Chapter 10
The Role of Local Ecological Knowledge in the Conservation and Management of Reef Fish Spawning Aggregations

Richard Hamilton, Yvonne Sadovy de Mitcheson, and Alfonso Aguilar-Perera

Abstract Knowledge of the existence, location and timing of reef fish spawning aggregations is largely obtained from Local Ecological Knowledge in the fishing communities that exploit, or once exploited them. This information is typically collected by interviewing, followed, ideally, by validation by visiting and surveying reported aggregation sites. Conducting interviews is a relatively simple process that can be extremely productive but only if the interviewees are engaged and selected carefully (by gear, location, age, etc.), the interviewer is knowledgeable, prepared and gains the respect of the interviewee, and the various limitations of interviews as a source of information are clearly understood. Moreover, to ensure that information cannot potentially be misused and can be effectively applied to management and conservation, it is important that it is not only validated, and shared and communicated appropriately, but that it is integrated into the relevant scientific framework, and that confidentiality is respected as necessary. We review a range of studies from around the tropics based on the interview approach, evaluate its effectiveness against validated aggregations, and provide guidelines for what we believe to be good interview practices.

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10.1 Introduction

Local Ecological Knowledge (LEK), also frequently called traditional or indigenous ecological knowledge, refers to the cumulative knowledge of groups' or individuals' practices, experiences and beliefs about their natural environment. LEK contains empirical and conceptual aspects and is passed down over successive generations or intra-generationally (Berkes 1999; Hamilton 2005). LEK is a dynamic state of knowledge, kept alive in an oral form which makes it extremely fluid and flexible. It is constantly being tested and modified as individuals interact with their environment, adopt new technologies and make their own observations and refinements (Ruddle and Chesterfield 1977). Subsistence, artisanal, and commercial fishers often possess detailed LEK on the fisheries and environment upon which they depend (e.g. Johannes 1981; Neis et al. 1999a). As a general rule, those who spend more time on or in the water know the most, but much also depends on individuals' powers of observation and communication, curiosity about their environment and disposition for learning (Baird 2007).

The potential values of utilizing LEK for fisheries research and conservation are increasingly recognized, and there is a growing body of literature advocating its documentation and integration with more quantitative types of research and scientific methodology, for management planning, education and outreach, as well as for strengthening the case for conservation and management (Christie and White 1997; Johannes and Neis 2007; Sadovy de Mitcheson et al. 2008). Fishers can provide important information on such things as inter-annual, seasonal, lunar, diel, tide- and habitat-related differences in species behaviour, presence of concentrations of females with eggs, types and abundance of target species and their changes over time, and how these factors determine fishing strategies (Johannes et al. 2000). Fishers are often the first to discover the location of important habitats, such as nursery, feeding and spawning grounds of fishes on which scientists subsequently work (Johannes 1989; Hamilton and Walter 1999; Ames 2007). When time and care are taken to document LEK resource user's perceptions about their environment can also be understood, which can assist in directing future management efforts.

Local knowledge can be of great value for providing a historical perspective on the state of reef fish communities and is particularly important where there is no long-term monitoring or database, as for most tropical coastal fisheries. Specific examples range from declines in bonefish migrations in Kiribati disrupted by coastal construction to the rapid demise of bumphead parrotfish, *Bolbometopon muricatum*, and humphead, or Napoleon, wrasse, *Cheilinus undulatus*, populations in the Pacific (Johannes and Yeeting 2001; Sadovy et al. 2003; Dulvy and Polunin 2004). In the case of the Nassau grouper, *Epinephelus striatus*, in the Caribbean, informal discussions with local fishers identified a long since disappeared aggregation; this information was followed up by a questionnaire sent around the Caribbean soliciting local knowledge on the species, with results of the survey indicating similar losses and declines elsewhere and highlighting a problem with the species (Sadovy 1993; Sadovy and Eklund 1999). Suitably validated and treated within the appropriate

bounds, LEK and historical anecdotal records can be useful proxies for biological and fishery information and can help to identify 'shifting baselines'; long-term and usually negative changes that are often not immediately or readily apparent to new generations of fishers or scientists working in a data-poor area (Ainsworth et al. 2008; Holm et al. 2001; Pauly 1995). A testament to the value of fishers LEK is its increasing application in marine research, species assessments and planning processes that are linked with conservation and management programmes (Sadovy and Cheung 2003; Aswani and Hamilton 2004; Aswani and Lauer 2006; Smith and Hamilton 2006; Stanley and Rice 2007; Sadovy de Mitcheson et al. 2008; Almany et al. 2010; Game et al. 2011).

One of the most widely applied uses of LEK in the marine setting is its role in the research of Fish Spawning Aggregations (FSAs). In many locations, fishers have known of FSAs for centuries or have experienced seasonal gluts in landings subsequently identified as FSAs (Johannes 1978; Colin, et al. 2003). In recognition of this, and because of the practical difficulties of discovering FSAs that typically form at highly localized areas for brief periods of time, biologists and coastal managers have long drawn on the local knowledge of fishers in the initial stages of their fieldwork (Johannes, et al. 1999; Robinson et al. 2004; Hamilton et al. 2005a, 2011; Sadovy de Mitcheson et al. 2008). Indeed, most aggregations of commercial fishes known today were initially identified from descriptions of fishers. The value of this knowledge is heavily dependent on the methodology used to collect, process and validate it and the way(s) in which it is integrated into science-based management.

Our objectives in this chapter are to evaluate the methods for collecting, assessing and applying LEK, using lessons from our own work and numerous other case studies, and to develop a robust methodology for the documentation of FSAs using LEK. We consider the collection and validation of information, and integration of LEK with scientific knowledge. We also examine pitfalls and identify caveats in the collection and use of LEK.

10.2 Documenting Local Ecological Knowledge

The methods used for documenting LEK derive from the social sciences and require some understanding of the language and cultural context in which the interactions take place (Briggs 1986; Mailhot 1993; Neis et al. 1999a). For instance, social scientists interested in fishers' knowledge typically use ethnographic methods such as *interviewing* and *participant observation*. Interview formats range from structured to unstructured, while participant observation requires that the researcher live in the local society among the resource users and is actively partaking in fishing or related activities. In Melanesia, these techniques have documented extremely detailed LEK e.g. (Hviding 1996; Aswani 1997; Foale 1998). Participant observation requires a large investment of time within a very narrow geographical area. Consequently most studies of LEK with a predetermined conservation or management focus rely predominantly on interviews. Other approaches to information collection

are *analytical workshops*, where collective knowledge of participants is put into perspective, and *collaborative fieldwork*, where participants collaborate in scientific procedures (sampling, interpretation) (Fraser et al. 2006; Huntington 2000). Due to its widespread use, we focus in this chapter on interviews as a means of documenting LEK on fish spawning aggregations.

10.2.1 Interviews

Marine research and management interviews can range from informal exchanges to highly structured questionnaires (Briggs 1986; Huntington 1998, 2000; Gubrium and Holstein 2002). Some interviews may be analyzed by dedicated computer programmes [e.g. ANTHROPAC 4.92 (Borgatti 1996) ParFish www.fmsp.org.uk]. One commonly used interview method is the semi-structured form in which the interview flows relatively freely around a simple and predetermined core of questions. This allows the informant to introduce aspects of LEK with which they are particularly knowledgeable and may be unexpected or completely unknown to the interviewer. Interviews of single individuals are informative and detailed but biased to the particular point of view and experience of the informant. Group interviews may help the participants to encourage each other to provide information and assist in recall, but can be dominated by particular individuals (Huntington 1998).

Interviews can also be used as the basis for stock assessments in a way that not only collects information in unmonitored fisheries but can also engage stakeholders in management planning. Beyond spawning aggregations, aggregating species often need to be managed in the broader context of the whole fishery. Stock assessments, or at the least a better understanding of the overall fishery, may be needed. An example is ParFish, based on the logistical biomass growth model, in which interview data from fishers are used to construct 'priors' for the fishery model. Combined with other available information and opinions of fishers about other aspects of their fishery, a stock assessment can be conducted and management planning discussed.

Important advantages of the interviews are that they (1) are inexpensive, (2) are opportunities for establishing a rapport for increasing accuracy and honesty of answers, (3) give in-depth coverage of given topics (semi-structured interviews), (4) allow for data comparison for different geographical areas, (5) act as a starting point to establish a trust between informants and interviewer that can aid in building towards effective management, (6) allow for identification of misunderstandings regarding the marine environment, and (7) enable identification of fishery and outreach needs. Disadvantages include (1) the time required, (2) that responses are highly dependent on gear type used, (3) that some information may be difficult to analyze and compare or to put in a suitable scientific context, (4) that some recorded interviews may need translation if performed in the native language, potentially introducing error and reducing the ease of information exchange, (5) that interviewers need to be suitably skilled for semi-structured interviews, (6) that informants may be unwilling to share information or purposely provide misleading information, and (7) usually requires validation of information for management planning.

Important considerations in developing a scientifically meaningful interview methodology are sample size (how many interviews), how to standardize catch data to allow for comparisons over time and space, and how to capture the historic perspective in a meaningful way or such that it could be represented quantitatively. Care is needed in the design phase of the work to address such questions and use appropriate data collection techniques and analytical methods.

