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ADVANCING MARINE CONSERVATION

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No. 1

GUIDE TO MONITORING SEAHORSE FISHERIES

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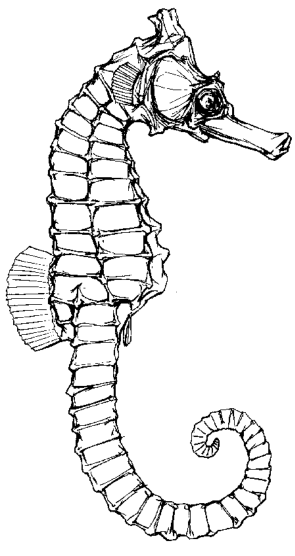

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Table of Contents

PROJECT SEAHORSE TECHNICAL REPORT NO. 1: MONITORING SEAHORSE FISHERIES

1. Introduction

Monitoring is a cornerstone of effective fisheries management. It can provide information on (i) the characteristics of the stock (catch per unit effort, size structure, sex), (ii) temporal and spatial variation in stock characteristics, and (iii) economic value derived by fishers. Moreover, monitoring data are often the inputs for fisheries models and are used to track the outcome of management interventions.

Fisheries monitoring data typically generate estimates of catch per unit effort (CPUE). CPUE is theoretically an index of stock abundance and thus fluctuations in CPUE are assumed to mirror fluctuations in abundance. The degree to which CPUE is in fact an accurate and unbiased index of abundance is, however, unclear and hotly debated (Richards & Schnute 1986, Connell *at al.* 1998). An alternative to relying on CPUE to estimate abundance is to measure abundance directly; underwater visual censuses (UVC) are increasingly popular as a fisheries-independent, direct measure of abundance in tropical inshore fisheries (Samoilys 1997). However, data from UVC can be relatively expensive and time consuming compared to fisheries monitoring data and thus cannot generate the same degree of temporal and spatial resolution.

Ideally, fisheries-dependent (CPUE) and fisheries-independent (UVC) data are both collected within a fisheries monitoring programme. One could combine a limited number of UVC surveys with a more intensive CPUE programme. In this way, the UVC surveys serve as a benchmark, or correction factor for the CPUE data, which in turn provide a more comprehensive picture of the fishery. CPUE data that provide temporal and spatial information are particularly important in tropical fisheries that may be dispersed over a large area, and highly seasonal. Bias in CPUE data is to be expected, but as long as the CPUE data are biased in a consistent manner, they can provide a useful picture of a fishery.

This technical Report outlines a programme for the collection of seahorse fisheries-dependent data. This report includes sections on: (1) variables and methods of their collection (catch calendars and landings data); (2) programme design, incentive programmes and providing feedback to communities; and (3) data encoding and analysis. Appendix 1 provides a general step-by-step outline for designing a catch calendar and landings data programme. Other Project Seahorse Technical Reports should be consulted for UVC methods for assessing seahorse populations and their habitats.

2. Variables and methods of their collection

Seahorse populations can be characterized by the density of individuals (number m^{-2}; hereafter referred to as abundance), size structure (mm), life history stages (adult vs. juvenile), sex ratio, and rate of reproductive activity. In the context of fisheries dependent data, abundance is estimated as CPUE which can be estimated based on numbers (number day^{-1}) or length (mm day^{-1}). Because CPUE varies according to skill of fisher and by gear, fisheries monitoring programmes ideally track the identity of fishers and the gear types used. The other variables are estimated directly from the catch and, if fishing is non-selective, are assumed to represent population characteristics. These data are collected over time and over space; thus date and location of fishing ground must be recorded.

Two complementary methods have been used to collect seahorse fisheries data: daily catch calendars (often called log books) and monitoring landings (also called creel surveys). Catch calendars are generally expected to provide reasonable estimates of catch but poor estimates of effort because they rely on fishers' recall, whereas landings data are expected to provide better estimates of effort and accurate measures of catch because the data are collected by the researcher as the fishers land their catch (Die 1997).

2.1 Catch calendars

The main objective of catch calendars is to generate estimates of daily catch, effort and CPUE. Catch calendars are filled in by fishers on a daily basis and the amount of information collected via catch calendars depends on the programme's goals and the fishers' level of interest and commitment. Typically, as the amount of information requested in the catch calendar increases, fewer fishers may participate or fishers may not complete the calendars on a daily basis. In the event that more information is required, the individual managing the catch calendar programme will need to spend more time with fishers, ensuring their complete participation. This may include establishing an incentive programme (see below).

