Red Algae (*Bangia atropurpurea*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, April 2021
Revised, April 2021
Web Version, 7/28/2021

Organism Type: Plant
Overall Risk Assessment Category: High

Photo: Gabriele Kothe-Heinrich (originally recorded as *Bangia fuscopurpurea* var *atropurpurea*, a synonym of *B. atropurpurea*). Licensed under Creative Commons Attribution-Share Alike 3.0 Unported. Available: https://commons.wikimedia.org/wiki/File:Bangia_fuscopurpurea_Helgoland.JPG. (April 2021).

1 Native Range and Status in the United States

Native Range

From Kipp et al. (2019):

"*Bangia atropurpurea* has a widespread amphi-Atlantic range, which includes the Atlantic coast of North America […]"

Kipp et al. (2019) considers the marine *Bangia fusco-purpurea* to be the same species as the freshwater *Bangia atropurpurea* (see Remarks, below, for discussion of taxonomy). *B. atropurpurea* would be considered native in the freshwater areas described by Kipp et al. (2019).

From Andrejic et al. (2010):

"*Bangia* is classified as an endangered species (EN) (Simić et al., 2007) in Serbia. So far, its presence has been established in three localities: the Trgoviški Timok River (Simić and Ranković 1998), the Gvozdovačka River (Obušković and Obušković, 1998) and the Raška River (Simić, 2008) […]. Even with its cosmopolitan distribution, this species is also endangered in Slovakia (Marhold and Hindak, 1998) and Germany (Kusber et al., 2005), while it is already extinct (EX) in Poland (Siemińska, 1992), found in one locality in Finland (Eloranta and Kwandrans, 2007), in five locations in Romania (Cărăuş, 2003), several locations in Ukraine (Tsarenko et al., 2006), Slovenia (Vrhovšek et al., 2006) and is common in Austria (Rot et al., 1999)."

Due to the taxonomic history of this species, see Remarks below, it is difficult to determine the exact native distribution of the species.

Status in the United States

From Mills et al. (1991):

"This filamentous red alga native to the Atlantic Coast was observed in Lake Erie in 1964 (Lin and Blum 1977). After this sighting, records for Lake Ontario (Damann 1979), Lake Michigan (Weik 1977), Lake Simcoe (Jackson 1985) and Lake Huron (Sheath 1987) were reported. It has become a major species of the littoral flora of these lakes, generally occupying the littoral zone with *Cladophora* and *Ulothrix* (Blum 1982). Earliest records of this algae in the basin, however, go back to the 1940s when Smith and Moyle (1944) found the alga in Lake Superior tributaries. Matthews (1932) found the alga in Quaker Run in the Allegheny drainage basin. Smith and Moyle's records must have not resulted in spreading populations since the alga was not known in Lake Superior as of 1987. Kishler and Taft (1970) were the most recent workers to refer to the records of Smith and Moyle (1944) and Matthews (1932)."

From Kipp et al. (2019):

"There are some records from the 1940s in the Lake Superior drainage, but they were probably misidentifications or records of failed establishments (Damann 1979; Jackson 1985; Kishler and Taft 1970; Lin and Blum 1976, 1977; Mills et al. 1993)."

"Established where recorded except in Lake Superior. The distribution in Lake Simcoe is limited (Jackson 1985)."

"Only asexual individuals occur in the Great Lakes (Graham and Graham 1987; Jackson 1988; Mills et al. 1993; Nicholls and Veith 1978; Sheath and Cole 1984)."

According to Kipp et al. (2019), *Bangia atropurpurea* has been recorded in the following locations (with observation years and HUCs in parentheses).

- Illinois (1995; Pike-Root)
- Indiana (2002; Little Calumet-Galien)
- Michigan (1995-2002; Au Gres-Rifle, Birch-Willow, Boardman-Charlevoix, Cedar-Ford, Lake Michigan, Little Calumet-Galien, Lower Grand, Manistee, Ottawa-Stony, Pere Marquette-White, Pigeon-Wiscoggin, St. Joseph)
- Minnesota (1944; Lake Superior)
- New York (1964-2002; Buffalo-Eighteenmile, Headwaters St. Lawrence River, Irondequoit-Ninemile, Lake Ontario, Niagara, Oak Orchard-Twelvemile, Samon-Sandy)
- Ohio (1970-2002; Ashtabula-Chargrin, Chautauqua-Conneaut, Cuyahoga, Western Lake Erie)
- Pennsylvania (1995; Chautauqua-Conneaut)
- Wisconsin (1995-2002; Door-Kewaunee, Lake Michigan, Manitowoc-Sheboygan)

According to Guiry and Guiry (2021b), *Bangia atropurpurea* is introduced to the United States and Great Lakes.

From Guiry and Guiry (2021a):

"North America: Connecticut (Schneider et al. 1979), Florida (Schneider & Searles 1991), Georgia (Schneider & Searles 1991), Maine (Mathieson & al. 2001), […] New Hampshire (Mathieson & Hehre 1986), North Carolina (Schneider & Searles 1991, Boekeker & Karsten 2005), […] Oregon (Hansen 1997), South Carolina (Schneider & Searles 1991)."

"Hawaiian Islands (Abbott 1999)"

From Shea et al. (2003):

"For the first time, this alga has been observed to be present in the St. Lawrence River (1995), Georgian Bay on Lake Huron (2002) and Lake Simcoe (eastern shore, 2002) and hence this alga appears to be spreading into new locations."

Means of Introductions in the United States

From Kipp et al. (2019):

"*Bangia atropurpurea* was likely transferred on ship hulls or in ballast water to the Great Lakes (Mills et al. 1993). Recent genetic analysis indicates that Great Lakes *B. atropurpurea* came from a European freshwater source (Shea et al. 2014)."

From Lin and Blum (1977):

"For the rapid invasion of a lake, e.g. Lake Michigan, transport by currents, aquatic animals, and ship hulls appear to be important dispersal mechanism"

Remarks

This ERSS was previously published in June 2018. Revisions were completed to incorporate new information and conform to updated standards.

