Editorial

This *Aquabyte* section has a more Asian content than the recent issues that have contained much on new directions in African aquaculture research and development. It is worth remembering that aquaculture remains underdeveloped in *all* tropical and subtropical developing regions and that many countries have common problems in initiating and expanding its adoption. Hence the article here on choice of species, by Chris Mathews and M. Samuel, is very welcome. More contributions on methods and guidelines for addressing common problems would be most welcome.

The NTAS secretariat has sent out a questionnaire to 579 members in 87 countries, soliciting views on the network and *Aquabyte*, etc. So far, replies have been received from less than 200 members. If you have received a questionnaire and have not yet returned it, please do so quickly so that we can analyze the returns and report on this in *Aquabyte* as soon as possible. Some responses have been very helpful and have shown that members have given a lot of thought to the future of the NTAS and *Aquabyte*. The letter from Ronald Jones (see p. 30) is a good example. One clear need is already emerging - we will need to publish a directory of NTAS members and their interests. The NTAS continues to grow and total membership now stands at 600. ***R.S.V. Pullin***

A Simple and Objective Bioeconomic Index for Choosing Species for Culture

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Mathews and Samuel (1990) recently applied a growth performance index proposed by D. Pauly on data from Kuwait. The index they used was $\phi' = \log_{10}K + 2\log_{10}L_\infty$, where L_∞ and K are parameters of the von Bertalanffy growth equation (Pauly 1991). They determined values of ϕ' for 10 different stocks and showed that high values occurred for stocks finally chosen for pilot or semi-commercial aquaculture. They also referred to some of the relevant literature on this subject which confirmed that ϕ' can be used to compare growth performances of wild and cultured stocks of fish, and that it is the most flexible and precise index of growth performance so far proposed.

Mathews and Samuel (1990) also noted that ϕ' is only useful for determining the contribution of growth, which is only one of several inputs relevant for choosing fish for culture. They showed that other factors could also be of decisive importance: the value of the fish and its popularity, i.e., its appeal to the consumers as well as biological characteristics such as a tendency to be cannibalistic or sensitive to handling. Biological characteristics can be determined experimentally, but popular taste and general appeal can only be estimated by scrutiny of fish prices. It is therefore proposed that a bioeconomic culture index can be used to assist in choosing fish for culture. The proposed culture index (CI'), is defined as follows:

$$CI' = \phi' \cdot P \qquad ...1)$$

where P is the mean annual price. Either wholesale or retail prices can be used, and any currency can be used in principle. Nevertheless, it will be helpful if some degree of standardization is established to facilitate international comparisons; furthermore, where the proposed culture index is to be used to compare the relative advantages of very different organisms, it is necessary to provide a standardized biological definition. Therefore it is proposed that:

(i) values of L_∞ and K be determined using total length in centimeters (cmTL) measured to the nearest 0.1 cm; and
(ii) prices be defined as mean annual wholesale or retail prices (to be specified in any publication) in US$/kg fresh, total weight.

This definition has the following advantages:

(i) total length is easy to measure with precision;
(ii) total length is recognized more easily than fork length or standard length by the nonscientist;
(iii) total fresh weight is easy to estimate;
(iv) total fresh weight is likely to be more recognizable to the layperson; and
(v) the US$ is the most widely recognized international currency.

Moreau et al. (1986) have defined four growth performance indices, including ϕ'. They defined the index $\phi = \log_{10}K$

+ $(2/3)\text{Log}_{10}W_\infty$ where W_∞ is the asymptotic size of the fish population in terms of weight. They also showed that the index ϕ, although less robust than ϕ', has the advantage that it estimates the growth performance in terms of weight; ϕ' on the other hand, while more robust, does so in terms of length. Because weight (e.g., W_∞) is usually more interesting than length (e.g., L_∞) for comparing species for aquaculture purposes, it was thought appropriate to provide a second index CI calculated in the same way as CI', using ϕ instead of ϕ':

$$CI = \phi \cdot P \qquad ...2)$$

This index would have the advantage of eliminating biases that may arise from comparing data from species of fish with very different shapes (e.g., eels, sunfish), and similar biases that may be caused by comparing, for instance, growth performance and culture indices for fish and crustacean populations. Use of CI instead of CI' should produce a more robust index, and be of more interest to aquaculturists.

