

## 6. NEUSTON NET SAMPLING

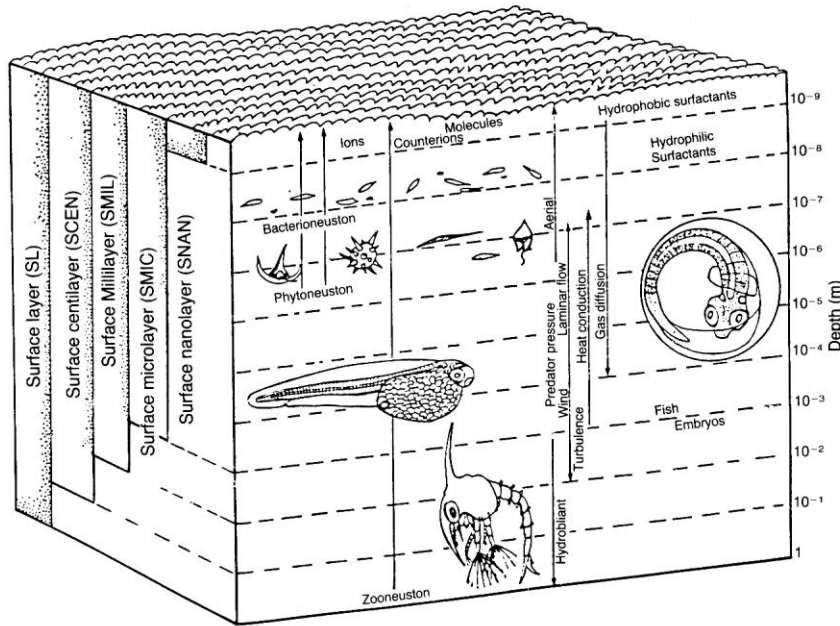
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### 6.1. Introduction

The early definition of neuston by Naumann (1917) distinguishes between phyto- and zooneuston but reduces the term to the very small organisms directly attached to the surface layer. Neuston nowadays comprises the whole living community closely related and restricted to this thin surface layer (Hempel and Weikert, 1972; Zaitsev, 1997) and covers the whole range of sizes and organism classes from bacteria to metazoa. Phytoneuston mainly consists of diatoms and dinoflagellates and is concentrated in the upper 1 mm at the sea surface layer (Wang et al., 2014). Sampling methods are described in chapters 2 and 3.

Extensive definitions of zooneuston are given e.g. by Zaitsev (1971, 1997). Hardy (1997) classified the neuston into size groups related to different strata of the surface layer. The nanolayer ( $< 10^{-6}$  m) and surface microlayer ( $< 10^{-3}$  m) are sampled with prisms and screens, membrane filters (chapter 4), glass plates (chapter 3), and the rotating drum technique (chapter 5). Millilayer ( $< 10^{-2}$  m) and centilayer ( $< 10^{-1}$  m) are collected using pumps and/or nets. Accordingly he classified the neuston organisms based on their size as piconeuston ( $< 2 \mu\text{m}$ ), nano/microneuston (2–200  $\mu\text{m}$ ), mesoneuston (200  $\mu\text{m}$ –20 mm), and macroneuston ( $> 20$  mm). He also suggested the term macroneuston to be used for large neuston organisms formerly called pleuston, which includes e.g. siphonophores that expose their bodies to the air. These surface dwelling larger species are a kind of exception in the size distribution as shown in Figure 1. The sketch from Hardy (1997) shows an increase in size of organisms with depth. While bacteria and unicellular algae dominate the upper micrometers, larger organisms such as crustaceans or fish eggs and larvae occupy the upper millimeters down to a depth of about five centimeters. Even if winds create turbulences and mix the upper cm or meters up, organisms move back into the microlayer within short times (Champalbert, 1977).

For larger organisms such as phyto- or zooplankton species the layer is important for different reasons. The spectral composition and intensity of light is still similar to sunlight. Inputs of nutrients and micronutrients from the air are enhancing primary production in this shallow layer providing food especially for small organisms. Hardy and Apts (1984) found enrichment ratios (microlayer:bulk water concentrations) for bacteria, microalgae, chlorophyll pigments and photosynthesis of 2444, 380, 12 and 40, respectively.