There is a minimum set of variables that must be collected in a catch calendar programme as well as other variables that are optional (Table 1). Depending on the goals of the data collection, some subset of the "optional" variables will be included in the catch calendars.

Table 1. Mandatory and optional variables collected in a catch calendar programme. The list is organized to indicate the mandatory information required on a daily basis, with additional corresponding variables that would provide greater information.

Mandatory	Optional
Fisher's name	
Date	
Went fishing (yes/no)?	
Hours fished	Time start/finish fishing, travel time
Location	
Seahorses targeted (yes/no)?	
Number of seahorses caught	Sizes (large/small) of seahorses caught, weight of catch
	Price received for seahorses (large & small)
Other catch targeted? (e.g. fish, sea-cucumbers, abalone)	Weight (kg); price received for catch; proportion sold / home consumption
	Depth (particularly for surface-supply divers)

CPUE varies temporally, spatially, by fisher and by gear. Thus, the choice of fishers and their consistent participation during the year is important. In target fisheries such as in the Philippines, individual fisher's skill and motivation will be important. Thus, participating fishers should represent a range of experience, age and marital status; if variation in gear exists, representatives of all gear types should be included. The total number of fishers required per experience category and gear type will depend on how much variation there is in CPUE among fishers. We would recommend a minimum of five fishers per category. Fishers participating in catch calendars should complete catch calendars throughout the year to determine seasonal patterns. Once these have been established, temporally stratified sampling may be done to reduce the collection of data.

2.2 Landings data

The main objectives of collection of landings data are to record characteristics of the catch that are unlikely to be collected via catch calendars, and to collect corroborative catch and effort data. Characteristics of the catch include: size (to determine population size structure), life history stage (adult vs. juvenile), sex (from which sex ratio is determined) and reproductive state. Seahorses are unusual in that all of these characteristics can be observed externally, unlike most other fishes where sex and reproductive state can only be determined by dissection. Researchers should refer to Lourie *et al*. (1999) and other Project Seahorse Technical Reports for details on measuring these variables. Landings data may be collected daily, to match fishers' daily catch calendars. However, they are much more labour intensive and are therefore unlikely to replicate catch calendars at the same spatial and temporal scales. Instead, landings data can be collected weekly, bimonthly or monthly, as representative of the catch calendars averaged over that period of time. The frequency of landings data collection will depend on the goals of the study and the scale of temporal variation in these characteristics. Landings data can also be collected on two levels: (1) a random sample of the combined landings of all the fishers for a particular date / time period (= pooled data, Table 2); or (2) landings data attributed to a specific fisher, fishing ground and date (= individual data, Table 2). Pooled data may often be collected from a central buyer (thus price *paid*), whereas individual data would be collected from the fisher (thus price *received*, Table 2). When collecting pooled data from a buyer, a sub sample of individuals should be randomly selected from the stock. We recommend measuring approximately 100 individuals per month as this allows calculation of proportions with respect to life history stage and reproductive state. Smaller sample sizes result in more discontinuous proportions. When collecting individual data, we recommend measuring the entire catch of each fisher if less than 20 individuals, and randomly sampling a subset if the total is greater than 20 individuals per fisher. A minimum of 8 fishers' catches should be measured monthly.

Table 2. Variables collected in a catch landings programme, using either "pooled" or "individual" data (see text).

Pooled	Individual
	Fisher's name
Date (time period sample represents)	Date
	Location
Sample size (n)	Sample size (n)
For each seahorse, measure:	For each seahorse, measure:
· Standard length (mm)	· Standard length (mm)
· Life history stage: adult (A) or juvenile (J)	· Life history stage: adult (A) or juvenile (J)
· Sex: female (F) or male (M)	· Sex: female (F) or male (M)
· Reproductive state	· Reproductive state
Price paid per seahorse	Price received per seahorse

2.3 Incentive programmes and data feedback to fishers

The monitoring programme design will depend on both the goals of the programme and the characteristics of the communities involved. The degree to which fishers share information among themselves and the degree to which they are willing to share information with "outsiders" is essential to both determining the goals and designing the programme. For example, in the Visayas, Philippines, fishers appear to freely share information on fishing grounds among themselves and with biologists (Vincent & Pajaro 1997). Thus incorrect catch calendars are more likely to represent forgetfulness or desire for incentives rather than deliberate misinformation to hide knowledge. Moreover, providing feedback to communities in group sessions (Meeuwig *at al.* 2002) in which information is shared and cross validated (see below) is possible. Alternatively, in communities where information in not shared, greater attention may have to be placed on the selection of reliable participants and feedback programmes may have to be adapted to protect property rights (e.g. excluding fishing ground locations). In all programmes, local partners are essential to establish and maintain monitoring programmes and to ensure that the cultural context is respected.

