A general approach to length-weight relationships for New Caledonian lagoon fishes

by

Michel KULBICKI (1, 2), Nicolas GUILLEMOT (2) & Marion AMAND (2)

ABSTRACT. - Most studies involving Pacific reef fishes use underwater visual censusing techniques to estimate their biomass and stock. This requires to know the length-weight relationships of all the species censused. Currently, only a small proportion of these relationships (15.4%) are available for reef fish species in the Pacific area. In the present article we propose length-weight relationships at four organisation levels: species, genera, families and morphological groups. A data base of 53,800 specimens belonging to 788 species from New Caledonia were used to estimate the relationships for 396 species, 185 genera, 75 families. At the genus level, the length-weight relationships cover 76% of the Pacific reef species and the coverage is nearly 85% at the family level. A study of the morphology of 1,100 specimens belonging to 311 species allowed to define 30 morphological groups, for which length-weight relationships were then estimated using 32,551 specimens belonging to these species. Using 3 classes of body thickness, a second clustering of these species defined 20 groups allowing length-weight relationships to be estimated from 2D pictures. These relationships allow to estimate weight from length data for most of the species not covered by the relationships at the species, genus or family level. The error levels increase from the species (average error 9.4%) to the family level (13.5%), the morphological groups yielding errors equivalent to those from the family level equations (13.2%). A graphical analysis of the coefficients from 396 length-weight relationships suggests that there are physical limits to fish shapes.

RÉSUMÉ. - Approche généralisée des relations longueur-poids des poissons lagonaires de Nouvelle-Calédonie.

La plupart des études visant à estimer la biomasse ou les stocks de poissons récifaux de l'Indo-Pacifique utilisent des méthodes de recensement visuel en plongée. Cela exige de connaître les relations longueur-poids de toutes les espèces recensées. À l'heure actuelle, seule une faible proportion de ces relations (15,4%) est disponible pour les espèces récifales du Pacifique. Notre article fournit des relations longueur-poids à quatre niveaux d'organisation : espèces, genres, familles et groupes morphométriques. Une base de données comportant 53800 poissons appartenant à 788 espèces de Nouvelle-Calédonie a été utilisée pour estimer les relations pour 396 espèces, 185 genres et 75 familles. Les relations longueur-poids au niveau générique couvrent 76% des espèces récifales du Pacifique et au niveau familial la couverture atteint 85%. Une étude sur la morphologie de 1100 spécimens appartenant à 311 espèces a permis de définir 30 groupes morphométriques pour lesquels des relations longueur-poids ont été estimées sur la base de 32551 spécimens appartenant à ces espèces. Une seconde classification de ces espèces fondée sur 3 classes d'épaisseur du corps permet de définir 20 groupes à partir desquels les relations longueur-poids peuvent être estimées en utilisant des images 2D. Ces relations permettent d'estimer le poids à partir de données de longueur pour la plupart des espèces pour lesquelles on ne dispose pas de relation au niveau espèce, genre ou famille. Les niveaux d'erreur augmentent de l'espèce (erreur moyenne 9,4%) jusqu'à la famille (13,5%), les groupes morphométriques comportant un niveau moyen d'erreur équivalent à celui de la famille (13,2%). L'analyse graphique des coefficients des relations longueur-poids de 396 espèces suggère qu'il existe des limites physiques aux formes que peuvent prendre les poissons.

Key words. - Reef fish - New Caledonia - Lagoon - Length-weight relationships - Morphology.

Our current knowledge on the biological traits of Indo-Pacific shore fishes is still very limited. In particular, length-weight relationships are only known for a restricted number of species. There are 5,480 taxa of inshore fishes reported so far from the tropical Pacific (Kulbicki *et al*., 2004), but we have length-weight relationships for only 720 of them, i.e. 13% (the main source is Fishbase: Froese and Pauly, 2001; see also Kulbicki *et al*., 1993; Yanagawa, 1994; Kochzius, 1997; Arias-Gonzales *et al*., 1997, 1998; Letourneur *et al*., 1998; Gonzales *et al*., 2000; Khaironizam and Norma-Rashid, 2002). These values increase only slightly (15.4%) if the search is restricted to reef associated species (excluding the smallest Gobiidae and Trypterygiidae: 3,580 taxa and 553 relationships).

Length-weight relationships have many applications in fish stock assessments and ecological studies. They are of special interest for underwater visual censuses (UVC), in order to transform length data into weight data and, as a result, obtain biomass estimates (Samoilys, 1997). Most UVC surveys are performed on reefs by divers who record visual estimates of fish length. The use of video recordings is on the increase but still marginal. The accuracy of length estimates by divers has been the subject of many studies (e.g., Bell *et al*., 1985; Bellwood and Alcala, 1988; Kulbicki,

(1) École Pratique des Hautes Études, Université de Perpignan, Avenue de Villeneuve, 66860 Perpignan CEDEX, FRANCE. [michel.kulbicki@univ-perp.fr]

(2) Centre IRD, BP A5, 98848 Nouméa CEDEX, NOUVELLE-CALÉDONIE.

1990, 1997; Darwall and Dulvy, 1996), errors having potentially important consequences on biomass estimates as indicated by Bellwood and Alcala (1988). The precision of these length estimates varies according to authors, the most reliable study (Harvey *et al*., 2001, 2002) indicating a precision of 8-16% by divers and < 1% by video cameras for a range of three species.

Biomass estimates for reef fish based on length estimates from UVC work are confronted with the problem of the absence of validated length-weight relationships for a large number of species. So far, there is no standardised procedure to attribute a length-weight relationship to a species for which it is lacking. Most authors use the relationship from a species within the genus or the family of the species of interest. At times they also use relationships from species, which have a similar morphology. However, no author follows an explicit protocol. It is difficult to assess the errors on biomass that these procedures will produce. One possible way to consider this problem would be to use length-weight relationships at the genus or family level. Unfortunately, few of these relationships are available because most studies give length-weight relationships only at the species level, and only a few (Bauchot and Bauchot, 1978) indicate relationships at a higher taxonomic level (genus or family). Averaging the values of the regression coefficients of length-weight relationships in order to obtain an average relationship for a genus or a family is statistically erroneous. It is, therefore, necessary to estimate these relationships at the genus or family level by considering the initial data on individuals. Unfortunately, this initial data is not available from the literature.

In the present article, we propose to create classes of fish inside which length-weight relationships are homogenous. Two ways of classification have been considered: according to phylogenic criteria and according to morphological criteria. Such a choice has led to four levels of classification: by species, genera, families or by general morphological characteristics. Our purpose is to enable users to find the best length-weight relationship for any species, for which no validated relationship is available. The three first groups are based on taxonomic relationships because most species within a genus or a family tend to have similar shapes. Unfortunately, there are a number of exceptions to this trend and the data we have available do not cover all families or genera. We propose to use the morphological characteristics of a large number of species to define morphological groups, to which almost all Pacific reef species could be related. To achieve this goal the following steps are taken: (1) estimate species specific length-weight relationships, (2) estimate genus and family specific length-weight relationships, (3) explore the physical limits of these relationships, (4) identify discrete morphological groups using multivariate analysis, and (5) estimate the length-weight relationships for each morphological group.

MATERIALS AND METHODS

Morphological parameters

In order to group fish according to their morphology, weight and various morphological measures were taken on each fish specimen, as described on figure 1. This was done on a total of 1,100 fish, representing 311 species, 138 genera and 53 families. Fishes were caught by different methods: rotenone poisoning, spear-fishing, hand-line and gillnet. The sampling was operated from July to September 2003, on various sites and thus various biotopes in the south-eastern lagoon of New Caledonia. Neither geographical nor time influence was taken into consideration. Two to 8 specimens were used for each species. This low number of specimens per species is because morphometric measurements are at the basis of fish taxonomy and are very stable between individuals, as attested by the high correlations between them (e.g., Loubens, 1980).

Several measurements were performed on each fish: CH (Caudal Height), FL (Fork Length), SL (Standard Length), HL (Head Length), H33 (Height at the first third -based on FL- of body, starting from the tail), Hmax (Maximum Height), HH (Head Height), and T (Width or body thickness) (Fig. 1). Species were grouped using the statistical Ward's method, with Euclidian distances, based on the following ratios: SL/Hmax, SL/H33, SL/HT, T/H33, T/HH, T/Hmax, SL/T, SL/FL, SL/CH. The ratios were standardised amongst all species using SL as the common measurement. A second cluster analysis was similarly conducted by using 3 classes of thickness instead of a continuous variable for body thickness (T).

Length-weight relationships

In addition to the fish sampled for their morphology, data

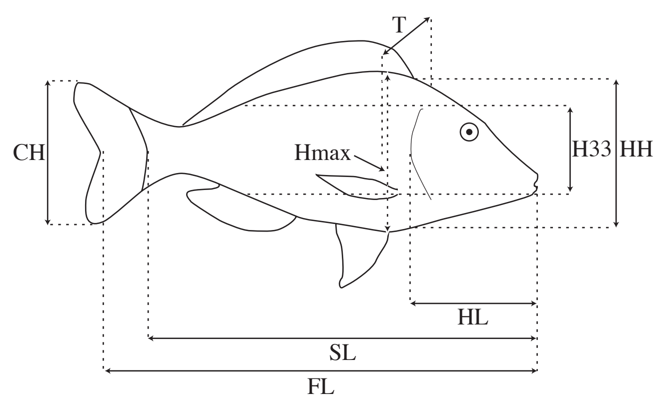

Figure 1. - Measurements performed on each fish. CH: Caudal fin Height; FL: Fork Length; SL: Standard Length; HL: Head Length; H33: Height at the first third (based on FL) of body (starting from the tail); Hmax: Maximum Height; HH: Head Height; T: Width or body thickness. *[Mesures réalisées sur chaque poisson : CH : hauteur de la caudale ; FL : longueur à la fourche ; SL : longueur standard ; HL : longueur de la tête ; H33 : hauteur au premier tiers du corps (en partant de la queue) ; Hmax : hauteur maximale ; HH : hauteur de la tête ; T : épaisseur du corps.]*

Table I. - Class limits for fish shapes. The class "oddly-shaped" regroups all species which do not fall within the other classes. *[Limites des classes pour les formes de poisson. La classe "odd" regroupe toutes les espèces qui ne tombent pas dans une des autres catégories.]*

Shape	SL/Hmax	T/Hmax
Very-flat	< 2.0	< 0.3
Compressed	2.0 - 3.0	0.3-0.45
Cylindrical	2.5 - 4.8	> 0.45
Semi-elongated	5.0 - 10.0	
Elongated	> 10.0	
Odd	Any other combination	

on a number of lagoon species were used to calculate length-weight relationships. The relationships were thus established from a total of 53,800 specimens, representing 788 species, 191 genera and 77 families. These data were collected between 1985 and 2003. All fishes were caught in the lagoon of New Caledonia, either by rotenone poisoning, spear-fishing, hand-line, gillnet, trawl nets, trammel nets or bottom long-line fishing.

Fork length was the measure used for all species in order to establish these relationships, except for rays, for which disk width is measured instead. The sexes are not differentiated here, although we are aware that males and females may have different length-weight relationships. The parameters *a* and *b* of relationships of the form $W = aL^b$ were estimated through a logarithmic transformation, i.e. $\ln W = \ln a + b \ln L$, with *a* and *b* estimated by ordinary least squares regression. L and W are respectively length in cm and weight in g.

The length-weight relationships were estimated according to taxonomic (species, genera, families) and morphological groupings (as defined above). The relationship for a given group was considered as valid when the measures from at least 8 specimens were available and when the significance level was at least of 0.01. In order to compare these relationships among groups, fish were classified (using a cluster analysis using the statistical Ward's method, with Euclidian distances, followed by an ANOVA) according to the ratios of SL/Hmax and T/Hmax into the following classes or shapes: elongated, semi-elongated, cylindrical, compressed, very-flat and oddly-shaped (Tab. I). Genera or families where several of these fish shapes were present were labelled "heterogeneous".

Error estimates

Once the length-weight relationships were estimated the weight of each fish entering the estimate was back-calculated, yielding an estimated weight W_{est}. This value was compared to the true value W, allowing to have an estimation of the relative error E_{rel}:

$E_{rel} = 100\ [W-W_{est}]/\text{maximum}\ (W;W_{est})$

For each species, genus, family or morphological group the E_{rel} were averaged, either for all the specimens or for only the largest ones (the fourth upper quartile) yielding respectively E_{aver} and $E_{75\%}$.

