Wakame *(Undaria pinnatifida)*

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Common name(s) in English	Wakame (the Japanese name). Japanese kelp. Asian kelp. Apron-ribbon vegetable.
… and in other languages	Chinese: Ito-wakame. Kizami-wakami. Qundai-cai. Japanese: Wakame. Ito-wakame. Kzami-wakami. Nambu wakame. Korean: Ito-wakame. Kizami-wakami. Miyok.
Scientific name	*Undaria pinnatifida*
Organism group	Macroalgae. Brown algae (Phaeophyta).
Size and appearance	*Undaria pinnatifida* is a very large brown alga, golden-brown in colour, related to the *Laminaria* species and other kelps. Adult specimens can grow to an overall length of between 1.5 and 3 m in less than a year – a rate of growth of up to one centimetre per day. *U. pinnatifida* is an annual species, with two life stages: microscopic male and female gametophytes and a macroscopic sporophyte, the form which we see. Typical features of the sporophyte stage are the distinct, yellowish, up to 1–3 cm wide midrib, which forms a continuation of the stem (stipe), and the characteristic wavy spore-forming blades (sporophylls) round the base of the stem. Above the stem, the midrib runs the entire length of a large, leaf-like blade (lamina), which is feathery in appearance and can be 50–100 cm long. This part of the plant is symmetrically divided into a large number of lobes, resembling a succession of leaves. Special gland cells (Yendo cells) develop early on, appearing as small, dark dots on the blade. The alga attaches to the substratum by means of root-like formations (haptera).
May be confused with	*Alaria esculenta* (dabberlocks), which also has a distinct midrib. This species, found on the west coast of Norway but not yet in Swedish waters, reaches up to 4 m in length, but is much narrower than *U. pinnatifida.* What is more, its blade is not divided into lobes. Its sporophylls consist of several thick, decimetre-long, leaf-like formations, quite different from the wavy "frills" of *U. pinnatifida*. The Atlantic species *Saccorhiza polyschides* (furbelows), which is also found on the west coast of Norway but not yet in Swedish waters, often grows together with *U. pinnatifida*. *S. polyschides* has a sporophyll formation more similar to that of *U. pinnatifida*, but does

	not have the same type of long, root-like haptera attaching it to the substratum. Instead it has a warty formation, reminiscent of a suction cup. Furthermore, it lacks the midrib typical of *U. pinnatifida*. Very young specimens of *U. pinnatifida*, at the stage before the typical midrib develops, can more easily be confused with other kelps. However, this species very soon develops the distinctive dark Yendo cells on its blade.
Geographical origin	Sea of Japan. The species is native to the north-western Pacific coast – Japan, Korea, south-eastern Russia and eastern parts of China.
First observed in Swedish waters	Has not yet been observed in Swedish waters.
Occurrence in Swedish seas and coastal areas	Has not yet been observed in Swedish waters.
Occurrence in other sea areas	*Undaria pinnatifida* was introduced accidentally to the Mediterranean coast of France in 1971, probably with oysters imported from Japan. Attempts were then made to cultivate this alga, first in French Mediterranean waters, and subsequently on the coast of Brittany and further south along the Atlantic coast of France. In 1987, in one of the areas where the species was farmed, naturally recruited plants were found outside the cultivation sites. The species was recorded in 1988 in French Atlantic waters close to the border with Spain, and in 1990 it was reported from northern Spain (Ria de Arosa), where it was probably associated with oyster farming. It has not yet been reported from the Mediterranean coast of Spain. Since 1992 the species has been found around the shores of Italy (including in the canals of Venice and in the Mar Piccolo in southern Italy). Its occurrence in Italian waters is believed to be attributable either to shellfish farms or to shipping. The species was first reported in Britain in 1994, presumably brought there by ships from France. Since 1999 it has also been present in Belgian and Dutch waters, so far probably its northernmost sites on the mainland coast of Europe. *U. pinnatifida* occurs widely around the world and can now be found, for example, in the United States (California), Mexico, Argentina, Australia and New Zealand.
Probable means of introduction	Aquaculture (imported shellfish) and shipping (in ballast water and as a fouling organism).
Habitat(s) in which species occurs	*Undaria pinnatifida* is a tolerant and opportunistic alga. It grows on natural hard substrata of every kind – stones, rocks and reefs, as well as mobile cobble substrates. It can also establish itself on soft sediments, if there are hard surfaces such as shells to attach to. It can rapidly colonize new and disturbed hard substrates, as well as man-made and mobile surfaces such as ropes, pontoons, buoys and ships' hulls. In the early stages of its life cycle, *U. pinnatifida* can also grow epiphytically on other algae and sea-grasses. As an adult, the species grows in dense stands ("forests"), forming large canopies. Up to 200–250 plants have been observed per square metre, with a biomass of over 10 kg (wet weight). *U. pinnatifida* can grow at varying depths, from shallow intertidal and subtidal areas (most commonly found in waters 1–3 m deep) to depths of around 15–18 m in clear water. It does not thrive in areas with high exposure to waves, developing best at sheltered sites. It can grow in temperate areas with cold water, growing best of all at water temperatures below 12°C, and does less well in water warmer than a