10.2.2 Documentation of LEK Requires Both Anthropological and Biological Skills

The seemingly simple process of asking a few questions about fish spawning aggregations must be carefully conducted and interviewers must be suitably trained and knowledgeable. If workers are poorly prepared and are unclear of their goals, they will not understand the social, cultural, economic or biological context of the fishery they are interested in. The result of poor preparation is that much time, energy, money and patience can be wasted. The frustration felt by interviewees who can recognize an interviewer who knows little of the topic at hand, could reduce their willingness to participate in the future, lead to misleading responses, cause them to disrespect the interviewer (Sect. 10.3), or lead to management inaction where action might be needed. It is also our experience that LEK surveys will only be done effectively if time and funding are set aside to do this type of ethnographic research and if interviewers are carefully selected and trained. The apparent simplicity of this (interview) approach is deceptive but interviewing well requires considerable preparation. As one of many examples, workers who did not know local species and understood very little about aggregations quickly ran into difficulty when they could not distinguish fish schools from spawning aggregations in the Philippines (YSM personal observation 2005).

10.2.3 Selection of Experts

Identifying who to interview in LEK surveys is critical (Davis and Wagner 2003). The gender, degree of involvement in a fishery and the type of fishing gear may substantially influence the distribution of LEK in a community (Sect. 10.3.1). At times the target group to interview may be obvious to researchers already familiar with an area. In the Solomon Islands for example, Hamilton (2003a) knew that night spear fishers were the only group that targeted bumphead parrotfish and were the obvious source of information. Similarly, in southern Manus, Papua New Guinea, preliminary interviews revealed that fishing at grouper spawning sites was traditionally restricted to one specific clan within a community, and that this clan has retained highly detailed LEK on these aggregations (Hamilton et al. 2005a).

Identification of expert fishers in a new area can be informal and opportunistic, or conducted in a structured manner (Fig. 10.1). Referrals from local associations,

Fig. 10.1 (**a**) (*left*) Interview with patriarch fisher in Palau with local fish pictures and map (**b**) (*right*) Group interview with fishers in Indonesia with fish photos to aid identification (Photos: Yvonne Sadovy de Mitcheson)

from one or more community peers, or responses from a large sample of resource-users to select experts are useful (Ferguson and Messier 1997; Olsson and Folke 2001). 'Snowballing' is often used to identify additional experts whereby, at the end of an interview; fishers are asked to give the name(s) of other fishers experienced and knowledgeable in the area or species of interest (Neis et al. 1999b). Sadovy and Cheung (2003) had to interview everybody they could find with knowledge of the giant yellow croaker, *Bahaba taipingensis*, as few fishers of this species were still surviving, whereas, when looking at historical changes in a fishery, selection of patriarch or locally respected, often older, fishers is preferable (Johannes and Yeeting 2001; Alves et al. 2005; Gass and Willison 2005; Fraser et al. 2006). In Brazil, interviews revealed just a small number of "goliath grouper experts" (*Epinephelus itajara*), in each community, with referrals for interviews rapidly converging on just a few names (Gerhardinger et al. 2006).

10.3 The Data Collection Process

In this section, we examine methods for conducting and assessing interviews and other informal sources of information. Specifically, we examine how to select interviewees, some of the challenges of data gathering and interpretation, and

other considerations such as confidentiality and data quality. Follow-up steps for management and conservation are considered while validation is addressed in Sect. 10.4.

10.3.1 LEK Is Not Distributed Equally

The depth and precision of LEK can vary enormously among fishers. Geography, gender, age, fishing method used, area fished, dependency on fishery resources and fishing traditions are all important factors. Knowledge is often proprietary and not always widely shared within a community; this alone produces a vast array of knowledge levels. Therefore, before gathering fishers' LEK it is important to learn as much as possible about the practices, species, trade and history of fisheries in the area, by reading and talking to people knowledgeable about the region or society. Such preparation allows interviewers to be better informed to select and, importantly, engage with appropriate interviewees, formulate appropriate questions and be able to supply answers to questions likely to arise.

10.3.2 Gear, Species, Location and Fish Handling Practices

The gear used, fishing locations, species of greatest interest, or the typical practice of cleaning fish will all determine interviewee experiences and knowledge, and influence questions and responses. For example, spearfishers may know about behaviours and colour changes of the fishes they see underwater, while inshore net fishers may know little of species taken offshore by hook and line but much about seasonally migrating species that follow the shoreline. In some communities, women may target fish inshore while men travel further offshore, so experiences concerning marine resources are often very different within a community, or even a household. In Brazil, long-line fishers were unaware of spawning aggregations of goliath grouper fished only by spearfishers from the same city; long-liners and spearfishers used different popular names for goliath grouper (Gerhardinger et al. 2006). If fishers do not clean their catch (removal of abdominal contents and gills) before sale, either because fish are sold 'whole' or because others in the community, such as a fisher's wife, do the cleaning, questioning fishers about ovary condition may be meaningless.

Different types of aggregating species may be easier than others to identify from interviews. Large *transient* aggregations of certain mullets (Mugilidae), rabbitfishes (Siganidae) and groupers (Serranidae), being brief and highly time- and location-specific, are more readily recognizable as spawning aggregations than are *resident* aggregators that gather in many smaller groupings throughout much the year at poorly defined sites (for definitions of aggregation type see Chap. 1). Surgeonfishes (Acanthuridae), for example, normally move around in schools but also form

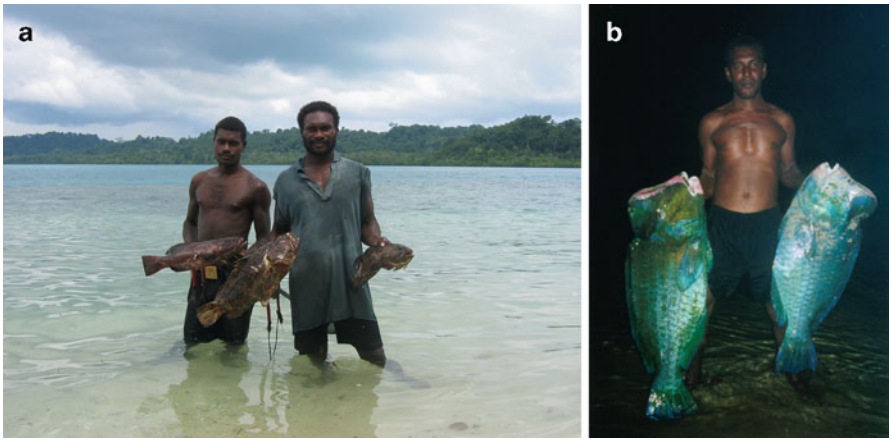

Fig. 10.2 (**a**) Papua New Guinean fishers from New Ireland Province displaying, from *left* to *right*, a squaretail coral-, brown-marbled and camouflage grouper that were speared during the day from a known FSA (**b**) Solomon Island fisher displaying two bumphead parrotfish, *Bolbometopon muricatum*, speared at night while resting in large groups (Photos: Richard Hamilton)

resident aggregations on a regular, even daily basis, for much of the year and at specific sites; LEK does not tend to readily identify such species as aggregation spawners. Local ecological knowledge on valuable, iconic or distinctive species, such as the bumphead parrotfish or humphead wrasse may be easily remembered (Sadovy et al. 2003; Dulvy and Polunin 2004) (Fig. 10.2).

10.3.3 Individual Attributes of Interviewees

The depth of individual LEK depends on the extent of their reliance on marine resources, their age and length of time fishing and/or trading, as well as cultural, personal and economic considerations. Long-time traders may have a better perspective of overall changes in species composition, sizes or landings than individual fishers who only know their own fishing area. Full-time fishers who are dependent on marine resources in one area may be more aware of long-term changes in that area than those who move between fishing grounds, or are only partially or seasonally dependant on fishing. Again, careful selection of the local experts is critical to interview outcomes (Sect. 10.2.3).

Older fishers usually have a broader perspective on changes and problems in local fishing grounds and may be less inhibited than younger ones about speaking openly (Fig. 10.3). In Fiji many older fishers had reported substantial declines in bumphead parrotfish, humphead wrasse or large sweetlips (Haemulidae) (probably Giant sweetlips *Plectorhinchus obscurus)*, while younger men rarely reported seeing these species (Dulvy and Polunin 2004, YSM personal observation 2006).

Fig. 10.3 (**a**) Experienced Papua New Guinean fishers from Manus Province openly sharing their fishing experience and writing the local names of their reefs onto a satellite map (**b**) Women fishers often fish in different areas, usually more inshore, from men and can share these experiences in interviews, as in Fiji (Photos: (**a**) © Michael Berumen (**b**) Yvonne Sadovy de Mitcheson)

Conversely, in many places, older fishers may never have visited offshore aggregation sites because of lack of access prior to mechanization (outboard engines) of the fishery and a tendency for them to focus on inshore resources as they age. In areas where destructive fishing practices are used, fishers are reluctant to be interviewed; in Busuanga Island, for example, Philippines, many young men use cyanide as a fishing method to maximize their incomes but are reluctant to be interviewed because its use is illegal (YSM personal observation 2006).

