

	<b>Subject details</b>
<b>1. Subject title:</b>	Fisheries Biology
<b>2. Code:</b>	-----
<b>3. Scientific area:</b>	Fisheries
<b>4. Module no.:</b>	-----
<b>5. Bloc no.:</b>	3
<b>6. Semester:</b>	First
<b>7. ECTS:</b>	5
<b>8. Work load:</b>	140 h
<b>9. Hours of lectures:</b>	Lectures – 15 Lectures + laboratory work – 9 Seminars – 2 Tutorials – 1 Other (Examinations) – 4
<b>10. Study hours:</b>	109
<b>11. Subject for the courses:</b>	Master's in Marine Biology (compulsory) Master's in Aquaculture and Fisheries (optional)
<b>12. Language of lecturing:</b>	Portuguese
<b>13. Coordinator:</b>	Manuel Afonso-Dias
<b>14. Other lecturers:</b>	Ricardo Melo (University of Lisbon) - invited to give the Algae seminar on behalf of Rui Santos, in sabbatical licence during the academic year of 2007/2008.
<b>15. Aims:</b>	This course aims to give you the basic biological foundations to fisheries stock assessment and management, including sampling methodology, age and growth methods to estimate fish and invertebrate growth rates. During this course you will be able to understand the dynamics of sexual maturity; to know the methods to assess sexual maturity and also to estimate fecundity.
<b>16. Learning outcomes:</b>	Fisheries Biology will introduce you to fundamental biological issues relevant to stock assessment and management studies. These biological aspects concerning marine exploited resources include morphometric, age, growth, reproduction, maturation and fecundity. This subject will be focus on: methods used to estimate age of fish and invertebrates, estimation of growth parameters, gonad classification according to the degree of maturation, estimation of length and age at first maturity and estimation of fecundity. Although the core of this subject is the study of marine animals, some relevant information on the exploitation of marine algae will also be presented in a dedicated seminar (2 hours).
<b>17. Subject requirements:</b>	-----
<b>18. Programme:</b>	Introduction: Summary of topics covered during the course (lectures and laboratory classes), recommended literature, assessment criteria, scheduled field work, visits and

seminars. Activities timetable:

**LECTURES PROGRAMME:**

Fisheries importance, particularly in Portugal. Contexture of the Fisheries Biology subject within the fishery sciences. Managing renewable resources: theoretical and empirical issues for the case of fishing and the need to assess and manage fish resources.

Life cycle of an exploited fish resource: exploited and non-exploited phases; recruitment to fishing area and recruitment to the fishery. The concept of stock and cohort; the evolution of an exploited cohort; main aspects of the dynamic of an exploited fish resource (growth, mortality and reproduction).

Exploited stock: Abundance in number and in weight (biomass), adult biomass (spawning); Catches, landings and discards. Fishing effort; Catches per unit effort (fishing success) – abundances indices. Stock and catches structure (sex, size and age).

Data sources: research surveys, sampling on board fishing boats and on the fish harbour. Data from official commercial fishing statistics.

Age and growth

1. Introduction.

2. Direct methods: fundamentals and applicability.

2.1. Calcified structures: Otoliths, scales, vertebrae and other bones. Selection criteria, sampling extraction, preparation for observation and storage. Examination: methods and equipment.

2.2. Interpretation of growth marks. Terminology used. Criteria used to estimate age from calcified structures. Validation and verification (precision analyses).

2.3. Estimation of age composition. Age group and year class concepts. Age-length keys and its use to convert length compositions into age compositions. Determination of mean lengths at age and mean age.

2.4. Growth and growth analyses. Growth indices. Relative growth and allometry: weight/length relationship, condition factors and other morphometric relationships. Growth models: data used in the growth models, von Bertalanffy model in length: Adjusting the model and estimating parameters; parameters estimation by graphical methods and by linear regression; non-linear estimation. von Bertalanffy model in weight. Methods used to compare

growth curves.

3. Indirect methods: fundamentals and applicability. Petersen method. Modal Progression analyses. Graphical and integrated methods.

## Reproduction

1. Introduction

2. Reproductive behaviour. Sexual dimorphism and secondary sexual characteristics. Sex determination in teleosts and elasmobranchs, molluscs and crustaceans. Sexual proportion.

