User Manual for FishAssess 0.1-1

Sandro Klippel and Mônica Brick Peres

Document version: 0.1-1 (DRAFT)

For bibliographic purposes this document should be cited as follows:
Klippel, S and M. B. Peres (2001) User Manual for FishAssess 0.1-1.xx p. [available at http://www.fishassess.sourceforge.net]

Contents

1 Theory and methods

2 Functions

2.1 Growth parameters

VBGFl

Length based von Bertalanffy growth function

Usage

```
VBGFl(t, Linf, K, t0)
```

Where

t age

Linf asymptotic length

K growth rate

t0 age at zero length

$\longrightarrow$ Return the length

References

von Bertalanffy (1938); Sparre and Venema (1998)

VBGFw

Weight based von Bertalanffy growth function

Usage

```
VBGFw(t, Winf, K, t0, b=3)
```

Where

t age

Winf asymptotic weight

K growth rate

t0 age at zero length

b alometric coefficient

$\longrightarrow$ Return the weight

References

von Bertalanffy (1938); Sparre and Venema (1998)

VBGFinv

Inverted von Bertalanffy growth function

Usage

```
VBGFinv(l, Linf, K, t0)
```

Where

l length

Linf asymptotic length

K growth rate

t0 age at zero length

$\longrightarrow$ Return the age

References

von Bertalanffy (1938); Sparre and Venema (1998)

NEWk

Adjust growth rate (K) according new L_∞ hold the same ϕ' (phi prime)

Usage

```
NEWk(k, Linf, Linf2)
```

Where

k growth rate

Linf asymptotic length

Linf2 new asymptotic length

$\longrightarrow$ Return the new value of K.

References

Munro and Pauly (1983)

phi.prime

Usage

```
phi.prime(k, Linf)
```

Where

k growth rate

Linf asymptotic length

$\longrightarrow$ Return the value of phi prime.

References

Munro and Pauly (1983)

phi

Usage

```
phi(k, Winf)
```

Where

k growth rate

Winf asymptotic weight

$\longrightarrow$ Return the value of phi.

References

Munro and Pauly (1983)

2.2 Mortality rates

Z.hoenig

Usage

```
Z.hoenig(Tmax)
```

Where

Tmax maximum age observed

⟶ Return total mortality estimate (Z)

References

Hoenig (1983)

Z.joneszalinge

Cumulative plot of Jones and van Zalinge to estimate total mortality rate (Z)

Usage

```
Z.joneszalinge(obj, dlower=0, dupper=0, plot.it=T, ...)
```

Where

obj object of the class **lengthdata**

dlower number of lower points to be deleted (close to L_∞)

dupper number of upper points to be deleted (not fully recruited)

plot.it TRUE for plot graph

`...` parameters to be passed to plot method

⟶ Return total mortality estimate (Z)

References

Sparre and Venema (1998)

M.gunderson

Natural mortality (M) estimation by gonad-somatic index (GSI)

Usage

```
M.gunderson(GSI)
```

Where

GSI gonad-somatic index

⟶ Return the estimated natural mortality.

References

Gunderson and Dygert (1988)

M.jensen1

Natural mortality (M) estimation by age at first maturity

Usage

```
M.jensen1(Tmat)
```

Where

Tmat age at first maturity

⟶ Return the estimated natural mortality.

References

Jensen (1996)

M.jensen2

Natural mortality (M) estimation by growth rate (K)

Usage

```
M.jensen2(K)
```

Where

K growth rate

⟶ Return the estimated natural mortality.

References

Jensen (1996)

M.jensen3

Natural mortality (M) estimation by growth rate (K)

Usage

```
M.jensen3(K)
```

Where

K growth rate

⟶ Return the estimated natural mortality.

References

Jensen (1996)

M.pauly

Natural mortality estimation by Pauly's relationship of von Bertalanffy growth parameters and mean water temperature.

Usage

```
M.pauly(Linf, K, Temp)
```

Where

Linf asymptotic length

K growth rate

Temp mean water temperature experienced by the stock

⟶ Return the estimated natural mortality.

References

Pauly (1980)

M.pauly.w

Natural mortality estimation by Pauly's relationship of von Bertalanffy growth parameters and mean water temperature.

Usage

```
M.pauly.w(Winf, k, Temp)
```

Where

Winf asymptotic weight

K growth rate

Temp mean water temperature experienced by the stock

⟶ Return the estimated natural mortality.

References

Pauly (1980)

M.ralston

Natural mortality estimation by Ralston's relationship for snappers and groupers.

Usage

```
M.ralston(K)
```

Where

K growth rate

⟶ Return the estimated natural mortality.