Fisher participation in monitoring may require an incentive programme. Ideally, fishers participate as an in-kind contribution to the management of their resources. However, incentives may be required in order to ensure consistent participation throughout the year and completion of calendars. Such programmes may be particularly important where monitoring continues for many years. There are a number of options:

1. Individual subsidies – each participating fisher receives a small incentive for each month's calendar. Such monthly incentives could be in the form of rice or other food items. Alternatively, each fisher receives a bi-annual incentive for full completion of 6 months of calendars. This incentive could be in the form of school supplies, a cap or household items.
2. Lottery programme – each participating fisher receives a lottery ticket for each completed calendar. Winning tickets are then pulled quarterly or semi-annually with prizes for first, second and third.

While incentive programmes may be necessary, they may cause several problems. First, incentives erode fishers' sense of responsibility for co-management. Second, an incentive programme adds cost to the monitoring programme. Third, a permanent incentive programme is unlikely, thus fisheries monitoring is likely to end with the termination of an incentive programme. Fourth, fishers may fill out the catch calendars erroneously to ensure that they are eligible for incentives.

Providing feedback of information collected through catch calendars and landings monitoring to fishers is essential. The long-term sustainability of fisheries requires that fishers are co-managers of their resources rather than simply providers of information. Such a role requires that fishers be fully informed. This is particularly the case for small-scale, subsistence tropical fisheries that rely on local management. Providing feedback is one tool to enhance participation and exchange. Participatory approaches to marine resource management are widely used in the Philippines (Walters *at al.* 1998, White & Vogt 2000, Meeuwig *at al*. 2002); therefore fishing communities in this country will expect and readily engage in feedback sessions. The Philippines therefore provides a rich source of examples for designing feedback sessions. These sessions must be tailored to the community and monitoring programme, and will have to be modified in communities where fishers share less information. Basic principals of feedback session include:

1. Fisheries data are shared with fishers / community in a popular format that is easily understood by participants. This should include graphics, maps and other easily digested formats.
2. Fishers are invited to validate information (e.g. names of fishing grounds, seasonal patterns in landings) as well as share other local knowledge.
3. Fishers and managers discuss possible management interventions based on the shared information.

Feedback to the fishers has the additional advantage of encouraging cross-validation of information collected in the catch calendars. Reported data can be cross-checked by groups of fishers. Moreover, the knowledge that other fishers will cross-validate the data may encourage fishers to answer correctly.

3. Data management, encoding and analysis

Seahorse fisheries monitoring data collected using the above protocol will exist as two complementary data sets: catch calendar data and landings data. The following steps are recommended for managing catch calendar and landings data:

1. Catch calendars are collected monthly from fishers, at which time calendars for the next month are distributed. Mid-month visits are likely to be necessary to check on the data recording. Fishers should be queried on any records that are unclear.
2. For both catch calendars and landings data, originals calendars and data sheets are photocopied and originals are stored at a central data repository (see Data Management Technical Report).
3. Data are encoded onto computer from the data sheet copies. Archival backup CDs or zip disk copies are made of the raw databases and stored at the central data repository (see Data Management Technical Report). Data sheet copies are stored separately.
4. Data encoding can be done easily in a spreadsheet programme such as Excel, though a relational database such as Access is recommended. Appendix 2 provides a suggested format for database design.

A number of questions can be tested statistically using seahorse fisheries monitoring data. The primary questions are whether the variables collected (CPUE, size, life history state, sex, and reproductive state) vary by year (if multiple years data exist), season, lunar phase, fishing ground, fisher and gear type. Typically, a combination of ANOVA for categorical independent variables such as year, fishing ground, fisher and gear; regression for continuous independent variables such as months and lunar phase; and ANCOVA for combinations of categorical and continuous independent variables may be used (Zar 1999). Table 3 indicates the appropriate tests for standard questions (see Vincent *at al.* in prep.) Additionally, longer term, intensively collected fisheries data can be used as input for fisheries models. Such models provide estimates of key fisheries parameters such as growth rate (k), length at infinity (L_∞), and fishing and natural mortality (F, Z). Standard fisheries texts should be consulted for these approaches.