3. Reproductive organs. Sexual differentiation. Anatomic and cytological description of the gonads. Testis: sperm production; spermatogenesis and spermiogenesis. Morph-cytological changes in the testes throughout the maturation process. Ovary: oocyte production; morph-cytological changes in the ovary throughout the maturation process; follicular cells and oocyte evolution. Oogenesis. Atresia.

4. Dynamic of sexual maturation. Factors affecting maturation: macroscopic and microscopic maturity scales.

5. Gonadosomatic (GSI) and hepatosomatic (HSI) relationships. Reproductive cycle and spawning season. Synchronous and asynchronous gonad development: total and batch spawners.

6. Sexual maturation ogives by length and age. Models and methods to adjust the ogive. Length and age at first maturity. Separation of the adult fraction from the juvenile fraction in a stock and catches.

7. Fecundity. Fecundity definitions. Relationships with individual biological characteristics. Methods to estimate fecundity.

## **LABORATORY PROGRAMME:**

1. Random sampling. Length and weight sampling. Statistical procedures to manipulate data. Raising the sample to the catch. Length frequency distributions by size: tables and graphics. Mean length estimation (confidence limits).

2. Morphometric relationship and conversion factors. Length – weight estimation. Parameters estimation by

	<p>simple linear regression. Hypothesis testes to compare the regression coefficients (slopes). Relative growth: isometry and allometry. Condition factors.</p> <p>3. Direct methods used for age determination: sampling for age and growth studies. Extraction, preparation for reading and preservation of otoliths. Interpretation of growth marks.</p> <p>4. Observation of growth marks in other calcified structures: scales, <i>illicia</i> and vertebrae. Develop age-length keys. Estimation of mean length at age. Conversion of length compositions into age compositions. Estimation of mean age.</p> <p>5. Growth models. von Bertalanffy growth model in length and Gompertz model. Parameters estimation by simple linear regression (Ford-Walford, Gulland-Holt, Bertalanffy e Stamatopoulos-Caddy). Growth non-linear estimation. Comparing two growth curves: using the growth performance indices <math>\Phi</math> and <math>\Phi'</math> and statistical methods.</p> <p>6. Age determination using indirect methods: Bhattacharya method. Modal Progression Analyses. Cohort separation. Growth estimation.</p> <p>7. Stratified random sampling. Biological sampling: sex determination, gonad maturation, fat contents, gonad and liver weight. Estimation of gonadosomatic (GIS) and hepatossomatic (HIS) indices.</p> <p>8. Analysis of sexual maturity data, fat contents, GSI and HIS to determine the spawning season. Sexual ratio.</p> <p>9. Adjusting an ogive to the percentage of mature individuals per length class. Non linear adjust of a logistic model. Estimation of length at first maturity (Lm50). Separation of spawning (adults) from juvenile fraction. Maturity- age keys. Maturation ogives. Maturation ogives by age. Estimation of age at first maturity (tm50).</p> <p>SEMINARS: Algae as a fisheries resource. Stock assessment and its current exploitation in Portugal and in the world. Biological management reference concepts.</p>
<p><b>19. Assessment details:</b></p>	<p>One written examination will be made at the end of each semester, which will be 60% of the final mark. The practical examination will be based on one single report containing data analyses and results from a given example (team work). Data on growth and reproduction will be provided. The objective is to analyse real data. Some questions</p>

