Musky Bay 2020 Assessment Documentation

Excerpt from Lac Courte Oreilles Phosphorus Site-Specific Criteria Analysis. WDNR Technical Support Document.

Lac Courte Oreilles, Sawyer County Phosphorus Site-Specific Criteria Analysis

WDNR Technical Support Document

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Wisconsin Department of Natural Resources
101 S. Webster St.
Madison, WI 53703

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6.4 SSC Recommendation for small bays

There is no technical basis to assign a separate criterion for the small bays of Lac Courte Oreilles. We do not recommend that a phosphorus criterion be applied to the small bays that is different from the overall lake, for two main reasons:

- Standardized methods for assessing health of small bays independent from the overall lake are not yet available, and methods for developing appropriate criteria for small bays are also unavailable.
- Each of the four small bays with data exhibit very low chlorophyll levels, attaining even the most stringent thresholds, and a healthy aquatic plant community. There is no justification for treating these bays differently from bays on other lakes in the state.

As a general matter, the criterion applied to the main basins in a lake should be considered inclusive of the small bays, whether that be the statewide criterion or an SSC. Assessment of that criterion should follow standard protocols for all lakes, using measurements only at the deep hole(s), not samples within the small bays. In this case, the statewide phosphorus criterion for Lac Courte Oreilles is protective of the designated uses of the lake, and therefore also protective of the small bays.

7. Musky Bay

In Musky Bay, residents are concerned about both aquatic life habitat issues (low dissolved oxygen affecting musky spawning) and recreation issues (inhibition of navigation due to abundance of curly-leaf pondweed and algal mats). These specific concerns, however, are difficult to assess using existing information and methods available to the department. In order to establish a phosphorus SSC, we must demonstrate 1) that there is an impairment of uses, 2) a clear link between the impairments and phosphorus concentrations, and 3) that a more-stringent phosphorus concentration is needed to attain those uses. While we cannot directly measure or assess the residents' specific concerns with the data and methods available to us, we evaluated whether phosphorus concentrations are having a general impact on aquatic life and recreation by using standard protocols for evaluating chlorophyll *a* concentrations and aquatic plant condition, consistent with the proposed rule. Both metrics indicated healthy conditions and did not warrant a site-specific phosphorus criterion for Musky Bay. However, these conclusions do not preclude future studies that may directly the condition of musky spawning habitat, curly-leaf pondweed and algal mat abundance and establish their relationships to pollutants and nutrients, including phosphorus.

A summary of the attainment status for Musky Bay for each of the recreation and aquatic life use thresholds contained in the proposed revisions to ch. NR 102 is shown in Table 17. These are described in detail in this section.

Table 17. Summary of attainment status for Musky Bay (2012-2016). The metrics in this table are proposed in ch. NR 102 revisions.

Designated Use	Metric (proposed in revisions to ch. NR 102)	Assessment Status
Recreation	Chlorophyll *a* (% summer days with moderate algae levels)	Attains
Aquatic Life	Chlorophyll *a* concentration	Attains
	Macrophytes – General condition	Attains
	Macrophytes – Phosphorus response	Attains (did not attain in 2011 and 2012)

7.1 Phosphorus

Main findings:

- Musky Bay's summer mean phosphorus concentration is 29.53 µg/L, which attains the currently applicable TP criterion of 40 µg/L.
- Musky Bay's annual average TP does not exhibit a significant trend over time when looking at the entire data record from 2000 to 2017. However, prior to 2010 TP was more variable and exceeded the criterion in some years. After 2012, TP was less variable and declined through 2017.

Total phosphorus data were provided by WDNR staff and the Lac Courte Oreilles Tribe. Data collected on Lac Courte Oreilles from 2012-2016 were used in the 2018 assessments. Calculations and data selection methods are outlined in the 2018 Wisconsin Consolidated Assessment and Listing Guidance (WisCALM) document.

In Musky Bay the total phosphorus data were clearly below the criterion for recreation and aquatic life uses (Table 18).

Table 18. Total phosphorus (TP) assessment data for Musky Bay (2018).