	little over 23°C. The species is not particularly demanding as regards light availability, being able to grow in everything from full sunlight to very low levels of light. It does not thrive, though, in areas affected by inputs of fresh water. Provided that the salinity is above roughly 27 psu, the species can establish itself virtually anywhere, from cold to moderately warm waters.
Ecological effects	The dense growth pattern of this alga and the large, shading canopy which it forms modify the habitats of the species that end up below it. Light availability and water movements are reduced. In addition, the species may attach itself to shellfish on the seabed. Since *U. pinnatifida* is an annual species, in European waters it can only compete with other large annual macroalgae, such as *Saccorhiza polyschides.* Experiments have shown that entirely bare surfaces are primarily colonized by native brown algae, rather than by *U. pinnatifida.* What probably favours this species is above all its opportunistic character, i.e. its ability to grow quickly, establish itself on disturbed and artificial substrata, and tolerate a wide range of environmental conditions (in terms of light, exposure, temperature and salinity). As with other large algae that form dense stands, forests of *Undaria* provide shelter for various benthic animal species. The alga is also grazed by certain animals.
Other effects	The large, dense canopies, and the fact that the species attaches to shells, can make it difficult for fishermen to spot shellfish on the seabed. *U. pinnatifida* fouls ropes and lines, buoys, pontoons, cages used in aquaculture, jetties and other harbour structures, and ships' hulls. There are also reports of the species blocking water intakes. Drifting specimens may be washed up on beaches, forming unpleasant, foul-smelling banks of rotting plant material.
Additional information	In its microscopic gametophyte stage, the species can survive on boat hulls, for example, even when the boat is moved by trailer from one area to another, without contact with water. The gametophyte is very tolerant and can survive several months of darkness, desiccation and varying temperatures. *Undaria pinnatifida* has traditionally been cultivated, above all, in Japan, and since the 1940s also in China. As a cultured species it is of great economic significance in Asia. Wakame, which is rich in fibre, low in fat and rich in B vitamins and minerals, is used as an ingredient in a variety of dishes, for example as a characteristic seasoning in *miso* soup. As well as in soups, it is served roasted, as a salad vegetable, with rice and in pickles. The species is also used as a natural remedy.

FIND OUT MORE

- 120 kB: AquaAliens: *Undaria pinnatifida*
  http://www.aqualiens.tmbl.gu.se/Undaria_pinnatifida.pdf
- 548 kB: AquaAliens: Additions and corrections
  http://www.aqualiens.tmbl.gu.se/Undaria_Correction_Addition.pdf
- 2,5 MB: ICES: Alien Species Alert: *Undaria pinnatifida* (wakame or Japanese kelp)
  http://www.ices.dk/reports/ACME/2006/WGITMO06.pdf
- Global Invasive Species Database: *Undaria pinnatifida*
  http://www.issg.org/database/species/ecology.asp?si=68&fr=1&sts=
- AlgaeBase: *Undaria pinnatifida*
  http://www.algaebase.org/speciesdetail.lasso?species_id=350
- FAO Fisheries Global Information System (FIGIS): *Undaria pinnatifida*
  http://www.fao.org/figis/servlet/species?fid=2777
- European Nature Information System Database (EUNIS): *Undaria pinnatifida*
  http://eunis.eea.europa.eu/species-factsheet.jsp?idSpecies=65721&idSpeciesLink=65721

- Joint Nature Conservation Committee: *Undaria pinnatifida*
  http://www.jncc.gov.uk/page-1676
- Marine Life Information Network for Britain & Ireland: *Undaria pinnatifida*
  http://www.marlin.ac.uk/species/Undariapinnatifida.htm
- 3,4 MB: Nationaal Natuurhistorisch Museum: Non-indigenous marine and estuarine species in The Netherlands: *Undaria pinnatifida*
  http://www.marbee.fmns.rug.nl/pdf/marbee/2005-Wolf-ZoolMed.pdf
- Marine and estaurine macroinvertebrates, macroalgae and fish introduced to the Netherlands: *Undaria pinnatifida*
  http://home.hetnet.nl/~faassema/introduced%20algae.html
- Natuurlijk mooi: *Undaria pinnatifida*
  http://www.natuurlijkmooi.net/zeeland/wieren/undaria_pinnatifida.htm
- ETI BioInformatics: *Undaria pinnatifida*
  http://www.soortenbank.nl/soorten.php?soortengroep=duikgids&id=340&menuentry=soorten
- IFREMER: *Undaria pinnatifida*
  http://www.ifremer.fr/aquaculture/en/algae/undaria.htm
- Asturnature.com: Especies invasoras del Cantábrico: *Undaria pinnatifida*
  http://www.asturnatura.com/Consultas/Ficha.php?Especie=Undaria%20pinnatifida
- National Introduced Marine Pest Information System (NIMPIS): *Undaria pinnatifida*
  http://www.marine.csiro.au/crimp/nimpis/spSummary.asp?txa=6808
- Governación de la Provincia del Chubut, Dirección General de Protección Ambiental (Argentina): Especies Invasoras: *Undaria pinnatifida*
  http://www.chubut.gov.ar/dgpa/archives/010937.php?id=-1
- Institute de Biociências, Brazil: The threat of bioinvasions on biodiversity of benthic communities: *Undaria pinnatifida* in Argentina
  http://www.ib.usp.br/apf/argentina.html
- Te Ara: Invasive marine algae and plants in New Zealand: *Undaria pinnatifida*
  http://www.teara.govt.nz/EarthSeaAndSky/OceanStudyAndConservation/MarineInvaders/4/en
- University of California, Santa Barbara: Japanese Kelp an Unknown Factor in Local Ecology
  http://www.ia.ucsb.edu/93106/2004/March15/japanese.html
- Mie University. Lab. Phycology: *Undaria pinnatifida*
  http://soruipc2.bio.mie-u.ac.jp/sourui_photo/phaeo/wakame.html

PHOTO CREDIT

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