RESULTS

Species, genera and families

The results of length-weight analysis and grouping according to taxonomical criteria are presented in annexe 1. The identifications are essentially based on Rivaton *et al*. (1989), with recent updates in the literature being taken into account.

Relationships were not computed if there were less than 8 specimens. At the species level this allowed to estimate length-weight relationships for 444 species, but only 396 were kept. Relationships were rejected if they were not sufficiently significant ($p > 0.01$) or if the length interval for which weights were available was too narrow compared to the usual length of the species. At the genus level, all 191 genera had at least 9 specimens and only 6 relationships were rejected. At the family level, there were at least 11 specimens in each of the 77 families tested. Two families were rejected.

The error rates are given in table II. There is a slight but significant increase ($p < 0.05$) in the error rates from species to families. The average error on all specimens (E_{aver}) is higher than the error on the largest ones ($E_{75\%}$) (Tab. II), this difference being significant ($p < 0.05$) only at the species level. The error level was independent of body size within a species or morphological group, as there was no significant relationship between the level of error and the shape or size of the fish. At the genus level, genera with either odd shapes, elongated, compressed or very flat had higher relative errors than other shapes (Tab. III). At the family level the highest error levels were found in families with heterogeneous shapes, odd, elongated and semi-elongated shapes.

The coefficients of the length-weight relationship at the species level are function of the fish shape as indicated by figure 2A. An analysis of covariance indicates that the slopes and intercepts are different ($p < 0.05$) between each shape with the exception of "compressed" and "very flat" which are not significantly different. Similar results are found if one considers the genus or family levels.

One notices that the relationships between the coefficients *a* and *b* may be bounded by two lines (Fig. 2A). These two lines are only approximations, but may be defined by the following equations:

Lower boundary: $\log(a) = -4.86\ b + 7.17$

Upper boundary: $\log(a) = -2.66\ b + 4.92$

These lines could be physical or/and physiological lim-

Table II. - Distribution of the relative errors according to the taxonomic level or group. Confidence intervals are given for $p = 0.05$. E_{aver}: error based on average for all individuals, $E_{75\%}$: error based on average for the largest individual (last quartile). *[Distribution des erreurs relatives en fonction du niveau taxinomique ou du groupe. Les intervalles de confiance sont donnés pour p = 0.05. E_{aver} : erreur basée sur la moyenne de tous les individus. $E_{75\%}$: erreur basée sur la moyenne des plus gros individus (dernier quartile).]*

	Species	Genera	Families	Groups (I)
E_{aver}	9.4 ± 0.5	11.4 ± 1.0	13.5 ± 1.5	13.2 ± 1.4
$E_{75\%}$	8.1 ± 0.4	10.2 ± 0.9	13.8 ± 1.8	13.7 ± 2.0

Table III. - Average relative error at the genus and family levels for various fish shapes. "Heterogeneous" refers to genera or families represented by species with different shapes (e.g., Acanthuridae which have "compressed", "very-flat" species as well as "cylindrical" ones). *[Erreur moyenne relative pour différentes formes de poissons au niveau du genre ou de la famille . "Hétérogène" se réfère aux genres ou familles représentés par plusieurs formes (par exemple les Acanthuridae englobent des espèces "comprimées", "très plates" aussi bien que "cylindriques").]*

Shape	Nb genera	$E_{75\%}$ genera	E_{aver} genera	Nb families	$E_{75\%}$ families	E_{aver} families
Cylindrical	103	9.0	9.8	28	11.4	11.5
Compressed	35	9.4	10.1	12	9.6	9.4
Elongated	13	11.9	14.1	4	18.6	16.0
Semi-elongated	14	11.9	20.1	9	14.9	17.9
Very flat	8	13.4	12.8	4	12.0	10.5
Oddly shaped	10	19.4	17.0	5	25.9	20.4
Heterogeneous	4	9.6	10.5	13	16.5	16.0

its. To test this, it is possible to assimilate elongated fish as elongated cylinders with a density of 1. In that case if L is the length of the fish and T its thickness, then the weight W of the fish can be approximated by:

$W = \pi T^2L/4$

The most elongated species we observed (a Syngnatidae) had a ratio L/T of 36. This would result in an approximation of its weight by:

$W = \pi L3/(4 \times 36^2)$, or $a = 0.0000596$

If we use $b = 3$ in the equation of the lower boundary (Fig. 2A) we get an *a* of 0.0000654, which corresponds to an L/T ratio of 40 which could be a maximal limit.

If one considers the upper boundary one could assimilate a fish to a three dimensional volume with a length L, a height H and a thickness T. Assuming in a very simplistic manner that these dimensions are linearly related and the fish density equal to 1, we would get a crude approximation of the weight W by:

$W = LHT/2$

Replacing H and T by their relationship to L by respectively:

$H = kL$ and $T= qL$

one would then get: $W = kqL^3/2$

Looking at the value of a in the upper boundary equation (Fig. 2A) for $b = 3$ one finds $a = 0.047$. This means that the value *kq* is lower than 0.1 if our crude hypothesis on general fish shape is respected. Interestingly, out of 298 values of *kq* only 14 were found over 0.1 and only one above 0.15.

Another way to consider the constraints on fish shapes is to analyse the variations of relative (using standard length as the reference) thickness and relative height (Fig. 2B). Fish belonging to the same shape are grouped, the separation between groups following a gradient according to the relative diameter of the species (from the most elongated to the most compact species). The overlap tends to increase as one goes towards the upper limits due to the log scaling. The values are again clearly bounded by an upper and a lower line, indicating that fish shapes are bounded by some physical limits.

Morphological groups

A first cluster analysis allowed to define 16 groups. Eight of these groups were either very large or not homogeneous, containing species with different shapes. In order to have homogeneous groups, a second cluster analysis was performed within each of these 8 heterogeneous groups resulting in a total of 30 groups (Group-I in Tab. IV). Differences in the ratios used to define the groups were tested by ANOVAs. All ratios were significantly different between groups (i.e. each ratio discriminated at least one group from the others). A MANOVA indicates that groups were statistically different from one another when considering all the ratios together. The most discriminating ratios were SL/Hmax, T/H33, T/HT, SL/T and the least discriminating ones were SL/FL, SL/CH. The length-weight relationships for the fish within each group were estimated from a total of 32,551 specimens of fish. The specifications of these relationships along with the characteristics of each group (Group-I) are given in table IV.

The error estimates for the groups are similar to those for families but larger than for genera or species (Tab. II). Errors within groups are always higher than for genera or species (Fig. 3). Compared to families, in the lower error ranges (less than 13% error), groups have larger errors on average, and on the opposite, past the 13% error rate groups yield lower estimates than families (Fig. 3).

To use this grouping to obtain the length-weight relationship for a new species supposes that one has access to at least one specimen in order to take the measurements as indicated on figure 1. As specimens are not necessarily available we propose an alternative method. There are pictures available for most species in Fishbase (Froese and Pauly, 2001) and FAO guides (Carpenter and Niem, 1998). From these pictures we can take all measurements of figure 1 except body thickness (T). This latter parameter may be estimated in 3 major classes: flat (or compressed), i.e. fish for which the

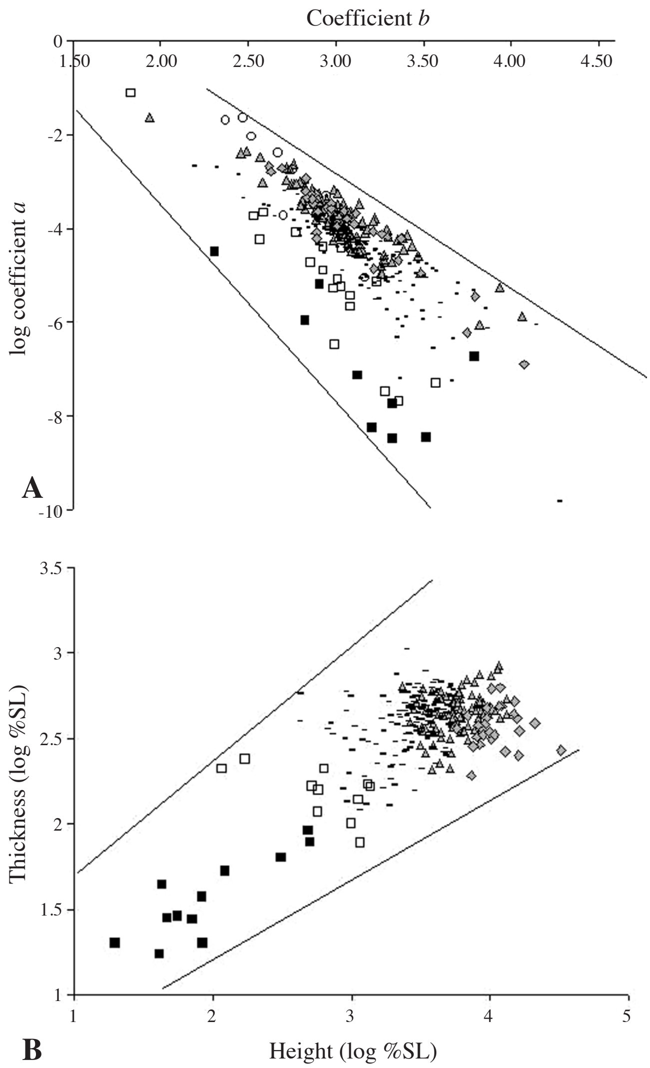

Figure 2. - **A**: Relationship between the regression coefficients *a* and *b* for various fish shapes at the species level. The upper and lower boundary lines are only approximate (see text). **B**: Relationship (on a log-log scale) between the relative (SL: standard length) thickness and relative height of fish for the various fish shapes at the species level. The upper and lower boundary lines are only approximate (see text). △ Compressed, ■ Elongated, - Cylindrical, ○ Odd, □ Semi-elongated, ◇ Very-flat. *[**A** : Relation au niveau spécifique entre les coefficients de régression* a *et* b *pour différentes formes de poisson. Les droites de limite supérieures et inférieures sont approximatives (voir texte). **B** : Relation (échelle log) entre l'épaisseur relative (SL: longueur standard) et la hauteur relative des poissons de différentes formes au niveau spécifique. Les droites limite supérieures et inférieures sont approximatives (voir texte). △ Comprimé, ■ Allongé, - Cylindrique, ○ Divers, □ Semi-allongé, ◇ Très plat.]*

ratio of body thickness to body height (T/Hmax) is less than 35%; normal fish for which this ratio is between 35 and 50%; round fish for which this ratio is above 50%. Using these 3 classes in table V as a proxy of body thickness will reduce the number of valid groups from 30 to 21 (Group-II), ANOVAs on the remaining ratios (SL/Hmax, SL/HH, SL/H33,

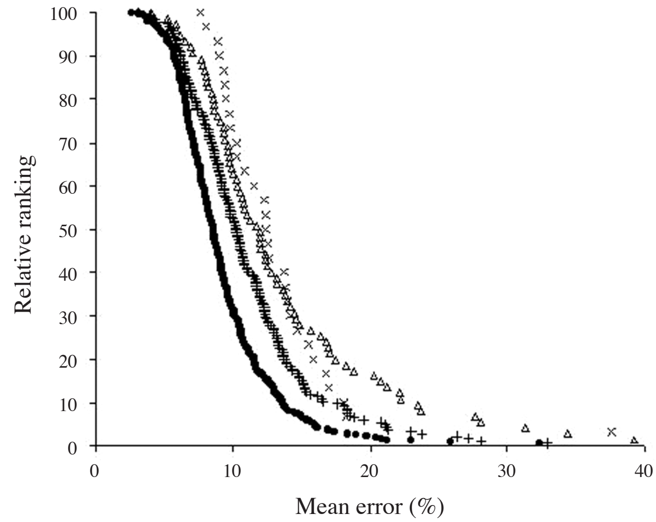

Figure 3. - Distribution of the mean error per species, genus, family or group. Errors are ranked from the lowest to the highest, the highest being given the relative rank 100 and the lowest the relative rank 1. ● Species, + Genus, △ Family, X Group. *[Distribution de l'erreur moyenne par espèce, genre, famille ou groupe. Les erreurs sont rangées de la plus petite à la plus grande, la plus grande se voyant attribuer le rang relatif 100 et la plus petite le rang relatif 1. ● Espèce, + Genre, △ Famille,* X *Groupe.]*

SL/FL, SL/CH) indicating that each group is significantly different from at least one other group. The error estimates for this new grouping is almost identical to the one for the grouping with 30 classes and is therefore not given on the graphs or tables.

