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Short Contribution

High Ash Content in Net-Plankton Samples from Shallow Coastal Water: Possible Source of Error in Dry Weight Measurement of Zooplankton Biomass

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Annual examination of net-plankton biomass in dry weight, ash-free dry weight, organic carbon, and nitrogen weight at the Manazuru Harbor, central Japan revealed that net-plankton samples from shallow coastal water contained considerable amount of ash (53 ± 13% of dry weight) which would be caused by contamination of inorganic materials from re-suspension of sediments, terrestrial runoff and chain-forming diatoms. Therefore, in coastal water, dry weight is inadequate for determination of zooplankton biomass involving the possibility of over-estimation. Practical estimation of net-plankton biomass in shallow coastal waters, ash-free dry weight, organic carbon, and/or nitrogen are more adequate.

Keywords:
· Net-plankton biomass,
· ash contents,
· dry weight,
· ash-free dry weight,
· organic carbon.

Measurement of zooplankton biomass with net-plankton samples has been conducted all over the sea in order to estimate the secondary production of marine environments. To determine the net-plankton biomass, a number of techniques such as measurements of settled volume, displacement volume, wet weight, dry weight, ash-free dry weight, carbon content weight have been applied (Omori and Ikeda, 1984). Estimation of biomass with settled volume, displacement volume and wet weight is inadequate due to considerable variation which is caused by the manner of treatment (e.g. shrinkage caused by fixation and removing process of interstitial fluids), although it is easy and quick. On the other hand expression with dry weight, ash-free dry weight and carbon is believed to provide more accurate estimation of zooplankton biomass since water recognized as a source of variation is excluded from samples. Specifically, expression by elemental units such as carbon or nitrogen is ideal for study of ecological energetics, whereas dry weight has been often adopted to determine the net-plankton biomass due to its simple procedure. However, expression of net-plankton biomass in dry weight includes two problems, which were caused by ash contents. Firstly, real biomass, organic contents, within dry weight depends on the composition of zooplankton community since ash contents of zooplankton is highly variable between non-gelatinous zooplankton such as crustaceans (2–37%, Omori, 1969) and gelatinous organisms such as jellyfishes (60–73%, Clarke *et al*., 1992). Secondly, contamination of inorganic materials such as phytoplankton-originated detritus and re-suspended sediments are possible sources of errors in over-estimation of zooplankton biomass. Such problems due to ash contents are more severe in studies on shallow coastal water, since its environment is more susceptible of effects from river runoff and sediments re-suspension in which zooplankton community is characterized by drastic succession among non-gelatinous and gelatinous organisms (Deason and Smayda, 1982). However, knowledge of temporal variation in ash contents at coastal area is scarce. In this study, the net-plankton biomass was investigated by measurement of dry weight,

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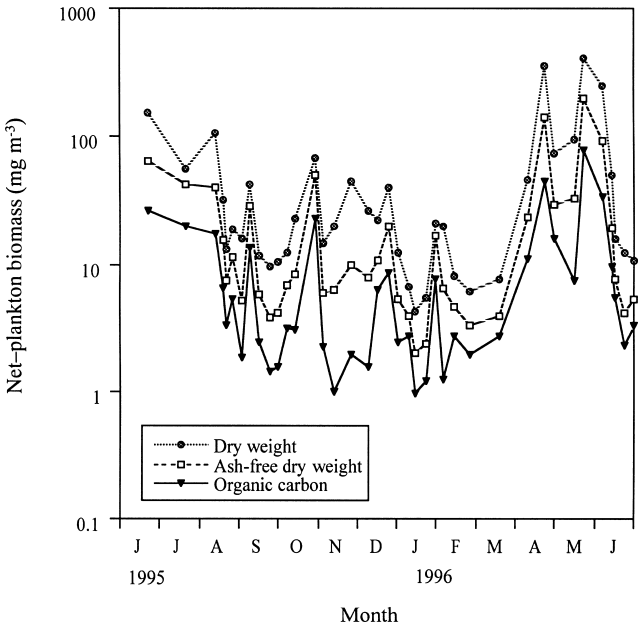

Fig. 1. Seasonal variations of net-plankton biomass in the Maznazuru Harbor, Sagami Bay, Japan.