10.3.4 Cultural and Social Contexts

Some cultures use or retain detailed information on resources. Others appear to have little awareness of particular species or trends in catches. Whether this is due to educational background, historic dependence on the sea, contemporary factors, cultural factors, beliefs or attitudes is not always apparent. Interviews across the Indian and Pacific Oceans in two studies show low awareness of spawning aggregations in India, Indonesia, Sri Lanka, Philippines and Thailand with much higher awareness in the Maldives and western Pacific islands (Sadovy de Mitcheson et al. 2008; Tamelander et al. 2008). In Indonesia and the Philippines many people were uprooted or have migrated to more promising fishing grounds and have little or no traditional knowledge of their present fishing areas (e.g. Sadovy and Liu 2004). It is also possible that local knowledge on FSAs may be absent because, due to heavy fishing, few aggregations remain. In many places such as parts of Southeast Asia, the fisheries are in such poor condition, with low catches predominantly of small fishes, that spawning aggregations of many species may no longer occur (Sadovy de Mitcheson et al. 2008). By contrast, many western Pacific coastal communities have long traditions of fishing on their customary reefs and fisheries remain in relatively good shape. Knowledge continues to be passed from one generation to the next; where communities rely heavily on marine resources the most detailed LEK is found (e.g. Johannes 1981).

10.4 LEK Can Provide Critical Information for Conservation and Management

LEK can assist marine conservation and management efforts by providing information on the physical and biological characteristics of aggregations, as well as insights into changes in fisheries over time. These attributes of LEK are elaborated below.

10.4.1 Physical and Biological Characteristics of Aggregations

Local fishers may know where and when some commercial species aggregate for spawning. If properly validated (Sect. 10.6) such knowledge may be relevant to

conservation or management objectives. For example, LEK on seasons when FSAs form has helped to establish closed seasons for fisheries (e.g. in Palau, Johannes 1981; YSM personal observation 2010). LEK on seasonality is often incomplete (Sect. 10.4) and seasonality can vary even over small spatial scales in some species. In Melanesia, the peak spawning times of the brown-marbled grouper, *Epinephelus fuscoguttatus*, can be staggered by a month or more across sites separated by as little as tens of kilometres (Johannes and Lam 1999; Hamilton et al. 2011). While spawning seasons can be linked to the months in a western Gregorian calendar, in many locations this calendar is not used. For examples, Daw (2004) found that the Islamic calendar was excellent for identifying synchrony between FSAs and the phases of the moon (Daw 2004), but of limited use for describing seasonal trends as it shifts each year relative to the Gregorian calendar. Similarly, in the Pacific traditional lunar calendars identify the months in which aggregations occur, by associating them with the flowering of particular plants, as is the case of groupers in Fiji with the 'tavola' or tropical almond tree, *Terminalia catapa* (YSM personal observation 2005).

To identify an aggregation as reproductive through LEK, as opposed to groupings formed temporarily for another reason, the occurrence of both *spawning* and *aggregation* should be established using clear criteria and definitions (Domeier and Colin 1997, Chap. 1). It is critical that interviewers understand and consider both criteria during interviews. Care must also be taken with terminology; in some locations spawning aggregations may be referred to as a 'school' (Bahamas for Nassau grouper), so careful interpretation is needed. Moreover, aggregations of fish may be caught at certain times and places that are not reproductive, such as during feeding.

10.4.2 Historical Baseline on Changes in Aggregation Fisheries

LEK is used increasingly by scientists to assess fisheries that have limited or no data, or to reconstruct their history (Neis et al. 1999a). Johannes and Yeeting (2001) used information from villages in Tarawa, Kiribati, on declines in bonefish spawning migrations, and their possible causes (demise of customary marine tenure, causeways and gillnets blocking migration routes) that led to a community management plan. Interviews in many countries mirror biological studies indicating declines in large reef fish species, providing alternative sources of information for species assessments and management discussions, and promoting strong local buy-in (Sect. 10.6) (Sadovy et al. 2003; Aswani and Hamilton 2004; Sadovy de Mitcheson et al. 2008).

A few specific examples illustrate the value of such information as well as the challenges of using an approach that depends on experience and memory. In these examples, information from interviews could be quantified and usefully compared to indicate apparent long-term trends. In Palau, grouper aggregation sites yield mixed species landings (mainly squaretail coralgrouper *Plectropomus areolatus* and camouflage grouper, *E. polyphekadion*). Fishers from several communities switched

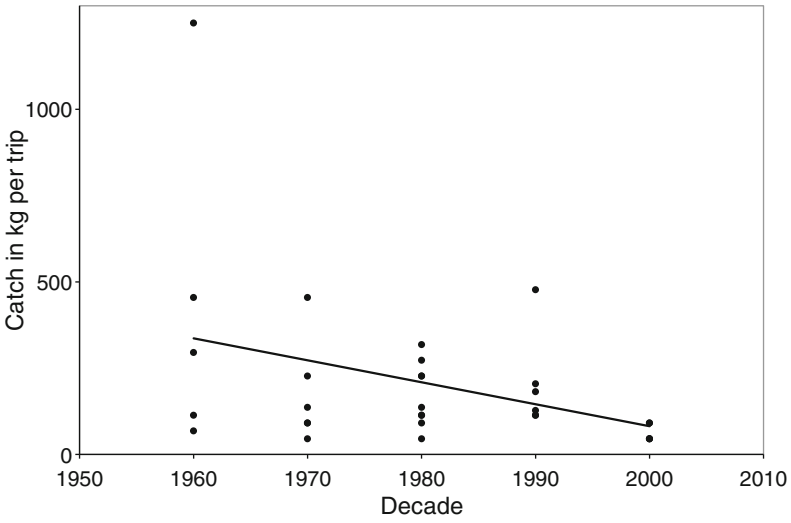

Fig. 10.4 Peak catches reported from multi-species spawning aggregations of groupers (*E. polyphekadion, E. fuscoguttatus* and *P. areolatus*) with trend line; catch data include all three species lumped together according to fisher interviews conducted in July 2003 in Palau (Adapted from Sadovy de Mitcheson et al. 2008)

among multiple locally known sites and reported landings reflecting the overall declines in catches perceived, rather than trends from a single aggregation or community (Fig. 10.4). In Fiji, for the camouflage grouper, it was most effective to direct questions at the scale of decades and to ask for recall of the highest catches encountered per trip (Fig. 10.5). The concept of average catch was either not understood or not easy to recall over the long term; maximum catch per boat in a day was the more memorable way in which landings were recalled. Consistent trends indicated from many independent fishers and from different communities allowed for acknowledgement and recognition of declines among stakeholders, and facilitated follow-up discussions and research planning. Clear and consistent trends, especially if expressed quantitatively, are also valuable for demonstrating interview outcomes persuasively to local government authorities, other interested stakeholders and the public.

10.4.3 Working with Local Partners and Information Exchange

Typically, interviews are conducted in partnership with local community and government officials, non-governmental organizations (NGO's), and educational institutions involved in conservation or management. Projects initiated or based

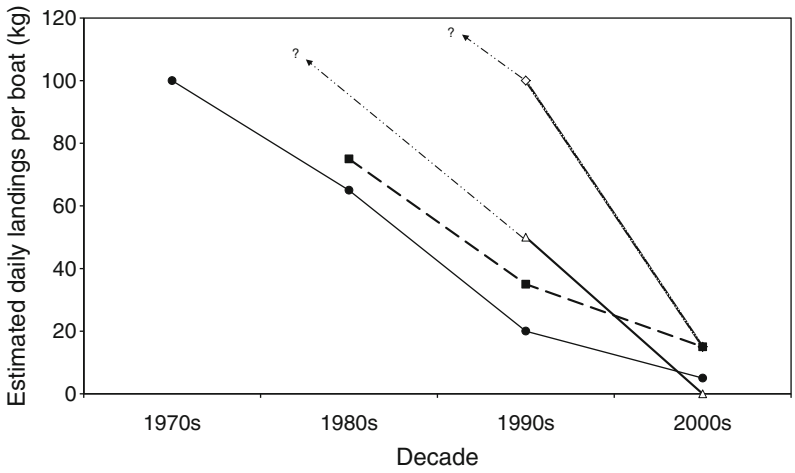

Fig. 10.5 Camouflage grouper, *Epinephelus polyphekadion*, peak landings from four different aggregations in Fiji and over at least four decades, according to fisher interviews conducted 2003–2005. Fishers were asked their highest recalled catches in each of the decades and the sites were validated as aggregation sites in 2005. *Dash/dot lines with '?'* point backwards to decades when fishers reported "hundreds" of kilograms per trip. Each *line* represents information from a separate aggregation site along contiguous coastline in northern Fiji (Sadovy 2006, YS, unpublished data)

outside of target countries should be closely aligned with the work of local partners to ensure that studies are appropriately designed and that significant outcomes are communicated and understood. Such steps build a platform for future management or conservation initiatives that generate understanding, interest and trust, identify educational and management needs, and avoid duplication of effort.