DISCUSSION

Length-weight relationships are in great need for estimating the weight of fish for underwater visual censuses (UVC). UVCs are the most reliable and wide spread method to sample reef fish (e.g., English *et al*., 1994; Cappo and Brown, 1996; Samoilys, 1997; Samoilys and Carlos, 2000; Labrosse *et al*., 2001). Even so there are a number of problems linked to UVCs in particular estimating fish length accurately. Harvey *et al*. (2001, 2002) found that divers have a precision of approximately 10% on estimating fish lengths, which is much less accurate compared to stereo video camera systems which yield estimates within 1%. Several other studies have considered the precision of fish length estimates (see Kulbicki, 1998 for a review). Kulbicki (1997) found that this precision did not change much with the shape of the fish. On the opposite the precision is highly dependent on the training of the diver (Dalwall and Dulvy, 1996). These errors on length estimates may lead to a much higher error in weight. For instance, if one considers a 50 cm grouper, according to our equations (Annexe 1) its real weight would be 1,900 g, if underestimated at 45 cm its estimated weight would be 1,400 g, and over-

Table IV. - Groups defined from the analysis of the fish shapes. The notations used are similar to those from figure 1. The intervals are confidence limits with a probability level of 95%. N: number of species in group; n-LW: number of specimens used to estimate *a* and *b*. *[Groupes définis à partir de l'analyse des formes de poisson. Les notations utilisées sont similaires à celles de la figure 1. Les intervalles sont les intervalles de confiance au niveau 95%. N : nombre d'espèces dans un groupe; n-LW : nombre de spécimens utilisés pour estimer* a *et* b.*]*

Group-I	N	n-LW	r	a	b	SL/Hmax	SL/H33	SL/HH	SL/HL	SL/CH	T/H33	T/HH	T/Hmax	SL/T	Thickness	Group-II	r	a	b
27	23	2069	0.985	0.0412	2.8590	1.6 ± 0	2.4 ± 0.7	3 ± 0.4	3.3 ± 0.4	3.1 ± 0.5	0.33 ± 0.02	0.41 ± 0.02	0.22 ± 0.06	7.31 ± 1.17	flat	a	0.985	0.04128	2.8590
21	11	598	0.991	0.0406	2.8679	2.0 ± 0	3.6 ± 0.6	3 ± 0.4	3.5 ± 0.4	3.5 ± 0.9	0.64 ± 0.02	0.53 ± 0.03	0.35 ± 0.02	5.71 ± 0.49	flat	b	0.983	0.03984	2.8752
23	9	192	0.989	0.0235	3.1220	1.9 ± 0.1	2.8 ± 0.4	3.2 ± 0.2	3.4 ± 0.2	2.9 ± 0.5	0.5 ± 0.02	0.57 ± 0.01	0.34 ± 0.03	5.59 ± 0.44	flat	b			
26	24	1518	0.992	0.0340	2.9415	1.9 ± 0	3.3 ± 0.5	2.9 ± 0.3	3.5 ± 0.4	3.1 ± 0.7	0.51 ± 0.02	0.46 ± 0.01	0.29 ± 0.04	6.4 ± 0.48	flat	b			
25	11	1927	0.991	0.0199	3.0442	2.2 ± 0.1	3.4 ± 0.4	3.5 ± 0.3	3.9 ± 0.3	2.5 ± 0.3	0.44 ± 0.01	0.46 ± 0.01	0.28 ± 0.02	7.69 ± 0.8	flat	c	0.991	0.01990	3.0442
11	15	1009	0.996	0.0373	2.7496	2.2 ± 0.2	5.5 ± 1.4	3.1 ± 0.5	3.5 ± 0.5	3.9 ± 1.5	0.81 ± 0.04	0.46 ± 0.02	0.33 ± 0.04	6.72 ± 0.85	flat	d	0.993	0.04037	2.7227
24	5	381	0.966	0.0374	2.7630	2.3 ± 0.1	5.1 ± 0.4	3.1 ± 0.1	3.3 ± 0.4	3.3 ± 2.2	0.61 ± 0.05	0.37 ± 0.03	0.28 ± 0.04	8.41 ± 0.53	flat	d			
19	3	123	0.985	0.0253	2.9455	2.6 ± 0.2	4.2 ± 1	4.4 ± 0.6	4.8 ± 0.7	2.5 ± 0.5	0.52 ± 0.08	0.56 ± 0.06	0.33 ± 0.02	7.98 ± 0.92	flat	e	0.985	0.02538	2.9455
6	7	104	0.992	0.0197	3.0153	2.4 ± 0	4.6 ± 0.2	4 ± 0.3	4.2 ± 0.2	2.2 ± 0.3	0.72 ± 0.03	0.62 ± 0.05	0.38 ± 0.03	6.51 ± 0.27	normal	f	0.992	0.01976	3.0153
2	6	715	0.992	0.0178	3.1304	2.6 ± 0.1	3.7 ± 0.3	3.4 ± 0.2	3.1 ± 0.3	4.2 ± 1.9	0.63 ± 0.04	0.57 ± 0.02	0.44 ± 0.02	5.97 ± 0.35	normal	g			
20	16	4717	0.998	0.0250	2.9258	2.7 ± 0.1	4.3 ± 0.5	3.5 ± 0.4	3.4 ± 0.4	3.2 ± 1.1	0.58 ± 0.02	0.47 ± 0.01	0.37 ± 0.01	7.42 ± 0.75	normal	g	0.994	0.02855	2.8931
22	4	210	0.998	0.0214	3.0146	2.6 ± 0	3.2 ± 0.4	3.8 ± 0.6	3.3 ± 0.5	3.9 ± 0.8	0.49 ± 0.06	0.59 ± 0.06	0.4 ± 0.03	6.49 ± 0.53	normal	g			
4	17	5255	0.99	0.0149	3.0803	2.8 ± 0	4.8 ± 0.4	3.5 ± 0.2	3.2 ± 0.2	3.7 ± 2.6	0.71 ± 0.02	0.52 ± 0.01	0.41 ± 0.03	6.78 ± 0.55	normal	h	0.984	0.02066	2.9681
14	23	3518	0.995	0.0232	2.9163	2.8 ± 0.1	5.6 ± 0.5	3.5 ± 0.3	3.2 ± 0.4	3.7 ± 1	0.91 ± 0.03	0.56 ± 0.02	0.44 ± 0.04	6.26 ± 0.41	normal	h			
12	7	132	0.985	0.0089	3.4046	2.8 ± 0.2	7.2 ± 0.4	3.6 ± 0.3	3.5 ± 0.5	5.4 ± 3.7	1.04 ± 0.08	0.52 ± 0.03	0.41 ± 0.04	6.96 ± 0.36	normal	i	0.985	0.00892	3.4046
5	9	1151	0.996	0.0193	2.9695	3 ± 0.1	5.2 ± 0.4	3.9 ± 0.1	3.3 ± 0.2	3.8 ± 1.3	0.7 ± 0.03	0.53 ± 0.01	0.41 ± 0.03	7.43 ± 0.47	normal	j	0.996	0.01933	2.9695
13	7	354	0.986	0.0123	3.1365	3.2 ± 0.3	6.4 ± 0.6	4.5 ± 0.3	4 ± 0.5	3.6 ± 1	0.88 ± 0.02	0.62 ± 0.05	0.44 ± 0.04	7.29 ± 0.71	normal	k	0.986	0.01236	3.1365
8	3	150	0.969	0.0198	2.9042	3.2 ± 1.3	6.2 ± 0.4	5.4 ± 0.5	3.2 ± 0.1	5.7 ± 0.9	0.85 ± 0.09	0.71 ± 0.17	0.49 ± 0.08	7.08 ± 0.17	normal	l	0.969	0.01984	2.9042
3	16	851	0.987	0.0194	2.9790	3.4 ± 0.2	4.7 ± 0.5	4.3 ± 0.3	3.5 ± 0.3	4.5 ± 1.8	0.59 ± 0.03	0.53 ± 0.05	0.41 ± 0.08	7.91 ± 0.87	normal	m	0.987	0.01940	2.9790
1	13	543	0.989	0.0205	2.7353	4.5 ± 0.4	6.9 ± 0.9	6.1 ± 0.6	4.3 ± 0.3	6.3 ± 2.7	0.6 ± 0.06	0.53 ± 0.05	0.39 ± 0.06	11.7 ± 1.69	normal	n	0.989	0.02057	2.7353
30	10	82	0.958	0.0132	2.4060	> 10	> 10	> 10	7.2	> 10	1.08 ± 0.33	1.09 ± 0.38	0.75 ± 0.1	28.0 ± 3.67	round	o	0.958	0.01322	2.4060
28	1	342	0.982	0.00075	3.3577	13.2 ± 0	24.7 ± 0	13.5 ± 0	5.4 ± 0	7.6 ± 0	2.47 ± 0	1.35 ± 0	1.32 ± 0	10 ± 0	round	p	0.982	0.00075	3.3577
17	3	28	0.994	0.00733	3.5978	3.0 ± 0.8	4.2 ± 1.7	4.5 ± 1.3	2.9 ± 0.8	3.6 ± 0.3	1.05 ± 0.28	1.12 ± 0.03	0.78 ± 0.15	4.02 ± 1.32	round	q	0.994	0.00733	3.5978
9	5	204	0.994	0.0114	3.0936	3.3 ± 0.1	4.9 ± 0.4	3.7 ± 0.1	2.8 ± 0.3	3.7 ± 0.7	0.86 ± 0.03	0.67 ± 0.06	0.58 ± 0.02	5.7 ± 0.45	round	r	0.986	0.01921	2.9718
10	11	2542	0.993	0.0175	3.0023	3.1 ± 0.1	5 ± 0.4	3.8 ± 0.1	3.1 ± 0.2	3.5 ± 0.9	0.8 ± 0.03	0.61 ± 0.01	0.5 ± 0.01	6.21 ± 0.32	round	r			
7	11	939	0.997	0.0203	2.9194	3.8 ± 0.3	5.6 ± 0.6	4.9 ± 0.3	3.6 ± 0.6	3.1 ± 0.7	0.77 ± 0.05	0.68 ± 0.03	0.52 ± 0.04	7.28 ± 0.55	round	s	0.993	0.02183	2.8856
16	12	1181	0.995	0.0191	2.9174	3.9 ± 0.6	6.5 ± 1.3	4.7 ± 0.8	3.3 ± 0.6	4.9 ± 2.1	1.08 ± 0.04	0.78 ± 0.05	0.64 ± 0.09	6.02 ± 0.85	round	s			
15	8	585	0.987	0.00599	3.0064	6.8 ± 0.9	8 ± 1.2	9.3 ± 0.9	4.6 ± 0.7	5.6 ± 5.3	0.64 ± 0.06	0.74 ± 0.08	0.54 ± 0.05	12.9 ± 2.49	round	t	0.962	0.02109	2.6979
18	5	1096	0.989	0.00889	3.0250	6.4 ± 0.8	9.6 ± 1	7.9 ± 1.4	4.6 ± 0.4	6.7 ± 2.7	1.34 ± 0.1	1.1 ± 0.2	0.89 ± 0.07	7.16 ± 0.5	round	t			
29	3	35	0.992	0.0061	3.0818	7.4 ± 0.9	12.1 ± 1	9.9 ± 1.1	3.1 ± 0	7.3 ± 4.1	2.17 ± 0.27	1.78 ± 0.38	1.33 ± 0.12	5.58 ± 0.18	round	u	0.992	0.0061	3.0818

estimated at 55 cm it would yield 2,500 g. In other words, a 10% error estimate on length may generate an error on weight of approximately 25%. On top of this error linked to the length estimate there is the error linked to the choice in the length-weight relationship. The number of relationships available for reef fish species in the Pacific is rather limited. Before this work there were relationships for only 15.4% of the species (Fishbase: Froese and Pauly, 2001). We are adding relationships for a few more species (59 species in our list had no relationship available in Fishbase 2000), but what is new is that we provide relationships at higher taxonomic levels. Our data covers 92% of the 100 most speciose genera (amongst the 405 genera of shore fish in the tropical Pacific). In other words the data presented here allows to attribute length-weight relationships at the genus level for 75.6% of the reef species. At the family level, the coverage is nearly 85% and most of the missing families are usually not taken into account during UVC work (e.g., Carapidae, Ophichtidae, Tripterygiidae,…). Unfortunately the precision of the estimates from length-weight relationships at the family level and for some genera is not always satisfactory, in particular for those which have odd shapes or are elongated or semi-elongated or those which have heterogeneous shapes (Tab. III, Fig. 3). The group approach proposed in this article allows to close the gap in giving relationships which may be useful for either species for which no other relationship are available at present, or for species for which the existing relationships at either the genus or family level are not satisfactory. It may also provide a relationship when the observed fish is out of the length range for which the species, genus or family equation is provided for.