The values of L_∞, K and ϕ' for some Kuwaiti fish stocks are provided by Mathews and Samuel (1990); prices are provided as weighted annual mean retail values in the Kuwaiti fish markets for 1983, converted to US$ at the October 1984 exchange rate (Mathews 1987). The value for ϕ was calculated from ϕ' using the equation of Moreau et al. (1987):

$$\phi = \phi' + (2/3)\text{Log}_{10}a \qquad ...3)$$

where a is defined in the well-known length-weight equation:

$$TW = a(TL)^b \qquad ...4)$$

in which a and b are constants. TW is fresh total weight in grams (g) and TL is total length in cm (cmTL).

Table 1 summarizes data on L_∞ and K for male *Penaeus semisulcatus* from Mathews (1987), obtained by fitting ELEFAN to monthly size-frequency samples over six years. Values of L_∞ for shrimp were converted from mmCL (millimeter carapace length) to cmTL using morphometric equations provided by Farmer (1986). Values of ϕ' cover a very small range, about 2.4% of the mean; this range compares favorably with the values of about 4% obtained for ϕ' in fish, based on rather smaller samples of known length at age (Mathews and Samuel 1990). The range shown in Table 1 for ϕ is also very similar (1.8%). Estimates of ϕ' (and ϕ) for shrimp, obtained by applying ELEFAN to large length-frequency samples, provide a stable estimate of the growth performance for shrimp populations.

Table 1. Growth parameters and values of ϕ' and ϕ for *Penaeus semisulcatus* from Kuwait (Mathews 1987). L_∞ in cmTL.

Year	L_∞	K	ϕ'	ϕ
1979	17.65	1.00	2.493	1.09
1980	17.65	0.95	2.471	1.07
1981	16.91	1.05	2.471	1.08
1982	17.65	0.95	2.471	1.07
1983	18.39	1.00	2.529	1.09
1984	17.65	1.00	2.493	1.08
Mean	17.65	0.99	2.490	1.09
Range	16.9-18.4	0.95-1.05	2.471-2.529	1.07-1.09
%	9.5	9.5	2.2	1.8

Table 2 summarizes available data on L_∞, K, ϕ', a and ϕ and the proposed culture indices CI' and CI for some of Kuwait's commercially important populations. Values of a for fish were obtained from Mathews (1992) and for shrimp from Farmer (1986), except for *P. semisulcatus* for which no total* length/weight relationship is available so that a value of a=0.0080 was assumed (Pauly et al. 1984).

Using CI', the most suitable species for aquaculture was *Acanthopagrus cuvieri*, with a very much higher CI' than the next species *A. latus*. Three species followed with very close values of CI': *Epinephelus suilis* had the highest index with a similar value of CI' to that

* *Farmer (1986) recorded total length as total body length, i.e., the distance from the rear edge of the orbit to the tip of the telson. Several other measurements are used in crustaceans and need to be identified carefully in each case. Of these, total body length is probably most closely analogous to total length in fish, and should be used in estimating ϕ', ϕ, CI' and CI.*

Table 2. Estimates of growth parameters ϕ' and ϕ of the culture indices CI' and CI, for some of Kuwait's commercially important populations. L_∞ in cmTL; retail price in US$/kg fresh, total weight; a is a constant defined in the length-weight equation (see text).

Species	L_∞	K	ϕ'	a	ϕ	Price	CI'	CI
Acanthopagrus cuvieri	81.86	0.278	3.269	0.0160	1.979	6.27	20.50	12.41
A. latus	44.26	0.227	2.635	0.0287	1.607	5.24	13.81	8.42
Epinephelus suilis	93.07	0.165	3.132	0.0140	1.896	4.09	12.81	7.75
Otolithes argenteus	69.60	0.505	3.830	0.0100	2.497	3.63	12.26	9.06
Pomadasys argenteus	66.00	0.238	3.016	0.0424	2.101	3.62	10.47	7.61
Penaeus semisulcatus	17.70	0.990	2.490	0.0080	1.092	3.62	8.61	3.95
						4.52	10.74	4.94
						8.10	9.26	8.85
Lutjanus malabaricus	68.90	0.358	3.260	0.0200	2.127	1.51	4.92	3.21
Metapenaeus affinis	12.90	1.140	2.271	0.0235	1.185	1.63	3.70	1.93
						2.72	6.15	3.22
Parapanaeopsis stylifera	10.10	1.230	2.100	0.0356	1.134	1.63	3.42	1.84
						2.72	5.71	3.08