				Total Phosphorus (µg/L)		
WBIC	WATERS ID	Station Name	Natural Community	TP Crit. (Rec. & Aqu. Life)	Mean (80% confidence interval)	Recreation & Aquatic Life Status
2390800	1850472	Musky Bay (MB-1)	Shallow Lowland	40	29.53 (27.10-32.19)	Clearly Attains

To analyze trends over time, we calculated the annual average TP concentrations from samples taken at < 2 m deep between June 1 and September 15. We used the same methods as we did for the Main Basins to calculate annual averages. Musky Bay data were available from 2000 to 2017. Simple linear regressions were performed predicting TP based on year for station MB-1. TP has not significantly changed over time at the Musky Bay station (Figure 26). TP varied greatly from 2001 – 2009 with average TP ranging from 25.5 to 49.6 in consecutive years. Since 2012, TP has gradually declined from 41.6 to 23.9 in 2017.

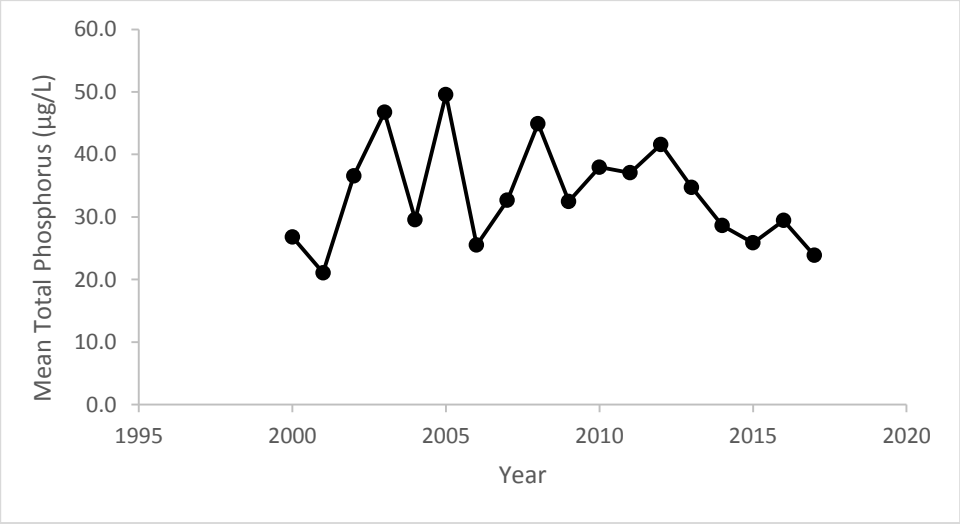

Figure 26. Trend over time of mean annual total phosphorus in Musky Bay.

7.2 Chlorophyll *a*

Main findings:

- Musky Bay attains the chlorophyll *a* thresholds for recreation and aquatic life for unstratified drainage lakes. Musky Bay's mean chlorophyll *a* concentration is 5.75 µg/L (attained if <27 µg/L). It has ~6% of summer days with moderate algae levels (attained if <25% of summer days have moderate algae levels).
- Chlorophyll *a* was still well below the threshold in years when TP exceeded the current criterion applied to Musky Bay of 40 µg/L.
- Therefore, 40 µg/L TP is protective of both the recreation and aquatic life chlorophyll *a* metrics.
- Chlorophyll *a* in Musky Bay did not exhibit a significant trend over time, though it did fluctuate over time with changing TP concentrations.
- Chlorophyll *a* is higher in Musky Bay than elsewhere in Lac Courte Oreilles.

Chlorophyll *a* data were provided by WDNR staff and the Lac Courte Oreilles Tribe. Data collected in Musky Bay from 2012-2016 were used in the 2018 assessments. Calculations and data selection methods are outlined in the 2018 Wisconsin Consolidated Assessment and Listing Guidance (WisCALM) document.