The present work by giving estimates of the relative error shows that: (i) the differences between species, genus, family and groups is on average small (less than 5% - Tab. II); (ii) there is much dispersion in these errors within an organisation level, the range being between 3 and 40% (Fig. 3) and (iii) the error level is linked to the shape of the fish (Tab. III). Looking at the very high values of the correlation coefficient (r) one tends to think that length-weight relationships yield excellent predictions. This is true if one considers the average of a large number of estimates, but our data shows that the dispersion of the estimates may be important in some cases and that it is not predictable from looking at r. A number of authors indicate that length-weight relationships vary with regions (see Écoutin and Albaret, 2002) or with season or year (e.g., Cucalon-Zenck, 1999; Anibeze, 2000). We have not investigated this matter, even though we have enough material to do so, but the level of difference found by most authors suggest that for UVC purposes these differences would remain minor compared to the error made on length estimates by divers. There are also differences according to sexes, but sex is very seldom taken into account during UVC work and the differences due to sex are much lower than those from other sources.

A number of length-weight relationships are available in the literature. Unfortunately for some of them, there are either errors or the types of measure are not indicated (e.g. fork length, standard length or total length). Figure 2A is a convenient way to check that the values available fall within an acceptable range. More interesting, the upper and lower boundaries on the values of the relationship between the coefficients a and b appear to be some physical limits to the dimensions of fish as suggested by our crude approach (Fig. 2B) on general fish shapes (see Pauly (1997), for a discussion on such physical limits). More refined modelling on these limits with more realistic equations of fish volumes could represent a path in understanding some of the physical constraints on fish shapes and connected capacities such as speed or energy consumption (see O'Dor and Hoar (2000) for a comparison between squids and fish; and Blier *et al.* (1997) for a discussion on fish capacities in this domain), which are useful in bounding some estimates in ecological modelling such as ECOPATH (Christensen and Walters, 2004).

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ANNEXE 1

Species are arranged by families in alphabetical order; species and genera within each family are presented alphabetically. For each family, each genus and each taxa, the estimation of parameters *a* and *b*, the number of specimens used (N), the correlation coefficient (r), maximum and minimum length (cm), and % of error are given. Name: if no name given, all specimens within the family were considered; "spp." after the genus name indicates that all specimens within the genus were considered. *[Les espèces sont rangées par ordre alphabétique au sein des familles et genres, les familles étant elles-mêmes ordonnées alphabétiquement. Pour chaque famille, genre et taxon les estimations des paramètres* a *et* b*, le nombre de spécimens utilisés (N), le coefficient de corrélation (r), les longueurs maximum et minimum (cm) et le % d'erreur sont donnés. Nom: si aucun nom n'est donné, tous les spécimens au sein d'une famille sont considérés; "spp." après le nom de genre indique que tous les spécimens au sein du genre sont considérés.]*

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Acanthuridae		heterogeneous	1141	0.995	2.0	60.0	0.0301	2.946	13.3
	Acanthurus spp.	compressed	639	0.996	2.5	57.0	0.0280	2.983	10.2
	Acanthurus blochii	compressed	249	0.996	2.5	38.0	0.0251	3.032	9.8
	Acanthurus dussumieri	compressed	95	0.993	2.5	51.5	0.0426	2.868	10.7
	Acanthurus nigricauda	compressed	51	0.995	4.6	22.5	0.0168	3.168	8.8
	Acanthurus mata	compressed	48	0.990	10.0	29.5	0.0222	3.008	6.9
	Acanthurus nigrofuscus	compressed	124	0.990	4.5	18.7	0.0264	3.028	8.7
	Acanthurus triostegus	compressed	22	0.972	6.5	16.5	0.0831	2.570	9.1
	Acanthurus xanthopterus	compressed	35	0.999	8.0	57.0	0.0267	2.984	5.9
	Ctenochaetus spp.	compressed	198	0.994	3.8	21.0	0.0237	3.056	6.5
	Ctenochaetus binotatus	compressed	18	0.969	8.5	15.3	0.0392	2.875	9.3
	Ctenochaetus striatus	compressed	180	0.995	3.8	21.0	0.0231	3.063	7.7
	Naso spp.	heterogeneous	123	0.996	2.0	60.0	0.0085	3.250	15.1
	Naso annulatus	compressed	9	0.989	28.0	42.0	0.0510	2.715	3.6
	Naso brevirostris	cylindrical	27	0.991	2.0	33.0	0.0107	3.243	32.3
	Naso hexacanthus	compressed	9	0.996	18.5	46.0	0.0202	2.956	6.6
	Naso unicornis	compressed	66	0.989	18.5	60.0	0.0179	3.035	6.8
	Zebrasoma spp.	very-flat	181	0.991	4.0	26.5	0.0378	2.857	14.4
	Zebrasoma scopas	very-flat	104	0.989	4.0	16.0	0.0291	2.993	9.1
	Zebrasoma veliferum	very-flat	77	0.995	4.0	24.0	0.0343	2.866	8.0
Albulidae	*Albula* spp.	cylindrical	31	0.995	35.5	78.0	0.0205	2.869	7.7
Antennariidae	*Antennarius* spp.	odd	17	0.982	4.0	11.0	0.0236	3.293	9.5
Apogonidae		heterogeneous	1873	0.970	2.0	18.5	0.0143	3.143	17.2
	Apogon spp.	cylindrical	1381	0.975	2.0	16.0	0.0155	3.121	17.3
	Apogon angustatus	cylindrical	59	0.938	2.6	9.0	0.0049	3.780	15.6
	Apogon aureus	cylindrical	116	0.980	6.2	12.0	0.0064	3.509	8.4
	Apogon bandanensis	cylindrical	72	0.959	3.5	10.0	0.0140	3.250	12.9
	Apogon catalai	compressed	9	0.962	5.0	7.0	0.0052	3.935	8.8
	Apogon compressus	cylindrical	13	0.941	6.0	10.4	0.0186	2.984	10.1
	Apogon cookii	cylindrical	15	0.950	4.8	7.0	0.0058	3.689	11.3
	Apogon cyanosoma	cylindrical	42	0.873	4.0	6.9	0.0074	3.563	16.9
	Apogon doderleini	cylindrical	74	0.963	3.5	9.4	0.0090	3.460	15.0
	Apogon ellioti	cylindrical	23	0.975	5.5	13.0	0.0172	2.991	9.8
	Apogon exostigma	cylindrical	62	0.972	4.0	10.3	0.0164	3.069	14.0
	Apogon fraenatus	cylindrical	218	0.982	3.5	11.0	0.0130	3.165	9.2
	Apogon fuscus	cylindrical	53	0.981	4.0	15.0	0.0407	2.699	9.4
	Apogon hyalosoma	cylindrical	42	0.983	6.0	15.0	0.0071	3.449	8.6
	Apogon kallopterus	cylindrical	66	0.980	4.5	12.0	0.0101	3.314	9.2
	Apogon lateralis	cylindrical	106	0.970	3.5	8.5	0.0184	3.051	15.2
	Apogon lineolatus	cylindrical	11	0.901	6.0	7.5	0.0045	3.683	10.7
	Apogon nigrofasciatus	cylindrical	28	0.973	3.5	8.0	0.0086	3.510	10.9
	Apogon norfolcensis	cylindrical	74	0.942	5.8	12.0	0.0102	3.277	10.0
	Apogon novemfasciatus	cylindrical	17	0.971	3.0	9.5	0.0086	3.414	11.6
Apogonidae	*Apogon trimaculatus*	cylindrical	55	0.977	2.0	16.0	0.0217	2.971	12.7
	Archamia spp.	cylindrical	105	0.924	5.2	8.5	0.0084	3.395	10.3
	Archamia fucata	compressed	49	0.954	5.2	8.5	0.0089	3.323	9.6

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Apogonidae	*Archamia leai*	compressed	17	0.957	5.2	8.2	0.0072	3.480	9.2
	Archamia lineolata	compressed	16	0.924	6.0	8.0	0.0485	2.586	7.1
	Cheilodipterus spp.	cylindrical	282	0.978	3.0	18.5	0.0132	3.085	8.1
	Cheilodipterus artus	cylindrical	21	0.976	4.7	14.4	0.0038	3.590	14.6
	Cheilodipterus lachneri	cylindrical	51	0.963	6.0	12.5	0.0022	3.858	8.6
	Cheilodipterus macrodon	cylindrical	16	0.996	8.0	18.5	0.0054	3.433	6.6
	Cheilodipterus quinquelineatus	cylindrical	194	0.974	3.0	11.0	0.0161	2.999	11.6
	Fowleria spp.	cylindrical	70	0.938	3.0	8.2	0.0082	3.567	17.3
	Fowleria aurita	cylindrical	12	0.997	4.1	8.2	0.0376	2.776	4.3
	Fowleria marmorata	cylindrical	13	0.959	4.0	7.5	0.0024	4.136	17.4
	Fowleria variegata	cylindrical	35	0.960	3.0	8.0	0.0134	3.350	19.7
Atherinidae	*Atherinomorus lacunosus*	cylindrical	49	0.968	6.5	13.0	0.0064	3.298	9.7
Aulostomidae	*Aulostomus chinensis*	elongated	11	0.989	31.8	68.0	0.0002	3.514	9.8
Balistidae		heterogeneous	595	0.994	5.0	61.0	0.0057	3.393	18.3
	Abalistes stellaris	compressed	111	0.991	14.0	53.5	0.0472	2.760	5.7
	Balistoides spp.	compressed	12	0.994	27.4	61.0	0.0190	3.078	6.6
	Balistoides viridescens	compressed	10	0.998	27.4	61.0	0.0244	3.018	3.9
	Pseudobalistes fuscus	compressed	76	0.989	16.3	58.0	0.0726	2.760	6.2
	Sufflamen spp.	compressed	122	0.982	16.6	36.5	0.0324	2.929	6.0
	Sufflamen fraenatus	compressed	118	0.980	18.5	36.5	0.0287	2.966	6.5
Belonidae		semi-elongated	81	0.974	16.5	88.0	0.0008	3.203	10.6
	Strongylura spp.	semi-elongated	51	0.957	29.0	75.0	0.0011	3.101	10.3
	Strongylura incisa	semi-elongated	11	0.950	36.5	72.5	0.0016	2.996	11.8
	Strongylura urvilli	semi-elongated	23	0.991	29.0	73.5	0.0005	3.361	8.4
	Tylosurus crocodilus	semi-elongated	29	0.985	29.5	88.0	0.0006	3.285	10.1
Blenniidae		heterogeneous	246	0.860	3.5	16.6	0.0022	3.901	29.9
	Atrosalarias fuscus	cylindrical	50	0.926	3.6	10.2	0.0149	3.018	16.2
	Cirripectes spp.	cylindrical	41	0.981	5.5	10.0	0.0130	3.150	7.8
	Cirripectes chelomatus	cylindrical	19	0.949	7.0	10.0	0.0147	3.099	7.3
	Cirripectes stigmaticus	cylindrical	17	0.989	5.5	9.0	0.0183	2.969	5.7
	Ecsenius spp.	cylindrical	49	0.939	4.0	9.5	0.0239	2.584	7.5
	Ecsenius bicolor	cylindrical	46	0.930	4.0	9.5	0.0239	2.583	10.6
	Meiacanthus spp.	semi-elongated	9	0.866	4.5	6.0	0.0009	4.470	13.7
	Petroscirtes spp.	semi-elongated	15	0.885	3.5	10.5	0.0097	3.016	29.7
	Plagiotremus spp.	elongated	33	0.854	5.0	9.5	0.0018	3.581	22.8
	Plagiotremus rhinorhynchos	elongated	20	0.913	6.0	9.5	0.0012	3.792	13.9
	Plagiotremus tapeinosoma	elongated	10	0.921	5.5	9.0	0.0057	2.908	15.9
	Salarias fasciatus	cylindrical	25	0.922	4.0	11.0	0.0138	2.980	13.6
Bothidae		very-flat	260	0.962	5.5	20.5	0.0072	3.213	13.4
	Arnoglossus spp.	very-flat	32	0.894	6.0	11.5	0.0002	4.811	27.2
	Asterorhombus intermedius	very-flat	59	0.914	7.0	12.5	0.0010	4.075	15.7
	Bothus pantherinus	very-flat	21	0.963	8.0	18.0	0.0020	3.751	18.3
	Engyprosopon grandisquama	very-flat	108	0.979	5.5	12.0	0.0168	2.894	7.1
	Grammatobothus polyophthalmus	very-flat	39	0.969	11.0	20.5	0.0148	2.895	6.8
Bythitidae	*Dinematichthys* spp.	elongated	55	0.869	4.0	10.2	0.0072	3.155	18.0
Caesionidae		cylindrical	377	0.986	6.0	24.3	0.0085	3.278	5.3
	Caesio spp.	cylindrical	195	0.986	6.7	24.3	0.0093	3.253	7.1
	Caesio caerulaurea	cylindrical	90	0.996	6.7	21.4	0.0200	2.991	6.1
	Caesio cuning	cylindrical	9	0.989	19.5	24.3	0.0149	3.121	2.6
	Pterocaesio spp.	cylindrical	182	0.988	6.0	15.5	0.0092	3.234	5.2
	Pterocaesio diagramma	cylindrical	82	0.991	8.0	15.5	0.0069	3.341	5.2
	Pterocaesio trilineata	cylindrical	94	0.987	6.0	15.0	0.0107	3.178	6.8
Callionymidae		cylindrical	35	0.972	3.5	16.0	0.0329	2.466	15.1
	Synchiropus spp.	cylindrical	25	0.989	3.5	16.0	0.0491	2.317	12.2
	Synchiropus rameus	cylindrical	13	0.930	10.0	16.0	0.0687	2.184	9.4

