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Review Article

# Identification of fish stocks based on Truss Morphometric: A review

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**ABSTRACT**

Stock identification is an interdisciplinary field that involves the recognition of self-sustaining components within natural populations. The concept of stock separates the population into groups with different growth rates and reproductive dynamics, irrespective of genetic similarities. Morphometric differences among stocks of a species are recognized as important tool for evaluating the population structure and identifying stocks. The use of geometric pattern for determining the shape of an organism can be used as a tool for stock identification. It has evolved as effective technique in stock management and conservation programmes in determining the stock. Truss Network System is a landmark-based technique using geometric morphometrics and imposes no restrictions on the direction of variation or localization of shape changes. It is highly effective in capturing information about the shape of an organism. Truss network measurements are a series of distances calculated between landmarks that form a regular pattern of connected quadrilaterals or cells across the body form. Identifying stocks, discriminating among them and determining the stock composition of mixed stocks are integral elements of fishery management. Determination of the population structure of species is an essential component for the successful management of fisheries.



## INTRODUCTION

Stock identification is an interdisciplinary field that involves the recognition of self-sustaining components within natural populations (Cadrin *et al.*, 2005). In an aquatic ecosystem, fish population is distributed over extensive geographical areas with oceanographic barriers (temperature, salinity, food and predation). Environmental conditions in these regions control important population attributes like reproduction, fecundity and longevity. These attributes are intimately related to population dynamics parameters i.e. carrying capacity, productivity and resilience (Cole, 1954). Thus, identification of stock helps to effectively:

- manage the stock separately.
- estimate stock-wise population abundance.
- retain the biologically sustainable productivity.
- determine how each stock respond to fisheries exploitation.
- fulfill the purpose of fishery stock assessment by modeling

This makes it essential to know the stock structure of an explored species. Studies in fishery biology are generally directed to particular species targeted by fishing operations. For instance, Sardine and Mackerel fishery in Indian waters are fully exploited. In the light of decreasing catches, fishing down effects and threatened marine ecosystem, there is an imperative need to understand the interdependence of targeted species on other species and the marine environment where they co-exist. A fundamental requirement of stock identification is to consider the full impact of management actions, including identifying the stock complexity of a fish species (Begg *et al.*,1999).

### *Concept of Stock*

A stock is "a sub-set of one species having the same growth and mortality parameters, and inhabiting a particular geographical area sharing a common gene pool" (FAO, 1998). It is a panmictic subunit of a species that follows the Hardy Weinberg Equilibrium (the frequency of the dominant and recessive alleles will remain unchanged from one generation to the next, given there is no migration, selection and gene drift). The concept of `stock' is fundamental to the fisheries management. Stocks are arbitrary groups of fish large enough to be essentially self-reproducing, with members of each group having similar life history characteristics (Hilborn and Walters, 1992).

In fisheries science, stock first referred to any group of a fish species that was available for exploitation in a given area (Milton and Shaklee, 1987). Marr (1957) explicitly differentiated stocks and subpopulations, considering the subpopulation to be a genetically self-sustaining entity, *i.e.*, a deme, or the smallest self-perpetuating unit. In general, a 'fish stock' is a local population adapted to a particular environment, having genetic differences from other stocks. The unique biological, serological, genetic, spatial and temporal characteristic of the stock of the species generates an imperative need to study the biology separately.

In fisheries studies, the estimation of stock abundance is important in determining the effects of fishing and environmental disturbances as well as in estimating parameters such as mortality. Although estimates of absolute abundance (the total number of individuals) are sometimes required, it is often sufficient to obtain estimates of relative abundance – the number of individuals in one area in relation to the numbers present in another area, or in the same area at another time (King, 2007).

*Conventional morphometrics*

Historically, the morphology of fishes has been the primary source of information for taxonomic and evolutionary studies. There are numerous characters *viz.* upper jaw length, slandered length, body depth at dorsal fin origin, mandibular length, body depth at dorsal fin origin, fleshy orbit head length, pre-dorsal length, pelvic fin length, pre-anal length, pre-pelvic length, dorsal fin base, peduncle depth, anal fin base, peduncle length, snout length, pre-maxillary teeth and head width available for morphological study. As you can see, most of the measurements are parallel and horizontal along the vertebral column of the fish. Many measurements have a common landmark i.e., the tip of snout. A major drawback of this morphometric system is their dependency on the size of the fish and high correlation with total length of the fish (Fig. 1).

