# Environment Canada
## Water Science and Technology Directorate

## Direction générale des sciences et de la technologie, eau
# Environnement Canada

A new planktic species of pseudanabaena (Cyanoprokaryota, Oscillatoriales) from North America large lakes

By:

Hedy J. Kling & Susan Watson

03-165

**A new planktic species of *Pseudanabaena* (Cyanoprokaryota, Oscillatoriales) from North American large lakes.**

Hedy J. Kling and Susan Watson

**ABSTRACT**
A new species of *Pseudanabaena* (Cyanoprokaryota, Oscillatoriales) from the plankton of North American large lakes is documented, with ecological and distributional data. This taxon differs from previously described *Pseudanabaena* species with respect to a characteristic undulating and coiling filament structure. *Pseudanabaena contorta* spec. nova appears to be specific to large North American Great Lakes with a drainage basin that is not totally Precambrian shield. Recently, it has been found as a consistent but minor component of the planktic cyanoprokaryote populations during the spring and summer months in Lake Superior and Lake Ontario. Comparisons are made with other common species of this genus as well as another undulating morphotype of the genus *Glaucospira,* that could possibly result in confusion, found in other large Alberta and northern Saskatchewan lakes.

## NWRI RESEARCH SUMMARY

**Plain language title**
A new species of the bluegreen alga Pseudanabaena from North American large lakes

**What is the problem and what do sicentists already know about it?**
Bluegreen algae are usually associated with polluted water and water quality problems, because blooms of toxic and odourous bluegreens species are often produced by nutrient-rich runoff from human and agricultural waste. However, many bluegreen species are found mainly in unimpacted waters, still others show an apparent ability to adapt to a wide range of nutrient supplies. In order to understand and predict noxious species outbreaks we need to first understand which species are found where, and whether differences in their shape and size among lakes really represents differences in species or physical adaptations to differences in environment.

**Why did NWRI do this study?**
NWRI is involved in collaborative research on different lakes, providing the opportunity for careful investigative work to characterize some of the lesser known algal species. In particular the Great Lakes represent a range of nutrient levels, and are thus ideal systems to carry out comparative sampling. Outbreaks of nusance and toxic blue-green algae are becoming more prevalent again in these lakes, despite widespread efforts which have successfully reduced the elevated nutrient levels seen in last century, therefore understanding these algae is important to ecologists and lake managers.

**What were the results?**
We have identified a new species, Pseudanabaena contorta, belonging to a subgroup of bluegreen algae that is widespread throughout the world. This species was found in both Lake Superior and Ontario, indicating that it is well adapted to low-moderate nutrient levels. As other species of Pseudanabaena are known to be potent odour producers, this new species is of interest as a potential player in taste and odour episodes.

**How will these results be used?**
These results will be used to develop future research to identify the major species producing odour, and to understand how they adapt to the different environments. Other bluegreen species with similar morphology have been identified as Glaucospira, and were found in lakes from Western Canada. Our next goal will be to determine if these are, in fact, this new species P. contorta.

**Who were our main partners in the study?**
Algal Taxonomy and Ecology Inc., Dept. of Fisheries and Oceans (DFO), Large Lakes Observatory (LLO; Duluth, MN)

**Description d'une nouvelle espèce de *Pseudanabaena* (Cyanoprocaryotes, Oscillatoriales), planctonte des grands lacs de l'Amérique du Nord**

Hedy J. Kling et Susan Watson

**RÉSUMÉ**
Nous documentons la présence d'une nouvelle espèce de *Pseudanabaena* (Cyanoprocaryotes, Oscillatoriales) dans le plancton des grands lacs de l'Amérique du Nord, avec des données sur son écologie et sa distribution. Ce taxon diffère des espèces déjà décrites de *Pseudanabaena* par la présence d'une structure filamenteuse caractéristique qui ondule et s'enroule sur elle-même. *Pseudanabaena contorta* spec. nova semble être un planctonte spécifique des grands lacs d'Amérique du Nord dont le bassin n'appartient pas entièrement au bouclier précambrien. On a récemment découvert que cette algue bleue est une composante régulière mais mineure des populations planctoniques de cyanoprocaryotes pendant les mois du printemps et de l'été dans le lac Supérieur et le lac Ontario. Nous présentons des comparaisons avec d'autres espèces communes du genre ainsi qu'avec un autre morphotype ondulant du genre *Glaucospira* qui pourrait être source de confusion, et dont la présence est signalée dans d'autres grands lacs de l'Alberta et du nord de la Saskatchewan.