A big advantage of working with spawning aggregations is that they are easy to explain and understand. Everybody knows and appreciates the importance of reproduction, and most people are naturally interested to learn more about the resources on which they depend, especially when odd or interesting behaviours are concerned; some aggregations can be quite spectacular to see or fish. This provides excellent opportunities for two-way transfer of information; the interviewee responding to the questionnaire, and the interviewer able to discuss and explain the collective outcomes of interviews in light of experiences and relevant information from outside. This allows further opportunities for discussion after interviews and again highlights the need for well-prepared and knowledgeable interviewers who know something of fishery and marine resources of the area as well as the general biology and ecology of the species being reported (Sect. 10.2.2).

Local collaborators may or may not be knowledgeable about fishing communities in their own countries. In the Solomon Islands and Papua New Guinea many fisheries officers grew up in small fishing communities and have an excellent knowledge of and genuine interest in the fishery and fishing communities (RH personal observations 1996–2011). In some areas of Indonesia and parts of the

Pacific, by contrast, fisheries officers typically have little contact with fishing communities and their understanding of the state of the fishery can differ greatly from that of the fishers, often impeding progress on fisheries issues (YSM personal observation 2005). In the eastern Yucatan Peninsula of Mexico (Quintana Roo), most fisheries officers know little of the needs of fishing communities, and tend to treat fishers with distrust, regarding them all as potential poachers of lobster and conch (AA-P personal observation 2006).

After completing surveys, it is important that results are discussed in community meetings, presented to government departments or communicated via the radio and television. Further possible outreach opportunities need to be explored. Other interested and important parties for communications might be religious organizations and leaders, education departments, journalists, enforcement officers and tourism interests. Changes in policy and behaviour start with an understanding of the issues among users and the wider public. There remain large knowledge gaps and considerable misunderstanding in many countries in relation to the sea, in general, and the challenges faced by, and needs of, those who depend directly on its living resources. In many places, even fishery managers are little engaged in fisheries management and have insufficient training. It is worth highlighting here that in most countries fisheries issues, or at least small-scale coastal fisheries, are not taught in schools. Fish biology and ecology is not typically covered in school curricula so a general understanding of the sea is very limited in most communities.

10.5 LEK Can Be Incomplete, Inaccurate or Misleading

Interviews are a first step in a process enabling researchers to ask more specific questions and design focused studies and validation (Sect. 10.4) (Valbo-Jorgensen and Poulsen 2000). This section examines ways in which LEK falls short of providing all necessary information for management and conservation, and identifies what additional work is needed once interviews are completed.

10.5.1 Observation Versus Interpretation

Documentation of information and its interpretation are distinct activities. Divergences in interpreting the meaning or significance of an observation are common between the interviewer and interviewee (Ruddle et al. 1992). Learning how fishers or other interviewees view the sea and interpret the changes they witness, as well as identifying means to bridge information or perception gaps, is critical for planning educational materials and interventions. Therefore, interviews should include questions that explore the views, perspectives, and attitudes of interviewees and allow opportunity for them to ask questions. It is common, for example, for

fishers to observe that fishes have declined in a given area over time, and then to interpret this as being due to the fish having moved elsewhere, gone deeper or changed behaviour, such as no longer biting hooks. The interpretation of the observation in this case is not that the fish are no longer in the sea (i.e. possibly overfished) but that they are still present in the area but can no longer be caught. Such a perspective would make the concept of spatial protection or effort reduction in an area unacceptable or even incomprehensible as a solution to the changes perceived in catches. Discussion of such perceptions opens up opportunities for additional possible explanations, including overfishing, or discussions of various options for management as well as the longer term implications of inaction.

Interviewers must exercise care in formulating unambiguous questions while anticipating possible confounding factors. For example, in asking about trends in catches over time, fishers may report no changes. The reality could indeed be no change, but the perception of the fisher could also be due to him/her spending longer at sea, or shifting between fishing grounds, behaviours that could mask overall declines in the fishery, to compensate for declining catch per unit effort. A progressive increase in the power of outboard engines, facilitated by well-intentioned government and international aid programmes has also led many fishers to move further offshore, often to the edges of shallow water coastal platforms, with an initial boost in landings, as largely unexploited fishing grounds were entered.

Even simple gear changes can markedly affect catch rates. Spearfishers in the Pacific boosted catch rates when new technologies as simple as prefabricated flippers (dive fins) dive masks, spearguns and underwater flashlights (which enabled night spearfishing) were introduced (Gillett and Moy 2006, YSM and RH personal observations 1996–2011). In many Pacific Island locations the relatively recent initiation of night spearfishing, especially when combined with compressed air diving, has resulted in substantially increased catches. This fishing method in particular is having profoundly negative impacts on populations of large species such as the bumphead parrotfish which sleeps on the reef at night and is easy to catch at this time (Hamilton 2003a). Spearfishing is considered a major problem when aggregations are targeted in Fiji and the Solomon Islands (Gillett and Moy 2006) and is also a considerable issue in Palau and Papua New Guinea (YSM and RH personal observations 2005). An interview with a Solomon Island spear fishermen demonstrates this:

> I remember a spear fishing trip in 1985, not long after I had learned to use fins, when we were asked to spear Topa (bumphead parrotfish) for an upcoming wedding… I speared 74 big Topa that night. I could have speared many more, but our canoe began to sink from the weight of all the Topa (Hamilton 2004, p 66).

In some instances, of course, LEK can be unreliable, and fishers' interpretations of their own observations incorrect, but interviewers should not be too swiftly judgemental (Johannes 1989). Tibby et al. (2007) reported on an assessment of a coastal dune lake in Australia in which local perceptions and accounts were inconsistent and did not always match historical evidence. Johannes (1981) recorded stories of octopi climbing trees to give birth to young, noting this to be biologically unlikely. Some initially unlikely reports, however, have turned out to be partially

correct and highlight the need for interviewers to be open-minded. For example, Johannes and Neis (2007) reported how fishers informed marine biologists of an area off the coast of Belize where whale sharks aggregated and were swimming through milky clouds of water. The fishers assumed the whale sharks were spawning but their assumptions were wrong, as whale sharks are viviparous and do not release eggs. While their observations were accurate, the whale sharks were in fact feeding on spawn released by large aggregations of snappers (cubera snapper – *Lutjanus cyanopterus*, dog snapper – *L. jocu*) (Heyman et al. 2001). In Brazil, fishers reported that mullet, *Mugil platanus*, enter coastal rivers and estuaries to spawn during extensive spawning migrations, whereas scientists suggest that spawning occurs in the open ocean; although this has yet to be confirmed and the different instead accounts call for further work (Silvano and Valbo-Jorgensen 2008). Clearly, LEK is most useful in science and conservation if it is carefully collected, evaluated, cross-referenced and validated whenever possible (Johannes 1981; Ruddle et al. 1992; Usher 2000).

10.5.2 Only Knowing Part of the Picture

LEK in a local context is, by its nature, selective; it is a small part of a much bigger picture. Workers need to be just as clear about what they will not learn through interviews as about what they will (Sect. 10.3 and Table 10.1). One illustrative example is blacktail snapper, *Lutjanus fulvus*, in Palau. This is a small snapper evidently not known in aggregations or of particular interest to fishers, and yet predictably forms massive groups of ripe adults (Chap. 12.10). However, it has never been picked up in LEK despite numerous interviews in Palau over the last two decades or so (Johannes 1981; Sadovy 2007).

People also differ enormously in how observant they are. Spearfishers in Fiji, Papua New Guinea, Cook Islands, and the Solomon Islands, for example, provided impressive details on features such as colour changes, orientation relative to water currents and behaviours among aggregated groupers (Passfield 1996, YSM and RH personal observation 2005). These fishers could only have known such details from their own experiences thus providing strong evidence that spawning aggregations had been observed.

It is our experience that only the more obvious aggregations, or those of more valuable species, are clearly and consistently reported in interviews. In Fiji, for example, on a SCUBA dive to validate an aggregation site reported by many fishers to contain the camouflage and squaretail coralgroupers, another species, the speckled blue grouper, *Epinephelus cyanopodus*, was also found that no one had mentioned in interviews despite its presence in the fishery. We later discovered that only shallow-water spearfishers caught it and noted that our original interviews had not included these fishers (YSM personal observation 2006). In Palau, several groupers were reported to assemble in significant number in May and June in interviews (Johannes 1981), and these months were later included in a traditional seasonal closure ‘bul’ and in national laws. Aggregations also occur in July and August, as

described by Johannes et al. (1999) based on field studies, and were reported in interviews to last from April to August (Sadovy 2007). While aggregations are also protected in July, August is still unprotected.

Likewise, interpretations of the condition of a resource can depend heavily on experiences based on gear types being used. In Brazil, those fishers using spears perceived the goliath grouper fishery to have declined; they attributed this to illegal fishing with underwater breathing apparatus, pollution and decreased availability of food resources, such as lobsters. Long-line fishers from Brazil, however, perceived abundance as being unchanged or even higher than before (Gerhardinger et al. 2006).