Musky Bay "Clearly Attains" the chlorophyll *a* thresholds for both recreation use (Table 19) and aquatic life use (Table 20). The recreation use threshold for shallow lowland drainage lakes is attained if less than 25% of summer days have moderate algae levels, defined as >20 µg/L chl *a*. Musky Bay has moderate algae levels on 2% of summer days (Table 19). The mean chlorophyll *a* concentration in Musky Bay is 6 µg/L, which is well below the aquatic life threshold of 27 µg/L (Table 20).

Table 19. Musky Bay recreation use assessment data (2018) for frequency of moderate algae levels. Chlorophyll *a* thresholds in this table are proposed in ch. NR 102 revisions.

				Chlorophyll *a* *(% summer days with moderate algae levels)*		
WBIC	**WATERS ID**	**Station Name**	**Natural Community**	**Chl-a Thresh. (Rec.)**	**Mean (80% confidence interval)**	**Recreation Status**
2390800	1850472	Musky Bay (MB-1)	Shallow Lowland	25%	1.9 (0.2-9.4)	Clearly Attains

Table 20. Musky Bay aquatic life use assessment data (2018) for chlorophyll *a* concentrations. Chlorophyll *a* thresholds in this table are proposed in ch. NR 102 revisions.

				Chlorophyll *a* (µg/L)		
WBIC	**WATERS ID**	**Station Name**	**Natural Community**	**Chl-a Thresh. (Aqu. Life)**	**Mean (80% confidence interval)**	**Aquatic Life Status**
2390800	1850472	Musky Bay (MB-1)	Shallow Lowland	27	5.75 (4.50-7.34)	Clearly Attains

As expected, chlorophyll *a* is higher in years with high TP (Figure 27). There were four years in which the mean annual TP was greater than the current criterion of 40 µg/L (2003, 2005, 2008, and 2012). Despite high

phosphorus, mean annual chlorophyll *a* was still well below the aquatic life criterion of 27 µg/L and even below the definition of moderate algae levels at 20 µg/L chl *a*. In general, chlorophyll *a* for a given phosphorus concentration is lower than expected given the statewide relationship between phosphorus and chlorophyll *a* (Figure 27). Thus, the standard statewide TP criterion for shallow lowland lakes is protective of the chlorophyll *a* aquatic life and recreation uses.

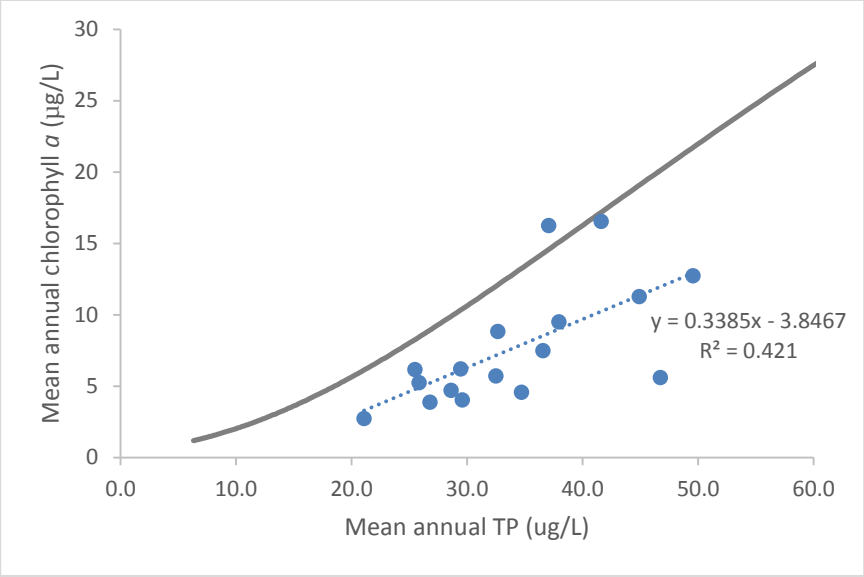

Figure 27. Relationship between annual mean TP and chlorophyll *a* in Musky Bay (station MB-1, blue points and blue dashed regression line) compared to the statewide relationship (gray line).