**Sommaire des recherches de l'INRE**

**Titre en langage clair**
Nouvelle espèce d'algue bleue du genre *Pseudanabaena* dans les grands lacs d'Amérique du Nord.

**Quel est le problème et que savent les chercheurs à ce sujet?**
Les algues bleues sont généralement associées à la pollution et aux problèmes de qualité de l'eau, du fait que les proliférations toxiques et malodorantes de ces algues sont souvent produites par le ruissellement riche en matières nutritives des eaux usées humaines et agricoles. Toutefois, de nombreuses espèces d'algues bleues se retrouvent principalement dans des eaux non polluées, et d'autres semblent capables de s'adapter à une vaste gamme de teneurs en matières nutritives. Pour comprendre et prédire les proliférations d'espèces nuisibles, nous devons d'abord savoir quelles sont les espèces présentes, et si les différences dans leur taille et leur forme d'un lac à l'autre représentent réellement des différences spécifiques ou de simples adaptations physiques à des milieux différents.

**Pourquoi l'INRE a-t-il effectué cette étude?**
L'INRE participe à des travaux en collaboration sur différents lacs, ce qui donne aux chercheurs la possibilité de mener des études fines pour caractériser certaines espèces algales peu connues. Les Grands Lacs, en particulier, présentent une gamme intéressante de teneurs en matières nutritives, et constituent donc des systèmes idéaux pour effectuer des échantillonnages comparatifs. Les proliférations d'algues bleues nuisibles et toxiques redeviennent plus courantes dans ces lacs, malgré les interventions à grande échelle qui

ont permis de réduire les niveaux élevés de matières nutritives observées au siècle dernier; il est donc important pour les écologistes comme pour les gestionnaires des lacs de mieux connaître ces algues.

**Quels sont les résultats?**
Nous avons identifié une nouvelle espèce, *Pseudanabaena contorta*, qui appartient à un sous-groupe d'algues bleues répandues dans le monde entier. Cette espèce a été observée à la fois dans le lac Supérieur et dans le lac Ontario, ce qui indique qu'elle est bien adaptée à des teneurs faibles à moyennes en matières nutritives. On sait que d'autres espèces de *Pseudanabaena* peuvent produire des odeurs désagréables, aussi cette nouvelle espèce est-elle intéressante par son rôle potentiel dans les épisodes de coloration et d'odeur désagréable des eaux.

**Comment ces résultats seront-ils utilisés?**
Ces résultats feront avancer les recherches en permettant d'identifier les principales espèces causant les proliférations malodorantes et de comprendre leur mode d'adaptation à des milieux différents. D'autres algues bleues à morphologie similaire, identifiées comme *Glaucospira*, ont été observées dans des lacs de l'Ouest du Canada. Notre prochain objectif consiste à vérifier s'il ne s'agirait pas en fait de la nouvelle espèce *P. contorta*.

**Quels étaient nos principaux partenaires dans cette étude?**
Algal Taxonomy and Ecology Inc., ministère des Pêches et des Océans (MPO), Large Lakes Observatory (LLO; Duluth, Minnesota)

Figures should be in removed order as much as possible

## INTRODUCTION

The genus *Pseudanabaena* first was established in 1915 by Lauterborn, and has since undergone several revisions. Initially the genus contained only two species (*P. catenata* and *P. constricta*), but following detailed characterization by Chang et al. (1985) and others, encompassed >33 species and forms. More recently, Anagnostidis and Komárek (1988) divided the species described to date among two genera and five subgenera.