10.5.3 Knowledge Beyond Fishers

There are sources of knowledge, or means of corroborating interview-based information, other than fishers and fishery managers. Experienced and long-serving dive guides, local researchers and traders may have a wealth of knowledge on the status or history of a local fishery or on particular species. Historical documents can provide unique insights into past fisheries and, in some countries, trade, fish processing or market data, or even tax offices may yield useful information. For example, Sadovy and Cheung (2003) used LEK of older fishers and literature on swim bladders to reconstruct the history of the giant yellow croaker, also known as the Chinese bahaba, fishery. This large fish spawned in river mouths in southern China and was abundant in the mid twentieth century. Now it is on the verge of extinction after its spawning aggregations were heavily targeted for its valuable swim bladder. LEK regarding changes in its abundance was cross-checked by conducting reviews of the English and Chinese published and unpublished literature (e.g. Sadovy and Cheung 2003). In Cuba, an 1884 account on grouper migrations provides a fascinating insight into a fishery that has clearly changed profoundly in recent decades (Vilaro-Diaz 1884; Claro et al. 2009). In the Mexican Caribbean, early accounts by a geographer (Craig 1966) attracted the attention of researchers to study the Nassau grouper "corridas" (migrating runs) along the Mesoamerican Reef (Aguilar-Perera 1994). Traditional seasonal calendars in Fiji associate the times of the flowering of certain trees with increased abundance of certain grouper species (see above). Saenz-Arroyo et al. (2006) documented past marine fauna of the Gulf of California mainly through the use of accounts from early travellers, while Lajus et al. (2001) reconstructed Atlantic salmon fisheries in Russia mainly through the use of tax records.

10.5.4 Recall

Possible bias introduced from memory loss or distortion is a serious consideration with interviews that seek to document past conditions. The nature of the bias will depend on the questions, the importance of the species or issues to the interviewee

and on how the information is to be used. The problem is likely to be greater the further back in time information is sought since memory fades with time (and age) (Neis et al. 1999a; Pascale et al. 2002). Memory aids that assist recall relative to special or historic events include major wars, an election, introduction of a new regulation, a marriage or birth, etc. (e.g. Ames 2007). Memory that is personal, long-lasting, and related to self-esteem can be positively biased (Thompson et al. 1996) such that maximum or 'best' catches,' largest' fish, for example, may be more memorable than 'average' fish size or low catches.

10.5.5 Exaggeration and Misleading Information

Unintentionally or otherwise, interviewees may exaggerate their responses or provide information that is misleading. In our experience, this is not a major problem. For certain sensitive issues, and if pressures on and interest in aggregations increase, it may become one. While difficult to detect, long-time experience with interviewing, internal consistency of answers (through questions that seek the same information in different ways, or across interviewees) and simple 'gut feeling' can help to identify many cases of misleading responses. Interviewees may exaggerate or mislead if they are trying to impress an interviewer, do not take the interview seriously, do not know answers to questions, are concerned about the use to which interview outcomes will be put, are in a hurry, tired or bored, as well as other possibilities (Silver and Campbell 2005, RH and YSM personal observations 2005). Problems often arise if interviews are being translated. YS had a case in Indonesia in which the translator decided, after the first few interviews, that he already knew the answers because he heard similar responses in earlier interviews. He then started to reply himself rather than to translate replies. Questionnaire design should include test questions for which the answer is known and photo-aids that include non-local species, as a "truth test".

10.5.6 Secretiveness

It is inevitable that interviewees might be secretive about an activity on which their livelihood depends, or with strangers. They may be competing with other fishers, not want to provide information indicating their income, feel threatened because they do not understand the purpose of the questions, or be fishing illegally. Collectively, we have experienced little indication of secretiveness, although there are exceptions and this is obviously difficult to judge. In most locations in Melanesia fishers willingly showed researchers the locations of spawning sites once the purpose of LEK surveys was explained. But in southern Choiseul, Solomon Islands, no one would discuss the locations of known leopard coralgrouper, *P. leopardus,* squaretail coralgrouper aggregation sites; these communities have a history of keeping the locations

of these sites 'private' from other fishers, and will paddle off the site if they see another canoe approaching (RH personal observation 2004). In Mexico, fishers are often secretive about the locations of recently discovered sites. However, once the site becomes widely known, these fishers typically communicate. Currently, fishers from the Mexican Caribbean are collaborating with researchers to find ways to protect Nassau grouper spawning aggregations after learning from Honduran fishers about major declines in catches of this grouper (AA-P personal observation 2007). Where illegal fishing methods such as cyanide or dynamite are extensively used, as in parts of Indonesia or in the Philippines, it was hard to find cyanide fishers to agree to participate in interviews (YSM personal observation 2006).

Overall, where communities have effective local controls or where resources are not considered to be in short supply, we encountered little reluctance to answer general questions. However, questions that relate to money, especially when the interviewee is a trader or middleman, where catches are subject to taxation, or when government officers are present, may not be welcome. Government officials are sometimes wary or defensive, especially when they have little knowledge of the resources in question.

10.5.7 Basic Points to Remember When Interviewing

Basic points to remember when preparing for interviews and conducting interviews in the field are outlined in Appendix 10.1 and elaborated below.

10.5.8 Confidentiality

Most aggregation sites, revealed through fisher interviews, continue to be exploited but not managed. Although the interview process itself is often closely linked to ongoing local management initiatives and awareness-raising, this is by no means always the case. Management can take many years to implement, and even then enforcement may be weak or non-existent, hence release of detailed aggregation site information (including on maps and in final project reports) into the public domain is likely ill-advised, until a management framework is in effect. Moreover, the general question of the release of indigenous knowledge where there is no direct benefit to the source communities or consensus from the communities on the matter, and where this could possibly lead to increase in exploitation from outside pressures, is not only a practical but also an ethical issue.

The issues of confidentiality and accountability in marine studies in relation to sensitive areas or species have received little attention to date; certainly not to the same extent as in terrestrial situations where such concerns are often addressed. However, several fisheries agencies (for example the Great Barrier Reef Marine Park Authority in Australia and the Seychelles Fishing Authority) have a policy not to publicly release fish aggregation site locations (Jan Robinson, Martin Russell

personal communication). In Palau and Fiji, local NGOs or authorities prefer not to release site data on aggregations for fear that local recreational and commercial fishers, many with powerful outboard boats and using SCUBA and spears, could quickly reach newly reported sites. Poaching is common in both countries, enforcement minimal, and fish stocks close to more highly populated areas are overfished leading to interest in expansion of fishing grounds (YSM personal observation 2005). For data-sharing purposes, confidentiality agreements could be developed.

10.6 Validating and Integrating LEK with Science to Support Management and Understanding

The major challenges in incorporating LEK into management agendas is assessing the reliability and accuracy of the information collected and using this information to gain support for management, if needed. This section addresses the issue of validation, communication and integration of interview-sourced information. Possible approaches range from visits to reported sites at the time(s) and place(s) indicated for spawning (although this does not exclude the possibility that spawning occurs at other times and places not recorded) to market visits, discussion with dive guides, fishery reports, cross-sector interviews (i.e. traders, wholesalers, etc.), underwater visual census (UVC) surveys, dedicated follow-up studies and assessment of consistency among or within communities of experiences reported.

To assess fisher's knowledge effectively, an interviewer must be certain of which species informants are talking about and where and when their observations were made. Having good fish reference materials greatly facilitates this process. Local fishing communities often have a highly developed folk taxonomy for food fishes and experienced fishers can quickly attribute local species names to photos of fish in a reference book. Photos may need to include both dead and live specimens, according to the likely experience of the interviewee. An experienced and prepared interviewer will already have a good knowledge of folk names but, nonetheless, should continue to cross-check local names with fish reference guides; local names can vary markedly even at small geographic scales and important species may have several different names that relate to different size classes of the same species. In the Yucatan Peninsula, for example, fishers from the Yucatan State call the black grouper, *Mycteroperca bonaci*, 'negrillo'; in contrast, those from Quintana Roo call it 'abadejo'. To fishers from the Yucatan, however, "abadejo" is the gag grouper, *M. microlepis* (AA-P personal observation 2006).

Maps, charts and satellite photos of reefs are useful for documenting fish migratory pathways, checking site names and identifying locations of FSA sites. To collect fine-scale information, interviewers can ask knowledgeable fishers to draw a sketch map. Spearfishers, in particular, can often provide a wealth of information on the physical features of a site, depth ranges of aggregating species, aggregation boundaries, water conditions, and variations in fish densities. However, not all fishers can

read maps and spatial information should be carefully documented if aggregation sites cannot be visited.

Once validated, the importance of LEK cannot be overstated. Community support for conservation plans consistently emerges as one of the most important factors in maintaining long term effectiveness and support from local people (King and Faasili 1999; Johannes 2002; Aswani and Hamilton 2004). Moreover, community acknowledgement and understanding of key threats engender greater respect for regulations, as noted for marine protected areas (MPAs) in the Bahamas (Broad and Sanchirico 2008), and can garner government and community support for management, as in Pohnpei, Fiji and elsewhere.