To analyze trends over time, we calculated annual average chlorophyll *a* concentrations from samples taken at < 2 m deep between July 1 and September 15. Simple linear regressions were performed predicting chlorophyll *a* based on year for each station. Chlorophyll *a* in Musky Bay did not exhibit a significant trend over time, though it did fluctuate over time with fluctuating TP concentrations (Figure 28). Chlorophyll *a* is higher in Musky Bay than in the main basins or other bays.

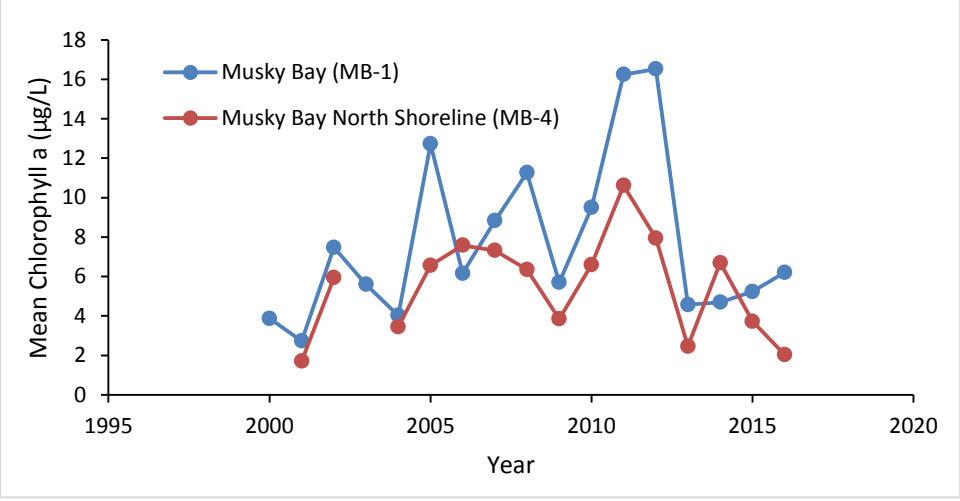

Figure 28. Annual mean chlorophyll *a* over time in Musky Bay.

Algal mats

In conjunction with dense plant growth, periodic algal mats in Musky Bay reportedly impede navigation (recreation). The department's standard assessment methods do not quantify the presence or extent of algal mats. Chlorophyll *a* is measured within the top 2 meters of the water column to quantify the abundance of phytoplankton, and algal mats are specifically avoided. To develop a site-specific phosphorus criterion based on algal mats, two pieces of information are needed: 1) a quantitative measure of algal mat abundance and 2) a demonstrated phosphorus concentration that would limit the extent of algal mats. Neither of these are available at this time.

7.3 Aquatic plants

Main findings:

- Plant data collected with high spatial resolution in Musky Bay in 2007 and in all years 2010 – 2016 revealed that Musky Bay attained the general condition threshold in all years (attained if tolerant species ≤73%). In 2011 and 2012, it failed to attain the plant phosphorus response threshold (attained if phosphorus-sensitive species >51%), indicating there may have been a short-term impairment that could be related to nutrient levels. Since then (2013-2016), plants consistently attained the phosphorus response thresholds.
- The available data suggest that 40 µg/L is protective of aquatic plants in Musky Bay. Three aquatic plant surveys attained the phosphorus response indicator when phosphorus was 32.7 – 38.0 and two aquatic plant surveys did not when phosphorus was 37.1 - 41.6 µg/L.
- Musky Bay was listed as impaired for high densities of curly-leaf pondweed, an invasive aquatic plant, in 2012. The number of acres treated with herbicide has declined in recent years, suggesting that curly-leaf pondweed is not as pervasive as it was in 2010-2012. The curly-leaf pondweed population likely responds to the combined influence of a large number of environmental variables, and we currently lack sufficient understanding of the relationship between curly-leaf pondweed biomass and water column nutrient concentration to use curly-leaf pondweed density as an indicator of nutrient impairment. In addition, the active management of curly-leaf pondweed may hamper our ability to discern the specific relationship between environmental factors and the present population.
- The density and biomass of aquatic plants and their relationship with phosphorus could not be evaluated with available data or methods.