Table 3. Recommended analyses for catch calendar and landings data, indicating the variable, the time scale(s) over which mean values are calculated, the units, and possible transformations. Possible analyses are indicated for the following effects: Year, Season (month), lunar phase (day), Fishing ground, fisher and gear. If effects are combined, use multi-way ANOVA if all effects are analyzed by ANOVA (e.g. they are all categorical variables), and ANCOVA for combinations of variables analyzed by ANOVA (categorical variables). Periodic regression (deBruyn & Meeuwig, 2001) or time series analysis (Batschelet 1981**)** can be used for continuous, circular variables such as lunar phase. For variables for which units are expressed as a percentage, it is possible to use χ^2 goodness of fit and contingency tests to test whether observed ratios match expected ratios or are consistent across "effects". However, where many levels exist for an effect (e.g. fishing ground), it may be preferable to use ANOVA if the data can be appropriately transformed.

Variable	Mean by:	Units	Transform	Year	Season (month)	Lunar Phase (day)	Fishing Ground	Fisher	Gear
CPUE-n	Day, month	SH/day	log, arcsin	ANOVA	Periodic Regression	Periodic Regression	ANOVA	ANOVA	ANOVA
CPUE-l	Day, month	mm/day	log	ANOVA	Periodic Regression	Periodic Regression	ANOVA	ANOVA	ANOVA
Size	Day, month	mm	log	ANOVA	Periodic Regression	Periodic Regression	ANOVA	ANOVA	ANOVA
LH	Month	%Adults	log, arcsin	ANOVA	Periodic Regression	-	ANOVA	ANOVA	ANOVA
LH	Month	counts	none	χ^2	χ^2	-	-	-	-
Sex	Month	%Males	log, arcsin	ANOVA	Periodic Regression	-	ANOVA	ANOVA	ANOVA
Sex	Month	counts	none	χ^2	χ^2	-	-	-	-
RS	Month	%Pregnant	log, arcsin	ANOVA	Periodic Regression	-	ANOVA	ANOVA	ANOVA
RS	Month	counts	none	χ^2	χ^2	-	-	-	-

4. Conclusion

Catch calendars and landings data provide essential information for fisheries management for both industrial and subsistence fisheries. Fishers are central stakeholders in marine resource management and thus need to be involved, both with respect to information provision and management decisions. Voluntary or incentive based programmes such as catch calendars and landings monitoring are a cost-effective approach to both collect information and enhance participation in resource management.

5. Literature cited

Batschelet, E. (1981). *Circular Statistics in Biology*. New York: Academic Press.

Connell, S.D., Samoilys, M.A., Lincoln Smith, M.P. & Leqata J. (1998). Comparisons of abundance of coral reef fish: catch and effort surveys versus visual census. *Aust. J. Ecol.* **23:** 579-586.

deBruyn, A.M.H. & Meeuwig, J.J. (2001). Detecting lunar cycles in marine ecology: periodic regression versus categorical ANOVA. *Mar. Ecol. Prog. Ser.* **214:** 307- 310.

Die, B. (1997). Fishery (CPUE) Surveys. In: Samoilys, M.A. (ed.) *Manual for Assessing Fish Stocks on Pacific Coral Reefs*. Brisbane: Queensland Department of Primary Industries.

Lourie, S.A., Vincent, A.C.J. & Hall, H.J. (1999). *Seahorses: An identification guide to the world's species and their conservation*. London: Project Seahorse.

Meeuwig, J.J., Samoilys, M.A., Erediano, J. & Hall, H.J. (2002). Fishers' perceptions of the seahorse fishery in central Philippines: interactive approaches and an evaluation of results. *Proc. Putting Fishers' Knowledge to Work Conf., Fisheries Centre, University of British Columbia, Aug 2001*.

Richards, L.J. & Schnute, J.T. (1986). An experimental and statistical approach to the question: Is CPUE an index of abundance? *Can. J. Fish. Aquat. Sci.* **43:** 1214-1227.