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Callionymidae	*Synchiropus splendidus*	cylindrical	12	0.935	3.5	6.0	0.0109	3.341	14.8
Carangidae		heterogeneous	988	0.984	3.3	93.0	0.0083	3.197	17.9
	Atule mate	cylindrical	62	0.985	10.0	27.7	0.0166	2.949	11.1
	Carangoides spp.	compressed	352	0.994	8.5	86.0	0.0361	2.812	9.4
	Carangoides armatus	compressed	12	0.990	32.0	51.0	0.0115	3.126	4.9
	Carangoides chrysophrys	compressed	130	0.997	12.5	60.0	0.0267	2.902	7.5
	Carangoides ferdau	compressed	31	0.990	24.5	60.5	0.0368	2.851	6.6
	Carangoides fulvoguttatus	compressed	54	0.993	16.0	81.0	0.0329	2.808	8.8
	Carangoides gymnostethus	compressed	23	0.999	8.5	86.0	0.0463	2.746	5.6
	Carangoides hedlandensis	compressed	16	0.996	9.5	32.0	0.0381	2.864	6.0
	Carangoides orthogrammus	compressed	34	0.994	28.0	62.0	0.0156	3.026	6.3
	Carangoides uii	compressed	19	0.994	12.0	30.5	0.0321	2.902	7.7
	Caranx spp.	compressed	267	0.998	5.5	93.0	0.0198	2.986	13.9
	Caranx ignobilis	compressed	94	0.998	7.0	93.0	0.0164	3.059	8.1
	Caranx melampygus	compressed	25	0.999	5.5	54.0	0.0234	2.918	6.9
	Caranx papuensis	compressed	135	0.997	6.5	65.0	0.0235	2.923	10.2
	Decapterus russellii	cylindrical	17	0.993	11.5	30.0	0.0139	2.963	6.9
	Gnathanodon speciosus	compressed	20	0.999	4.0	74.5	0.0199	2.995	10.9
	Pseudocaranx dentex	compressed	11	0.998	27.0	59.0	0.0271	2.886	3.1
	Scomberoides lysan	cylindrical	14	0.995	11.5	55.5	0.0109	2.923	6.2
	Scomberoides tol	cylindrical	189	0.993	3.3	37.0	0.0154	2.787	9.6
	Selar crumenophthalmus	cylindrical	34	0.966	18.0	27.5	0.0097	3.194	6.0
Carcharhinidae		cylindrical	159	0.949	45.1	120.0	0.0010	3.566	15.9
	Carcharhinus spp.	cylindrical	131	0.970	45.1	120.0	0.0013	3.508	9.3
	Carcharhinus albimarginatus	cylindrical	10	0.921	61.0	76.0	0.0001	4.268	7.3
	Carcharhinus amblyrhynchos	cylindrical	54	0.951	45.1	120.0	0.0023	3.373	9.3
	Carcharhinus limbatus	cylindrical	26	0.977	47.5	86.0	0.0033	3.283	7.7
	Carcharhinus sorrah	cylindrical	27	0.982	52.0	91.0	0.0007	3.656	6.6
Centropomidae	*Ambassis interruptus*	cylindrical	12	0.899	5.5	7.5	0.0079	3.543	12.4
Chaetodontidae		very-flat	2097	0.983	2.0	23.5	0.0421	2.847	12.9
	Chaetodon spp.	very-flat	1927	0.982	2.0	19.0	0.0450	2.814	11.7
	Chaetodon auriga	very-flat	246	0.992	2.4	19.0	0.0404	2.829	10.3
	Chaetodon bennetti	very-flat	20	0.994	3.0	12.6	0.0384	2.885	7.9
	Chaetodon citrinellus	very-flat	74	0.986	3.0	10.5	0.0353	2.834	9.6
	Chaetodon ephippium	very-flat	63	0.995	3.4	17.5	0.0225	3.061	6.7
	Chaetodon flavirostris	very-flat	174	0.994	2.6	16.5	0.0251	3.113	8.4
	Chaetodon lineolatus	very-flat	89	0.987	2.0	20.0	0.0693	2.622	13.3
	Chaetodon melannotus	very-flat	138	0.988	2.0	11.1	0.0267	3.049	9.9
	Chaetodon mertensii	very-flat	15	0.983	7.0	10.0	0.0043	3.793	5.4
	Chaetodon pelewensis	very-flat	26	0.967	5.0	9.0	0.0153	3.297	11.2
	Chaetodon plebeius	very-flat	283	0.980	2.0	10.0	0.0606	2.628	9.0
	Chaetodon speculum	very-flat	444	0.984	2.0	11.5	0.0664	2.693	8.9
	Chaetodon trifascialis	very-flat	23	0.985	3.0	14.0	0.0258	2.969	10.2
	Chaetodon trifasciatus	very-flat	189	0.983	3.5	12.1	0.0311	2.976	8.0
	Chaetodon ulietensis	very-flat	36	0.995	3.3	12.1	0.0311	2.874	6.9
	Chaetodon unimaculatus	very-flat	13	0.998	4.5	18.0	0.0533	2.833	5.2
	Chaetodon vagabundus	very-flat	65	0.990	4.0	14.0	0.0278	2.973	6.4
	Heniochus spp.	very-flat	146	0.991	3.5	21.4	0.0252	3.082	11.2
	Heniochus acuminatus	very-flat	85	0.990	3.5	17.5	0.0247	3.106	11.6
	Heniochus chrysostomus	very-flat	24	0.981	5.0	14.0	0.0161	3.262	12.8
	Heniochus monoceros	very-flat	29	0.991	9.0	21.0	0.0170	3.211	9.1
Chanidae	*Chanos chanos*	cylindrical	85	0.978	14.5	35.0	0.0047	3.389	9.1
Chirocentridae	*Chirocentrus dorab*	semi-elongated	30	0.926	32.5	63.0	0.0051	2.987	10.5
Cirrhitidae		cylindrical	22	0.985	4.3	15.0	0.0093	3.268	8.0
	Cirrhitichtys falco	cylindrical	17	0.939	4.3	8.0	0.0033	3.849	12.6

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Clinidae		semi-elongated	34	0.893	3.5	8.9	0.0021	3.855	9.0
	Heteroclinus roseus	semi-elongated	10	0.914	3.5	8.0	0.0168	2.775	76.3
Clupeidae		cylindrical	896	0.987	3.5	24.0	0.0093	3.314	19.8
	Anodontostoma chacunda	cylindrical	691	0.994	3.5	24.0	0.0202	3.049	7.4
	Herklotsichthys quadrimaculatus	cylindrical	70	0.946	5.0	14.5	0.0065	3.317	9.2
	Sardinella fijiensis	cylindrical	36	0.992	5.5	15.5	0.0163	2.971	9.4
Congridae	*Conger cinereus*	elongated	14	0.999	10.9	110.0	0.0008	3.127	9.7
	Muraenesox bagio	elongated	14	0.989	56.0	106.0	0.0026	2.824	6.5
Dasyatidae		very-flat	82	0.990	17.0	49.5	0.0094	3.352	16.0
	Dasyatis spp.	very-flat	82	0.990	17.0	49.5	0.0094	3.352	16.0
	Dasyatis kuhlii	very-flat	78	0.992	17.0	49.5	0.0092	3.357	7.9
Diodontidae	*Diodon* spp.	odd	25	0.969	1.0	75.0	0.0678	2.784	37.6
	Diodon hystrix	odd	22	0.982	28.0	75.0	0.1934	2.472	9.5
Echeneididae	*Echeneis naucrates*	cylindrical	342	0.982	12.0	84.5	0.0008	3.358	9.4
Eleotrididae	*Butis amboinensis*	cylindrical	14	0.919	4.5	8.5	0.0075	3.029	15.3
Elopidae	*Elops machnata*	semi-elongated	68	0.953	18.5	85.0	0.0125	2.927	21.2
Engraulidae		cylindrical	96	0.961	5.0	12.5	0.0034	3.492	14.3
	Stolephorus spp.	cylindrical	11	0.829	8.5	12.5	0.0252	2.600	13.8
	Thryssina baelama	cylindrical	85	0.966	5.0	11.5	0.0028	3.586	10.6
Ephippidae	*Platax* spp.	very-flat	11	0.999	4.5	50.0	0.0443	2.951	12.4
Fistulariidae	*Fistularia* spp.	elongated	47	0.976	18.5	44.0	0.0005	3.048	10.1
	Fistularia petimba	elongated	43	0.993	19.0	44.0	0.0003	3.205	5.7
Gerreidae	*Gerres* spp.	compressed	1590	0.989	3.0	34.0	0.0194	3.070	9.0
	Gerres filamentosus	compressed	273	0.995	5.0	21.5	0.0240	3.011	8.6
	Gerres ovatus	compressed	963	0.992	3.0	19.0	0.0229	3.005	8.1
	Gerres oyena	cylindrical	339	0.979	4.0	20.0	0.0095	3.337	12.8
Gobiidae		cylindrical	296	0.951	2.3	36.5	0.0264	2.623	24.0
	Amblygobius phalaena	cylindrical	57	0.958	3.0	11.7	0.0184	2.834	13.6
	Exyrias spp.	cylindrical	28	0.984	4.5	13.5	0.0120	2.921	12.7
	Exyrias bellissimus	cylindrical	23	0.969	7.0	13.5	0.0130	2.882	8.8
	Gnatholepis spp.	cylindrical	13	0.925	3.5	8.5	0.0175	2.827	9.7
	Gobiodon citrinus	cylindrical	12	0.932	2.8	5.2	0.0577	2.439	11.4
	Istigobius spp.	cylindrical	51	0.961	3.0	11.0	0.0183	2.782	9.9
	Istigobius decoratus	cylindrical	24	0.978	5.5	11.0	0.0180	2.777	8.9
	Istigobius ornatus	cylindrical	14	0.949	3.8	9.0	0.0098	3.108	20.5
	Oxyurichthys spp.	cylindrical	23	0.949	7.0	14.5	0.0134	2.903	13.9
	Oxyurichthys papuensis	cylindrical	12	0.968	8.0	14.0	0.0126	2.910	10.4
	Priolepis cinctus	cylindrical	13	0.951	3.5	7.0	0.0153	3.008	11.6
	Valenciennea spp.	cylindrical	17	0.989	4.5	12.5	0.0104	2.859	4.5
	Valenciennea longipinnis	cylindrical	9	0.980	7.5	12.5	0.0054	3.136	6.5
Grammistidae		heterogeneous	22	0.987	1.0	27.0	0.0124	3.234	30.8
	Diploprion bifasciatum	compressed	16	0.942	13.4	20.0	0.0089	3.278	10.1
Haemulidae		heterogeneous	1530	0.997	4.0	75.0	0.0217	2.898	10.5
	Diagramma pictus	compressed	547	0.997	7.0	75.0	0.0144	2.988	5.8
	Plectorhinchus spp.	compressed	106	0.988	7.0	55.5	0.0197	2.969	9.2
	Plectorhinchus chaetodonoides	compressed	17	0.998	14.0	53.5	0.0173	3.040	6.1
	Plectorhinchus gibbosus	compressed	14	0.975	7.0	38.0	0.0226	2.962	13.8
	Plectorhinchus lineatus	cylindrical	22	0.994	19.5	44.0	0.0126	3.079	4.8
	Plectorhinchus obscurus	compressed	27	0.995	17.5	55.5	0.0270	2.885	6.9
	Plectorhinchus picus	compressed	16	0.990	36.0	54.5	0.0115	3.089	3.8
	Pomadasys argenteus	cylindrical	875	0.997	4.0	43.0	0.0188	2.954	6.6
Hemigaleidae	*Triaenodon obesus*	cylindrical	20	0.971	52.0	108.0	0.0018	3.344	10.7
Hemiramphidae		semi-elongated	92	0.896	13.0	44.5	0.0000	4.920	35.4
	Hemiramphus affinis	semi-elongated	12	0.985	13.5	27.5	0.0007	3.575	13.3
	Hemirhamphus far	semi-elongated	69	0.921	22.0	44.5	0.3298	1.831	9.0