Aquatic plant survey methods are described in section 5.3. Musky Bay was assessed as part of the 2010 whole-lake assessment, using a subset of sampling points from the overall assessment (Figure 6). Using this analysis Musky Bay attained both the assessment for general condition (MAC) and the assessment for phosphorus response (MAC-P). Musky Bay, like the whole lake, falls into the Northern Drainage category for this assessment. Results are shown in Table 21.

Table 21. Draft macrophyte condition assessment decision for Musky Bay based on aquatic plant data collected in 2010. The aquatic plant metrics in this table are proposed in ch. NR 102 revisions.

	General Condition Assessment (MAC)			Phosphorus Response Assessment (MAC-P)		
	Threshold (attains if…)	% Tolerant	MAC Status	Threshold (attains if…)	% Phosphorus sensitive	MAC-P Status
Musky Bay	Tolerant species ≤73%	67%	Attains	Phosphorus-sensitive species >51%	68%	Attains

Following the analysis of the 2010 whole-lake survey, WDNR obtained data from external partners on Musky Bay collected in 2007 and all years from 2010 to 2016. The surveyors applied the baseline monitoring protocol, using a sampling grid of 394 points, which is more than recommended by the baseline protocol (Figure 29). Surveyors collected data on aquatic plant presence/absence at all points of this grid.

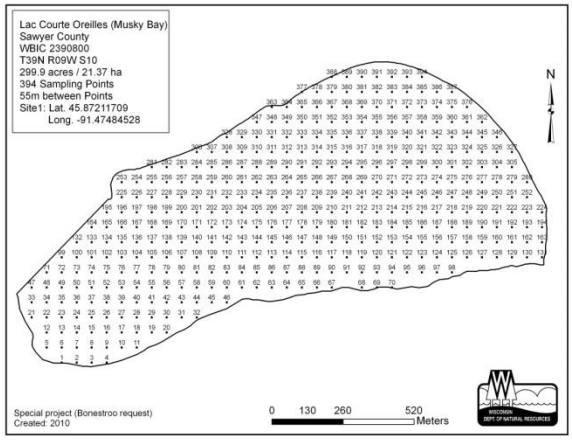

Figure 29. Musky Bay with aquatic plant sampling grid (394 Sampling points).

MAC and MAC-P assessments were calculated on Musky Bay following Mikulyuk et al. (2017). Echoing patterns found lakewide, the assessments most often met established thresholds (Table 22). However, in 2011 and 2012, the population of phosphorus-sensitive species declined slightly below the threshold, providing some evidence that the aquatic plant community was impacted during those two years. Since that time both plant thresholds have been attained.

Table 22. Draft macrophyte condition assessment decisions for Musky Bay using data collected on a sampling grid specific to Musky Bay. For reference, mean annual TP concentrations in Musky Bay are also listed here.

	General Condition Assessment (MAC)			Phosphorus Response Assessment (MAC-P)			Mean Annual TP (µg/L)
Musky Bay Year	Threshold (attains if…)	% Tolerant	MAC Status	Threshold (attains if…)	% Phosph.-Sensitive	MAC-P Status	
2007	Tolerant species ≤73%	48%	Attains	Phosphorus-sensitive species >51%	97%	Attains	32.7
2010		67%	Attains		68%	Attains	38.0
2011		60%	Attains		42%	*Does not attain*	37.1
2012		25%	Attains		42%	*Does not attain*	41.6
2013		60%	Attains		63%	Attains	34.7
2014		53%	Attains		60%	Attains	28.6
2015		45%	Attains		66%	Attains	25.9
2016		42%	Attains		84%	Attains	29.4