10.6.1 Examination of LEK for Internal Consistency and Reliability

Internal consistency and reliability of LEK can be assessed by comparing within and between transcripts and through expert consensus. Carefully examining an interview transcript will help assess the likely accuracy of the information. If the information provided clearly contradicts itself, then its validity is thrown into question (Huntington 1998). When many fishers have been interviewed, multiple transcripts can be compared to identify components of LEK that are consistent and frequently raised, and highest reliability assigned to these aspects of LEK or to particularly reliable respondents (Neis et al. 1999b). A cautionary note is that not all 'experts' are created equal. In cases where a single individuals' LEK could potentially be highly relevant to management, extra effort is needed to cross-check with independent data sources or conduct independent research (Hamilton 2005).

Researchers can hold review sessions with a community after completion of interviews to discuss the LEK gathered and reach consensus. LEK documented during interviews is presented to a group of expert fishers for discussion and consensus-building as well as to raise further awareness about the purpose of the study, the implications of the results and to build support and explore possible responses (e.g. Huntington 1998).

10.6.2 Independent Validation of LEK

There is no substitute for independently validating LEK before incorporation into conservation and fisheries management (Usher 2000). Table 10.1 lists several attempts at validation to illustrate possible outcomes and lessons learned. Key points include that aggregations may last for more months than reported by LEK, with first and last months or the months with lower numbers of fish less obvious or possibly varying from year to year, and therefore often excluded from LEK (as in the case of August in Palau – see above). Highly variable responses tend to be found in areas with weak

Table 10.1 Outcomes of activities that sought to validate local ecological knowledge on aggregations

Location and species	Method(s) for collecting LEK	Assumption(s) of LEK tested using validation	Method(s) for validating LEK	Outcome	Source
Manus, Papua New Guinea, *Epinephelus fuscoguttatus* and *Plectropomus areolatus*	Semi-structured interviews	*E. fuscoguttatus* aggregate at a specific site in March, April, May and June. Aggregations of *P. areolatus* form at this site in every month of the year, peaking in the months that *E. fuscoguttatus* aggregate	UVC monitoring data collected at the aggregation site several days prior to the new moon from July 2005 to December 2007	Results confirm LEK: *E. fuscoguttatus* aggregate between March –August, and *P. areolatus* aggregate every month with highest densities typically in months when *E. fuscoguttatus* aggregate to spawn (Fig. 10.6)	Hamilton (2003b), Hamilton et al. (2004), and Manuai Matawai and RH, unpublished data
Manus, Papua New Guinea, *Epinephelus ongus*	Semi-structured interviews	*E. ongus* aggregates by the thousands to release eggs in the week leading up to and including the new moon in March, April, May and June. Aggregations disperse on or just after the new moon	Sampling fish from an aggregation site in June	Results support LEK. Gonads of 89 *E. ongus* captured at the FSA before and just after the new moon in June 2005 provided evidence that *E. ongus* aggregated for spawning at time and place indicated by fishers	Hamilton et al. (2004, 2005c)
Roviana Lagoon, Solomon Islands, groupers	Participant observation, semi-structured interviews	LEK details a spawning season for all groupers in Roviana Lagoon between October to January each year	UVC monitoring data collected monthly at one aggregation site in Roviana Lagoon several days prior to the new moon from April 2004 to June 2006	LEK on spawning season incomplete. UVC monitoring data show that *P. areolatus* aggregations of variable size occurred in virtually every month of the year, whereas aggregations of *E. fuscoguttatus* and *E. polyphekadion* occurred from December to April	Aswani (1997), Johannes and Lam (1999), Hamilton and Kama (2004), and Smith and Hamilton (2006)

Papua New Guinea and Solomon Islands, *Epinephelus polystigma*	Semi-structured interviews, participant observation	*E. polystigma* forms large nocturnal aggregations in shallow waters of river mouths and brackish mangrove regions throughout year, prior to new moon. Sites identified in several regions in Melanesia using maps	Comparison of LEK that was documented in different regions in Melanesia and sampling fish from one aggregation site in February	Results partially support LEK. Visited one site 3 days before new moon at night in 1 month (February) and found many small clusters of fish in very shallow water of a range of sizes, species identification confirmed by caught fish; 18 with ripe ovaries and running ripe testes	Johannes (2001) and Hamilton and Potuku (2007)
Kimbe Bay, Papua New Guinea, *E. fuscoguttatus and P. areolatus*	Semi-structured interviews	Fishers identified eight sites in Eastern Kimbe Bay where groupers aggregate to spawn. No annual season was identified	A single UVC survey was conducted at each site in the week leading up to the new moon in March 2005 and April 2006. Timing of these surveys was based on knowledge of peak aggregating period for these species in Manus Province	Results consistent with LEK. Snapshot surveys verified that five of these eight sites (63%) had *P. areolatus* and/or *E. fuscoguttatus* aggregations in the months surveyed. At verified sites groupers were present in relatively high densities (20–200 fish), groupers displayed aggressive behaviours consistent with spawning and gravid females were sighted. At remaining three sites no FSA were sighted on either occasion	Hamilton et al. (2005b) and Aitsi et al. (2006)

(continued)

Table 10.1 (continued)

Location and species	Method(s) for collecting LEK	Assumption(s) of LEK tested using validation	Method(s) for validating LEK	Outcome	Source
Solomon Islands. *Lethrinus erythropterus*	Semi-structured interview with one fisherman	Large aggregations (100s–1000s) of *L. erythropterus* form at a specific site in shallow water around the new moon for the purpose of spawning	Dived at the aggregation site on the new moon in 1 month (March) to make observations and sample fish	Results consistent with LEK. 300–500 *L. erythropterus* were aggregated in shallow water; 26 fish caught with ripe ovaries and running ripe testes	Hamilton (2005)
Kadavu Island, Fiji, *E. polyphekadion, E. fuscoguttatus* and *P. areolatus*	Semi-structured interviews in multiple communities in northern Kadavu	Aggregations of groupers occur at three reef passages between July -September with no obvious lunar cycle. Leaves of the local tree turn red/yellow and start to fall at time that fish appear at aggregations	Single 'snapshot' SCUBA surveys at two sites July followed by intensive diving (i.e. daily for 10 days and on both sides of indicated passage) at the site reported to be the most productive. Visited fish markets to identify and squeeze fish taken from Kadavu for eggs/sperm. Fish sampled on site	Where intensive diving was undertaken all three species aggregated in July and August, gravid females were sighted and chasing behaviour observed. Fish sold in markets had running sperm in early August and Tavola leaves started to go red and fall. Single dives conducted on other sites did not confirm fish aggregating but probably were conducted a little early according to men fishing at sites; this would be consistent with gonad inspection. Interestingly the dominance of different species varied with side of the passage monitored.	Sadovy de Mitcheson et al. (2008) and YSM and Aisake Batibasaga, unpublished data

Fiji, *E. polyphekadion* and *P. areolatus*	Semi-structured interviews in several communities along contiguous coastline	Spawning aggregations of groupers occur at four sites in northern Fiji during at least one of the months indicated	Dived at four reported aggregation sites on one of peak months indicated by interviews, July. Checked gonads of groupers being captured at this site by fishers	Confirmed presence of both species at three of four sites; consistent outcomes by four communities. Fourth site had no fish or boats despite excellent weather and local community reported it to be fished out. Found *E. cyanopterus* at one site that had not been otherwise reported – only noted by shallow water spearfishers. Traders at the main trading town of the region confirmed large numbers of the same three species during indicated months	Sadovy (2006) and YSM, personal observation
Palau, *E. polyphekadion, E. fuscoguttatus* and *P. areolatus*	Unstructured and semi structured interviews	Spawning months from April to July for *P. areolatus. E. fuscoguttatus* and *E. polyphekadion*	UVC surveys in every month of year at three sites during days leading up until full moon and until fish numbers declined after spawning. Market sampling of fish to examine gonad condition	Months reported correct but incomplete; August is also a month in which spawning aggregations form although can be smaller than other months. *Plectropomus areolatus* misidentified as *P. leopardus* in earlier study and at one site also was present in other months in small numbers	Johannes et al. (1999), Sadovy (2007), Johannes (1981), Patrick Colin, personal communication 2009, and Palau Conservation Society, unpublished data
Philippines Groupers	Semi-structured interviews	Some interviewees reported several small aggregation sites off NE Palawan of *Plectropomus* spp.	SCUBA dived at several sites at indicated times	Confirmed aggregation of fish for one of the indicated months. Gravid females sighted	YSM and Jose Ingles, unpublished collaboration with WWF Philippines

(continued)

Table 10.1 (continued)

Location and species	Method(s) for collecting LEK	Assumption(s) of LEK tested using validation	Method(s) for validating LEK	Outcome	Source
Seychelles	Semi- and unstructured interviews. 39 semi-structured over 10 months, catch, sizes, species, habitat, location, timing. Patriarch fishers targeted	Eight spawning sites for several species of grouper and a rabbitfish	Combinations of fish sampling for sizes and gonad condition, including GSI and histology, and dives at reported sites at indicated times and places	Validation of six out of eight reported sites and for all species reported except for *E. multinotatus* which may be overfished. Confirmed *P. punctatus, E. fuscoguttatus, E. polyphekadion* and *Siganus sutor.* Project raised awareness leading to further work and some protection	Robinson et al. (2004, 2007)
Puerto Rico, Caribbean	Interviews locally and questionnaires circulated regionally on status of past and present Nassau grouper aggregations and populations	That many of the Nassau grouper aggregations known historically have declined	Literature review, discussions with local biologists, visiting reported sites	Declines confirmed in many places quantitatively and qualitatively. Difficult logistically to reach many of the sites said to be existent. Still seeking funds to do so, e.g. Bahamas	Sadovy and Eklund (1999)