Over time *Bangia atropurpurea* has been lumped together with the closely related *B. fusco-purpurea*. At times each name has been subsumed under the other (see information below). Currently, Guiry and Guiry (2021b) consider *B. atropurpurea* and *B. fusco-purpurea* as two separate, valid species. This screening has followed that accepted taxonomy. In cases where the information could not be reliable attributed to only *B. atropurpurea* this has been noted.

From Kipp et al. (2019):

"ITIS lists *Bangia atropurpurea* as an unaccepted name, with a correction of the name to *Bangia fusco-purpurea* citing NODC Taxonomic Code, database (version 8.0) 1996. However, recent publications (Chou et al 2015, Shea et al 2014) verified by personal communications (Muller 2015) indicate that this name change applied to only marine members of the species - freshwater strains were retained as *Bangia atropurpurea*. Algaebase uses the name *Bangia atropurpurea* for this species."

"*Bangia atropurpurea* [synonymized with *Bangia fusco-purpurea* in this source] has been recorded from marine and freshwater environments in many regions around the world, including Antarctica, Asia, Europe, and North America. Experiments indicate that plants of saltwater origin can typically be transferred to freshwater environments and flourish because some cells within the thallus appear to be resistant to large salinity fluctuations and can develop into new plants."

"The genetics and life cycle of *B. atropurpurea* are complicated. In marine environments, this species produces both asexual and sexual plants. Plants from freshwater environments in North America are all monosporic and asexual with three chromosomes. When marine plants also exhibit three chromosomes, the third chromosome is larger than that found in freshwater plants. This indicates that marine and freshwater plants may not actually be conspecific. Populations along the North American coast have complex genetic composition with different numbers of chromosomes and comprise sexual or monosporic plants. In one known case from Sicily, a freshwater population exhibited both sexual and asexual forms. Finally, there are genetic

differences between northern hemispheric and Australian isolates of *B. atropurpurea*, indicating that the taxonomy may not be synonymous (Gargiulo et al. 1998, 2001; Muller et al. 2003; Notoya and Iijima 2003; Woolcott and King 1998)."

From Guiry and Guiry (2021a):

"Based on molecular data, as well as chromosome number and morphology, Müller et al. (2003: 217) propose that *B. atropurpurea* should be re-recognized as a distinct species, separate from *Bangia* populations found in the marine environment. They suggest that marine populations should continue to be recognized as *B. fuscopurpurea* until their complex relationships can be resolved."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Guiry and Guiry (2021b):

"Plantae (Kingdom) > Biliphyta (Subkingdom) > Rhodophyta (Phylum (Division)) > Eurhodophytina (Subphylum (Subdivision)) > Bangiophyceae (Class) > Bangiophycidae (Subclass) > Bangiales (Order) > Bangiaceae (Family) > *Bangia* (Genus) > *Bangia atropurpurea* (Species)"

"Status accepted"

Size, Weight, and Age Range

From Kipp et al. (2019):

"Size: 75 microns in diameter"

"Size varies greatly depending on the population. In the Great Lakes, spores are around 15.5 µm in diameter and asexual filaments are around 75 µm in diameter (Sheath and Cole 1984)."

From Womersley (1994):

"[…]1–10 cm long and 20–200 (–300) µm in diameter, […]"

Environment

From Guiry and Guiry (2021a):

"This is a freshwater species."

From Kipp et al. (2019):

"*Bangia atropurpurea* is frequently tolerant to warm water, and its upper survival temperature can vary between 16–31°C depending on the population in question"

From Andrejic et al. (2010):

"Studies show that the seasonality of *Bangia* [*atropurpurea*] is influenced greatly by changes in the light regime (Sheath, 1984), as well as temperature (Sheath and Hambrook, 1990). Gargiulo et al. (1996) conclude that the temperature and photoperiod appear to be critical ecological factors acting together as a seasonal trigger, though they emphasized a stronger effect of temperature."

Climate

From Leghari (2000):

"Haga and Leghari (1995) described *Bangia atropurpurea* from Kunhar river at an elevation of 1470 m above sea level […]"

From Womersley (1994):

"Cosmopolitan in temperate regions […] widely distributed in temperate freshwater areas […]"

Distribution Outside the United States

The following is a detailed distribution of *Bangia atropurpurea* from Guiry and Guiry (2021a). It does not indicate either the native or introduced status of the species at each location. Areas listed in Guiry and Guiry (2021a) that were determined to be part of the native or introduced range through other sources have been removed from this list and the associated information is in the appropriate section.

From Guiry and Guiry (2021a):

"(as *Bangia atropurpurea* (Mertens ex Roth) C.Agardh)
[…]

Atlantic Islands: Azores (Neto 1994, Tittley & Neto 1994, Tittley & Neto 2005), Canary Islands (John, Price, Maggs & Lawson 1979, Guadalupe et al. 1995, Haroun & al. 2002, Gil-Rodríguez et al. 2003, John & al. 2004, Anon. 2011), Greenland (Boekeker & Karsten 2005), Madeira (Neto, Cravo & Haroun 2001, John & al. 2004).

Europe: […] Albania (Kashta & Miho 2016), Balearic Islands (Cremades 1989), […], Britain (Guiry 1997, Sheath & Sherwood 2002, Hardy & Guiry 2003, Whitton & al. 2003, John, Whitton & Brook 2011), Croatia (Koletic & al. 2020), Faroe Islands (Irvine 1982, Nielsen & Gunnarsson 2001), France (Ben Maiz, Boudouresque, Lauret & Riouall 1988, Verlaque 2001, Dizerbo & Herpe 2007, Anon. 2017), […], Greece (Athanasiadis 1987, Boekeker & Karsten 2005), Helgoland (Bartsch & Kuhlenkamp 2000), Hungary (Németh 2005), Ireland (Adams 1908, Sheath & Sherwood 2002), Italy (Furnari, Cormaci & Serio 1999, Rindi, Sartoni & Cinelli 2002, Furnari & al. 2003, Furnari & al. 2003, Furnari & al. 2003, Furnari & al. 2003), Netherlands (Stegenga & Mol 1983, Stegenga & al. 1997, Veen & al. 2015), Norway (Rueness 1997, Brattegard & Holte 2001), […], Sardinia (Furnari & al. 2003), Scandinavia (Athanasiadis