In 2011 and 2012, the biodiversity of the plant community was lower relative to other years. This means that in 2011 and 2012, there were fewer species recorded, and abundance patterns were skewed toward a dominant few species. In addition, the fern-leaf pondweed (*Potamogeton robbinsii*) population decreased substantially in 2010 and did not recover. This species tends to have lax stems and, though caulescent and

capable of extending up into the water column, is often found lying horizontally on the substrate. Compared to other wide-leafed submergent plants, fern-leaf pondweed is relatively sensitive to shading and changes in water clarity. Natural, anthropogenic, stochastic or observer differences are all candidate drivers for the observed community shift in 2011 and 2012. It does coincide with the years when large areas of Musky Bay were treated with herbicide to control invasive curly-leaf pondweed (Table 24). Although the decrease in fern-leaf pondweed was sustained, biodiversity and phosphorus-sensitive plant species recovered after 2012 (Table 23, Figure 30).

Table 23. Information on biodiversity by year. Number of species is the simple count of species observed, evenness describes how similar each species is in terms of relative abundance, and Shannon's H index combines number of species and evenness into a single index of biodiversity. Note that Shannon's H index is lowest for years 2011 and 2012.

Musky Bay Year	Number of species	Evenness	Shannon's H index
2007	26	0.68	2.2
2010	19	0.73	2.2
2011	26	0.59	1.9
2012	22	0.56	1.7
2013	25	0.66	2.1
2014	25	0.66	2.1
2015	27	0.70	2.3
2016	30	0.73	2.5