Mexico (eastern Yucatan Peninsula), Caribbean, *Epinephelus striatus*	Semi-structured interviews with commercial fishers.	A Nassau grouper spawning aggregation forms at a specific site around the full moon in December and January each year	UVC monitoring in December and January around the full moon period between 1988 and 1993, and examining gonads of fish captured at the site	Confirmed aggregation of 500–1000 ripe adults forms during the full moon period in the months of December and January	Aguilar-Perera (1994) and Aguilar-Perera and Aguilar-Dávila (1996)

Refer to Chap. 12 for individual species accounts on many of the species
LEK local ecological knowledge, *UVC* underwater visual census, *GSI* gonadosomatic index

aggregation signatures, which is common in particularly heavily exploited FSAs (e.g. Indonesia and Philippines – YSM personal observation 2006; Sadovy and Liu 2004). Validation efforts tend to focus initially on the reported sites and months. To establish full timing of aggregation, validation should ideally be conducted during all months of the year and for extended periods each month. Single "snapshot" visits to sites are of limited use for seasonal protection, although may effectively serve spatial protection initiatives by confirming the existence of an aggregation site. Interviews need to involve fishers, particularly those using different gears, to obtain a detailed profile of aggregating species and timing. CPUE information must be carefully collected and the alternative possible hypotheses for any trends explored. Fish should be sampled for reproductive condition whenever possible and this could be done in fish markets if the source of the fish is local (see GSI in Chap. 9).

10.6.3 Conducting Research to Validate LEK on FSA

Many aspects of LEK pertaining to aggregations lend themselves particularly well to being independently validated. Information on lunar and annual seasonality, FSA location, species composition and purpose for aggregating (i.e. reproduction or feeding) can be verified by UVC or by examining the gonad state of fish captured from a FSA (Chap. 1, Table 10.1).

10.6.4 Underwater Visual Censuses

Divers can often make direct observations on whether or not a FSA is present, the species aggregating and whether courtship or spawning is occurring. This process is relatively simple and effective if local knowledge on FSA seasonality is detailed and if the precise locations of FSA were previously documented with a GPS, or using a good quality map. Independent validation at a potential FSA site will often be done on SCUBA over days or a few weeks and typically includes activities such as estimating the numbers and species of fish present and collecting indirect or direct evidence of spawning (Chap. 1, Table 10.1). However, given the spatial and temporal variation of FSAs, several short or extended trips may be necessary or it will be difficult to determine what it means if no FSA is found. In this scenario, researchers cannot know whether local knowledge was incorrect, they simply missed the exact location, visited it during the wrong lunar or annual period or if FSA timing varies naturally.

Long-term UVC monitoring of a given FSA is typically conducted to determine whether conservation measures in place at a FSA are working, to fine-tune management or for research (Colin et al. 2003). While data collected from long-term monitoring programmes primarily serve to inform adaptive management, another important objective of monitoring is to validate LEK, especially in scenarios where management strategies have been developed based purely on LEK (Hamilton et al. 2005a). For example, year-round monthly UVC surveys from a FSA in Manus,

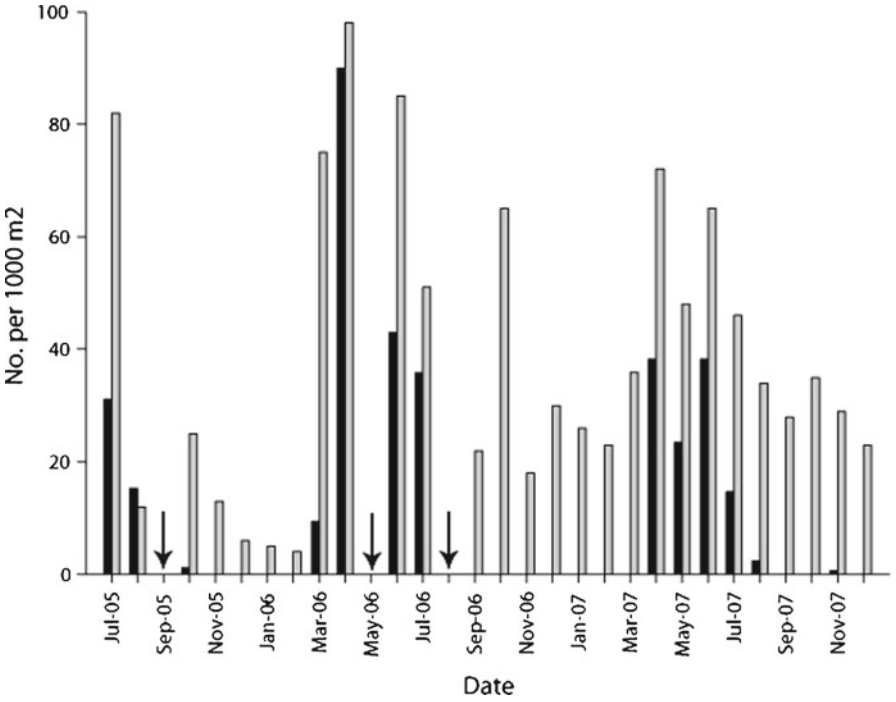

Fig. 10.6 Number of *Epinephelus fuscoguttatus* (*dark bars*; 20 m deep transect) and *Plectropomus areolatus* (*light bars*; 10 m deep transect) per 1,000 m^2 at a spawning aggregation site in Manus, Papua New Guinea, based on underwater visual census surveys conducted on one occasion several days prior to the new moon in each of the indicated months. *Arrows* indicate no data from months when surveys could not be conducted for logistical reasons (Manuai Matawai and RH unpublished data)

Papua New Guinea (Fig. 10.6) validated LEK pertaining to this FSA (Table 10.1) and informed adaptive management. In addition, follow-up projects can be developed that increase understanding and awareness of aggregations and their significance; examples include a simple tagging project in Fiji where fish were tagged and local fishers assisted by returning tagged fish they caught. Interest can be generated by such studies which become a focus for discussion and opportunity for outreach (YSM personal observation 2005).

10.7 Combining LEK and Science Assists Effective FSA Management

In this chapter, we attempt to show that if LEK is collected judiciously it can provide an excellent source of data on aggregating species, as well as the probable historical and current status of their fisheries, can create excellent opportunities for awareness and information exchange, and can assist in promoting and supporting management development. An interesting example of a direct comparison between

scientific data (e.g. bottom trawl, fishery data) and LEK in the English Channel showed good overall agreement between fishers' statements and scientific data with both sources suggesting declines in some commercially important species (Rochet et al. 2008). The study noted that fishers had an accurate perception of changes and their time-frames, but not necessarily of their causes, and that fishers had a greater power than scientific survey data to detect recent changes. This suggests that fishers' perceptions have great potential as early warning signals. However, the two sources differed in suggested causation for the observed changes; science suggesting overfishing and fishers suggesting that declines in cod had been due to movements away from their fishing ground. This example highlights the important role of science in addressing causation and of LEK in being able to capture general longer term trends more easily than is possible in typically short duration scientific surveys.

Although LEK on FSAs can be highly detailed, in our experience it is a combination of LEK and science that leads to effective forms of FSA management. Ideally, the two-way exchange of information that occurs during the interview process can advance management initiatives and develop a scientific perspective (Drew 2005). Scientists can play a valuable role by sharing their knowledge, answering questions fishers may have, and providing information on larval stages, recruitment and life history parameters of aggregating fish. Such biological information is typically absent from LEK (Foale 2006) which addresses the 'what' kind of question but not necessarily the 'why' and the 'how'. Judiciously developed questions and consistent and careful questioning can allow for a degree of quantification of LEK which can be very powerful when talking to politicians or others who might otherwise be unreceptive to what may sometimes be seen as anecdotal information. Scientists can also provide regional and global perspectives on FSAs -something even the most knowledgeable fishers typically lack- and one reason why workers must be familiar with aggregating species.

Often informing fishers of the critical biological role that FSAs play and the ease with which they can be destroyed is the only catalyst required to have communities initiate the process of managing their FSA (Hamilton et al. 2005a). Documenting LEK regarding the presence of FSAs, or changes in landings from FSAs, is often important for reinforcing what people have already experienced, and a better understanding of aggregations can help communities make sense of what they have learned from experience or tradition. Importantly, scientists should be open with their collaborators regarding data collected and analysed and not expect to withhold it until publication. Confirming that FSAs form does not necessarily mean that they all have to be protected. Moreover, it is not necessary to know the location of all aggregations if seasonal protection is likely to be more effective. Depending on the local context, seasonal rather than spatial protection may be more appropriate in many places, especially where enforcement of distant sites is highly unlikely; the best protected sites are those that nobody knows.