*Pseudanabaena* species are morphologically simple members of the Oscillatoriales commonly present in low numbers in the plankton of many lakes. The taxonomy of this genus is still unresolved. Although its members occur in many different habitats, their morphological variability and range of ecological requirements are relatively unknown. Similar morphotypes may occur under very dissimilar ecological conditions, while different morphotypes sometimes occur under the same conditions, leading to taxonomic confusion. Individual species can demonstrate considerable morphological variability. Romo et al. (1993) observed a range of morphotypes in clonal cultures of *Pseudanabaena galeata* (subgenus *Ilyonema*), especially in end cell morphology, length to width ratio and sheath production. In addition to this ambiguity within the genus *Pseudanabaena*, there is confusion between this species and such morphologically similar genera as *Limnothrix* (Meffert 1987). Here, we describe a new, coiled morphological species of *Pseudanabaena* from North American Great Lakes and comment on the genus *Glaucospira* another undulating morphotype of filamentous cyanoprokaryote found in large western prairie lakes.

## METHODS

Samples were collected during routine sampling for phytoplankton and water chemistry by the Dept. of Fisheries and Oceans (DFO), Large Lakes Observatory (LLO; Duluth, MN) and Environment Canada (EC). Subsamples were preserved immediately with Lugol's Iodine for subsequent identification and enumeration.

Analyses were undertaken on an M-40 Wild Inverted Microscope, using Utermöhl chambers and standard methods (Findlay & Kling, 1996). The coiled morphotype of *Pseudanabaena* first was observed in samples from Lake Superior offshore of Thunder Bay in 1990-91, during a DFO study of large lakes (Kling, unpub.data). In 1999 & 2000, this coiled filamentous cyanobacterium was observed in samples from the Western tip of Lake Superior (Duluth; Fig 9), while in 2001, a similar morphotype was observed in samples from Western Lake Ontario (Ontario). Many previous records of phytoplankton in the Great Lakes (1970- present) have recorded an *Oscillatoria sp.*, that may have included this coiled species under its umbrella. The past data used to show depth distribution in Lake Ontario (Fig 10) was made available from the Environment Canada collection (S. Watson unpub.data)

Another undulating morphotype (included here for comparison) belonging possibly to the genus *Glaucospira* Lagerheim (Komarek pers. comm.) but originally thought to belong to this *Pseudanabaena* genus (Fig 7 & 8) was found in Reindeer Lake, Lac LaRonge (Saskatchewan),Lake Athabasca (Alberta) and enclosure experiments near Glenmore Reservoir Calgary ( S. Watson). These habitats are very different ecologically from Eastern Great Lake where the *Pseudanabaena* contorta was found.

## RESULTS AND DISCUSSION

We observed a new filamentous cyanoprokaryote species belonging to the Oscillatoriales in recent plankton samples from the Great Lakes. This species has been included in under the genus *Pseudanabaena* subgenus *Pseudanabaena*, following the revised classification (Anagnostidis and Komárek, 1988).

Along with the common planktic species *Pseudanabaena limnetica* (straight trichomes)(Fig 6), unidentified coiled and undulating morphotypes occurred in the plankton of Lake Superior and other Great Lakes such as Lake Ontario.

These coiled morphotypes did not fit the description of any *Pseudanabaena* species previously described from this group (Table 1; adapted from Komárek & Kling 1991).

The morphology of coiled populations seems to be relatively stable within lakes, and among the large lakes and warrants being described as a new species. Lake Superior and Lake Ontario morphotypes were very similar in coiling morphology and cell size (Figs. 1-5).