References

Ralston (1987)

M.rikhter

Natural mortality (M) estimation by age at first maturity

Usage

```
M.rikhter(Tmat)
```

Where

Tmat age at first maturity

⟶ Return the estimated natural mortality.

References

Rikhter and Efanov (1976)

2.3 Virtual populations methods

vpa.age

Performs a virtual population analysis on catch data grouped into age classes by backward solve the nonlinear catch equation

Usage

```
vpa.age(agesdf, catches=NULL, M=NULL, species=NULL)
```

Where

agesdf a vector with lower limit of age classes or an object of class agedata containing all required arguments

catches a vector with catch in numbers for each age class

M natural mortality rate

species identification of the species analyzed

⟶ Return an object of the class vpaage with the results.

References

Jones (1984); Quinn and Deriso (1999); Lassen and Medley (2001)

solveCatchEq

Solves catch equation using Newton-Raphson iteration

Usage

```
solveCatchEq(catch, number2, M, approxeps=0.01)
```

Where

catch catch in number in t

number2 number at sea in t+1

M natural mortality rate

approxeps precision for approximation

⟶ Return a list with number at sea and fishing mortality rate.

References

Press et al. (1992); Lassen and Medley (2001)

vpa.length

Performs a cohort analysis on catch data grouped into length classes by converting lengths to ages using an assumed von Bertalanffy growth curve.

Usage

```
vpa.length(lengthsdf, catches=NULL, Linf=NULL,
           k=NULL, M=NULL, a=NULL, b=NULL, species=NULL)
```

Where

lengthsdf a numeric vector with lower limit of length classes or an object of class length-data containing all required arguments

catches a vector with catch in numbers for each length class

Linf asymptotic length of the von Bertalanffy growth curve

K Brody growth parameter of the von Bertalanffy growth curve

M natural mortality rate

a intercept of the length-weight relationship

b exponent of the length-weight relationship

species identification of the species analyzed

⟶ Return an object of the class vpalength with the results.

References

Jones (1984); Quinn and Deriso (1999); Lassen and Medley (2001)

summary.vpalength

Print the summary of results from length based cohort analysis

Usage

```
summary.vpalength(obj)
```

Where

obj object of the class **vpalength**

plot.vpalength

Plot profile of fishing mortalities over lengths and relative ages from length based cohort analysis

Usage

```
plot.vpalength(obj, xlab="Relative age", ylab="Fdt", toplab="Length", ...)
```

Where

obj object of the class vpalength

xlab label of age axis

ylab label of fishing mortality axis

toplab label of length axis

... parameters to be passed to plot method

print.vpalength

Print results from length based cohort analysis

Usage

```
print.vpalength(obj)
```

Where

obj object of the class **vpalength**

ThompsonBell

Perform the predictive Thompson & Bell model

Usage

```
ThompsonBell(obj, factors, prices=rep(0, length(obj$lengths)))
```

Where

obj object of the class **vpaage** or **vpalength**

factors vector of multiplication factors of F

prices vector of prices

⟶ Return an object of the class **TB** with results of the model

References

Sparre and Venema (1998); Quinn and Deriso (1999)

ThompsonBell.MaxY

Find the factor that maximize the yield

Usage

```
ThompsonBell.MaxY(obj,interval=c(0, 10))
```

Where

obj object of the class **TB**

interval interval of factors to be searched

⟶ Return the factor

ThompsonBell.MaxE

Find the factor that maximize the economic yield

Usage

```
ThompsonBell.MaxE(obj,interval=c(0, 10))
```

Where

obj object of the class **TB**

interval interval of factors to be searched

⟶ Return the factor

2.4 Beverton and Holt yield per recruit model

Beverton.Holt

Beverton and Holt biomass and yield per recruit calculation for a given set of parameters. Default method for integration is numerical, but also Gulland aproximation and relative yield concept are available.

usage

```
Beverton.Holt(F=NULL, FZ=NULL, Tr=NULL, Tc=NULL, Lc=NULL, Tmax=NULL, M,
              Wt=NULL, Winf=NULL, Linf=NULL, K=NULL, t0=NULL, b=3,
              approxim=c("integration", "gulland","relative"))
```

Where

F fishing mortality rate

FZ exploitation rate F/Z

Tr age at recruitment

Tc age at first capture

Lc length at first capture

Tmax maximum age attained

M natural mortality rate

Wt weight at age (function)

Winf asymptotic weight

Linf asymptotic length

K growth rate

t0 age at zero length

b constant in length-weight relationship ($W = aL^b$)

approxim method for calculation

$\longrightarrow$ Return a object of class **BH** with the components:

YR yield per recruit

BR biomass per recruit

... input parameters

References

Beverton and Holt (1957, 1966); Sparre and Venema (1998); Quinn and Deriso (1999)

plot.BH

Plot the yield/recruit curve. The points on the curve for $F_{0.1}$ and F_{max} are shown.