1996), […], Spain (Ballesteros 1981, Romero Martinengo & Romero Martinengo 1982, Pérez-Cirera & Maldonado 1982, Alvárez Cobelas 1984, Gallardo & al. 1985, Rodriguez Prieto & Polo Alberti 1988, Soto & Conde 1989, Sabater, Aboal & Cambra 1989, Granja, Cremades & Barbara 1992, Guillermes, Cremades & Pérez-Cirera 1994, Bárbara, Cremades & Pérez-Cirera 1995, Bárbara & Cremades 1996, Conde & al. 1996, Rodriguez-Prieto et al. 1997, Cremades, Bárbara, Granja & Veiga 1997, Veiga, Cremades & Bárbara 1998, Peña & Bárbara 2002, Gorostiaga & al., 2004, Bárbara & al. 2005[a], Bárbara & al. 2005[b], Cires Rodriguez & Cuesta Moliner 2010), Sweden (Tolstoy & Österlund 2003).

North America: […], Mexico (Pedroche & Sentíes 2020), Mexico (Atlantic) (Mendoza-González, Mateo-Cid & García-López 2017, Ek García-García & al. 2020), New Brunswick (Bates & al. 2005), […] Nova Scotia (Scrosati 2016), […].

South America: […], Chile (Ramírez & Santelices 1991, Hoffmann & Santelices 1997), Colombia (Díaz-Pulido & Díaz-Ruíz 2003), Peru (Ramírez & Santelices 1991), Temperate South America (Ramírez & Santelices 1991), Uruguay (Coll & Oliveira 1999).

Africa: Benin (Lawson & John 1987, John, Lawson & Ameka, 2003), Gabon (Lawson & John 1987, John, Lawson & Ameka, 2003, John & al. 2004), Ghana (Lawson & John 1987, John, Lawson & Ameka, 2003, John & al. 2004, Smith, Smith & Nii Yemoh Annang 2015), Morocco (Gil-Rodriguez & Socorro Hernández 1986, Moussa & al. 2018), Nigeria (John, Price, Maggs & Lawson 1979, Lawson & John 1987, John, Lawson & Ameka, 2003, John & al. 2004), Senegal (John & al. 2004), South Africa (Silva & al. 1996, Stegenga, Bolton & Anderson 1997), Tunisia (Ben Maiz, Boudouresque & Quahchi 1987).

Middle East: Cyprus (Taskin & al. 2013), Egypt (Aleem 1993), Iraq (Maulood & al. 2013), Israel (Einav & Israel 2008), Kuwait (Silva & al. 1996, Al-Yamani & al. 2014), Turkey (Cirik, Zeybeck, Aysel & Cirik 1990, Zeybek, Güner & Aysel 1993, Aysel 2005, Taskin & al. 2008, Taskin & al. 2008, Taskin (ed.) & al. 2019).

South-west Asia: India (Silva & al. 1996, Sahoo et al. 2001, Rao & Gupta 2015), Pakistan (Silva & al. 1996).

South-east Asia: Philippines (Silva, Meñez & Moe 1987, Ang, Sin Man Leung & Mei Mei Choi 2014), Vietnam (Abbott, Fisher & McDermid 2002).

Asia: China (Hu & Wei 2006, Shi, Xie & Hua 2006), Commander Islands (Selivanova & Zhigadlova 1997, Klochkova & al. 2021), Japan (Hirose, Yamagishi & Akiyama 1977, Yoshida, Nakajima & Nakata 1990, Yoshida 1998), Korea (Lee & Kang 1986, Lee & Kang 2001), Russia (Kozhenkova 2009), Russia (Far East) (Perestenko 1980), Russia (Sea of Japan) (Kozhenkova 2020), Taiwan (Lewis & Norris 1987, Huang 2000, Shao 2003-2014), Tajikistan (Barinova & Niyatbekov 2018).

Australia and New Zealand: Australia (Silva & al. 1996), New South Wales (Womersley 1994), New Zealand (Nelson & Phillips 1996), Queensland (Lewis 1984, Womersley 1994 , Phillips 1997, Phillips 2002, Bostock & Holland 2010), South Australia (Womersley 1994, Boekeker &

Karsten 2005), Tasmania (Womersley 1994), Victoria (Womersley 1994), Western Australia (Womersley 1994).

Pacific Islands/Pacific Ocean: Central Polynesia (Tsuda & Walsh 2013), Easter Island (Ramírez & Müller 1991), […], Line Islands (Tsuda & Fisher 2012).

Subantarctic Islands: Île Saint-Paul (St Paul I.) (Silva & al. 1996), South Shetland Islands (Wiencke & Clayton 2002).

Antarctic and Antarctic islands: Antarctica/Subantarctic Islands (Wiencke & Clayton 2002), King George Island (Wiencke & Clayton 2002, Boekeker & Karsten 2005).

(as *Bangiadulcis atropurpurea* (Mertens ex Roth) W.A.Nelson)
[…]

Europe: [..], Bulgaria (Berov & al. 2012), […]"

Native

From Kipp et al. (2019):

"*Bangia atropurpurea* has a widespread amphi-Atlantic range, which includes the Atlantic coast of North America […]"

Kipp et al. (2019) considers the marine *Bangia fusco-purpurea* to be the same species as the freshwater *Bangia atropurpurea* (see Remarks, above, for discussion of taxonomy).
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From Andrejic et al. (2010):

"*Bangia* is classified as an endangered species (EN) (Simić et al., 2007) in Serbia. So far, its presence has been established in three localities: the Trgoviški Timok River (Simić and Ranković 1998), the Gvozdovačka River (Obušković and Obušković, 1998) and the Raška River (Simić, 2008) […]. Even with its cosmopolitan distribution, this species is also endangered in Slovakia (Marhold and Hindak, 1998) and Germany (Kusber et al., 2005), while it is already extinct (EX) in Poland (Siemińska, 1992), found in one locality in Finland (Eloranta and Kwandrans, 2007), in five locations in Romania (Cărăuş, 2003), several locations in Ukraine (Tsarenko et al., 2006), Slovenia (Vrhovšek et al., 2006) and is common in Austria (Rot et al., 1999)."