## SPECIES DESCRIPTION

**Habitat:** plankton of North American Great Lakes.

**Description:** Trichomes solitary, irregularly undulating to spirally coiled 50- >200 µm long and up to 2 (2.2) µm wide, without mucilage or sheath, deeply constricted at cross walls. Cells elongated, cylindrical, with ends rounded or bluntly pointed, pale homogenous, blue-green contents, sometimes with a granule (aerotopes?) at the cross-walls, 2.5-7 (9) µm long x 1.6 (2.2) µm wide. Trichome coils 28-30 µm in diameter. Cell division perpendicular, trichomes separate by cell disintegration or fragmentation

This new species has similar cell dimensions and coiling pattern to the coiled species in the genus *Planktolyngbya* (*P. circumcreta, P. contorta, P. capillaris*, and *P. tallingii*). The taxa that are most similar, especially in trichome morphology, are *Planktolyngbya*

*contorta* and *P. tallingii*. Our species has deep constrictions at the cross walls and has not been found with a sheath.

Diagnosis: Trichomata solitaria, libere natantia, irregulariter undulata vel spiraliter contorta, 50- >200 um longa, ad 2(2.2) um lata, distincte constricta ad dissepimenta; mucus et vagina carentes. Cellulae elongatae, cylindricae, cum apicalibus rotundatis vel rotundate-obtuse acutis, 2.5-7(9) um longae, 1.6-2.2 um latae, contentu homogeneo, aeruginoso, interdum cum granulis facultativis ad dissepimentibus. Spirae trichomatibus 28-30 um diametro. Divisio cellularum perpendiculariter, reproductio trichomatibus disintegratione vel fragmentatione. Heterocytae akinetesque carentes. - Habitatio: Planktice in lacubus grandis; locus classicus: lacus Lake Superior prope oppido Thunder Bay, Canada centralis; VII. 1990 (legit H. Kling et S. Watson). - **Iconotypus: figura nostra 3, 4.**

Isotypi: preserved sample Cana #75387 Canadian National Museum, Ottawa Ontario and 011Kling, Freshwater Institute, Winnipeg Manitoba..

Slightly thinner undulating morphotypes most likely belonging to the genus Gla*ucospira* Lagerheim were also identified from large more nutrient rich, light limited shallow lakes such as Lake Athabasca, Reindeer Lake and Lac La Ronge, and some experimental enclosures (Calgary, S. Watson, unpub. data). These *Glaucospira* morphotypes from Lac La Ronge and the experimental enclosures (Calgary, Alberta) with undulating trichomes (Figs. 7, 8), had an average length of ca. 70 µm (cell sizes 4.2 -5.6 X 1.4 (2) µm). Reindeer Lake trichomes were similar, with large undulations or waves, ca. 60-70 µm long, cells 4.2 - 5.6 X 1.4 (2) µm. Lake Athabasca morphotypes were broken up into mainly short curved trichomes with average length of ca. 28 µm; 1.4 µm wide. These will be dealt with further in a later publication.

## DISTRIBUTION AND SEASONALITY

In Lake Superior coiling *Pseudanabaena contorta* (Figs. 3-5) and *Pseudanabaena limnetica* (Fig. 6) were most prevalent at the western basin station near Duluth during late May through to August with a maximum biomass record in mid July 2000 (Fig 9). *Pseudanabaena contorta* was present in low biomass (< 6 µg/L) relative to the biomass (maximum 45 µg/L) of *P. limnetica*. In Lake Ontario these coiling morphotypes of *P. contorta* also were most abundant in late summer and reached their highest density deeper in the water column below 5 meters depth (Fig 10).

The geographic distribution seems to be limited, but is relatively unknown at present. We have recorded it only in low numbers in samples from Lake Superior, L. Ontario and it may be endemic to these types of water bodies. The undulating & coiling morphotypes typical of this taxon seem to prefer the large lake habitat, as they were not recorded from smaller lakes sampled at the same time in the vicinities of these large lakes.