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Holocentridae		heterogeneous	1533	0.988	2.9	31.5	0.0222	3.059	11.1
	Myripristis spp.	cylindrical	504	0.990	3.5	22.5	0.0276	3.030	8.7
	Myripristis amaena	cylindrical	22	0.995	5.0	17.0	0.0158	3.261	5.1
	Myripristis berndti	cylindrical	87	0.994	4.5	22.5	0.0277	3.003	8.2
	Myripristis hexagona	cylindrical	16	0.997	4.6	19.0	0.0250	3.089	7.9
	Myripristis kuntee	cylindrical	81	0.953	6.0	14.0	0.0099	3.468	13.5
	Myripristis melanosticta	cylindrical	61	0.993	4.0	19.5	0.0292	3.024	9.8
	Myripristis pralinia	cylindrical	41	0.996	5.0	15.0	0.0227	3.095	5.8
	Myripristis violacea	cylindrical	138	0.991	3.5	19.2	0.0364	2.940	8.4
	Neoniphon spp.	cylindrical	196	0.995	3.5	19.0	0.0288	2.867	8.7
	Neoniphon argenteus	cylindrical	57	0.993	4.5	18.2	0.0317	2.823	7.0
	Neoniphon sammara	cylindrical	138	0.995	3.5	19.0	0.0276	2.888	7.3
	Plectrypops lima	cylindrical	11	0.963	5.5	10.5	0.0177	3.139	11.7
	Sargocentron spp.	cylindrical	822	0.993	2.9	31.5	0.0219	3.047	8.7
	Sargocentron diadema	cylindrical	322	0.989	5.0	15.0	0.0251	2.955	8.3
	Sargocentron rubrum	cylindrical	371	0.993	2.9	23.0	0.0275	2.998	7.4
	Sargocentron spiniferum	compressed	122	0.975	11.5	31.5	0.0154	3.119	9.0
Kuhliidae	*Kuhlia* spp.	cylindrical	36	0.997	4.0	24.0	0.0160	3.034	5.0
	Kuhlia marginata	cylindrical	31	0.996	4.0	17.5	0.0146	3.083	7.8
Kyphosidae	*Kyphosus* spp.	compressed	22	0.987	17.7	53.5	0.0129	3.151	5.1
	Kyphosus vaigiensis	compressed	12	0.997	17.7	48.0	0.0200	3.037	6.1
Labridae		heterogeneous	1382	0.995	2.5	93.0	0.0107	3.178	15.9
	Anampses spp.	cylindrical	13	0.980	4.5	13.6	0.0226	2.793	10.6
	Bodianus spp.	cylindrical	510	0.994	8.0	59.0	0.0108	3.173	5.5
	Bodianus perditio	cylindrical	496	0.991	16.5	59.0	0.0119	3.149	5.9
	Cheilinus spp.	cylindrical	111	0.996	4.2	93.0	0.0155	3.058	15.5
	Cheilinus bimaculatus	cylindrical	28	0.967	5.0	13.0	0.0679	2.317	10.9
	Cheilinus chlorourus	compressed	44	0.994	4.2	32.0	0.0197	2.993	11.7
	Cheilinus trilobatus	compressed	9	0.997	8.5	24.0	0.0162	3.059	8.5
	Cheilinus undulatus	compressed	16	0.998	23.0	93.0	0.0113	3.136	4.4
	Cheilio inermis	semi-elongated	12	0.997	5.8	23.7	0.0035	3.082	8.5
	Choerodon graphicus	cylindrical	140	0.998	4.0	51.5	0.0151	3.122	9.3
	Coris spp.	cylindrical	20	0.998	5.2	55.0	0.0065	3.254	8.3
	Coris aygula	cylindrical	11	0.992	32.5	55.0	0.0027	3.489	5.2
	Epibulus insidiator	compressed	19	0.985	8.7	35.0	0.0161	3.081	11.6
	Gomphosus varius	odd	22	0.995	5.0	21.2	0.0244	2.703	8.6
	Halichoeres spp.	cylindrical	80	0.980	3.1	19.3	0.0160	2.987	13.7
	Halichoeres argus	cylindrical	18	0.965	3.1	10.1	0.0175	2.957	14.9
	Halichoeres melanurus	cylindrical	26	0.949	3.6	10.6	0.0093	3.262	19
	Halichoeres trimaculatus	cylindrical	22	0.994	3.5	16.0	0.0275	2.736	10.8
	Hemigymnus melapterus	cylindrical	22	0.997	6.2	34.5	0.0242	2.923	7.1
	Labroides dimidiatus	semi-elongated	36	0.981	4.5	11.3	0.0059	3.231	10.1
	Stethojulis spp.	cylindrical	170	0.959	2.5	11.5	0.0185	2.892	7.1
	Stethojulis bandanensis	cylindrical	23	0.922	3.0	10.0	0.0304	2.581	25.9
	Stetholulis interrupta	cylindrical	24	0.960	3.1	9.0	0.0292	2.608	23.1
	Stethojulis strigiventer	cylindrical	147	0.971	2.5	11.5	0.0191	2.876	12.6
	Thalassoma spp.	cylindrical	158	0.956	2.8	17.6	0.0123	3.097	24.4
	Thalassoma hardwicke	cylindrical	10	0.997	5.5	16.3	0.0178	2.978	7.0
	Thalassoma lunare	cylindrical	85	0.977	2.8	16.5	0.0211	2.832	15.4
	Thalassoma lutescens	cylindrical	51	0.994	4.5	17.6	0.0130	3.042	7.6
Leiognathidae		very-flat	1024	0.985	2.5	21.0	0.0187	3.110	13
	Gazza minuta	very-flat	151	0.993	2.5	21.0	0.0327	2.876	8.8
	Leiognathus spp.	very-flat	856	0.983	2.5	20.0	0.0157	3.187	11.8
	Leiognathus bindus	very-flat	127	0.959	3.0	9.0	0.0263	2.897	8.9
	Leiognathus equulus	very-flat	380	0.993	2.5	20.0	0.0270	2.980	9.2

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Leiognathidae	*Leiognathus fasciatus*	very-flat	61	0.994	5.0	15.5	0.0200	3.102	8.2
	Leiognathus leuciscus	very-flat	59	0.977	5.0	9.0	0.0070	3.488	7.5
	Leiognathus rivulatus	very-flat	39	0.961	6.0	10.0	0.0192	3.008	6.5
	Leiognathus splendens	very-flat	161	0.974	4.5	11.5	0.0288	2.949	8.3
	Secutor ruconius	very-flat	17	0.921	3.5	6.5	0.0268	2.969	13.3
Lethrinidae		heterogeneous	8527	0.996	2.5	86	0.0169	3.040	9.4
	Gnathodentex aurolineatus	cylindrical	53	0.983	8.5	20.5	0.0180	3.063	6.2
	Gymnocranius spp.	compressed	814	0.995	6.5	69.0	0.0302	2.909	5.9
	Gymnocranius euanus	compressed	372	0.991	10.0	49.0	0.0225	3.001	5.3
	Gymnocranius grandocculis	compressed	243	0.995	16.0	69.0	0.0320	2.885	6.5
	Gymnocranius sp. *FAO*	compressed	120	0.998	9.0	53.0	0.0276	2.933	4.5
	Lethrinus spp.	heterogeneous	7597	0.996	2.5	86.0	0.0165	3.043	9.6
	Lethrinus atkinsoni	compressed	2038	0.991	4.2	45.5	0.0178	3.057	6.3
	Lethrinus genivittatus	cylindrical	877	0.992	2.5	22.0	0.0179	2.995	8.3
	Lethrinus harak	cylindrical	111	0.997	6.0	32.0	0.0170	3.042	6.1
	Lethrinus lentjan	compressed	380	0.995	6.5	44.5	0.0197	2.986	5.5
	Lethrinus miniatus	cylindrical	59	0.991	18.5	54.5	0.0066	3.277	7.2
	Lethrinus nebulosus	compressed	2980	0.996	3.5	69.5	0.0187	2.996	6.1
	Lethrinus obsoletus	cylindrical	133	0.992	11.0	31.0	0.0173	3.026	7.5
	Lethrinus olivaceus	cylindrical	135	0.992	22.5	72.5	0.0294	2.851	8.8
	Lethrinus ravus	cylindrical	9	0.997	11.0	53.2	0.0141	3.065	9.5
	Lethrinus rubrioperculatus	cylindrical	661	0.985	16.5	39.5	0.0128	3.108	5.7
	Lethrinus semicinctus	cylindrical	155	0.993	3.0	29.0	0.0118	3.117	8.6
	Lethrinus xanthochilus	cylindrical	59	0.992	22.0	62.5	0.0201	2.964	7.7
	Monotaxis grandoculis	compressed	63	0.999	4.0	45.0	0.0230	3.022	7.3
Lutjanidae		heterogeneous	5281	0.994	4.0	92.0	0.0167	3.022	11.6
	Aprion virescens	cylindrical	121	0.980	22.5	88.0	0.0230	2.886	8.3
	Lutjanus spp.	heterogeneous	5107	0.993	4.0	77.0	0.0151	3.057	10.8
	Lutjanus adetii	compressed	269	0.991	18.5	47.0	0.0071	3.261	7.1
	Lutjanus argentimaculatus	cylindrical	308	0.997	5.5	68.0	0.0280	2.844	5.6
	Lutjanus bohar	cylindrical	510	0.997	4.0	75.0	0.0156	3.059	6.0
	Lutjanus fulviflammus	cylindrical	867	0.994	5.0	32.5	0.0205	2.960	6.6
	Lutjanus fulvus	cylindrical	318	0.994	4.0	31.0	0.0211	2.974	8.3
	Lutjanus gibbus	compressed	515	0.991	14.2	40.5	0.0131	3.138	6.3
	Lutjanus kasmira	cylindrical	127	0.983	4.0	26.0	0.0084	3.247	7.8
	Lutjanus lutjanus	cylindrical	68	0.994	8.5	28.0	0.0182	2.969	5.8
	Lutjanus monostigma	cylindrical	15	0.986	25.0	53.5	0.0222	2.913	9.4
	Lutjanus quinquelineatus	cylindrical	864	0.969	5.5	23.0	0.0146	3.100	9.9
	Lutjanus rivulatus	compressed	12	0.994	15.5	76.0	0.0084	3.260	11.8
	Lutjanus russelli	cylindrical	171	0.993	9.5	37.0	0.0166	2.978	7.8
	Lutjanus sebae	compressed	34	0.996	24.5	77.0	0.0116	3.152	4.8
	Lutjanus semicinctus	cylindrical	31	0.976	18.0	35.0	0.0040	3.428	8.1
	Lutjanus vittus	cylindrical	998	0.992	9.0	38.5	0.0125	3.075	7.5
	Symphorus nematophorus	cylindrical	41	0.983	44.5	92.0	0.0147	3.046	5.7
Megalopidae	*Megalops cyprinoides*	semi-elongated	35	0.993	17.0	47.0	0.0122	3.033	7.1
Microcanthidae	*Microcanthus strigatus*	compressed	14	0.956	9.2	15.0	0.0526	2.818	9.7
	Paramonacanthus japonicus	compressed	48	0.953	5.0	17.0	0.0219	2.889	13
Monacanthidae	*Pseudalutarius nasicornis*	compressed	209	0.955	8.0	13.5	0.0070	3.262	6.9
Monodactylidae	*Monodactylus argenteus*	compressed	203	0.993	2.0	18.5	0.0303	2.964	8.0
Mugilidae		cylindrical	2825	0.993	4.0	60.0	0.0127	3.046	7.0
	Liza spp.	cylindrical	1544	0.991	4.0	35.5	0.0141	3.023	6.5
	Liza macrolepis	cylindrical	806	0.992	6.0	29.0	0.0144	3.014	6.7
	Liza melinoptera	cylindrical	735	0.984	4.0	35.5	0.0133	3.045	6.7
	Mugil cephalus	cylindrical	182	0.996	6.5	48.5	0.0109	3.089	6.5
	Valamugil spp.	cylindrical	919	0.995	5.0	60.0	0.0088	3.148	10.7