Due to the taxonomic history of this species, see Remarks above, it is difficult to determine the exact native distribution of the species.

Introduced

From Cantonati and Lowe (2014):

"Neither of these species [*Bangia atropurpurea* and *Jaoa bullata*] nor similar taxa are mentioned in reliable historical papers on Lake Garda [Italy], so they probably were introduced to the lake in relatively recent times."

From Leghari (2000):

"In Pakistan Muhammad Nizamuddin (1988) reported *Bangia atropurpurea* from hot water falls on way to Askari village in Chitral district. […] Haga and Leghari (1995) described *Bangia atropurpurea* from Kunhar river at an elevation of 1470 m above sea level in Mansehra district, N.W.F. Province. Present reports documents [*sic*] the occurrence of *Bangia atropurpurea* from the Nomi and Naltar water in Gilgit area of Pakistan."

Guiry and Guiry (2021b) list *Bangia atropurpurea* as introduced to Argentina and the Mediterranean Sea area.

From Guiry and Guiry (2021a):

"South America: Argentina (Pujals 1963, Tell 1985, Boraso de Zaixso 2013), […]"

Kipp et al. (2019) reports nonindigenous occurrences of *Bangia atropurpurea* in Ontario, Canada between 1979 and 2002. *B. atropurpurea* is considered established there.

Means of Introduction Outside the United States

From Leghari (2000):

"Its presence in the fresh waters of Northern areas, Gilgit and, N.W. F. province [Pakistan] may be attributed to dispersal by birds."

Short Description

From Guiry and Guiry (2021a):

"Gelatinous, unbranched, blackish-purple filaments, at first uniseriate later multiseriate, attached by rhizoidal outgrowths from basal and adjacent cells. Cells with central star-shaped chloroplast with pyrenoid."

From Womersley (1994):

"[…] rose to dark red, occurring as a dense mass of flaccid, simple filaments, 1–10 cm long and 20–200 (–300) µm in diameter, with a prominent mucilaginous sheath, each filament basally attached by rhizoids from several suprabasal cells. Filaments […] at first uniseriate, becoming several cells broad by longitudinal divisions producing radially elongate, cuneate, cells surrounding a slight central cavity. Cells […] in uniseriate filaments 8–16 (–20) µm in diameter

and L/D (0.2–) 0.5–1.5, in thicker parts isodiametric in surface view, 8–12 µm across, each with a single stellate rhodoplast […] with a central pyrenoid."

Biology

From Kipp et al. (2019):

"*Bangia atropurpurea* is frequently tolerant to warm water, and its upper survival temperature can vary between 16–31°C depending on the population in question. There may be differences in ability to grow at different temperatures according to whether plants are asexual or sexual (Bischoff-Baesmann and Wiencke 1996; Bischoff and Wiencke 1993; Clayton et al. 1997; Gargiulo et al. 1996; Graham and Graham 1987; Hanyuda et al. 2004; Huang 2002; Kim and Ahn 2005; Notoya and Iijima 2003; Ramirez and Mueller 1991; Reed 1980; Woolcott and King 1998; Xie and Ling 2004)."

"*Bangia atropurpurea* is often recorded from regions of the Great Lakes that are disturbed by higher salt concentrations than normal. Moreover, Great Lakes freshwater parent plants can produce offspring that adapt to 2.6% salt water in just three generations. *Bangia atropurpurea* occurs in the Great Lakes in the littoral splash zone from just at or below the waterline to a maximum +1 m on exposed permanent rocky substrates; there, such native species as *Cladophora* and *Ulothrix* are unable to survive due to extremes in temperature, irradiance, and desiccation. *Bangia atropurpurea* grows best in the Great Lakes at 15–20°C and produces the most monospores at around 15°C and 16 hour day length. It produces highest biomass in spring and fall and persists through the summer at low biomass. In Lake Simcoe, *B. atropurpurea* occurs at maximum "vitality" in early June (Damann 1979; Graham and Graham 1987; Jackson 1985, 1988; Mills et al. 1993; Sheath and Cole 1980)."

From Guiry and Guiry (2021a):

"On rock, wood, etc., as fleecy mat, especially at high tide level on exposed coasts in autumn and winter, disappearing in spring or early summer, at other times present as sparse filaments in shade at all levels and subtidally. Widely distributed, seasonally abundant."

From Womersley (1994):

"Reproduction by monospores liberated from vegetative cells. Sexual plants dioecious; carpogonia […] with a slight prototrichogyne; carposporangia formed in vague groups of 8–16; spermatangia […] formed in more or less square (in surface view) packets of 16–64, pale in colour, with spermatia 2–3 µm in diameter."

From Lin and Blum (1977):

"*Bangia* [*atropurpurea*] colonizes a wide variety of substrates, including rubble, concrete, stonework, and algal filaments such as *Cladophora glomerata* (L.) Kütz., with the most conspicuous growth in the splash zone of breakwaters in the immediate vicinity of port cities. […] *Bangia* grows much better on a rough surface of broken rocks or eroded concrete than on any smooth surface observed. Attachment to solid substrates is secured by rhizoidal outgrowths

protruding from the basal cells of filaments. *Bangia* as well as other filamentous algae are largely excluded from sandy portions of the Lake Michigan littoral, presumably because of the unstable substrate.

Though *Bangia* appears to grow best in the spring and fall, populations remain in position during much of the ice-free seasons and are visible in a zone 5- l0 cm wide at and above the prevailing water level. When *Cladophora* is present in the warmer months, the light auburn or rusty-purple band of *Bangia* is in sharp contrast with the green *Cladophora* zone below […]. When water levels remain low during periods of calm weather, desiccation of waterline algae may occur. *Bangia atropurpurea*, like the marine entity *B. fuscopurpurea*, exhibits remarkable ability to withstand such desiccation (Biebl 1962).