Usage

```
plot.BH(obj, Flab="Fishing mortality",
        YRlab="Yield/Recruit", BRlab="Biomass/Recruit")
```

Where

obj object of the class **BH**

Flab label for fishing mortality axis

YRlab label for yield/recruit axis

BRlab label for biomass/recruit axis

profile.BH

Profile yield/recruit of Beverton & Holt model over fishing mortalities

Usage

```
profile.BH(obj, Fs=seq(0, round(Fmax(obj) * 3, 0), (round(Fmax(obj) * 3, 0)/100)))
```

Where

obj object of the class **BH**

Fs vector of fishing mortalities

plot.profileBH

Plot the yield/recruit curve as function of fishing mortality

Usage

```
plot.profileBH(obj, Flab="Fishing mortality",
               YRlab="Yield/Recruit", BRlab="Biomass/Recruit")
```

Where

obj object of the class **BH**

Flab label for fishing mortality axis

YRlab label for yield/recruit axis

BRlab label for biomass/recruit axis

isopleths

Plot yield/recruit isopleth diagram

Usage

```
isopleths(obj,F,T)
```

Where

obj object of the class **BH**

F vector of fishing mortalities

T vector of ages or lengths at first capture

References

Beverton and Holt (1957, 1966); Quinn and Deriso (1999)

F0.1

Fishing mortality rate at which the slope of the yield per recruit curve as a function of fishing mortality is 10% of its value at the origin. The fishing mortality level $F_{0.1}$ was proposed as a conservative target reference point.

Usage

```
F0.1(obj)
```

Where

obj object of the class **BH**

$\longrightarrow$ Return the $F_{0.1}$ value.

References

Gulland (1968); Caddy and Mahon (1995); Quinn and Deriso (1999)

Fmax

Fishing mortality for a given size at first capture, which maximizes the average yield from each recruit entering the fishery. It could be considered as an limit reference point for the stock.

Usage

```
Fmax(obj)
```

Where

obj object of the class **BH**

$\longrightarrow$ Return the F_{max} value.

References

Caddy and Mahon (1995); Sparre and Venema (1998); Quinn and Deriso (1999)

2.5 Selectivity

selection

Estimate selection curve from VPA or cohort analysis

Usage

```
selection(obj)
```

Where

obj object of the class **vpalength** or **vpaage**

$\longrightarrow$ Return an object of the class selection with a vector of selection over lengths or ages.

References

Sparre and Venema (1998)

S.f2logistic2

Fit a function of the product of two logistic equations on selection data

Usage

```
S.f2logistic2(obj, plot.it=T, maxiter=50)
```

Where

obj object of the class **selection**

plot.it TRUE for plot the function and data

maxiter maximum number of iterations (non-linear approximation)

⟶ Return an object of the class list with the coefficients of the function.

References

Sparre and Venema (1998)

S.f2logistic

Fit a function of the product of two logistic equations on selection data

Usage

```
S.f2logistic(obj, plot.it=T, ...)
```

Where

obj object of the class **selection**

plot.it TRUE for plot the function and data

... parameters to be passed to plot method

⟶ Return an object of the class list with the coefficients of the function.

References

Sparre and Venema (1998)

S.flogistic

Fit a logistic function on selection data

Usage

```
S.flogistic(obj, plot.it=T)
```

Where

obj object of the class **selection**

plot.it TRUE for plot the function and data

⟶ Return an object of the class list with the coefficients of the function.

References

Sparre and Venema (1998)

Plotlogistic2

Usage

Plot gill-net like selection curve

```
Plotlogistic2(lengths, S1, S2, D1, D2)
```

Where

lengths vector of lengths

S1 $L_{50\%}$ value

S2 $L_{75\%}$ value

D1 $D_{50\%}$ value

D2 $D_{75\%}$ value

References

Sparre and Venema (1998)

3 GNU Free Documentation License

Preamble

The purpose of this License is to make a manual, textbook, or other written document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

3.1 Applicability and Definitions

This License applies to any manual or other work that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you".

A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (For example, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The "Invariant Sections" are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License.

The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License.

A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, whose contents can be viewed and edited directly and straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup has been designed to thwart or discourage subsequent modification by readers is not Transparent. A copy that is not "Transparent" is called "Opaque".

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML designed for human modification. Opaque formats include PostScript, PDF, proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML produced by some word processors for output purposes only.

The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text.

