DAIMON Toolbox Fact Sheets:

Methods to Study the Impact of Dumped Munitions on Marine Biota

Assessment category 3: Biological effects

Toolbox component: Fitness

Fact Sheet 3.5: Fulton's Condition Factor (CF) in fish

Authors: Thomas Lang and Katharina Straumer, Thünen Institute of Fisheries Ecology

What is it?

Mathematical relationship between body length and body weight (Bolger & Conolly 1989, Nash et al. 2006):

$$CF(or\ K) = Body\ Weight\ (g) * 100 / Body\ Length\ (cm)^3$$

Preferably, body weight is based on somatic (gutted) weight instead of total weight, in order to avoid an impact of either stomach/intestine fullness, weight of inner organs or gonadal maturity status on CF (Knust 1996). However, CF can also be calculated based on total weight if somatic (gutted weight) cannot be recorded.

What does it tell you?

CF is in first instance an indicator of nutritional status/growth of fish. However, CF is also considered as a generic non-specific indicator of habitat quality and environmental stress, reflecting the well-being and fitness of fish and is, thus, often recorded as supporting variable for measurements of biological effects of contaminants in fish (Hansson et al. 2017). High values indicate a good status; low CF values a poor status. Changes in CF (often a decrease) may be caused by a variety of natural and anthropogenic stressors, including exposure to hazardous substances (Bervoets and Blast 2003, Benejam et al. 2010, Hansson et al. 2017, ICES 2017, Lang et al. 2017, Morado et al. 2017). CF may have a natural annual cycle, which has to be taken into account when interpreting data.

Since CF is a generic stress indicator, it is applicable in a screening or detailed study on effects of conventional or chemical munitions and warfare agents, but only in concert with selected more specific biological indicators (biomarkers). Because of the non-specificity of the indicator, it is not recommended to use it in isolation.

Type of Indicator (tick box)

☒ non-specific stress indicator
☐ specific for groups of contaminants incl. CWA or explosives
☐ CWA-specific indicator
☐ specific for substances related to explosives (e.g. TNT)

How to measure it?

***Species*:** CF can be measured in all fish species used for chemical/biomarker analysis.

***Matrix*:** whole fish

***Equipment*:** For measurement of weight and length, a balance and an appropriate length measure board are needed. For weight measurements at sea on unstable platforms (e.g., onboard research vessels), special balances (scales) are required (e.g. https://marel.com/fish-processing/systems-and-equipment/on-board/surimi/receiving--handling/weighing/marine-scales/303?prdct=1) which are able to integrate over fluctuating values.

***Measurements and units*:** For each fish, total weight (including organs) (in g) and total length (commonly in cm) are recorded. After dissection (gutting) of fish and removal of inner organs (digestive tract and attached liver, spleen and gall bladder as well as gonads) the somatic weight can be recorded. The weight of liver and gonads can be determined for calculation of the hepatosomatic index (HIS) (see Fact Sheet 1.2) and gonadosomatic index (GSI), respectively. Fish length is commonly measured as total length of the fish placed on the measure board in natural position (i.e., not with stretched caudal fin). Length is either measured on a cm or a mm scale. Commonly, length is recorded as cm below.

***Sample size*:** Ideally, the individual total weight and total length of all specimens used for disease examination (500 specimens, see Fact Sheet 3.16, Lang & Straumer 2019) should be recorded to calculate CF. As a minimum requirement for the calculation of CF based on somatic weight, a sample size of 100 specimens per sampling site taken from the 500 (see above) is recommended . For these 100 specimens, both total and gutted weight should be recorded.

How to analyse and assess the data?

From the individual CF values, mean values per sample and sampling site can be calculated; e.g., arithmetic means and standard deviation or arithmetic means and 95 % confidence intervals. Depending on the distribution of the data and the form of the mathematical relationship, medians with percentiles are also applicable.

For the assessment of effects on the CF, two commonly applied approaches can be used:

(1) Statistical comparison of mean CF values obtained from impacted areas (e.g. a munitions dumpsite) and from un-impacted reference areas,

(2) The use of assessment criteria (BAC: background assessment criteria; EAC: environmental assessment criteria) reflecting a good, medium or bad fitness status.

So far, no generally applicable assessment criteria for CF in fish have been established. One reason is that such criteria have to be species-specific, because the mean CF values and the range of CF values occurring in a population differ by species. In the data analysis and assessment for the DAIMON project, BAC and EAC values for CF (for total weight) were defined on the basis of the highest 25 % percentile (BAC) and the lowest 10 % percentile (EAC) of all CF values recorded in fish from reference areas. The following criteria were used:

- Cod (*Gadus morhua*): BAC: CF ≥0,91; EAC: CF <0,85

– Dab (*Limanda limanda*): BAC: CF ≥1,00; EAC: CF <0,95

References

Benejam L, Benito J, Garcia-Berthou E (2010). Decreases in condition and fecundity of freshwater fishes in a highly polluted reservoir. Water Air Soil Pollut 210: 231-242.

Bervoets L, Blust R (2003). Metal concentrations in water, sediment and gudgeon (*Gobio gobio*) from a pollution gradient: relationship with fish condition factor. Environmental Pollution 126: 9–19.

Bolger T, Conolly PL (1989). The selection of suitable indices for the measurement and analysis of fish condition. J. Fish Biol 34: 171-182.

Hansson T, Thain J, Martínez-Gómez C, Hylland K, Gubbins M, Balk L (2017). Supporting variables for biological effects measurements in fish and blue mussel. ICES Techniques in Marine Environmental Sciences. No. 60. 22 pp. http://doi.org/10.17895/ices.pub.2903

ICES (2017). Report of the Workshop on Fish condition (WKFICON), 17-18 November 2016, Girona, Spain. ICES CM 2016/SSGIEOM:30. 35 pp.

Knust R (1996). Food ecology of North Sa dab (*Limanda limanda*). Part I: Seasonal changes in food uptake and condition in the German Bight and in Dogger Bank. Arch. Fish. Mar. Res. 44: 1-12.

Lang T, Kotwicki L, Czub M, Grzelak K, Weirup L, Straumer K (2017). The health status of fish and benthos communities in chemical munitions dumpsites in the Baltic Sea. In: Towards the Monitoring of Dumped Munitions Threat (MODUM). J. Beldowski, R. Been. E.K. Turmus (eds.) NATO Science for Peace and Security Series – C: Environmental Security. Springer. p. 129-152.

Lang T, Straumer K (2019). DAIMON Ecotox Toolbox Fact Sheet 3.16: Externally visible fish diseases (EVFD). Interreg Project DAIMON.

Morado CN, Araujo FG, Gomes ID (2017). The use of biomarkers for assessing effects of pollutant stress on fish species from a tropical river in Southeastern Brazil. Acta Scientiarum. Biological Sciences 39: 431-439.

Nash RDM, Valencia AH, Geffen AJ (2006). The origin of Fulton's Condition Factor – setting the record straight. Fisheries 31 (5): 236-238