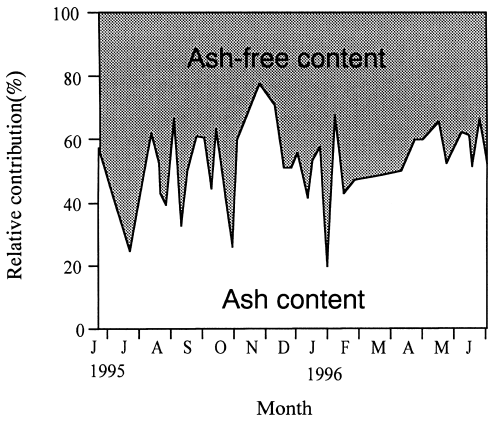

Fig. 2. Seasonal variation of ash contents in dry weight of net-plankton samples in the Manazuru Harbor, Sagami Bay, Japan.

ash-free dry weight, organic carbon, and nitrogen throughout the year in order to determine the effect of ash contents in the estimation of zooplankton biomass in a shallow coastal water ecosystem.

A total of 37 net-plankton sample was collected weekly from June 21, 1995 to June 27, 1996 by oblique tows of a ring net with 30 cm in opening diameter and 183 μm mesh aperture near the innermost pier in the Manazuru Harbor, central Japan (35°08′ 54″ N, 139°08′ 54″ E). The depth of sampling site is about 4.5–5.5 m and samples were collected from about 1 m above the bottom. Samples were immediately filtered on pre-combusted (500°C for 2 h) and pre-weighted Whatman GF/A filters. Samples were kept in deep freezer at –84°C until analysis. Frozen samples were thawed at room temperature and then dried at 60°C for 48 h by oven dryer. Dry weights were measured by a microbalance (SARTORIUS model MC 5). Weighted samples on the filters were ground using mortar and pestle. The first subsamples were analyzed for total carbon and nitrogen by CN analyzer (FISONS model EA 1108CHNS/O). The second subsamples were combusted at 500°C for 4 h to determine ash weight. The combusted subsamples were also analyzed for inorganic carbon. Ash-free dry weights were calculated by subtracting the ash content from the dry weight. Precipitation was measured every day during the sampling period with rain gauge located on the roof of the Manazuru Municipal Office (35°09′ 15″ N, 139°08′ 26″ E). Other information concerning about the Manazuru Harbor is described in Satoh *et al*. (2000).

Net-plankton biomass in the Manazuru Harbor varied from 4.1 to 410 mg m^{-3} in dry weight; from 2.0 to 200 mg m^{-3} in ash-free dry weight; from 0.98 to 78 mg m^{-3} in organic carbon (Fig. 1). Annual mean biomass with one standard deviation was 55 ± 92, 25 ± 40, and 10 ± 15 mg m^{-3} in dry weight, ash-free dry weight, and organic carbon, respectively. Annual variation in net-plankton biomass in carbon at the Manazuru Harbor was comparable to the values of other Japanese coastal waters, e.g. 17–111 mgC m^{-3} in the Suo-Nada (Koga, 1986) and 19–48 mgC m^{-3} in the Osaka Bay (Joh and Uno, 1983). Proportion of ash contents in net-plankton dry weight showed broad fluctuation like white-noise during the sampling period and no seasonal trend was observed (Fig. 2). Ash contents varied from 19 to 80% with a mean of 53 (±13 SD)% of net-plankton dry weight, this value was higher than that of oceanic area (e.g. 11%, Vinogradov, 1953). As crustaceans mainly consisted from copepods are dominated the zooplankton population in the Manazuru Harbor throughout the year (Yoshida, personal communication), the high ash contents from the net-plankton samples would not be originated from zooplankton solely. Particulate inorganic materials such as re-suspended sediment and terrestrial runoff are most possible sources of the ash contents. Relationships between precipitation and percentage of ash contents suggested that some samples were affected by terrestrial runoff, though obvious seasonal trend was not observed (Fig. 3). However, another factor for ash contamination should exist since 13 samples out of 20 cases which have no precipitation also contained more than 50% ash (Fig. 3). Contamination of chain-forming diatom, such as *Chaetoceros* spp. is quite possible source for the high ash contents since diatom contains much silica in their cell wall. Occurrence of phytoplankton in net-plankton samples was reported by several authors

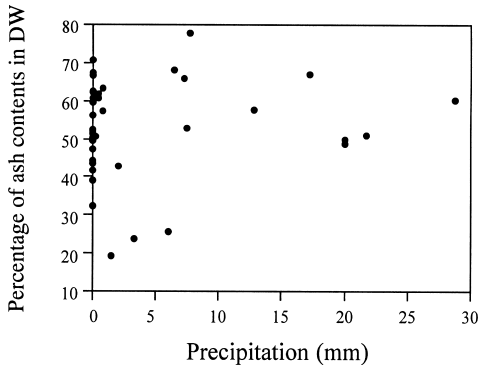

Fig. 3. Relationship between precipitation and percentage of ash contents in dry weight of net-plankton samples in the Manazuru Harbor, Sagami Bay, Japan. Precipitation expressed as average of the day before sampling and the day of sampling.