of *A. latus* which, however has a much lower value of ϕ'. The much higher price of *A. latus* increases the CI' markedly in comparison to ϕ'. The value of CI' for *Otolithes argenteus* is very close to the CI' for *E. suilis* which has a rather lower value of ϕ' and a rather higher mean price. Shrimp prices vary with size and market. The low value of ϕ' for *P. semisulcatus* corresponds to low prices of small summer shrimp and the high value to that of very large, old, winter shrimp; the intermediate value corresponds to the mean annual average price of whole fresh shrimp, used by Hopkins et al. (1984), and is probably the best estimate of CI' for shrimp to be sold in the local market.

Values of CI show essentially the same result as values of CI', except that the *O. argenteus* is second and is followed by *A. latus* and *E. suilis*: these three species have similar values of CI (just as they do for CI'). *O. argenteus*, with the second highest CI and the fourth highest CI', is a very popular fish in Kuwait and its culture was considered very seriously: it had to be abandoned on account of the highly cannibalistic nature of the young juveniles (Mathews and Samuel 1990). A high priority for this species was suggested by both CI' and CI.

It is clear from Table 2 that the species finally chosen for culture (*A. cuvieri* and *E. suilis*) were those that the culture index (either CI or CI') would have identified had it then been available; the two *Acanthopagrus* spp. are very similar and market demand can be met by *A. cuvieri* which has much higher values of CI', ϕ' and CI. Excepting *P. semisulcatus*, all the shrimp species studied showed rather low values of CI and CI' and shrimp culture was ultimately abandoned in Kuwait. Only culture for export would have been justified and higher priority was given to culture for the local market. Other species (*O. argenteus, Pomadasys argenteus*) were not chosen because of technical difficulties in culturing; they are voracious and cannibalistic.

Lutjanus malabaricus (often called *L. coccineus*) has a very low CI and CI' values, falling in the range of the values for *Metapenaeus affinis*, in spite of having very high ϕ' and ϕ values. Snappers are regarded as third class fish in Kuwait.

It is also interesting that the more highly priced finfish have nearly the same price as large shrimps produced for export, and are more highly priced in the local market than shrimp. Finfish are relatively very highly priced in Kuwait and this motivated the choice of finfish instead of shrimp for culture purposes.

For the reasons given above, CI will usually be preferred to CI'. Nevertheless, there are currently some difficulties in obtaining the parameters needed to estimate ϕ, and therefore CI, for many species of crustaceans and for most or all species of molluscs. Lengths for prawns are usually recorded in mmCL and often, data are not available on the relation between body length and total weight. Various kinds of body lengths are also used and these are not always properly distinguished in the literature; yet their indiscriminate use may introduce biases into the values of CI. Therefore, adjustments described above for calculating ϕ and CI are not always easy to make.

Until these practical difficulties have been overcome as they will be with the increasing development of FISHBASE (Froese 1990; Palomares et al. 1991), CI' may often be the preferred index. For example, Mathews and Ng (in preparation) have used CI' to compare the choices made for culturing fish, shrimp and molluscs in Malaysia using CI' because of the absence of many of the length/weight relations needed to estimate CI. Eventually, however, CI may be expected to replace CI' as the more convenient culture index.

The proposed culture indices (CI and CI') both give realistic output for Kuwait's commercially important fish species, and allow comparison and evaluation of different taxa with widely differing biological and economic characteristics. The Kuwaiti experience is relevant as a learning tool for other countries which may need to choose species for culture, and which may not choose, or be able, to invest large amounts of money in screening species for several years, as was done in Kuwait. The proposed culture indices may therefore be useful to research managers in making their choices in other environments.

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