the coastline and those that run parallel to the prevailing wind on the seasonality in fish availability. Marine harvesters working waters around small islands can operate year-round, since islands will experience a year-round upwelling, with only the side of the island on which it occurs varying according to the pattern of monsoon seasonality. Unless this is understood, researchers basing field studies on local fish landing data alone might draw false conclusions.

Climate and weather are also clearly a major factor distorting the predictions of the hypothesis. Particularly important in the south of Vietnam is the massive freshwater discharge of the Mekong River system during the rainy season. This would have a major effect on the behavioral response of fish to diminished salinity and increased turbidity levels in inshore waters. The same would also occur, although on a smaller scale, from the Red River system in the north of the country. In contrast, an absence of substantial river discharge along the coast of the Central Region will elicit a different response, but there, as in the Northern Region, the passage of typhoons also would have a seasonal and localized impact on salinity and turbidity. These physical phenomena are all indicated by harvesters' fishing behavior.

Ruddle (1986) hypothesized that the fundamental biological rhythm exploited by the fishery to supply the fermentation industry is the feeding and recruitment migration of juvenile planktivores.[3] Thus, the seasonal and diel behavioral characteristic exploited by the fisheries that supply the fermentation industry is the feeding aggregation of juveniles in shallow near-shore marine and brackish estuarine waters. Therefore, spawning off eastern coasts, for example, should occur at the end of the northeast monsoon, so that juveniles can feed in the inshore upwelling induced by the southwest monsoon.

### *Research Methodology*

Research was protracted and involved three stages. The first stage was a field survey of the fish fermentation industry, conducted between 1982 and 1985, followed by a "desk study" done during 1985–1986, when the hypothesis emerged. Finally, the LEK component was done in 1995–1996.

The 1982–1985 survey was a comprehensive study of the fish fermentation industry. Producers, selected with the assistance of local fisheries officers, were interviewed using questionnaires supplemented by structured interviews based on checklists. To understand species availability by season, data collected were interpreted in 1985–1986 using primary meteorological records and oceanographic data, and secondary information on fish behavior. That clarified the physical factors causing local upwelling, and led to a hypothesis on the biological rhythms of the species involved (Ruddle 1986).

A socioeconomic study of Baria Vung Tau, Binh Thuan, Khanh Hoa, Quang Nam Danang, and Quang Binh provinces was conducted for 6 months in 1995–1996, with three visits to each province. Questionnaires supplemented by checklists were used for semistructured interviews with stakeholders. These were translated into Vietnamese, pretested and revised. Samples of fishing boat captains and crewmembers were selected for interviewing based on the recommendations of the local Fisheries Department, the local People's Committee, and the head of the local *van chai*.[4] To compensate for potential bias, active marine harvesters were asked to suggest "other most knowledgeable" harvesters who should be interviewed. The rank ordering thereby generated was only partially followed in subsequent interviews, since some recommended fish harvesters were at sea, and practical considerations took precedence over strictly rank-ordered interviews. With only one questionnaire per boat, 403 interviews were conducted. Of these, 174 were with fishing boat captains and crew members, geographically distributed as follows: Baria Vung Tau (21), Binh Thuan (33), Khanh Hoa (44), Quang Nam Danang (56), and Quang Binh (38). Users of lift-nets and purse seines, the main gear types of 28% of the total sample of captains and crew who supply the fermentation industry, were regarded as being primarily knowledgeable about the behavior of those species. In addition to questions about seasonality, weather, monsoon phase, locations fished, and physical parameters of the fishing ground, asked of all captains and crew, members of this particular subgroup were asked special questions regarding fish size, fishing season, indicators (like seabird activity) of the presence of small clupeoids, and other species used for fermentation. Results were tabulated and compared with the information used to formulate the initial hypothesis. The seasonal data generated through these interviews were tabulated by month and ranked into "good" and "fair" seasons in terms of gear type, species, fishing location, and catch rates of the species destined for fermentation. The harvesters' "good" season was found to correspond with the "off-shore or southwest monsoon," and the "fair" season(s) with the two inter-monsoonals. The remaining months correspond to the "on-shore or northeast monsoon," when fishing was either relatively poor (regarded as "fair" by the harvesters) or simply not done.

### *Field Testing the Hypothesis by Fish Harvesters' LEK*

Fish harvesters' LEK was important in confirming major aspects of the hypothesis. Equally important was its role in highlighting "anomalies" or parts of the hypothesis that needed revision or rethinking.