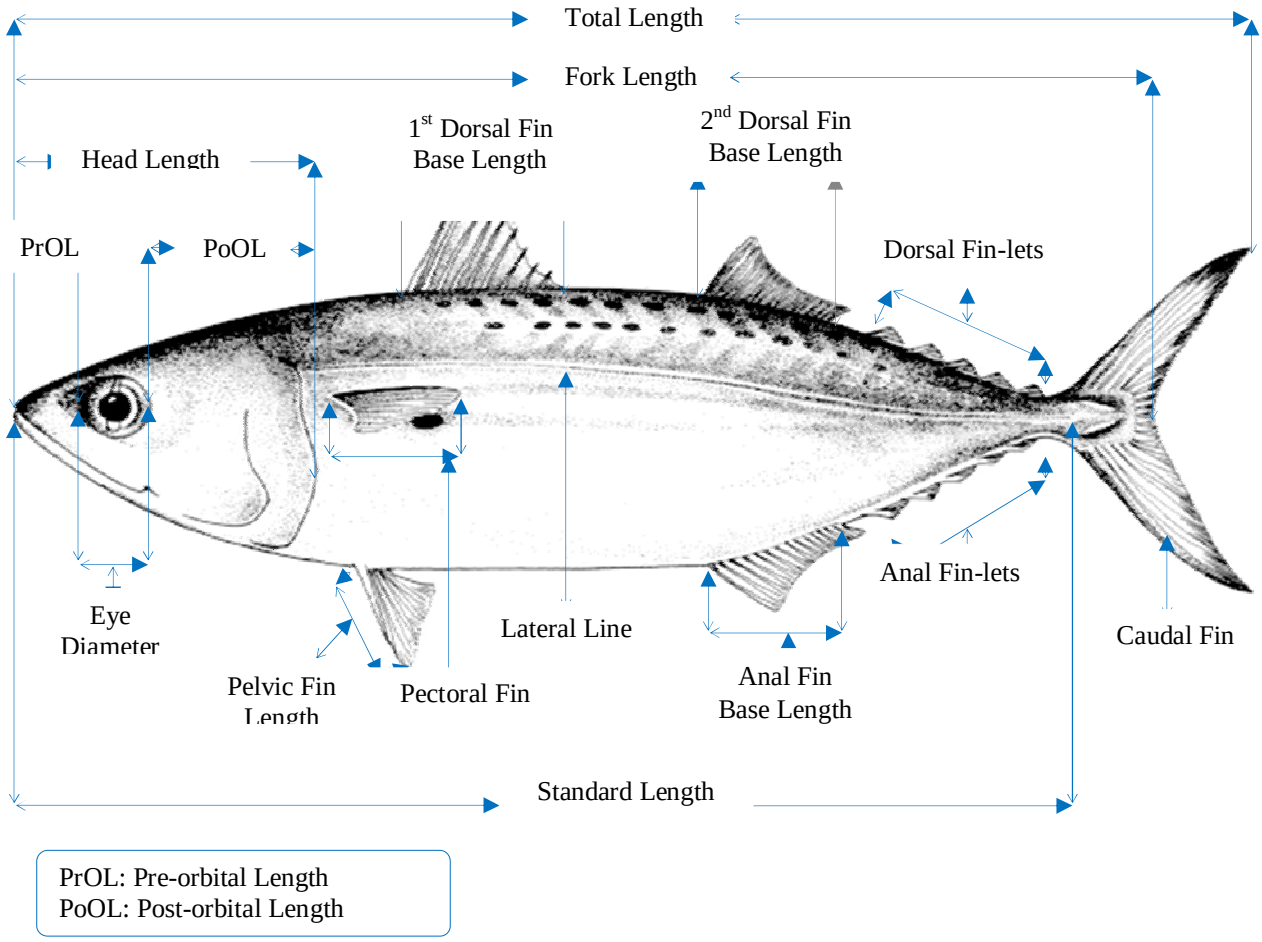


**Fig. 1**. Morphometric Traits

*Morphometric analysis as a tool for stock identification*

Morphology, refers to the phenotype of an organism. It is a primary and direct means by which organisms interact with environment. In population biology, it is useful to know whether two populations of organisms have the same typical body form to indicate:

- size allometry
- shape changes accompanying size increase over the life span
- characterization of the difference between sexes
- responses to environmental variation.

Morphometric, the study of geometrical form of organisms, indicate differences in growth and maturity patterns which are sensitive to environmental fluctuations and show little variation in the gene pool. The study of the

morphometric traits is one of the frequently employed and cost-effective methods (Sajina *et al.,* 2011).