## CONCLUSIONS

The most common species in these lakes is *Pseudanabaena limnetica*, with a straight trichome which is relatively constant on morphology within a lake but somewhat variable among lakes. This coiling species *Pseudanabaena contorta* spec. nova is present at low abundance in the North American Great lakes. *Pseudanabaena contorta* seems to be limited in distribution, preferring the pelagic regions of the Great Lakes that may be either light- or nutrient- limited and a neutral to high pH. At present we do not have undulating or coiling morphotypes in culture and do not know the range of morphological variability that can be expected. We also do not know whether or not it has the potential for taste/odour (T/O) production with is a common occurrence among several members of this genus. Cultures of some more common, more eutrophic species of the genus (particularly in the subgenus *Ilyonema*) such as *P. galeata* can produce potent odour compounds such as 2-methylisoborneol (MIB) and geosmin (S. Watson and G. Izaguirre, pers. comm). It maybe possible to answer some of these questions through more insitu observations and culture experiments.

## ACKNOWLEDGEMENTS

We are especially indebted to Dr. Jiří Komárek for critical comments and translating the species description into latin.
We would also like to extend our thanks Dr. Tom Johnson leader of the Large Lakes Observatory, Duluth, Minnesota for supporting the phytoplankton work in Lake Superior Western Basin, Drs. Derek Muir and Stephanie Guildford, and Environment Canada (EC) for including phytoplankton as part of their research on bioaccumulation of organic pollutants for the Saskatchewan and Alberta lakes and Murray Charlton and EC for support and collection of Lake Ontario samples.

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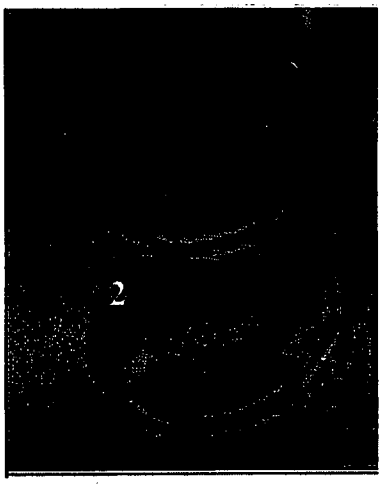
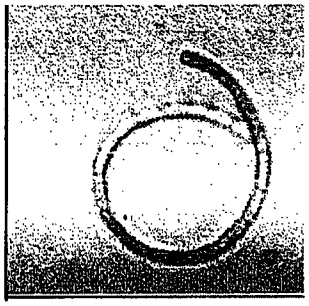
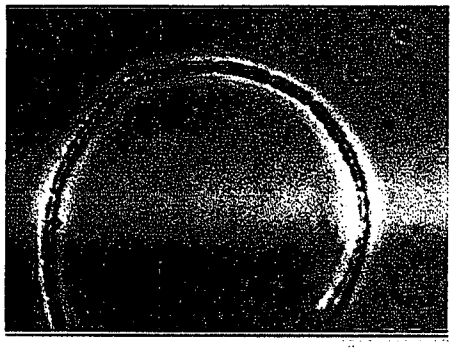
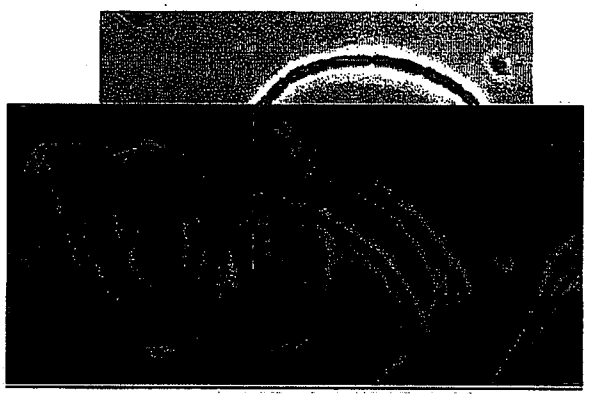
Romo, S., M. R. Miracle & M. Hernandez-Marine 1993. Remarks on the morphology of *Pseudanabaena galeata* Bocher. Arch. Hydrobiol./Algological Studies 68:39-49



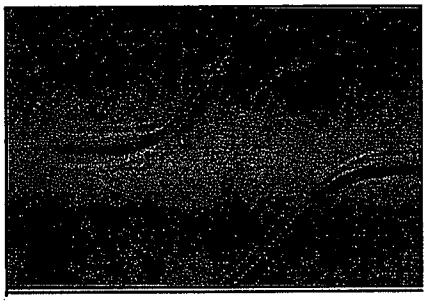



**Figures 1, 2: <u>Coiling morphotypes</u>**. Specimens from Lake Ontario. Short and long cells in filaments; granules (gas vacuoles?) apparent in most cells.