For example, the marine harvesters' LEK verified the basic assertions of the hypothesis regarding seasonality of fishing activities in near-shore waters during the monsoon cycle. For anchovies, the most important group of fish fermented, they confirmed the results of earlier field and archival research: (1) that stolephorid anchovies are taken during September–November, that is, from the end of the offshore southwest monsoon, through the inter-monsoonal, and into the beginning of the onshore northeast monsoon; (2) that *Coilia* spp. are caught from July to December; and (3) that *Setipinna* spp. and *Engraulis* spp. are caught only from July to September, that is, only after coastal upwelling induced by the southwest monsoon is firmly established.

The harvesters' LEK also confirmed the expected slight latitudinal variations in seasonality. For example, in waters off Binh Thuan Province, on the south-central coast, July–October (southwest monsoon and inter-monsoonal) is the intermediate season, when the catch is mostly scad, whereas off Quang Nam Danang Province, farther north, the good season is July–August (middle of southwest monsoon). The hypothesis was generally confirmed also for the Northern Region, where, for example, lift-netting for sardines is conducted nightly, except during full moon, from April until September (i.e., from early in the first inter-monsoonal, through the entire southwest monsoon season, and into the second inter-monsoonal). In addition, purse seining for scad and sardines is done during the period March–October (i.e., from the very end of the northeast monsoon, and through both inter-monsoonal periods and the southwest monsoon). LEK confirmed the role of the second inter-monsoonal and that the November–February is the "poor/no fishing" season coinciding with the northeast or onshore monsoon, when the upwelling is suppressed. In Binh Thuan Province, for example, with the better weather of the September–October, or second inter-monsoonal, fishing moves further offshore, as adult fish move away from inshore feeding to the deeper and warmer waters.

Some LEK on locations and depths fished also accorded with the hypothesis. For example, since lift-nets are not normally operated in waters deeper than 50 fathoms, the fishing grounds used for them are generally within the 50-fathom isobath, except off Quang Nam Danang Province, where deeper waters occur near the coast. Most operate in waters less than 20 fathoms deep. Although purse-seiners can operate effectively over a range of water depths, most are concentrated in waters less than 50 fathoms deep. This supports the hypothesis.

Some characteristics that could not be explained by the overall patterns of monsoon seasonality were also reported through LEK. For example, off the south-central province of Binh Thuan conditions are generally unfavorable from late July to August, in the middle of the southwest monsoon. Also inconsistent is that anchovy landings in Khanh Hoa Province peak in March–May, that is, during the inter-monsoonal, and thereafter decline as the southwest monsoon sets in. Although landings reach their lowest in October–December, that is, with the inter-monsoonal and the first half of the northeast monsoon, they increase rapidly from the second half of the northeast monsoon. Another inconsistency occurred among purse-seiners in the Southern Region that operate from February to May, targeting mostly smaller pelagics. In other words, they operate from the late northeast monsoon, through the entire first inter-monsoonal period, and cease operation at the very beginning of the southwest monsoon.[5]

However, some information derived from LEK on locations and depths fished was not always consistent with the hypothesis. For example, off Binh Thuan Province, coastal fisheries operate less than 130 km offshore. Lift-netters and purse-seiners sometimes operate up to 280 km from shore, and as far as 400 km south of Phan Thiet. Off Quang Binh Province marine harvesters operate 60–110 km from Dong Hoi City in the direction 45–100 degrees. Better catches are expected the further operations move offshore. None of this accords well with the hypothesis.

These examples demonstrate that local conditions can be of major importance, and override the expected behavior based on a strict interpretation of monsoon seasonality. This information emphasizes again the important role of LEK in calibrating the general hypothesis to local contexts, and indicating where scientific research based on localized sampling would be required to do so.

## Concluding Discussion

The first case study demonstrates that at the times and in the locations specified by peer-identified LEK experts, the consumption of juvenile lobsters by white hake would have little effect on the recruitment of the former species. The results suggest that the claims arose from the harvesters' basic livelihood dependency on the lobster fishery, such that juvenile lobster or lobster-like contents in white hake stomachs are remembered as occurring more frequently than was actually the case.

This demonstrates that although harvesters' local experiences and observations are important, they may not characterize accurately such key attributes of ecosystem processes as predator–prey dynamics. This is not surprising, as few harvesters would sample the stomach contents of target species; few would be expert enough in marine taxonomy to identify accurately all major prey species, particularly when semi-digested; few are likely to build rich observational experiences about predator–prey dynamics for populations with no commercial value; and few will know about all environmental processes affecting the seasonal distribution and accessibility of target species.