Conceptual model of the sea-surface layer (from Hardy 1997)

**Figure 1:** A conceptual model of the distribution of organisms in the upper 1 meter of water column (from Hardy 1997).

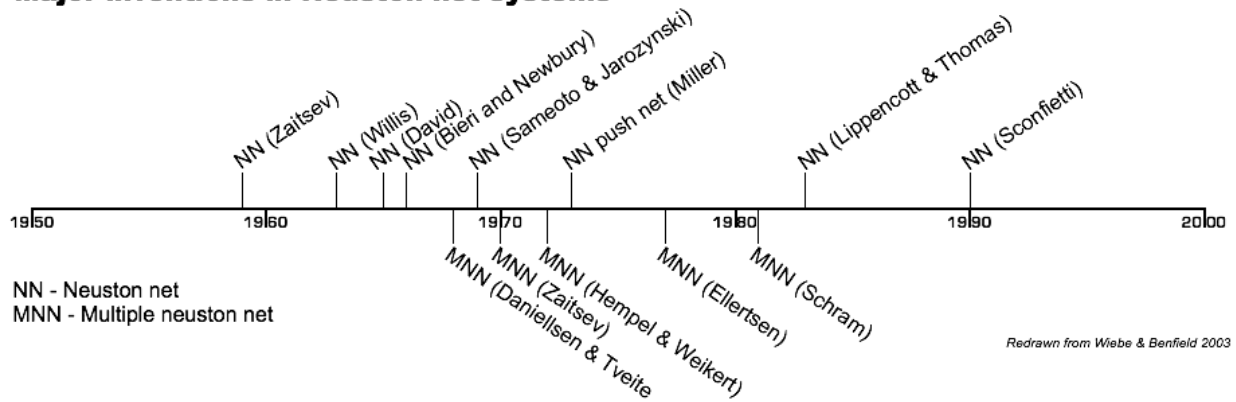
Above, or better directly on the surface, in the epineuston, many insect species are found. Zaitsev (1997) reports more than 40 species of water striders (*Halobates*) and some diptera (*Clunio marinus* and *C. ponticus*) and springtails (*Collembola* spp.). Besides these eupineuston species many land-born organisms can be found, that are able to survive substantial time on the sea surface (Ashmole, 1988). Euhyponeuston are those organisms that spend their entire life time in the hyponeuston, the upper 5 cm of the water column, respectively (Zaitsev, 1962, 1964, 1997). It contains a large variety of different taxa (Doyle et al., 1994) specially adapted to this extreme environment and benefiting from the food available near the surface such as mollusks (*Janthina*, *Glaucus*), copepods (*Pontellidae*), isopods (*Idothea*), decapods (*Planes* and *Portunus portunus*) (Flores et al., 2002), and fishes.

## 6.2. Design and characteristics of neuston nets

Design and use of sampling gears for neuston organisms depends strictly on the organism and layers targeted. As shown in Figure 1, meso- and macro neuston such as copepods, fish larvae and eggs occur in a layer of up to 5 cm (hyponeuston). Neuston sampling thus aims to separate this very thin layer from waters below and is usually performed with special nets equipped with floating elements to keep the devices at the surface. Neuston nets are normally non opening/closing designs (see also Wiebe and Benfield, 2003).

The first systematic design of a neuston net and sampling of meso- and macroneuston organisms is going back to Zaitsev and his work in the Black Sea in the 1950s and 1960s (Zaitsev, 1959, 1971). Single and multiple net devices have been developed over time as shown in Figure 2.

### Major inventions in Neuston net systems



**Figure 2:** Some milestones in neuston net development as reviewed by Wiebe and Benfield (2003).

#### 6.2.1. Surface sampling nets

First attempts to sample neuston (Figure 3) were performed by means of simple net constructions with small floating elements mounted aside and towed in a way to cut the surface (e.g. Zaitsev, 1959, 1971).