	<p>regarding selected scientific papers will be made to encourage students to read scientific work. This report will be 40% of the final mark.</p>
<p><b>20. Recommended references:</b></p>	<p>1. Cadima, E.L., 2003. Fish Stock Assessment Manual. FAO Fisheries technical Paper 393, Roma. <a href="http://www.fao.org/docrep/006/X8498E/X8498E00.HTM">http://www.fao.org/docrep/006/X8498E/X8498E00.HTM</a> <b>(versão recomendada)</b></p> <p><b>Spanish</b> version: Cadima, E.L., 2003. Manuel de evaluación de recursos pesqueros. FAO Documento Técnico de Pesca 393, Roma. <a href="http://www.fao.org/DOCREP/006/X8498S/X8498S00.HTM">http://www.fao.org/DOCREP/006/X8498S/X8498S00.HTM</a></p> <p><b>French</b> version: Cadima, E. L., 2002. Manuel d'évaluation des ressources halieutiques. FAO Document Technique sur les Pêches 393, Roma. <a href="http://www.fao.org/docrep/005/x8498f/x8498f00.HTM">http://www.fao.org/docrep/005/x8498f/x8498f00.HTM</a></p> <p>2. Holden, M. J. &amp; D. F. S. Raitt, 1974. Manuel de Science Halieutique. Deuxième partie - Méthodes de Recherches sur les Ressources et leur Application. FAO Document Technique sur les Pêches 115. Rev. 1: 223p. <a href="http://www.fao.org/DOCREP/003/F0752F/F0752F00.HTM">http://www.fao.org/DOCREP/003/F0752F/F0752F00.HTM</a></p> <p><b>Spanish</b> version: Holden, M. J. &amp; D. F. S. Raitt, 1974. Manual de Ciencia Pesquera. Parte 2 - Métodos para Investigar los Recursos y su Aplicación. Only online: <a href="http://www.fao.org/DOCREP/003/F0752S/F0752S00.HTM">http://www.fao.org/DOCREP/003/F0752S/F0752S00.HTM</a></p> <p><b>English</b> version: Holden, M. J. &amp; D. F. S. Raitt, 1974. Manual of Fisheries Science. Part 2 - Methods of Resource Investigation and their Application. Only online: <a href="http://www.fao.org/DOCREP/003/F0752E/F0752E00.HTM">http://www.fao.org/DOCREP/003/F0752E/F0752E00.HTM</a></p> <p>3. Jennings, S., M.J. Keiser &amp; J.D. Reynolds, 2001. Marine Fisheries Ecology. Blackwell Science</p> <p>4. King, M., 1995 - Fisheries Biology, Assessment and Management. Blackwell Science, Oxford, 341p.</p> <p>5. Lagler, K. F., J. E. Bardach, R. R. Miller &amp; D. R. May-Passino, 1977. Ichthyology. 2nd Edition. John Wiley &amp; Sons, 506p. (Capítulos 5 e 10)</p> <p>6. Panfili, J., H. de Pontual, H. Troadec &amp; P.J.Wright, 2002 (eds.). Manual of fish sclerochronology. Brest, France. Ifremer-IRD coedition, 464 p.</p> <p>7. Sparre, P. &amp; S. C. Venema, 1998 - Introduction to</p>

	<p>tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper N° 306.1. Rev. 2. Rome, FAO, 407 p. <a href="http://www.fao.org/docrep/W5449E/w5449e00.htm">http://www.fao.org/docrep/W5449E/w5449e00.htm</a></p> <p>Sparre, P. &amp; S. C. Venema, 1999. Introduction to tropical fish stock assessment. Part 2. Exercises. FAO Fisheries Technical Paper. No. 306.2, Rev. 2. Rome, FAO. 1999. 94 p. <a href="http://www.fao.org/docrep/W5448E/W5448E00.htm">http://www.fao.org/docrep/W5448E/W5448E00.htm</a></p> <p><b>Spanish</b> version: Sparre, P. &amp; S. C. Venema, 1997. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper. N°. 306.1, Rev. 2. Rome. <a href="http://www.fao.org/docrep/008/w5449s/w5449s00.htm">http://www.fao.org/docrep/008/w5449s/w5449s00.htm</a></p> <p>Sparre, P. &amp; S. C. Venema, 1997. Introduction to tropical fish stock assessment. Part 2. Ejercicios. FAO Fisheries Technical Paper. N° 306.2, Rev. 2. Rome. <a href="http://www.fao.org/docrep/W5448S/W5448S00.htm">http://www.fao.org/docrep/W5448S/W5448S00.htm</a></p> <p><b>Recommended statistical books:</b></p> <p>8. Zar, J.H., 1999. Biostatistical analysis. Prentice-hall international</p> <p>9. Engineering Statistical Handbook <a href="http://www.itl.nist.gov/div898/handbook/dtoc.htm#Top">http://www.itl.nist.gov/div898/handbook/dtoc.htm#Top</a></p>
<b>21. Other study material:</b>	Lecture notes and additional material will be provided (photocopies) to support the lectures, laboratory work and seminars.
<b>22. Infra-structures:</b>	1 lecture room equipped with multimedia (recto-projector and video projector); 1 computer room equipped with video projector; 1 Fisheries Biology laboratory equipped with optical microscopes (dissection and light microscopes)