*Advantages of phenotypic markers over genotypic markers*

Although genetic differences in a population is of utmost importance, phenotypic variations still continue to have a unique role in stock identification among groups of fish (Costa *et al.,* 2003). The usage of phenotypic characters is particularly important where the differences are attributed to environmental influences rather than to genetic differentiation (Mir *et al.,* 2013). Despite of their dependence on the environment, on to genetic rates influence many population attributes like reproduction, fecundity, longevity, size structure which are intimately related to population dynamics parameters i.e. intrinsic rate of increase (growth, recruitment), carrying capacity, productivity and resilience (Cole, 1954) which eventually determines how each stock respond to exploitation.

The traditional morphometric investigations concentrate the measurements along the specific locus of the fish i.e., from the head/ tip of snout to posterior end of the vertebral column thusuni-directional and non-uniform coverage of the body form. An alternative to the drawback of traditional measurements is the *Truss Network System.*

*Truss Network System-an overview*

Truss Network System is a landmark-based technique using geometric morphometrics and imposes no restrictions on the direction of variation or localization of shape changes. The truss network system is highly effective in capturing information about the shape of an organism (Cavalcanti *et al.,* 1999). Truss network measurements are a series of distances calculated between landmarks that form a regular pattern of connected quadrilaterals or cells across the body form (Strauss and Bookstein, 1982). One major advantage of deriving morphometric data from digital images is the ability to store the image and the potential for reprocessing each individual to confirm anomalous measurements or derive alternative sets of characteristics. Storage of images also allows detailed inspection of extreme variants or outliers, as well as more flexible characteristic selection (Cadrin and Friedland, 1999). The summary of the review of work done in India on analysis of truss morphometric are present in Table. 1.

*Landmarks*

These are anatomical points on the body form of an organism (Fig. 2). In truss system, Homologous landmarks on the boundary of the form are divided into two tiers and paired (Fig.3). Homogeneity in landmarks helps to appropriately archive the body form. The distances that connect these landmarks forms a series of quadrilaterals each having internal diagonals. Each quadrilateral share one side with each succeeding and preceding quadrilateral.

*Choice of landmarks*

Landmarks should be anatomical points, representing the same developmental feature among specimens, and should be easily located. The most effective landmarks are those defined by the intersection of different tissues, such as insertion points of fins and anal pores. The network should resemble the shape of the specimen from which it is derived.

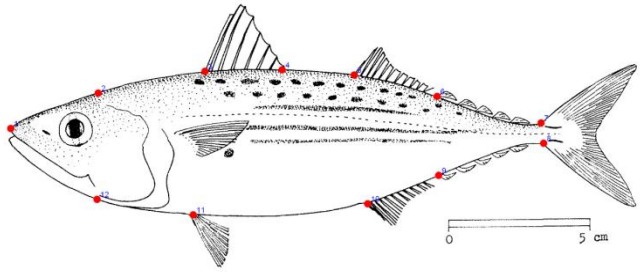


**Fig.2**. Locations of the 12 landmarks on *Rastrelliger kanagurta*

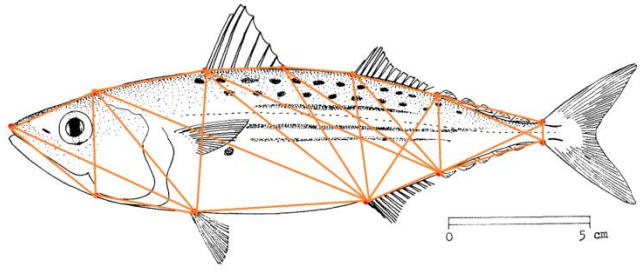


**Fig. 3.** Locations of the landmarks defining the truss network on *Rastrelliger kanagurta*

*Analysis of truss morphometric data*

Multivariate techniques are widely used to analyze patterns of differentiation between samples and assess similarities. The linear distance between landmarks is used to obtain truss variables in the truss network system. Multivariate statistics deals with the simultaneous observation and analysis of more than one outcome truss variable. Thus, extracts various independent truss variables that distinguish the stock from the population. The various statistical techniques under the umbrella of multivariate analysis are:

*Principal Component Analysis*

Principal components analysis is a procedure for identifying a smaller number of uncorrelated variables, called "principal components", from a large set of data. The goal of principal components analysis is to explain the maximum amount of variance with the fewest number of principal components. Principal component analysis helps in morphometric data reduction (Mir *et al.,* 2013), in decreasing the redundancy among the variables (Samaee *et al.,* 2006) and in extracting the independent variables for population differentiation (Samaee *et al.,* 2009).