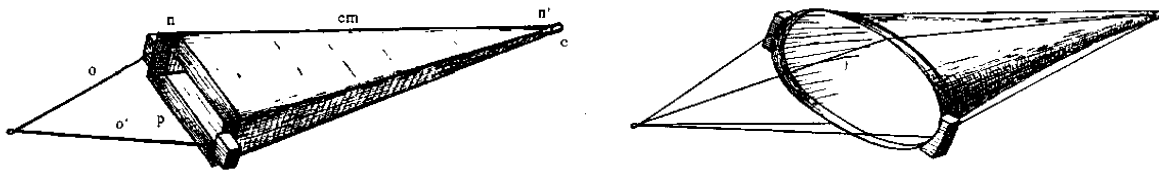


FIGURE 23. Fish-fry neuston trawl [MNT] (Zaitsev, 1964a)

**Figure 3:** First neuston nets (a, b). b) special version designed for fish-fry (from Zaitsev 1971).

David (1965) constructed a wooden catamaran where he mounted a horizontal net frame in the back between the two floating elements (Figure 4a). Opening of the frame was 30 cm x 15 cm with a net of 365 cm in length. Leal et al. (2009, 2010) used a similar model to sample neuston zooplankton and fish larvae with a mouth size of 100 cm x 20 cm (Figure 4b).



**Figure 4:** Neuston net mounted in front of the floating elements (picture a) adapted from Bieri and Newbury, 1966; picture b) by Miguel Leal).

### 6.2.2. Multiple layer plankton-neuston samplers

Zaitsev modified his construction into a multi-layer plankton-neuston net by mounting several of these nets top of each other (Figure 5a). Similarly, multi-layer neuston net has been adapted from the design by David (1965) to a neuston catamaran (Figure 5b). The frames are normally 15 cm high. The upper frame is mounted in a position that it ideally cuts the surface just in the middle and samples the upper ~7.5 cm, which includes the hyponeuston layer. The frames should be equipped with nets of 200 to 500  $\mu\text{m}$  mesh size depending on the target organisms.

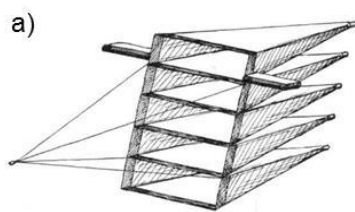
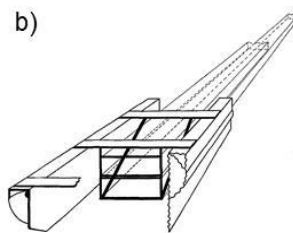


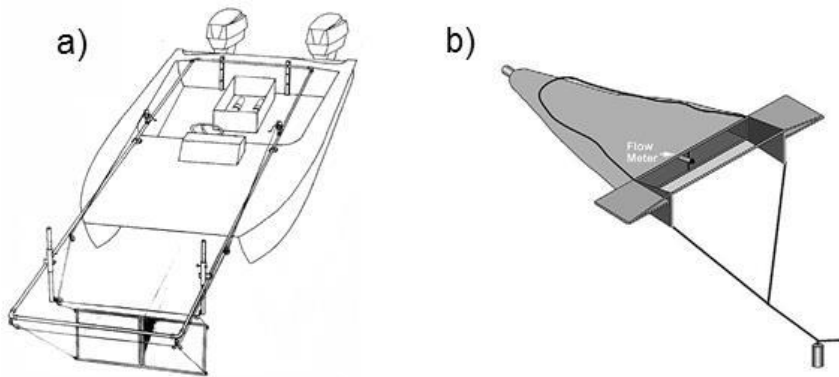
FIGURE 19. General view of the five-stage plankton-neuston net (Zaitsev, 1964a)



**Figure 5:** Neuston catamaran with two nets. a) original design by Zaitsev (1964a in Zaitsev 1971). b) Design by Hempel and Weikert (1972). c) Hydro-Bios© commercially mounted neuston catamaran. d) modified catamaran with a surface cutting net working in the Sine Saloum estuary, Senegal.



Other neuston net designs are the push net (Figure 6a) and the manta net (Figure 6b).