LEK is far more likely to be taken seriously by conservationists, scientists and managers if validated, and scientists are more likely to be taken seriously if what they say harmonizes with local understanding. LEK on FSA in Kimbe Bay, Papua New Guinea provides one such example. UVC 'snapshot' surveys conducted at FSAs in

Kimbe Bay independently confirmed that grouper aggregations formed at five out of eight sites previously identified through LEK. These verified sites were subsequently given a much higher ranking than non-verified sites when Marxan software was used to design a MPA network for Kimbe Bay by an NGO working in the area (Green et al. 2009). In Fiji, the participation during interview studies of the Research Division of the Fisheries Department and subsequent preliminary evaluation of several sites were important factors in the inclusion of grouper aggregation protection in both outreach work by the Division and in a draft revision of the national fishery ordinance. Management or conservation initiatives that are at least partly in line with traditional thinking have far more chance of success than approaches that are not familiar to, or consistent with, local beliefs and understanding.

Even communities might prefer to base their actions on more detailed studies. In 2004, traditional owners in Roviana Lagoon, Solomon Islands, expressed interest in placing a seasonal ban at one aggregation during the locally defined grouper spawning season (October to January) (Hamilton and Kama 2004). However, before placing a seasonal ban on this FSA they requested that an independent, long-term scientific monitoring be conducted. In June 2006, the results of 2 years of monthly monitoring were presented to the local community that claimed traditional ownership of this site (Table 10.1). On the basis of these scientific results, the community decided that a seasonal ban from October to January would not effectively conserve this grouper aggregation, and the community consequently voted to turn the aggregation site and the surrounding reef area into a community-based no-take MPA.

Attention attracted to aggregations can even lead to much broader initiatives, following validation. In the southern Philippines, the discovery of several small aggregation sites in TayTay Bay, northeastern Palawan, followed by on-site validations resulted not only in protection of the sites, but was also the catalyst for many communities to come together in the Bay to discuss marine protected area work in general, work that later helped to address concerns about the developing export trade in live fish, particularly the leopard coralgrouper (YSM personal observation 2006).

Finally, the case study from southern Manus (Table 10.1, Fig. 10.6) provides a contrasting example of where a community was so confident of their LEK on their FSA that they used it to immediately develop a community-based fisheries management strategy. In early 2004, the Pere community from Southern Manus placed a lunar-based ban on spearfishing and commercial fishing at the aggregation site in the 10 days leading up to and including the new moon in every month of the year. During this period only subsistence hook and line fishing was allowed at the aggregation site (Hamilton et al. 2004). In this particular case, long-term monitoring commenced only after management measures based on local knowledge were implemented, and long-term scientific monitoring simply confirmed what local fishers already knew regarding lunar and annual seasonality of the aggregations. This is not to say that monitoring did not serve an important role in adaptive management or broader conservation initiatives. In early 2007 when the Pere community saw monitoring data that indicated that the densities of groupers at their FSA had not improved, they voted to place a 1 year ban on all fishing at the aggregation site during lunar periods when aggregations formed. Initial efforts to protect and monitor this

FSA also led to increased awareness on a broad range of marine management issues in Pere, and in 2009 the Pere community and local government officials launched the Pere Environment and Conservation Area Management Plan (PECAMP 2009), which outlines management measures for three FSAs and many other important marine resources that occur within the traditional reef boundaries of Pere.

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Appendix 10.1 Basic Points to Remember When Preparing and Conducting Interviews and Applying Outcomes for Conservation, Management and Education

1. Preparing for a trip

- Clearly and concisely determine the intention/objective of the interview-based study.
- Obtain necessary permits and establish contacts or community permissions as well as understand local social protocols.
- Conduct meetings or give presentations to collaborators or government officials regarding purpose and relevance of work.
- Conduct background reading to prepare yourself about the fishery and fish species so that you can also provide information on the species to interviewees and assess information quality during interviews. Inform yourself not just of the target species but of aggregating species in general and experiences from overseas with aggregations so you can you provide examples and experiences from elsewhere.
- Learn the local names of the fish if necessary; they can change a lot, even between villages. Names can also refer to species groups and not just species. Note that different names might apply to different life history stages.
- Prepare cards with photos of fish from the area, both live and dead to accommodate different experiences of the species. Include photos from fish not in the area as a control.
- Purchase or prepare good marine maps of the area.
- Careful selection of interviewees, by gear, age group, area, peer review etc., is very important; stratify sampling if possible.
- Need to select appropriate vocabulary – be sure that key words or concepts are clearly conveyed in ways that will be unambiguously understood.

- In many settings providing items such as coffee, cigarettes, batteries or biscuits during the interview is culturally appropriate and helps to break down barriers between the interviewee and interviewer. However, determine whether or not it is appropriate to provide gifts to interviewees in each situation; differences in local practices can mean that giving rewards/incentive is sometimes insulting and sometimes expected. Rewards can show appreciation for time spent but should not be the incentive for the interview. Care is needed.
- Ensure proper dress codes – many communities are traditional and expect certain behaviour, especially by females.
- Carefully select interviewers; they should be knowledgeable about the resource, the fishery and the community, patient, open-minded and communicative. It is very important that interviewers are prepared to discuss their findings to communities, provide useful information to interviewees and gain their respect. Interviewers, ideally, should be knowledgeable on relevant issues internationally, including general matters of fishery management options.
- Consider filming or oral recording interviews, with permission, for later media or educational activities.

2. During a trip

- Make clear to the interviewee what the interview is about, why you are requesting it and what you will do with the information.
- Continually work to establish your own credibility through your knowledge – you will get respect and better responses. It would be useful to be introduced by credible people. Make clear that you respect the knowledge of interviewees
- Use open-ended and semi-structured questions during interviews and while participating in fishing, etc.
- Go fishing when possible with interviewee and inspect fish/catches when possible.
- Prepare a minimum subset of questions that are the most important to conduct: fishers might be tired and not have much time or patience.
- Be courteous and respectful and try to be engaging.
- Focus clearly on one species at a time and confirm species with photos. Always indicate in your notes what information applies to which species.
- Ask about opinions and likely causes of observed trends.
- Decide whether to conduct group or one-on-one interviews.
- Be open-minded and allow time for conversations to go off in multiple directions but also focus on the key questions you intend to cover – this is another reason the interviewer must have a sound knowledge of the subject. Don't dismiss information that sounds unlikely but follow up with further questions.
- Be patient and prepared to be flexible with your travel schedule – i.e. spend extra time in an area if it proves productive, or move on early if necessary and factor in delays.
- Repeat questions in different ways to check reliability of interviewees.

- Use every opportunity to exchange information and discuss interesting aspects of the life history of locally taken species. This is yet another reason for interviewers to be informed and prepared.
- Ask comparative questions, i.e. 'more or less fish than before?' and pick large time periods for temporal comparisons (such as decades). If you ask about proportions or percentages, make sure that this concept is understood.
- It may be necessary to talk about 'maximum' or 'best' catches since average or typical catches may not be well understood or not remembered. Try to quantify catches in kg or whatever is the local measure that is widely used (coolers, fish bundles, etc.), and catch rates in a consistent way. This will allow for a quantification and comparison of results.
- Don't just ask which species spawn and when; interviewees may have no idea about this even if they have seen spawning. Ask instead about the direct and indirect indicators of spawning such as seasonal highs in landings, eggs, concentrations, etc., good and bad seasons for catches. Ask about presence of eggs, moon phase, etc., behavioural or colour changes, etc. Adjust questions according to fishing method.
- Could work closely with local Government/NGOs who will later be involved in management while conducting interviews. Often it is better to not be accompanied by those who usually enforce or get taxes.
- It may be better to leave sensitive issues, like income, out of biological surveys.
- Make a note about possible reliability or otherwise of interviewee.
- Don't assume that everybody can easily read a map or have good recall or follows moon phases.
- Write down notes immediately; also allows for refining and going back to responses before leaving an area. This is especially important if recording interviews.
- Seek opinion about why changes occur if changes are noted.
- Be sensitive about difficulties that might arise due to gender of interviewer/ee.
- Seek to provide immediate feedback to the community and encourage discussion of interview outcomes before leaving the area.

3. Follow up to a trip

- Follow up with any promises made to communities/individuals. People often ask for photos, so be sure to make appropriate arrangements.
- Produce a report that is shared with communities and collaborators, and at least provide a preliminary report before leaving the country or very soon thereafter.
- Give presentations on outcomes of work and indicate how to apply the findings.
- If appropriate, talk about outcomes in various media.
- For non-nationals, be available even having left the country, for providing additional information.
- Follow up with educational materials if necessary.

- Be sure to reflect back to the communities visited, in the appropriate format, the outcomes of the interviews and the broader implications of the study findings. Identify possible studies that are needed to address original objectives or to address fisher concerns or questions identified during the interview process.
- Be sure to respect the information provided; this should not be released into the public domain unnecessarily, especially in the case of site-specific information, and not before the relevant conservation or management has been put in place. However, information will be needed for local planning.

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