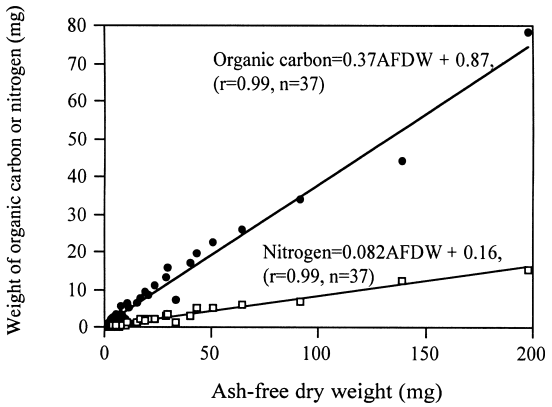

Fig. 4. Relationships between organic carbon, nitrogen and ash-free dry weight in net-plankton samples from the Manazuru Harbor.

(Foxton, 1956; Kawamura, 1986). Although further examination was not conducted in this study, transport of sediments by wind, drastic successions of zooplankton community (Deason and Smayda, 1982), and/or red tide of dinoflagellate (Satoh *et al*., 2000) are considered as other possible causes for fluctuation of ash contents. Consequently the result of this study clearly indicated that measurement of net-plankton dry weight as zooplankton biomass in coastal water is inadequate due to its highly variable contribution of ash contents and involves the possibility of over-estimation in zooplankton biomass.

Significant relationships between ash-free dry weight and organic carbon, nitrogen were detected in the all samples (Fig. 4). These relationships indicate that organic carbon and nitrogen occupy about 37 and 8.2% of ash-free dry weight in coastal shallow waters, respectively. These equations should be useful for estimation of zooplankton biomass in shallow coastal water. In conclusion, removal of the ash from field samples is inevitable process in determination of net-plankton biomass in coastal shallow water.

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References

Clarke, A., L. J. Holms and D. J. Gore (1992): Proximate and elemental composition of gelatinous zooplankton from the Southern Ocean. *J. Exp. Mar. Biol. Ecol*., **155**, 55–68.

Deason, E. E. and T. J. Smayda (1982): Ctenophore-zooplankton-phytoplankton interactions in Narragansett Bay, Rhode Island, U.S.A., during 1972–1977. *J. Plankton Res*., **4**, 203–217.

Foxton, P. (1956): The distribution of the standing crop of zooplankton in the Southern Ocean. *Discovery Rep*., **28**, 191–236.

Joh, H. and S. Uno (1983): Zooplankton standing stock and their estimated production in Osaka Bay. *Bull. Plankton Soc. Japan*, **30**, 41–51.

Kawamura, A. (1986): Has marine Antarctic ecosystem changed?—A tentative comparison of present and past macrozooplankton abundances. *Mem. Natl. Inst. Polar Res., Spec. Issue*, **40**, 197–211.

Koga, F. (1986): The occurrence and production of zooplankton in Suo-Nada, western Seto Inland Sea. *Bull. Nansei Reg. Fish. Res. Lab*., **20**, 91–113.

Omori, M. (1969): Weight and chemical composition of some important oceanic zooplankton in the North Pacific Ocean. *Mar. Biol*., **3**, 4–10.

Omori, M. and T. Ikeda (1984): *Methods in Zooplankton Ecology*. John Wiley & Sons, New York, 332 pp.

Satoh, F., K. Hamasaki, T. Toda and S. Taguchi (2000): Summer phytoplankton bloom in Manazuru Harbor, Sagami Bay, central Japan. *Plankton Biol. Ecol*., **47**, 73–79.

Vinogradov, A. P. (1953): The elementary chemical composition of marine organisms. *Mem. Sears. Fdn. Mar. Res*., **2**, 1–647.