Samoilys, M.A.(ed.) (1997). *Manual for Assessing Fish Stocks on Pacific Coral Reefs*. Queensland Department of Primary Industries, Brisbane.

Vincent, A.C.J. & Pajaro, M.G. (1997). Community-based management for a seahorse fishery. In: Hancock, D.A., Smith, D.C., Grant, A. & Beumer, J.P. (eds.) *Proc. World Fisheries Congress, Brisbane, 1996:* 761-766.

Vincent, A.C.J., Meeuwig, J.J., Pajaro, M.G. & Perante, N. (in prep.). Seahorse catches in the central Philippines: characteristics and conservation implications.

Walters, J.S., Maragos, J., Siar, S. & White, A.T. (1998). *Participatory Coastal Resource Assessment: A Handbook for Community Workers and Coastal Resource Managers*. Cebu City, Philippines: Coastal Resource Management Project & Silliman University.

White, A.T. & Vogt, H.P. (2000). Philippine coral reefs under threat: lessons learned after 25 years of community-based reef conservation. *Mar. Poll. Bull.* **40:** 537-550.

Zar, J.H. (1999). *Biostatistical Analysis*, 4th edn. New Jersey: Prentice-Hall International Inc.

Appendix 1. Steps for catch calendar and landings data programme

1. Identify in-country / local partner and establish collaboration / partnership.
2. Identify information needs for programme in consultation with relevant stakeholders and authorities.
3. Develop preliminary design for catch calendar and landings programme with relevant stakeholders and authorities, including calendars, incentive and feedback components.
4. Develop selection criteria for fishing communities and fishers with relevant stakeholders and authorities.
5. Identify potential fishing communities.
6. Visit communities and initiate discussions with local leaders and fishers to assess the appropriateness of programme, their interest in it, and the appropriateness of the community.
7. Revise programme design based on information from community meetings
8. Implement 3 month trial programme including fisher selection, possible incentive programme, catch calendars and landings collection and feedback in one community.
9. Revise programme if necessary and conduct a minimum of 12 month programme in desired number of communities. Annual programme should include monthly visits to communities to maintain communication, encourage participation and collect and disseminate calendars, and bi-annual or annual feedback sessions.
10. Maintain good communication with fishers and local leaders to assess programme success.

Appendix 2. Suggested data format.

The following is a list of column headings for a data sheet; see example table below (Table 4):

1. Code: A sequential number starting at 1 that provides a unique identifier for each data line in the order that they are entered. The sequential code allows for reconstructing the order following subsequent data sorting.
2. Date: If Excel is used Year, Month, and Day must be entered in separate columns to identify date; months range from 1-12, day from 1-31, sequentially. If Access is used, the Date/Time field type is used.
3. Fisher: Identifies the fisher who completed the catch calendar.
4. Location: Name of fishing ground; n.f. indicates fisher did not go fishing that night.
5. Target: “n” indicates seahorses were not targeted that night; “y” indicates seahorses were the primary target.
6. #SH-sm, #SH-lg: the number of small and large seahorses caught. Note, some seahorses may be caught even when they are not the primary target.
7. Price-sm, Price-lg: the total amount in local currency received by the fisher for his seahorse catch. In this example, small seahorses are valued at approximately 6PP each while large seahorses are valued at 8PP each.
8. Other catch: indicates the primary target (if target=n) or the other major catch of the night.
9. OC-kg: the weight of the other catch.

Table 4. Example of Excel data sheet for catch calendar data.

Code	Year	Month	Day	Fisher	Location	Target	# SH-sm	# SH-lg	Price-sm	Price-lg	Other catch	OC-kg
1	1999	1	1	Julio SantaCruz	Gauss	n	2	0	12	0	Seacucum.	2
2	1999	1	2	Julio SantaCruz	Putik	y	4	2	24	16	Fish	2.5
3	1999	1	3	Julio SantaCruz	n.f.							
4	1999	1	4	Julio SantaCruz	Putik	y	3	4	18	30	Fish	3
31	1999	1	4	Julio SantaCruz	Putik	n	0	0	0	0	Seacucum.	2.5
32	1999	1	1	Bobby Velasco	Jagoliao	y	5	2	30	16	Fish	3.5
33	1999	1	2	Bobby Velasco	Putik	y	7	1	42	8	Squid	1