**Figure 6:** Other neuston net designs. a) push net (Miller, 1973). b) manta net (Brown and Cheng, 1981).

Filtered volume is calculated on the basis of the track or distance ( $d$ ) through the water and the area of water cut by the upper frame (height ( $h$ ) x width ( $w$ )). The area to be used for the calculation is 50% of the opening area of the frame if the upper frame is perfectly adjusted to the water surface. Filtered volume is then calculated as:

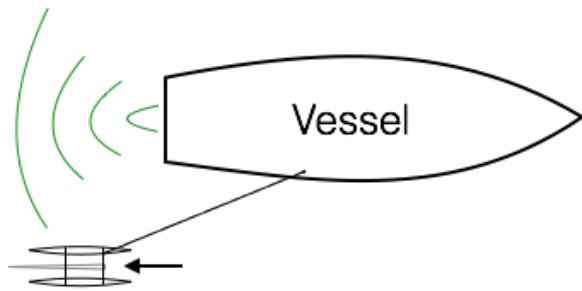
$$v_f = d \times h \times w \times 0.5 \text{ (m}^3\text{)}$$

Alteration of the area and the track measured through the water due to rough conditions will ultimately bias the calculated density of the target organisms being sampled.

### 6.3. Procedure for handling

Depending on the targeted organisms and size groups, mesh size and towing speed have to be adapted. Mesh size of 20  $\mu\text{m}$  is necessary for sampling of microneuston where towing speed should not go beyond 0.5 m s not damaging the nets. A mesh size of 200  $\mu\text{m}$  is common for catching mesoneuston. When targeting highly mobile organisms such as fish larvae the most important factor is towing speed. Neuston nets for fish larvae should be towed through the water with a speed of 2 to 3 knots ( $1 - 1.5 \text{ m s}^{-1}$ ; John et al., 2001) and a mesh size of 300  $\mu\text{m}$  to 500  $\mu\text{m}$ . David (1965) suggested a towing speed of 5-6 knots and a mesh size of 500  $\mu\text{m}$  in very calm waters. Low towing speeds may allow organisms to escape and avoid the net, while high towing speed may damage the sampling device (especially when using finer mesh sizes for smaller plankton organisms) and be harmful to collected organisms. Further, in case of rough sea with higher waves, high towing speeds may also impede an accurate sampling, as the sampling device will likely bounce at the water surface and not constantly sample the hyponeuston layer. This will also bias the measurement of the track through the water normally done by means of mechanical flowmeters.

Towing should always be over the side to get the net free of the turbulences created by the ship's propellers (Figure 7). These turbulences will damage the organisms, especially fish larvae. An asymmetric bridle or even better only one fixing point of the towing line at the catamaran keeps the gear free from the towing vessel and guarantees a free inflow of water into the nets and a minimum of dynamic pressure in front of the net.

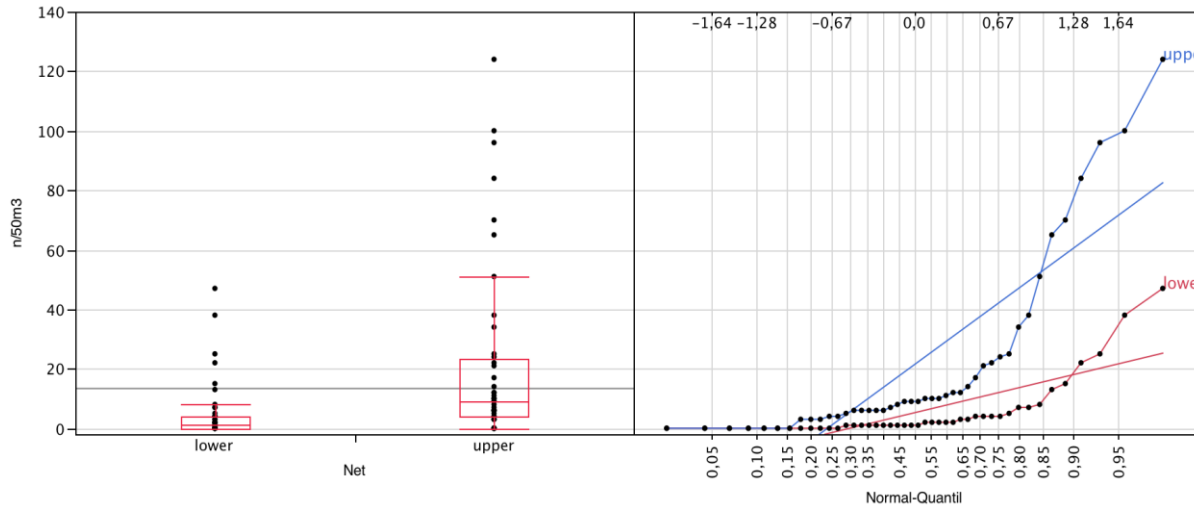


**Figure 7:** Position of towed nets to avoid turbulences by the moving vessel.

Net clogging may become a problem mainly in coastal waters with high abundance of phytoplankton. It strongly depends on mesh size, filtering area and net form (Smith et al. 1968). After sampling, the neuston net should be thoroughly cleaned using filtered water (sea water if sampling marine environments). This will move the sampled organisms and concentrate them in the cod-end. This should be performed with a relatively reduced water pressure to avoid damaging the sampled organisms. Regular cleaning of the net is mandatory.