*Factor analysis*

It is a method for explaining the structure of data by explaining the correlations between variables. Factor analysis summarizes data into a few dimensions by condensing a large number of variables into a smaller set of latent variables or factors

*Cluster analysis*

It involves the search through multivariate data for observations that are similar enough to each other to be usefully identified as part of a common duster. Clusters

consist of observations that are close together and that the clusters themselves are separated.

*Discriminant analysis*

It gives insight into the group membership and the variables used to predict group membership. The DFA calculates the Percentage of Correctly Classified (PCC) fish. The Wilks' λ was used to compare the difference between all groups. A cross-validation using PCC estimate the expected actual error rates of the classification functions.

**Table.1.** Summary of the review of work done in India on analysis of truss morphometric

| Species | Land-marks | Truss-distance | Inference | Source |
|---|---|---|---|---|
| *Nemipterus japonicus* | - | 21 | Presence of more than one stock is present in the west as well as east coasts of India | Sreekanth *et al.*, 2015 |
| *Penaeus monodon* | 12 | 27 | Homogeneous stock structure of the population in the southeast and southwest coasts of India | Rebello *et al.*, 2014 |
| *Rastrelliger kanagurta* | 10 | 21 | No separation of the stocks along south-east and south west coasts | Remya *et al.*, 2014 |
| *Harpadon nehereus* | 11 | 24 | Presence of three stocks of *Harpadon nehereus* populations, two on the east coast and one on the west coast of India. | Pazhayamadom *et al.*, 2014 |
| *Clupisoma garua* | 13 | 78 | Significant differences among five populations of Freshwater Catfish | Verma *et al.*, 2014 |
| *Tor putitora* | 12 | 30 | Occurrence of multi-stock structure in the Beas, Ravi, Chenab, Kosi and Jiabhoreli. | Barat *et al.*, 2013 |
| *Schizothorax richardsonii* | 14 | 31 | Significant phenotypic heterogeneity between the Western and Central Indian Himalayas stock | Mir *et al.*, 2013 |
| *Heteropneustes fossilis* | 11 | 29 | Discrete populations of *H. fossilis* in the Ganga River and its tributaries: the Yamuna and Gomti Rivers. | Khan *et al.*, 2012 |
| *Decapterus russelli* | 11 | 23 | Occurrence of separate stock in Bay of Bengal and Arabian Sea populations | Sen *et al.*, 2011 |
| *Catla catla* | 10 | 21 | Truss network' is an effective tool to describe the body shape and quantify the intra species variability of carps. | Ujjania *et al.*, 2011 |
| *Lates calcarifer* | 10 | 21 | Stock differences based on juveniles and pre-adults | Gopikrishna *et al.*, 2006 |
| *Rastrelliger kanagurta* | 16 | 36 | Gradual and progressive separation of socks along the west coast of India | Sajina *et al.*, 2011 |

The use of multivariate analysis for the truss variables develops a picture of:

- to identify a stock of a population with homogenous internal dynamics and limited exchange with other stocks of the same population.
- increase the resolving power for describing inter-specific shape differences
- visualize the impact of the various environmental parameters that leads to stock differentiation.

*Why stock identification?*

Information on the fish stocks is needed to meet objectives of fisheries management:

1. *Achieve sustainable yield*: A better knowledge regarding the size of the stock, its distribution and population characteristics (growth, recruitment, mortality) it helps to exploit the stock to its optimum level with respect to its MSY level, thus helps to achieve sustainability.
2. *Avoid recruitment failures and rebuild overfished stocks*: once if status of the stock is determined, it helps to understand its dynamics, i.e. recruitment, growth and mortality. Thus, the status of the stock whether under exploited, exploited or over-exploited can be evaluated.
3. *Conserve threatened and endangered species*: In the present scenario, the tropical waters are overfished, due to over exploitation of commercial species like Mackerel, Sardine, along with discard/ by –catch loss, unregulated and unreported fishing of many species. This ecosystem is facing tremendous pressure due to overexploitation of resources. Thus, there a need to conserve the threatened one, which is not possible without the joint efforts of understanding the population structure of the stock availability.

## CONCLUSION

The long-term isolation of populations and interbreeding can lead to morphometric variations within populations, and this morphometric variation can provide a basis for population differentiation. The concept of stock separates the population into groups with different growth rates and reproductive dynamics, irrespective of genetic similarities. Morphometric differences among stocks of a species are recognized as important tool for evaluating the population structure and identifying stocks (Turan, 1999). The use of geometric pattern for determining the shape of an organism can be used as a tool for stock identification. It has evolved as effective technique in stock management and conservation programmes in determining the stock.

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