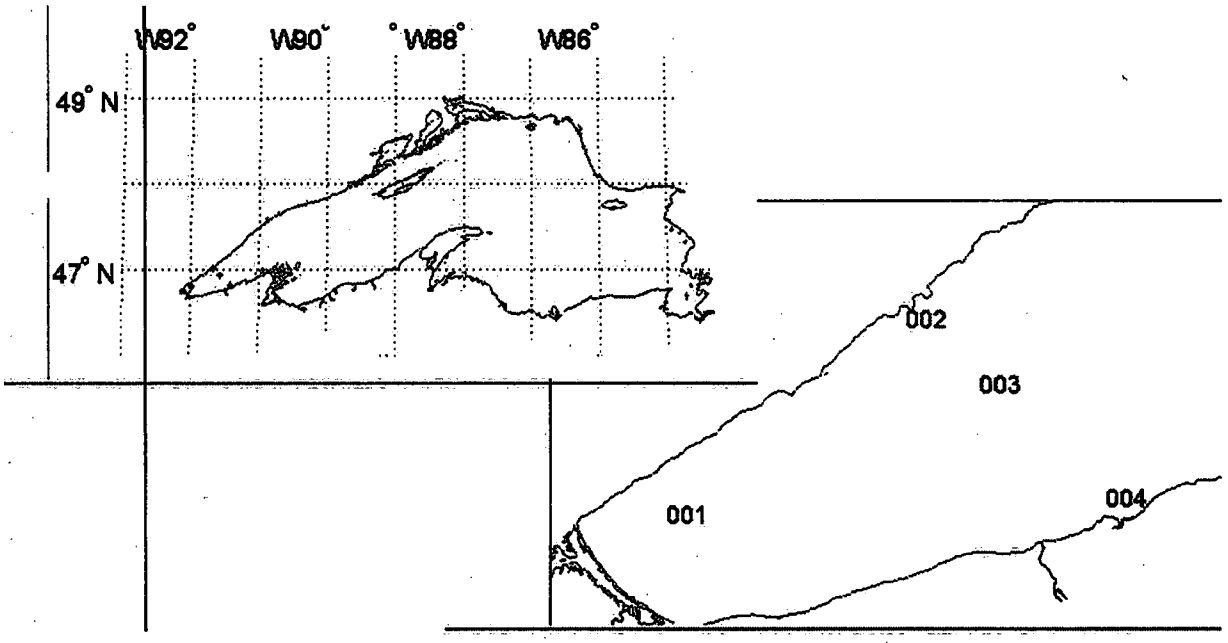




**Figures 3-6: Specimens from Lake Superior. 3,4: <u>Coiling morphotype</u>** (2 foci for the same filament), granules (gas vacuoles) present in most cells; **5,6** Coiling morphotype of new taxon compared to straight morphotype of *P.limnetica* .