3.2 Verbatim Copying

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3.3 Copying in Quantity

If you publish printed copies of the Document numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a publicly-accessible computer-network location containing a complete Transparent copy of the Document, free of added material, which the general network-using public has access to download anonymously at no charge using public-standard network protocols. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

3.4 Modifications

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- Use in the Title Page (and on the covers, if any) a title distinct from that of the

Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

- List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has less than five).
- State on the Title page the name of the publisher of the Modified Version, as the publisher.
- Preserve all the copyright notices of the Document.
- Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
- Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
- Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
- Include an unaltered copy of this License.
- Preserve the section entitled "History", and its title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.
- Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
- In any section entitled "Acknowledgements" or "Dedications", preserve the section's title, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
- Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

- Delete any section entitled "Endorsements". Such a section may not be included in the Modified Version.
- Do not retitle any existing section as "Endorsements" or to conflict in title with any Invariant Section.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties – for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

3.5 Combining Documents

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections entitled "History" in the various original documents, forming one section entitled "History"; likewise combine any sections entitled “Acknowledgements”, and any sections entitled “Dedications”. You must delete all sections entitled “Endorsements.”

3.6 Collections of Documents

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

3.7 Aggregation With Independent Works

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, does not as a whole count as a Modified Version of the Document, provided no compilation copyright is claimed for the compilation. Such a compilation is called an “aggregate”, and this License does not apply to the other self-contained works thus compiled with the Document, on account of their being thus compiled, if they are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one quarter of the entire aggregate, the Document’s Cover Texts may be placed on covers that surround only the Document within the aggregate. Otherwise they must appear on covers around the whole aggregate.

3.8 Translation

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License provided that you also include the original English version of this License. In case of a disagreement between the translation and the original English version of this License, the original English version will prevail.

3.9 Termination

You may not copy, modify, sublicense, or distribute the Document except as expressly provided for under this License. Any other attempt to copy, modify, sublicense or distribute the Document is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

3.10 Future Revisions of This License

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation.

ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

> Copyright © YEAR YOUR NAME. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.1 or any later version published by the Free Software Foundation; with the Invariant Sections being LIST THEIR TITLES, with the Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST. A copy of the license is included in the section entitled "GNU Free Documentation License".

If you have no Invariant Sections, write "with no Invariant Sections" instead of saying which ones are invariant. If you have no Front-Cover Texts, write "no Front-Cover Texts" instead of "Front-Cover Texts being LIST"; likewise for Back-Cover Texts.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

Bibliography

Beverton, R. and Holt, S. 1957. On the dynamics of exploited fish populations., volume 2. Sea Fish. Min. Agric. Fish Food G. B.

Beverton, R. and Holt, S. 1966. Manual of methods for fish stock assessment - Part 2. Tables of yield functions, volume 38/1 of *FAO Fisheries Technical Papers*. FAO, Rome. 67 pages.

Caddy, J. and Mahon, R. 1995. Reference points for fisheries management, volume 374 of *FAO Fisheries Technical Paper*. FAO, Rome.

Gulland, J. 1968. The concept of marginal yield from exploited fish stocks. *J. Cons. CIEM* 32:256–261.

Gunderson, D. R. and Dygert, P. H. 1988. Reproductive effort as a predictor of natural mortality rate. *J. Cons. int. Explor. Mer* 44:200–209.

Hoenig, J. 1983. Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin* 82:898–903.

Jensen, A. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. *Canadian Journal of Fisheries and Aquatic Sciences* 53:820–822.

Jones, R. 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis), volume 256 of *FAO Fisheries Technical Paper*. FAO, Rome.

Lassen, H. and Medley, P. 2001. Virtual population analysis - A pratical manual for stock assessment, volume 400 of *FAO Fisheries Technical Paper 400*. FAO, Rome.

Munro, J. and Pauly, D. 1983. A simple method for comparing the growth of fishes and invertebrates. *Fishbyte* 1:5–6.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *Journal du Conceil International pour l'Exploration de la Mer* 39:175–192.

Press, W., Teukolsky, S., Vetterling, W., and Flannery, B. 1992. Numerical Recipes in C: The Art of Scientific Computing. Cambridge University Press, Cambridge, 2nd edition.

Quinn, T. and Deriso, R. 1999. Quantitative fish dynamics. Oxford University Press, New York - Oxford.

Ralston, S. 1987. Tropical snappers and groupers. Biology and fisheries management., chapter Mortality rates of snappers and groupers. Westview Press, London. 659p.

Rikhter, V. and Efanov, V. 1976. On one of the approaches to estimation of natural mortality of fish populations. *ICNAF Res. Doc.* 76:12.

Sparre, P. and Venema, S. 1998. Introduction to tropical fish stock assessment - Part 1: Manual, volume 306/1 of *FAO Fisheries Technical Paper*. FAO, Rome.

von Bertalanffy, L. 1938. A quantitative theory of organic growth (inquiries on growth laws. ii). *Human Biology* 10:181–213.