Perennation of *Bangia* [*atropurpurea*] is accomplished by basal vegetative parts which penetrate into or become encrusted by the substrate. In early spring these parts give rise to erect thalli of uniseriate filaments ca. l0 pm in diameter which later develop to multiseriate thalli up to ca. 120 pm thick. 10 cm tall. Formation and release of monospores commonly occurs from mature thalli […] and these spores typically germinate on substrates where they have lodged, to form young filaments. However, spores may remain and germinate in the parent cells, thus giving rise to masses of germlings […]."

Human Uses

No information on human uses of *Bangia atropurpurea* was found.

Diseases

No information on diseases in *Bangia atropurpurea* was found.

Threat to Humans

No information on threats to humans was found for *Bangia atropurpurea*.

3 Impacts of Introductions

From Lin and Blum (1977):

"The establishment of *Bangia* [*atropurpurea*] in Lake Michigan has caused vigorous competition with existing species for limited substrates. For example, where massive *Bangia* populations have developed, *Ulothrix zonata* (Weber and Mohr) Kütz. [a native alga] has been largely displaced. This is especially evident in the southern portions of the lake, and it may be principally in the cold months that the spores of *Bangia* establish the massive waterline populations. Sporelings have been seen growing epiphytically on *Ulothrix*. *Cladophora glomerata* usually attaches at or just below the waterline and has very durable holdfasts and basal akinetes; possibly because of this it is less threatened by *Bangia* than *Ulothrix* is."

From Kipp et al. (2019):

"*Bangia atropurpurea* can be a biofouling organism and has contributed to hypoxic conditions in Lake Erie (Edlund et al. 2000; Stewart 2008)."

The following are **potential** impacts of introductions:

From Cantonati and Lowe (2014):

"Neither of these species [*Bangia atropurpurea* and *Jaoa bullata*] nor similar taxa are mentioned in reliable historical papers on Lake Garda [Italy], so they probably were introduced to the lake in relatively recent times. […] Thus, at present, 2 of the 3 dominant macroalgae of Lake Garda (*J. bullata* and *B. atropurpurea*) appear to be nonnative species, and they may have dislodged or strongly limited the spatial and temporal development of native species (e.g., *Ulothrix* spp.)."

"In Lake Garda, epilithic diatom assemblages were more diverse (75 taxa) than epiphytic diatom assemblages sampled from *B. atropurpurea* (51 taxa)."

From Kipp et al. (2019):

"*Bangia atropurpurea* can adapt to a broad range of salinities over time and can tolerate desiccation and osmotic stress. These traits allow *B. atropurpurea* to occupy the high littoral zone where other filamentous algae do not typically grow (Graham and Graham 1987; Jackson 1988; Lin and Blum 1976; Sheath and Cole 1984; Stewart 2008). There are conflicting reports about whether these characteristics allow *B. atropururea* to out-compete native species (Edlund et al. 2000; Stewart 2008)."

"The mucilaginous cell wall of *B. atropurpurea* is advantageous when living in the upper littoral zone; however it supports approximately 1000 fewer epiphyte cells/ mm^2 compared to native organisms like *Cladophora* (Lowe et al. 1982). This lack of quantity and diversity of algal epiphytes could negatively impact the littoral food web. Furthermore, *B. atropurpurea* can only support larval chironomids, while native *Cladophora* supports a larger diversity of macroinvertebrates (Chilton et al. 1986). Whether this will have an impact on invertebrate composition hinges upon the ability of *B. atropurpurea* to outcompete *Cladophora*."

"*Bangia atropurpurea* typically grows in association with *Uthorixa* and *Cladophora* [both species native to the Great Lakes]. All three of these species are considered biofouling organisms (Lin and Blum 1977). There is considerable research on the negative impacts of these three macrophytes in Lake Erie, however, it is difficult to identify what impacts can be specifically attributed to *B. atropurpurea* (Chilton et al. 1986; Edlund et al. 2000; Jackson 1988; Lowe et al. 1982; Stewart et al. 2008)."

The following information regards aspects of *Bangia atropurpurea* introductions that may have no impact on the introduced area.

From Kipp et al. (2019):

"The populations of *B. atropurpurea* in the Great Lakes are limited to asexual reproduction and therefore will not affect native species genetically (Chilton et al 1986; Sheath and Cole 1984)."

4 History of Invasiveness

The history of invasiveness for *Bangia atropurpurea* is High. *Bangia atropurpurea* has been introduced and has become established in a few countries around the world including the United States. It may be introduced and established in more, however, the complicated taxonomic history makes determining native or introduced status of populations difficult. *B. atropurpurea* is a biofouling organism, it has been shown to displace native species of algae through outcompeting for substrate space, and it has become the dominate algae species in one lake where it was introduced. It has also been reported as contributing to hypoxic conditions in another lake. *B. atropurpurea* also appears to support a lower species diversity for macroinvertebrates. This species is not found in trade.