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Mugilidae	*Valamugil buchanani*	cylindrical	680	0.995	7.0	60.0	0.0101	3.104	7.6
	Valamugil engeli	cylindrical	196	0.991	6.5	26.0	0.0058	3.287	8.9
	Valamugil seheli	cylindrical	38	0.996	11.5	43.5	0.0061	3.275	6.1
Mullidae		cylindrical	2902	0.987	3.5	41.0	0.0104	3.224	9.7
	Mulloides spp.	cylindrical	29	0.979	10	21.5	0.0074	3.293	12.9
	Mulloides flavolineatus	cylindrical	24	0.951	10	19.5	0.0120	3.101	7.6
	Parupeneus spp.	cylindrical	816	0.993	3.5	41.0	0.0145	3.130	10.1
	Parupeneus barberinus	cylindrical	19	0.998	8.0	41.0	0.0131	3.122	5.4
	Parupeneus ciliatus	cylindrical	92	0.997	3.5	24.5	0.0116	3.220	9.0
	Parupeneus heptacanthus	cylindrical	522	0.989	5.5	23.5	0.0169	3.078	6.9
	Parupeneus indicus	cylindrical	91	0.997	3.5.0	36.0	0.0142	3.114	11.7
	Parupeneus multifasciatus	cylindrical	53	0.981	3.5	22.8	0.0114	3.211	17
	Parupeneus spilurus	cylindrical	19	0.995	11.4	29.5	0.0192	3.022	4.6
	Upeneus spp.	cylindrical	2057	0.984	3.5	24.0	0.0103	3.215	7.5
	Upeneus moluccensis	cylindrical	955	0.975	6.5	17.0	0.0170	3.022	6.7
	Upeneus guttatus	cylindrical	21	0.990	8.0	13.5	0.0218	2.883	5.1
	Upeneus australiae	cylindrical	332	0.978	7.5	15.5	0.0130	3.112	7.2
	Upeneus sulphureus	cylindrical	38	0.948	11.0	17.0	0.0081	3.322	6.9
	Upeneus tragula	cylindrical	380	0.988	3.5	24.0	0.0137	3.068	8.0
	Upeneus vittatus	cylindrical	329	0.988	6.0	24.0	0.0072	3.354	8.5
Muraenidae		elongated	175	0.943	3.7	256.0	0.0047	2.614	43.4
	Echidna spp.	elongated	22	0.969	11.0	64.0	0.0003	3.352	13.9
	Gymnothorax spp.	elongated	99	0.922	3.7	120.0	0.0005	3.303	20
	Gymnothorax fimbriatus	elongated	20	0.993	11.0	44.0	0.0004	3.324	10.6
	Thyrsoidea spp.	elongated	40	0.995	22.0	223.5	0.0115	2.305	9.8
	Thyrsoidea macrura	elongated	37	0.995	22.0	223.5	0.0113	2.311	13.2
Nemipteridae		cylindrical	1539	0.984	3.5	27.0	0.0171	3.004	13.1
	Nemipterus spp.	cylindrical	869	0.974	11.5	27.0	0.0068	3.307	7.9
	Nemipterus furcosus	cylindrical	598	0.976	11.5	27.0	0.0060	3.357	8.7
	Nemipterus peroni	cylindrical	271	0.936	15.5	26.5	0.0079	3.251	8.2
	Scolopsis spp.	cylindrical	669	0.981	3.5	22.0	0.0157	3.054	17.1
	Scolopsis bilineatus	cylindrical	104	0.996	3.5	19.4	0.0138	3.174	8.3
	Scolopsis taeniopterus	cylindrical	563	0.980	7.0	22.0	0.0185	2.981	7.4
Opistognathidae	*Opisthognathus* spp.	cylindrical	28	0.897	3.5	7.5	0.0231	2.452	13.9
Ostraciidae		odd	67	0.962	2.5	41.0	0.0853	2.577	26.4
	Lactoria spp.	odd	24	0.890	7.5	30.0	0.4029	1.928	35.2
	Lactoria cornuta	odd	15	0.925	20.5	30.0	0.0065	3.168	7.6
	Ostracion cubicus	odd	20	0.998	2.5	41.0	0.1288	2.519	10.5
	Tetrosomus gibbosus	odd	23	0.970	5.0	26.0	0.1820	2.369	11.7
Pinguipedidae	*Parapercis* spp.	cylindrical	202	0.982	2.5	23.0	0.0133	2.943	9.5
	Parapercis cylindrica	cylindrical	159	0.971	2.5	13.0	0.0124	3.000	14.4
	Parapercis hexophtalma	cylindrical	15	0.996	7.0	23.0	0.0068	3.157	7.8
	Parapercis xanthozona	cylindrical	19	0.983	3.5	17.5	0.0133	2.890	14.1
Platycephalidae		cylindrical	113	0.988	6.0	52.0	0.0112	2.917	12.1
	Cymbacephalus beauforti	cylindrical	14	0.998	19.5	52.0	0.0040	3.211	4.5
	Onigocia macrolepis	cylindrical	39	0.988	6.0	17.0	0.0239	2.646	6.3
	Onigocia spinosa	cylindrical	26	0.990	6.0	19.0	0.0352	2.465	9.1
	Thysanophrys chiltonae	cylindrical	20	0.989	7.5	22.1	0.0027	3.347	9.9
Plesiopidae		cylindrical	57	0.923	3.5	10.5	0.0033	3.856	13.5
	Assessor macneili	cylindrical	27	0.934	3.7	7.0	0.0181	2.791	12.4
	Plesiops coeruleolineatus	cylindrical	23	0.943	3.5	10.5	0.0067	3.496	18.3
Polynemidae	*Polydactylus microstoma*	cylindrical	112	0.981	10.5	24.5	0.0135	3.117	6.5
Pomacanthidae		compressed	232	0.983	2.0	36.4	0.0584	2.718	15.5
	Centropyge spp.	compressed	210	0.968	2.0	13.5	0.0745	2.577	17.2
	Centropyge bispinosus	compressed	117	0.964	2.0	11.5	0.0920	2.458	15.3

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Pomacanthidae	*Centropyge tibicen*	compressed	77	0.979	2.0	13.5	0.0492	2.795	10.6
	Pomacanthus sextriatus	compressed	20	0.999	3.5	36.4	0.0669	2.724	3.7
Pomacentridae		heterogeneous	2262	0.969	1.5	17.8	0.0209	3.191	15.1
	Abudefduf spp.	compressed	135	0.987	5.0	15.5	0.0226	3.132	8.2
	Abudefduf sexfasciatus	compressed	98	0.981	5.0	15.0	0.0213	3.152	10.9
	Abudefduf whitleyi	compressed	34	0.996	5.0	15.5	0.0254	3.093	7.7
	Amblyglyphidodon spp.	compressed	34	0.952	4.5	10.5	0.0144	3.330	13.7
	Amblyglyphidodon curacao	compressed	18	0.986	4.5	10.5	0.0126	3.435	8.2
	Amblyglyphidodon leucogaster	compressed	14	0.926	6.5	10.4	0.0297	2.936	9.8
	Amphiprion spp.	compressed	71	0.978	2.2	12.9	0.0189	3.190	10.9
	Amphiprion akindynos	compressed	21	0.989	4.0	12.9	0.0316	2.930	9.9
	Amphiprion melanopus	compressed	32	0.961	2.2	10.8	0.0155	3.298	12.3
	Amphiprion tricinctus	compressed	13	0.984	5.5	12.0	0.0385	2.904	12.3
	Chromis spp.	compressed	373	0.971	2.0	12.0	0.0229	3.175	13.3
	Chromis atripectoralis	compressed	24	0.989	3.5	9.0	0.0179	3.291	10.4
	Chromis chrysura	compressed	58	0.979	5.5	12.0	0.0228	3.222	8.1
	Chromis fumea	compressed	61	0.975	4.5	9.0	0.0144	3.351	8.6
	Chromis iomelas	compressed	9	0.986	3.5	6.5	0.0151	3.383	7.9
	Chromis lepidolepis	compressed	16	0.898	5.0	6.8	0.1950	1.939	6.3
	Chromis ternatensis	compressed	30	0.921	5.0	7.5	0.0160	3.408	8.7
	Chromis viridis	compressed	144	0.932	2.0	7.0	0.0351	2.900	16.0
	Chrysiptera spp.	cylindrical	107	0.931	3.5	8.2	0.0260	2.926	12.6
	Chrysiptera taupou	cylindrical	85	0.946	3.5	8.2	0.0220	3.001	13.5
	Dascyllus spp.	compressed	138	0.976	2.4	13.5	0.0462	2.911	9.8
	Dascyllus aruanus	compressed	112	0.944	2.4	6.5	0.0415	2.989	12.9
	Dascyllus reticulatus	compressed	16	0.971	3.3	8.0	0.0311	3.133	13.6
	Dascyllus trimaculatus	compressed	10	0.997	5.5	13.5	0.0313	3.043	5.7
	Neoglyphidodon spp.	compressed	50	0.981	4.0	10.8	0.0175	3.212	5.8
	Neoglyphidodon nigroris	compressed	10	0.991	6.5	10.6	0.0178	3.182	3.8
	Neoglyphidodon polyacanthus	compressed	37	0.980	4.0	10.8	0.0206	3.146	11.2
	Neopomacentrus spp.	cylindrical	171	0.944	1.5	7.0	0.0258	2.933	10.2
	Neopomacentrus azysron	cylindrical	21	0.974	3.5	6.9	0.0258	2.943	8.1
	Neopomacentrus nemurus	cylindrical	101	0.901	4.5	7.0	0.0259	2.913	9.4
	Pomacentrus spp.	compressed	898	0.955	2.0	14.5	0.0280	3.024	12.1
	Pomacentrus adelus	compressed	143	0.937	2.0	8.0	0.0176	3.292	10.6
	Pomacentrus amboinensis	compressed	128	0.974	2.5	10.5	0.0439	2.824	11.3
	Pomacentrus chrysurus	compressed	54	0.972	2.5	14.5	0.0264	3.083	12.1
	Pomacentrus imitator	compressed	10	0.952	6.3	9.2	0.0102	3.469	11.2
	Pomacentrus lepidogenys	compressed	36	0.977	4.5	8.0	0.0215	3.210	9.2
	Pomacentrus melanopterus	compressed	13	0.989	4.0	9.5	0.0116	3.387	10.5
	Pomacentrus moluccensis	compressed	38	0.903	5.0	7.6	0.0305	3.012	10.4
	Pomacentrus pavo	cylindrical	172	0.977	2.5	9.5	0.0252	2.972	10.4
	Pomacentrus philippinus	compressed	73	0.972	3.5	9.5	0.0231	3.058	10.8
	Pomacentrus vaiuli	compressed	84	0.973	2.5	8.5	0.0472	2.775	13.1
	Teixeirichthys jordani	cylindrical	50	0.970	7.0	10.0	0.0197	3.072	5.4
	Stegastes spp.	compressed	205	0.983	2.5	15.5	0.0395	2.989	10.3
	Stegastes fasciatus	compressed	11	0.897	8.5	12.0	0.0028	4.063	11.7
	Stegastes lividus	compressed	12	0.943	7.5	15.5	0.0652	2.741	13.8
	Stegastes nigricans	compressed	182	0.986	2.5	12.5	0.0384	3.010	9.4
Priacanthidae		compressed	119	0.996	4.5	38.0	0.0294	2.807	7.7
	Heteropriacanthus cruentatus	compressed	10	0.990	9.0	20.0	0.0279	2.823	8.2
	Priacanthus hamrur	compressed	106	0.995	4.5	33.0	0.0300	2.801	5.7
Pseudochromidae		cylindrical	106	0.923	2.7	8.1	0.0192	2.812	8.1
	Pseudochromis spp.	cylindrical	97	0.951	4.0	8.1	0.0096	3.167	8.4
	Pseudochromis purpurascens	cylindrical	72	0.954	4.0	8.1	0.0099	3.145	13.7