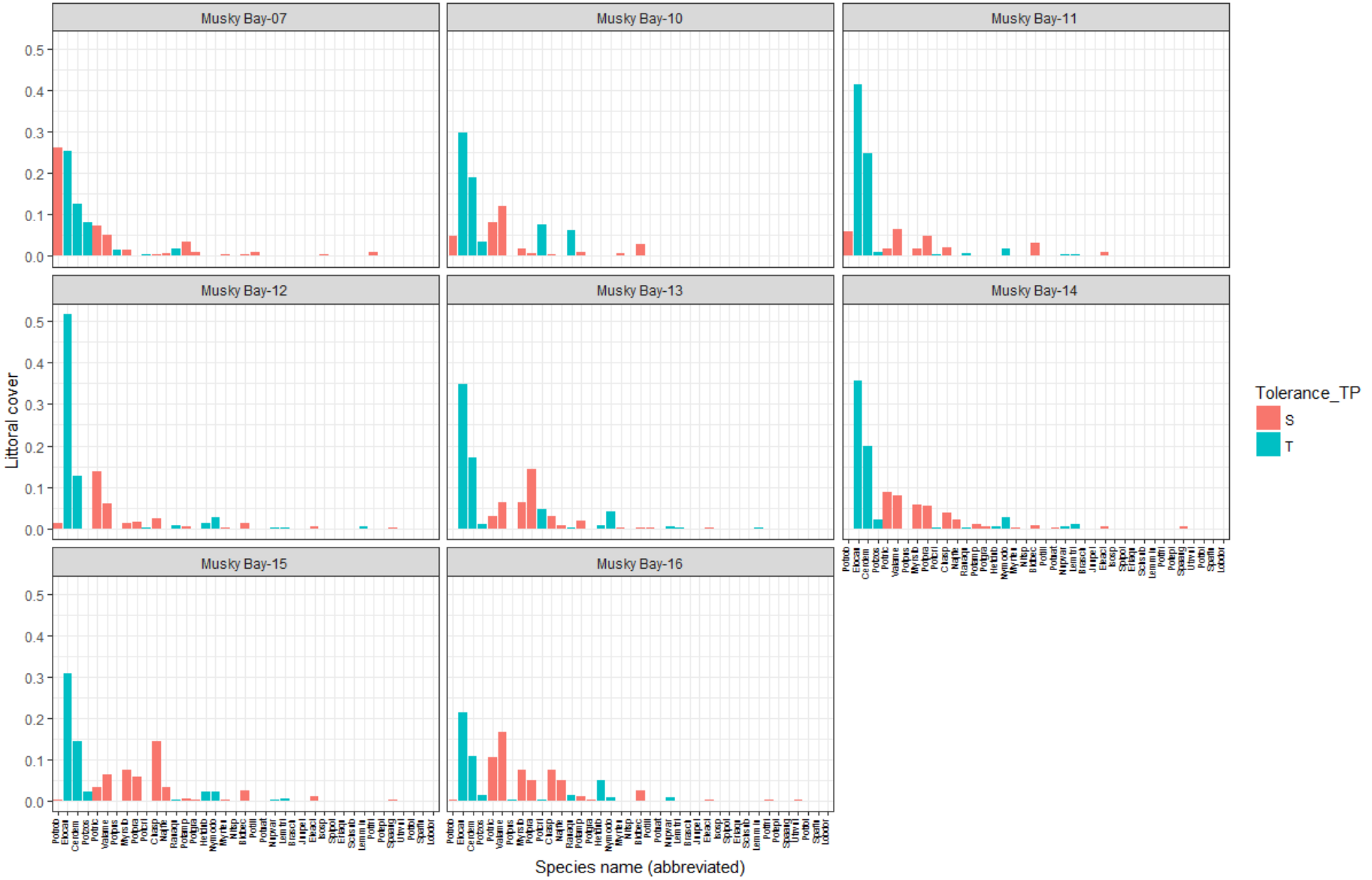

Figure 30. Littoral cover by species and across years (2007 in upper left). General shape of the abundance distribution is consistent across most years, with some notable changes in individual species abundance patterns (e.g. fern-leaf pondweed; *Potamogeton robbinsii*).

Plant abundance and curly-leaf pondweed

Although the composition of the aquatic plant community in Musky Bay is generally healthy and includes species that are not indicative of degradation, lake users have expressed significant concern over the amount (or abundance) of aquatic plants in the bay. Curly-leaf pondweed (*Potamogeton crispus*), an invasive plant that reaches peak abundance early relative to other Wisconsin plant species, reportedly interferes with navigation and recreational activities.

Musky Bay was listed as impaired for recreation due to curly-leaf pondweed in 2012 with phosphorus listed as the pollutant. Phosphorus was indeed high in 2012, but we do not have enough data on curly-leaf pondweed abundance over time to establish a relationship with phosphorus. Curly-leaf pondweed is a cosmopolitan species that tends to do well in lakes with high nutrients, but the presence of curly-leaf pondweed alone does not indicate nutrient impacts. The curly-leaf pondweed population likely responds to the combined influence of a large number of environmental variables, and we currently lack sufficient understanding of the relationship between curly-leaf pondweed biomass and water column nutrient concentration to use curly-leaf pondweed density as an indicator of nutrient impacts. A study of Minnesota lakes indicated that factors other than phosphorus can also influence curly-leaf pondweed abundance, such as water temperature and snow cover (Heiskary and Valley 2012).

Our mid-summer aquatic plant surveys occur after peak curly-leaf pondweed abundance in spring, but we do have a record of the number of acres that were treated with herbicide to reduce curly-leaf pondweed abundance in Musky Bay (Table 24). We assume that the number of acres treated approximates the extent of this invasive species each year. If this is the case, curly-leaf pondweed was extensive in 2010-2012, the years contributing to the 2012 curly-leaf pondweed impairment listing. Since then, the number of acres treated is much lower, suggesting that curly-leaf pondweed is still present, but less extensive.

Table 24. Acres of curly-leaf pondweed treated with herbicide in Musky Bay over time.

Year	Acres
2009	7.0
2010	79.9
2011	96.0
2012	65.0
2013	29.0
2014	3.0
2015	25.0
2016	25.0
2017	9.0

Currently, the department does not have procedures available for assessing 1) abundance of plants, 2) what constitutes a healthy level of abundance for aquatic life, 3) what level of abundance impairs recreation, or 4) how much phosphorus influences curly-leaf pondweed abundance compared to other factors. Therefore, we were not able to assess and report on plant abundance in the bay. While the department recognizes that recreational issues are a major concern for residents, neither of our available indicators of phosphorus impairment, chlorophyll *a* and aquatic plants, indicate a phosphorus impairment.