5 Global Distribution

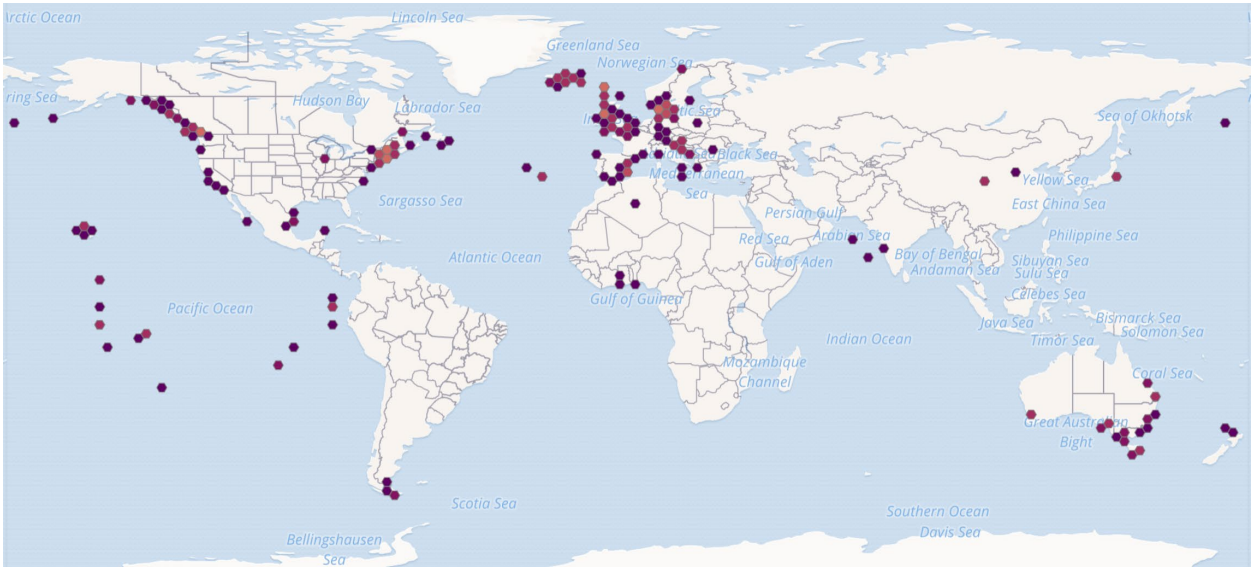

Figure 1. Known global distribution of *Bangia atropurpurea*. Observations are reported from every continent except for Antarctica. Map from GBIF Secretariat (2021). Due to the complicated taxonomic history of *B. atroputpurea* (see Remarks, above), only freshwater observations were used to select source points for the climate match. Marine observations were assumed to be of *B. fusco-purpurea* and mislabeled as *B. atropurpurea*.

Additional observations in Serbia were provided in Andrejic et al. (2010).

Georeferenced observations were not available for all areas where this widespread species has been reported (e.g. South Africa, India, Russia, Turkey; for further details, see section 2).

6 Distribution Within the United States

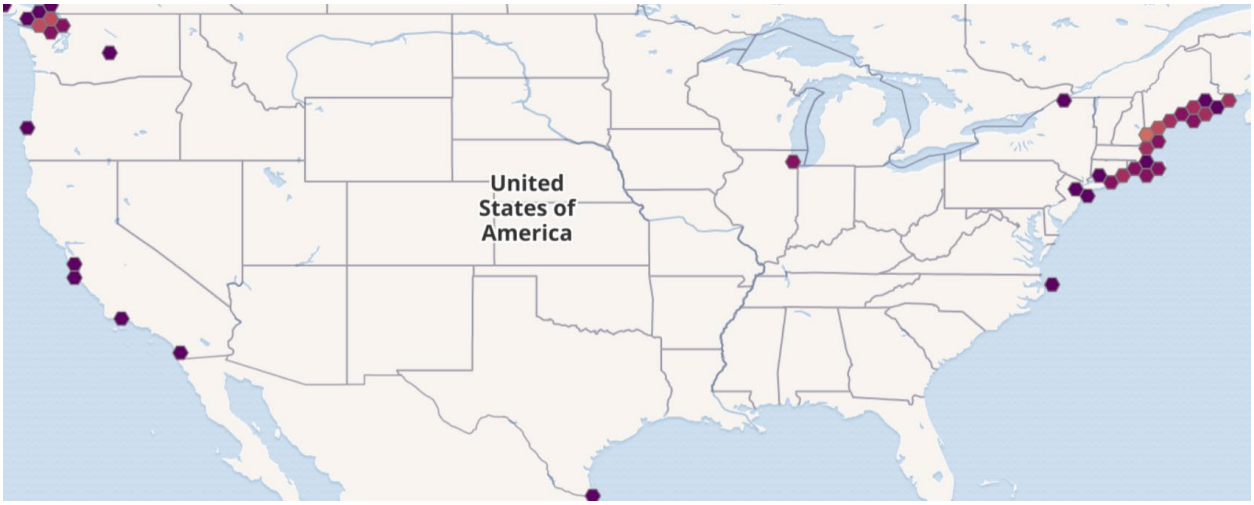

Figure 2. Known distribution of *Bangia atropurpurea* in the United States. Map from GBIF Secretariat (2021).