**Figures 7, 8. <u>Undulating morphotype</u>.** Specimens from experimental enclosures, Calgary (S. Watson unpubl. data) with morphology similar to the Lac La Ronge morphotypes. Straight to low undulations with some granules (gas vacuoles?) near cell ends.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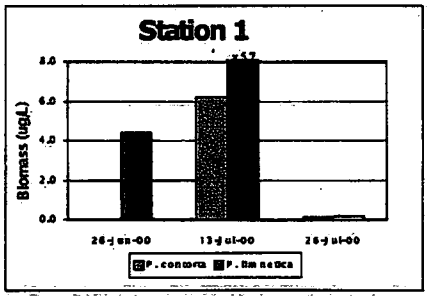
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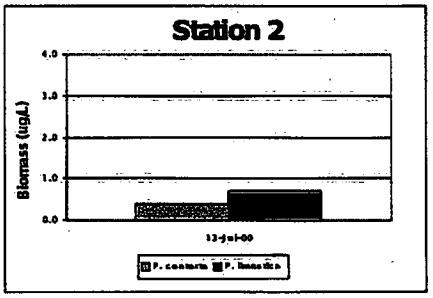
Biomass (ug/L)
8.0
6.0
4.0
2.0
0.0
26-jun-00
13-jul-00
26-jul-00
P. contorta
P. limnetica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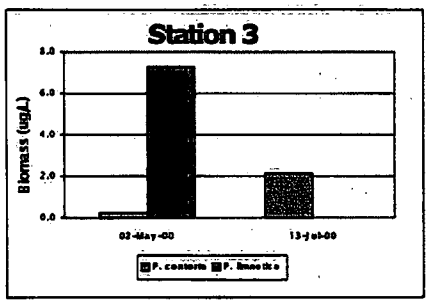
P. contorta
P. limnetica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Biomass (ug/L)
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6.0
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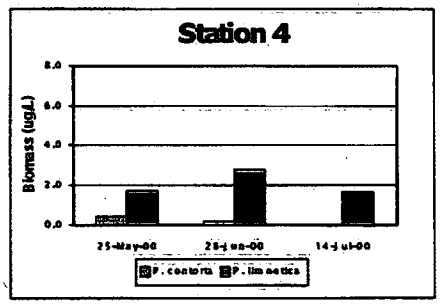
2.0
0.0
02-May-00
13-jul-00
P. contorta
P. limnetica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2.0
0.0
25-May-00
28-jun-00
14-jul-00
P. contorta
P. limnetica

**Fig 9**. Sampling sites (top) and distribution of *Pseudanabaena. contorta* spec nova and *P. limnetica* (bottom) in Lake Superior, July 2000.

**Figure. 10 .** The distribution of P. contorta n. sp. showing the depth (labels above bars) of maximum biomass at Station LV3 off shore Lake Ontario during 2000.

**Table 1.** Comparison of *Pseudanabaena* species (subg. *Pseudanabaena*; modified from Komárek and Kling 1991)

| | *Ps. catenata* | *Ps. articulata* | *Ps. limnetica* | *Ps. tenuis* | *Ps. moniliformis* | *Ps.* sp.1 | *Ps.* sp.2 | *Ps. contorta* |
|---|---|---|---|---|---|---|---|---|
| Filament length (µm) | -200 | 40-120(300) | -120(-300) | | | | | >28->100 |
| Cell length (µm) | 2-4(7) | 5-11 | (1.2)4-12 | 6-8 | 2.5-5.6 | 1.2-2.8(7) | -2-3(4) | 2.5-7 (9) |
| Cell width (µm) | 1.3-1.5(2) | 1-1.3 | 1-1.5(2) | 1-1.5 | +/-2 | .9-1.2 | .8-1(1.4) | 1.4-1.6(2) |
| Number of cells in trichome | | 4-40 | | | -18(-26) | ->50 | -6 | >50 |
| Cell contents | Pale blue-green | Pale grey- blue | Pale blue-green | Pale blue-green | Pale blue-green or olive green | Pale blue-green | Pale yellow-green with several prominent granules | Pale grey- blue-green with or with out granules |
| Ecology | Benthic or tychoplanktic slightly eutrophic water bodies | Planktic in lakes | Planktic, slightly eutrophic water, lakes reservoirs | Benthic in lakes | Planktic in large lakes | Planktic in large lakes | Planktic in large lakes | Planktic in large Deep temperate lakes |
| Distribution | Temperate zone | Northern Europe | Temperate zone, India? | Northern Europe | EastAfrican Lakes | East African Lakes | East Africa Lakes | North American Large Lakes |

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