It is unrealistic to expect marine harvesters' LEK and understanding of ecology to embody such attributes. Regardless of depth and richness, their experiences and observations are limited because they interact with ecosystems primarily to earn a living. They are, therefore, operating within a framework that specifies their interests and needs. It follows that diet-related and environmental observations will be limited almost exclusively to species with commercial value. Although harvesters know the likely seasonal locations and food of their targets, observations will be basically limited to informing such critical matters as bait, hook, or mesh size selection, and where to fish during each season.

Marine harvesters' understandings of ecological relationships cannot be expected usually to incorporate accurate representations of the trophic processes revealed through diet compositions and related studies and their relevance to seasonal occurrence and distribution. Rather, LEK consists of more general integrated assemblages of observations and experiences on such matters as seasonal and distributional attributes associated with the most common foods of commercially targeted species, coupled with understandings of such related biological and physical factors as tides, winds, bottom topography, bottom biotic assemblages, and abiotic composition (e.g., mixtures of mud, sand, gravel, pebble, and rock), and currents on the availability and location of "bait food" and targeted species (e.g., Neis et al. 1999). That is, the core of LEK is composed of what harvesters have observed and need to know to sustain their livelihood.

As demonstrated by the Vietnam case, marine harvesters' responses indicate their understanding of the general nature, location, and timing of the impact of physical environmental factors, since these affect the practical operations of fishing. However, a more precise understanding, as opposed to correlations that just imply causality, requires scientific sampling done according to accepted fisheries biological standards. In the same way, although marine harvesters know through their catches the timing of the arrival of juvenile small pelagics in specific and habitually fished locations, for example, they are unable to provide any information on either location or timing of spawning behavior, or, since these are invisible to the unassisted eye, of the patterns of planktonic drift (of eggs). The details of small pelagic spawning behavior and the drifting behavior of their fertilized eggs and postlarval forms, while the biological basis for the fishery, are not recognized as such by harvesters.

The second case study demonstrates that LEK provides an invaluable, rapid, and economical means both of substantiating various aspects of a hypothesis, and of highlighting points that need further consideration and research. As was demonstrated by the first case study, in the second case study the fisheries biological and oceanographic aspects of the hypothesis can be ascertained only by elaborate scientific sampling. Clearly, strong guidance in this can be provided by LEK, especially that related to the timing and location of the target species. This case also shows that LEK is important in pinpointing lacunae in the hypothesis regarding physical factors that play an important role in distorting the underlying patterns of monsoon seasonality, and that need to be better accounted for.

Additionally, harvesters' LEK claims also must be documented and examined, as must Western ecological science assertions, within in the "real-world" context of government-imposed management policies that dictate the conditions for access to and use of marine resources. Increasingly dependent on the lobster fishery, harvesters in the Nova Scotia setting support the expansion of a fishery targeting white hake. Harvesters' LEK claims positing damage to lobster recruitment through increasing white hake predation on juvenile lobster might also be understood as a strategic response to livelihood needs. The extent to which Western science and LEK are presented as competing epistemologies may be a focus of philosophical, political, and scientific interest. Yet what matters for the local peoples concerned is the effectiveness of their experienced-based knowledge in providing useful understandings that enable them to satisfy their various livelihood requirements. The realization that for millennia peoples all over the world have been quite successful at meeting these needs with their understandings of how ecosystems work provides irrefutable evidence concerning the effectiveness and value of LEK, however disputable contemporary debate on the various roles of LEK might become.

## Notes

1. For a fuller treatment of the first case study see Davis et al. (2004), and for copies of the questionnaire and interview schedules visit www.stfx.ca/research/srsf
2. The collaboration consisted of social scientists affiliated with St. Francis Xavier University, marine scientists with Fisheries and Oceans Canada, Gulf Region, and the Gulf Nova Scotia BonaFide Fishermen's Association.
3. In their reproductive strategy these fish migrate from inshore zones with extremely high predation rates, to spawn offshore, where the pressure is less intense, at times and in places where the eggs and larvae will be swept coastward. Winds, currents, and gyres ensure a steady coastward drift of eggs, larvae, and postlarval forms, so that the early juvenile stage arrives at plankton-rich inshore feeding grounds. Therefore, spawning should occur toward the latter part of the onshore monsoon.
4. The *van chai* is the traditional management institution in Vietnamese fishing communities (Ruddle and Tuong 2009).
5. However, further investigation might show that this is explained by latitudinal variation in the timing of the seasons.

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