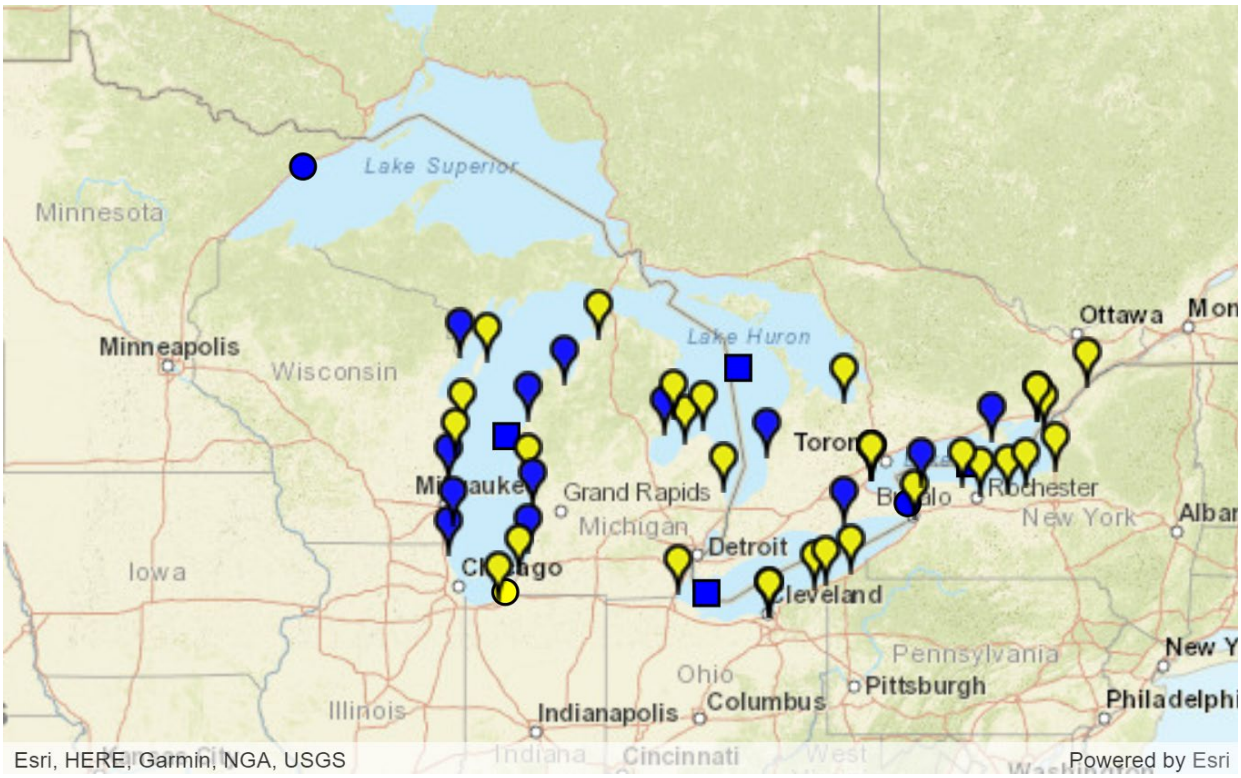

Figure 3. Known distribution of *Bangia atropurpurea* in the Great Lakes Basin. Map from Kipp et al. (2019). The observation in Lake Superior was not used to select source points as *B. atropurpurea* is not considered established in that lake.

Bangia atropupurea has been reported from Florida, Georgia, New Hampshire, and South Carolina but georeferenced observations were not available in those locations.

7 Climate Matching

Summary of Climate Matching Analysis

The majority of the contiguous United States had a medium to high climate match. High match was found through the Northeast, the Great Lakes States, the West Coast, and around the Gulf Coast. *B. atropurpurea* is possibly native to the Atlantic coastal drainages of the United States. The rest of the contiguous United States had medium match. Very small areas of low match were scattered in the Rocky Mountains and inland Southeast. The overall Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.638, high (scores of 0.103 or greater are classified as high). All States had a high individual Climate 6 score.

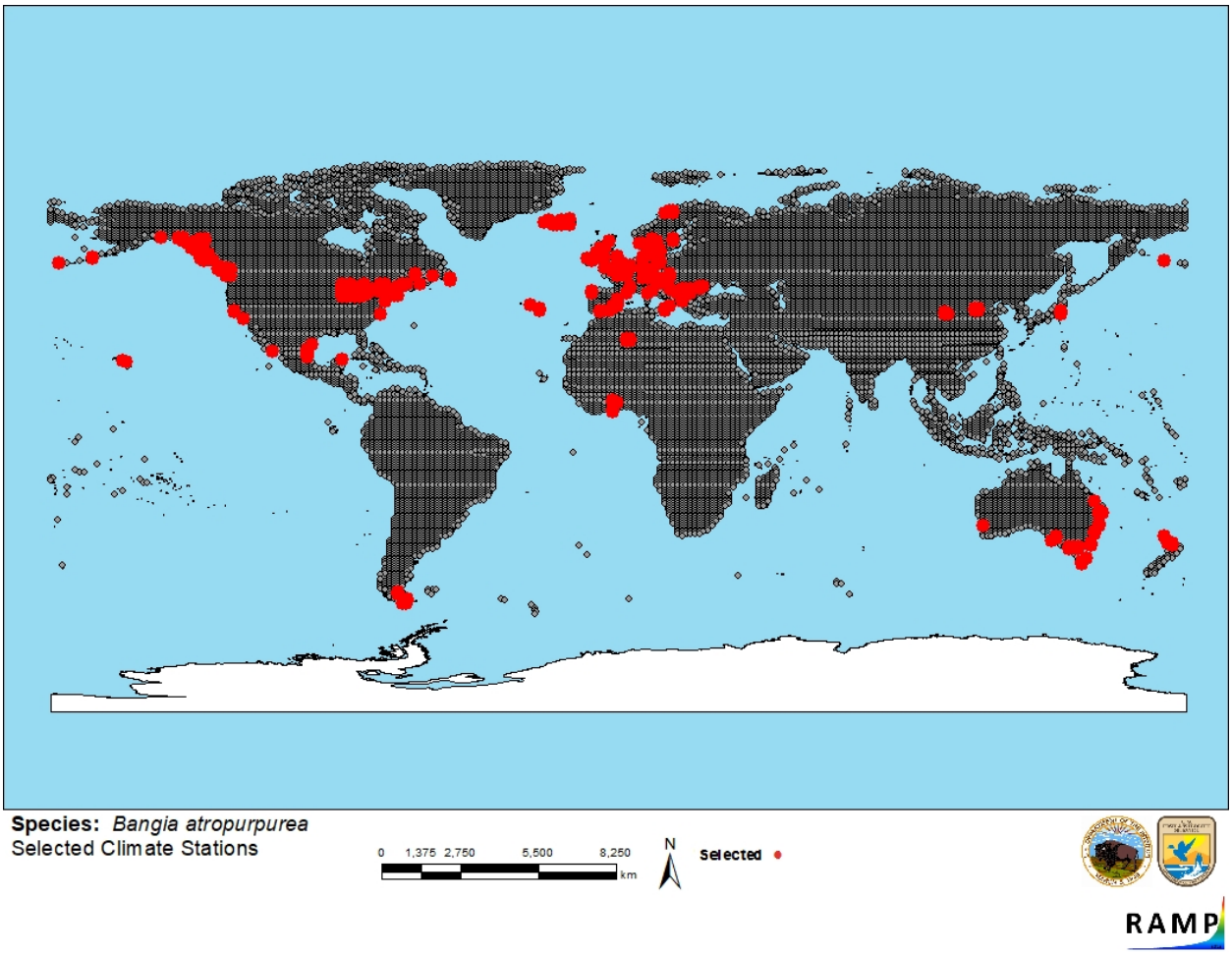

Figure 4. RAMP (Sanders et al. 2018) source map showing weather stations around the world (red; United States, Canada, Mexico, Chile, United Kingdom, Denmark, Spain, Faroe Islands, France, Iceland, Sweden, Germany, Norway, Portugal, Italy, Ireland, Netherlands, Belgium, Switzerland, Austria, Romania, Croatia, Serbia, Algeria, Ghana, China, Japan, French Polynesia, Kiribati, New Zealand, and Australia) and non-source locations (gray) for *Bangia atropurpurea* climate matching. Source locations from Andrejic et al. (2010), Kipp et al. (2019), and GBIF Secretariat (2021). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