The separation of the hyponeuston layer (0-5 cm) requires a very good adjustment of the upper net. Single net versions such as the Manta net provide a good qualitative and quantitative representation of the hyponeuston community. For a more detailed study of the plankton composition near the sea surface, a two- or multi-net version as shown in Figs xx6a and xx6c is required. The abundance of fish larvae in the uppermost 5 cm is significantly higher than in the layer 10 cm below (Lessa et al., 1999; Ekau and Westhaus-Ekau, 1996; Leal et al., 2010; see Figure 8).

Euhyponeuston are those organisms that spend their entire life time in the hyponeuston, the upper 5 cm of the water column, respectively (Zaitsev, 1962, 1964, 1997). It contains a large variety of different taxa (Doyle et al., 1994) specially adapted to this extreme environment and benefiting from the food available near the surface. This community is composed mainly of mollusks (*Janthina*; *Glaucus*), copepods (*Pontellidae*), isopods (*Idothea*), decapods (*Planes* and *Portunus portunus*) (Flores et al. 2002), and fishes.



**Figure 8:** Fish larvae concentrations in individuals per 50 m<sup>3</sup> in the upper (0-7.5 cm) and lower (10-25 cm) net of a neuston catamaran. Concentrations are significantly different with  $p < 0.001$  (Ekau and Westhaus-Ekau, 1996).

In a study in Northeast Brazilian waters 23 and 17 families occurred in the upper and the lower net of a double-netted neuston catamaran, respectively (Ekau and Westhaus-Ekau, 1996). Total abundance differed significantly between the upper and lower net. Lessa et al. (1999) found a ratio of up to 62 between number of fish larvae of one family in the upper and lower net at open ocean stations around Fernanco da Noronha island. Many groups only occurred in the upper net emphasizing the need for a strict adjustment of the nets to the targeted catching depths.

#### 6.4. Advantages and disadvantages

Lindsay et al. (1978) elaborated on the form of the net for surface tows. The authors argued that a normal ring net of 1m diameter is less than 3% effective in sampling the 5 cm near-surface layer. As can be seen from Figure 9, there is a significant difference between these upper 5 cm layer and the water below. Pumps are frequently used to collect water or plankton samples from discrete water layers to receive very precise vertical locations and volumes. However, targeting generally low abundant fish eggs and larvae requires high sample volumes not achievable with low speed pumps and without biasing the sample with organisms from deeper water layers. Cada and Loar (1982) compared towed nets and pumps finding the former more effective and the latter creating a higher avoidance of the organisms. Pumps also may damage the larvae and thus influence results (King et al., 1981). Taking the disadvantages of ring trawls and pumps into account, constructions such as the manta net or neuston catamarans based on the original design by David (1965) have shown to give the best results.

One main concern when sampling the neuston layer is net avoidance by plankton organisms. This issue may be significant when sampling in clear waters and at low speeds and targeting organisms displaying relatively high-mobility, such as larger fish larvae. The first neuston nets (Figure 3) had the disadvantage of having a bridle in front of the opening, which enhanced net avoidance by larger plankton/neuston organisms. The modifications performed by David (1965) minimized the shooping effect by having a bridle-less entrance. A complete prevention of shooping is only given, if no bridle is used and towing line is fixed asymmetrically at the device.

The development and use of the many different types of neuston nets creates a general problem in comparing the different studies. While in routine ichthyoplankton studies the simple Bongo net has been defined a kind of standard for the collection of fish larvae in the water column (UNESCO, 1975), a standardization of at least meso- and macroneuston sampling has not been achieved. Manta net and neuston catamaran are mostly used in recent studies; a quantitative comparison is not done yet.