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Pseudochromidae	*Pseudochromis salvati*	cylindrical	22	0.885	4.9	7.7	0.0218	2.752	9.1
Scaridae		cylindrical	668	0.996	2.3	68.0	0.0222	2.971	12.6
	Chlorurus sordidus	cylindrical	158	0.997	2.3	37.0	0.0243	2.969	7.6
	Leptoscarus vaigiensis	cylindrical	21	0.996	3.5	19.6	0.0163	2.991	8.7
	Scarus spp.	cylindrical	637	0.996	2.3	68.0	0.0234	2.956	13.3
	Scarus altipinnis	cylindrical	19	0.997	11.0	44.5	0.0184	3.029	6.4
	Scarus ghobban	cylindrical	247	0.997	6.0	49.5	0.0165	3.041	6.7
	Scarus niger	cylindrical	13	0.997	15.0	43.0	0.0134	3.160	6.0
	Scarus psittacus	cylindrical	21	0.970	6.1	15.0	0.0105	3.319	12.9
	Scarus rivulatus	cylindrical	37	0.999	5.0	41.5	0.0175	3.074	6.8
	Scarus schlegeli	cylindrical	75	0.983	4.5	37.0	0.0231	2.969	9.7
Scatophagidae	*Scatophagus argus*	compressed	45	0.998	5.0	36.0	0.0345	2.948	5.3
Scombridae	*Scomberomorus commersoni*	cylindrical	49	0.996	19.0	100.0	0.0162	2.856	6.6
Scorpaenidae		heterogeneous	140	0.984	3.0	31.0	0.0246	2.908	15.1
	Dendrochirus brachypterus	cylindrical	32	0.990	4.0	12.0	0.0097	3.337	6.8
	Pterois spp.	cylindrical	10	0.995	3.5	31.0	0.0358	2.697	14.2
	Scorpaenodes spp.	heterogeneous	77	0.976	3.0	15.7	0.0169	3.138	7.4
	Scorpaenodes guamensis	cylindrical	38	0.971	3.5	10.8	0.0196	3.038	13.0
	Scorpaenodes parvipinnis	cylindrical	11	0.983	3.0	15.7	0.0254	2.999	16.1
	Scorpaenodes scabra	cylindrical	15	0.969	3.0	9.5	0.0245	2.960	16.0
	Scorpaenopsis spp.	heterogeneous	15	0.948	3.5	10.0	0.0131	3.261	24.0
Serranidae		heterogeneous	3403	0.996	3.5	128.0	0.0134	3.031	11.7
	Anyperodon leucogrammicus	cylindrical	10	0.980	30.5	51.0	0.0014	3.548	8.3
	Cephalopholis spp.	cylindrical	378	0.995	4.8	50.0	0.0115	3.109	11.2
	Cephalopholis argus	cylindrical	15	0.988	21.5	44.0	0.0093	3.181	7.2
	Cephalopholis boenack	cylindrical	149	0.988	4.8	30.5	0.0146	3.019	9.
	Cephalopholis miniata	cylindrical	94	0.973	23.0	46.0	0.0107	3.114	8.0
	Cephalopholis sonnerati	cylindrical	96	0.968	24.0	50.0	0.0066	3.277	8.9
	Cephalopholis urodeta	cylindrical	17	0.953	15.0	25.5	0.0282	2.818	8.4
	Cromileptes altivelis	compressed	10	0.983	13.0	45.0	0.0962	2.489	12.1
	Epinephelus spp.	heterogeneous	2712	0.996	3.5	128.0	0.0122	3.053	10.3
	Epinephelus areolatus	cylindrical	268	0.990	6.0	42.5	0.0114	3.048	8.0
	Epinephelus caeruleopunctatus	cylindrical	24	0.997	3.5	61.0	0.0180	2.938	10.5
	Epinephelus cyanopodus	compressed	232	0.994	9.5	76.0	0.0111	3.114	7.9
	Epinephelus fasciatus	cylindrical	165	0.985	8.9	36.5	0.0138	3.041	9.6
	Epinephelus fuscoguttatus	cylindrical	22	0.997	18.5	100.0	0.0134	3.057	6.1
	Epinephelus howlandi	cylindrical	83	0.997	5.7	39.0	0.0153	2.999	9.6
	Epinephelus macrospilos	cylindrical	56	0.994	11.0	41.0	0.0132	3.031	7.8
	Epinephelus maculatus	cylindrical	775	0.989	6.5	60.5	0.0110	3.062	7.5
	Epinephelus malabaricus	cylindrical	172	0.998	8.5	128.0	0.0121	3.052	7.8
	Epinephelus merra	cylindrical	291	0.995	5.5	25.0	0.0158	2.966	9.5
	Epinephelus ongus	cylindrical	43	0.995	8.5	37.0	0.0190	2.928	7.1
	Epinephelus polyphekadion	cylindrical	359	0.992	8.5	61.5	0.0083	3.166	7.8
	Epinephelus rivulatus	cylindrical	158	0.965	16.0	40.5	0.0114	3.086	7.3
	Epinephelus coioides	cylindrical	44	0.997	6.5	111.0	0.0099	3.102	10.8
	Plectropomus spp.	cylindrical	212	0.996	10.7	95.0	0.0107	3.086	7.2
	Plectropomus laevis	cylindrical	17	0.996	18.1	95.0	0.0059	3.238	8.6
	Plectropomus leopardus	cylindrical	191	0.995	10.7	91.0	0.0118	3.060	7.1
	Pseudanthias hypselosoma	cylindrical	35	0.990	5.0	9.5.0	0.0137	3.149	7.0
	Variola louti	cylindrical	41	0.995	20.0	66.0	0.0122	3.079	5.8
Siganidae	*Siganus* spp.	compressed	2065	0.987	2.0	38.0	0.0145	3.122	12.2
	Siganus argenteus	compressed	31	0.991	10.0	32.0	0.0109	3.154	8.5
	Siganus corallinus	compressed	9	0.996	9.0	19.0	0.0023	3.821	6.4
	Siganus doliatus	compressed	669	0.981	2.0	22.5	0.0104	3.272	6.1
	Siganus fuscescens	compressed	481	0.996	3.0	29.5	0.0137	3.068	7.2

Family	Name	Shape	N	r	L.min	L.max	a	b	%error
Siganidae	*Siganus lineatus*	compressed	817	0.997	5.5	35.0	0.0219	2.998	5.9
	Siganus puellus	compressed	11	0.998	5.5	24.0	0.0176	3.028	4.7
	Siganus punctatus	compressed	27	0.994	10.0	36.5	0.0095	3.276	7.7
	Siganus spinus	compressed	9	0.993	6.5	14.0	0.0150	3.093	6.7
Sillaginidae	*Sillago* spp.	cylindrical	469	0.991	3.5	31.0	0.0040	3.264	6.3
	Sillago ciliata	cylindrical	169	0.988	15.5	31.0	0.0028	3.396	7.2
	Sillago sihama	cylindrical	249	0.992	3.5	29.0	0.0051	3.180	9.1
Soleidae		very-flat	12	0.999	4.5	28.0	0.0064	3.286	6.6
	Pardachirus pavoninus	very-flat	10	0.999	4.5	28.0	0.0078	3.218	4.4
Sparidae	*Acanthopagrus berda*	compressed	295	0.996	5.0	36.0	0.0224	3.044	6.9
Sphyraenidae		semi-elongated	646	0.990	5.5	104.0	0.0058	3.013	10.9
	Sphyraena spp.	semi-elongated	646	0.990	5.5	104.0	0.0058	3.013	10.9
	Sphyraena barracuda	semi-elongated	179	0.981	19.0	63.0	0.0062	3.011	7.4
	Sphyraena flavicauda	semi-elongated	43	0.961	5.5	35.5	0.0044	3.083	11.2
	Sphyraena forsteri	semi-elongated	95	0.995	8.5	60.0	0.0053	3.034	6.3
	Sphyraena novaehollandiae	semi-elongated	23	0.987	19.0	28.0	0.0240	2.530	4.2
	Sphyraena obtusata	semi-elongated	23	0.940	19.0	26.5	0.0257	2.588	7.7
	Sphyraena putnamiae	semi-elongated	226	0.994	19.5	104.0	0.0075	2.931	6.6
	Sphyraena waitei	semi-elongated	34	0.992	19.0	31.0	0.0089	2.855	3.8
Sphyrnidae	*Sphyrna lewini*	cylindrical	30	0.991	38.0	91.0	0.0042	3.239	7.6
Synanceiidae		heterogeneous	19	0.980	5.0	29.5	0.0044	3.694	35.5
	Inimicus didactylus	cylindrical	14	0.994	6.5	21.5	0.0232	2.865	6.3
Syngnathidae	*Hippocampus* spp.	odd	9	0.882	7.0	13.0	0.0004	4.120	36.1
Synodontidae		cylindrical	1188	0.988	4.0	33.0	0.0089	3.028	15
	Saurida spp.	cylindrical	1038	0.986	4.8	33.0	0.0080	3.059	9.1
	Saurida gracilis	cylindrical	95	0.991	4.8	23.0	0.0066	3.165	10.1
	Saurida nebulosa	cylindrical	11	0.996	8.0	18.5	0.0058	3.214	6.8
	Saurida undosquamis	cylindrical	932	0.976	6.5	33.0	0.0063	3.134	9.2
	Synodus spp.	cylindrical	145	0.980	4.0	22.0	0.0085	3.078	16.1
	Synodus dermatogenys	cylindrical	43	0.984	8.0	16.5	0.0047	3.346	8.9
	Synodus hoshinonis	cylindrical	45	0.965	9.0	19.0	0.0018	3.662	11.6
	Synodus variegatus	cylindrical	37	0.992	5.0	22.2	0.0031	3.484	10.6
Teraponidae	*Terapon jarbua*	cylindrical	87	0.988	2.0	28.5	0.0132	3.131	10.8
Tetraodontidae		odd	282	0.993	2.0	76.0	0.0397	2.788	20.8
	Arothron spp.	odd	96	0.996	2.5	76.0	0.0352	2.901	12.5
	Arothron hispidus	odd	19	0.997	6.5	52.0	0.0634	2.756	10.4
	Arothron immaculatus	odd	10	0.993	4.0	32.5	0.0351	2.845	19.8
	Arothron manillensis	odd	32	0.992	3.5	33.0	0.0299	2.907	13.8
	Arothron stellatus	odd	24	0.998	5.0	75.0	0.0915	2.672	8.6
	Canthigaster spp.	odd	87	0.947	2.0	9.5	0.0424	2.822	10.0
	Canthigaster solandri	odd	10	0.990	3.0	7.5	0.0299	2.979	10.1
	Canthigaster valentini	odd	66	0.915	2.0	8.6	0.0367	2.943	20.9
	Lagocephalus sceleratus	cylindrical	94	0.997	9.0	72.0	0.0182	2.924	11.8
Trichiuruidae	*Trichiurus lepturus*	elongated	105	0.974	18.0	110.5	0.0002	3.324	12.3
Trypauchenidae	*Ctenotrypauchen microcephalus*	semi-elongated	23	0.898	4.5	11.5	0.0144	2.568	13.7
Zanclidae	*Zanclus cornutus*	very-flat	11	0.985	6.5	15.0	0.0147	3.370	2.0