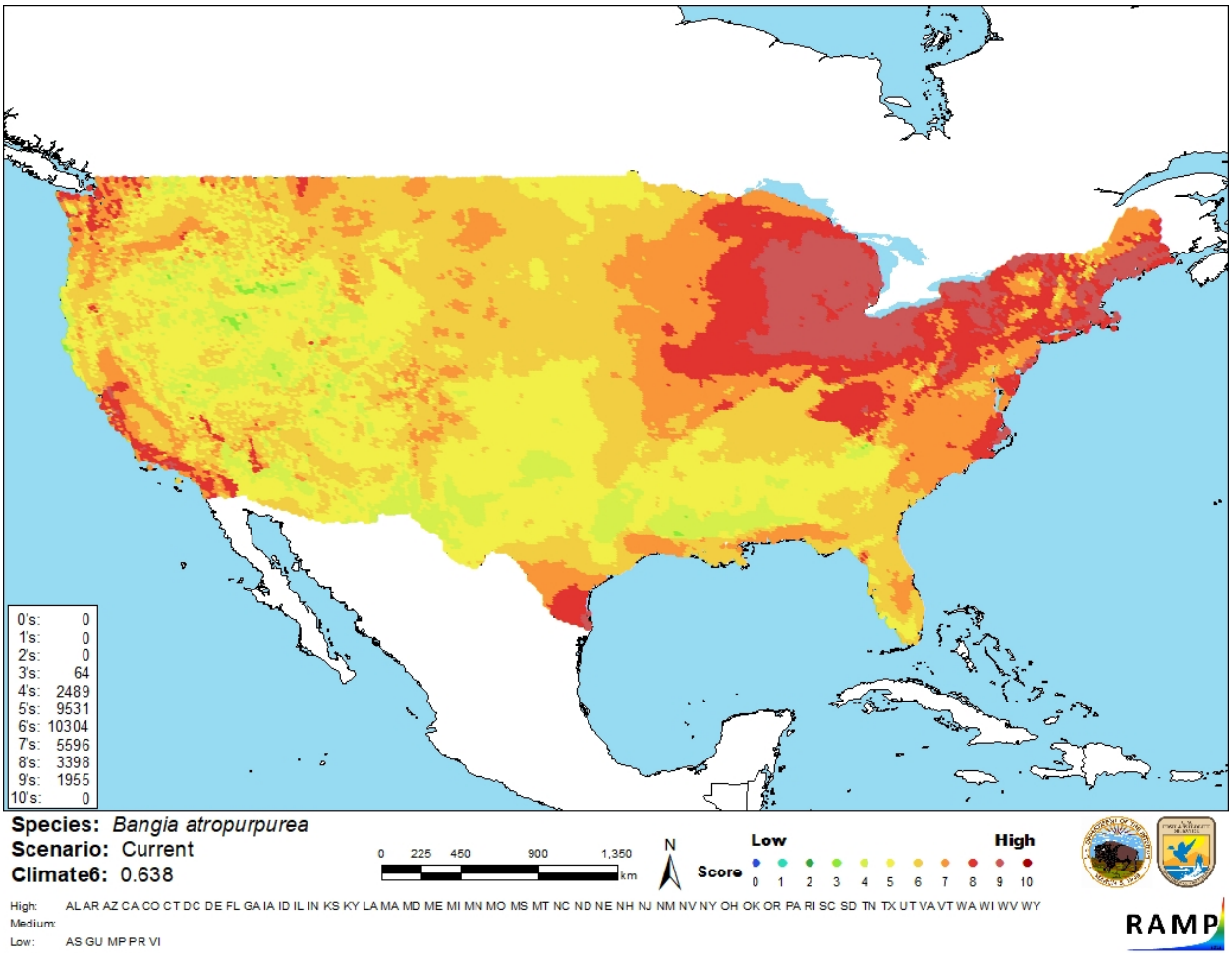

Figure 5. Map of RAMP (Sanders et al. 2018) climate matches for *Bangia atropurpurea* in the contiguous United States based on source locations reported by Andrejic et al. (2010), Kipp et al. (2019), and GBIF Secretariat (2021). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

The certainty of assessment is Medium. There was adequate information available for *Bangia atropurpurea*. However, there is uncertainty in the taxonomy of the species. Some sources use *B. atropurpurea* for the freshwater populations and *B. fusco-purpurea* for marine populations,

while others still considered it all a single species. Still other sources cite the complicated genetics and reproduction biology of the species as indication that more than one species may be lumped in this taxon. Information on the extent of this species native range compared to its introduced range is unclear. Records of introduction were found that resulted in established populations. Information regarding realized impacts were primarily from a strong observational study in a peer reviewed journal. Other information on impacts was either inconclusive or involved other nonnative species, lowering the certainty that *B. atropurpurea* was a main cause of those impacts. More information on potential impacts was found.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Red algae, *Bangia atropurpurea,* is native to freshwater environments in the amphi-Atlantic range, possibly including Atlantic coastal areas of the United States. This species can produce both asexual and sexual plants and can be found on a variety of substrates but prefers to grow on rougher mediums. *Bangia atropurpurea* is distributed on every continent except Antarctica. Introductions are reported in North America (including in the Great Lakes), Italy, and Pakistan. Studies from the Great Lakes have shown detrimental impacts both ecologically (displacing a native species and contributing to hypoxic conditions) and through biofouling. Elsewhere, *B. atropupurea* appears to support a less diverse macroinvertebrate community, but the impact of this is unknown. For these reasons the history of invasiveness is High. The Climate 6 score for the contiguous United States was high, with a high to medium match across most of the contiguous United States. *B. atropurpurea* is already present in the Great Lakes and Pacific coastal areas and is possibly native in coastal areas of the Atlantic Coast. The certainty of assessment is medium because some impact studies were inconclusive and the taxonomy of *B. atropurpurea* is unresolved. The overall risk assessment category is High.

Assessment Elements

- **History of Invasiveness (Sec. 4): High**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Medium**
- **Remarks, Important additional information:** Significant taxonomic confusion is associated with this species.
- **Overall Risk Assessment Category: High**

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