

[Research]

Checklist of Phytoplankton Taxa in the Iranian Waters of the Caspian Sea

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(Received: Nov. 25, 2012, Accepted: May. 11, 2013)

ABSTRACT

Phytoplankton taxa composition of the Caspian Sea were evaluated by using samples collected at 12 stations along the Iranian coast of the Caspian Sea between 1996 and 2010. This study identified 158 phytoplankton species consisted of diatoms (70 species), dinoflagellates (23 species), chlorophytes (29 species), cyanophytes (31 species), and euglenoids (5 species). The dominant species were the diatoms *Thalassionema nitzschioides*, *Dactyliosolen fragilissimus*, the dinoflagellate *Prorocentrum cordatum*, and the cyanophyte of genus *Oscillatoria*. The average species diversity index of phytoplankton community was 1.88 as recorded in this study. There were main changes in phytoplankton composition as compared with previous study. It could be related to the severe human activities and difference in sampling strategies.

Keywords: Phytoplankton, taxa, Caspian Sea, Iran

INTRODUCTION

The Caspian Sea is a vast inland depression with no connection with any oceans. With a dimension of 1200 km × 300 km, it is too large to be called a lake. The volume of the Caspian Sea is 78,100 km³, representing 44% of the total volume of inland lakes of the world. The catchment area is 3.6 million km² (Putans *et al.*, 2010; Mertens *et al.*, 2012). The south of Caspian holds over 63% of the Sea's water, while the northern basin holds only 6% of the water (Stolberg *et al.*, 2006). The Volga river accounts for 76.3% of the river inflow: the Kura river 4.9%, the Ural river 3.7%, and the Terek river 3.2%, while the remaining rivers, including all those of the Iranian shore, account for 11.9% (Dumont, 1998). The Caspian Sea has undergone significant ecological alteration during the past 30 years (Dumont, 2000). The main pollution in the south of Caspian is city sewage, industry pollutants, and agriculture

wastewater (fertilizer, herbicides, pesticides), these pollutants are transported via rivers into the Caspian Sea (Ayati, 2003; Nasrollahzadeh, 2010; Bagheri *et al.*, 2011, 2014). The phytoplankton composition of the northern Caspian Sea is different from that of the middle and southern zones, and includes typical features of estuarine plankton with impoverish by marine elements (Aladin & Plotnikov 2003).

Kosarev and Yablonskaya (1994) reported that a total of 449 taxa of phytoplankton were found in the Caspian Sea between 1962 and 1974. This 449 taxa consisted of Bacillariophyta (163 taxa), Chlorophyta (139 taxa), Cyanophyta (102 taxa), Dinoflagellata (39 taxa), Euglenophyta (5 taxa), and Chrysophyta (1 taxa). Diatoms accounted for the largest number of species and their specific composition was most stable throughout the whole vegetation period. The marine

Pseudosolenia calcar-avis has the largest, while dinoflagellates were represented by mainly marine and brackish water forms. *Prorocentrum cordatum* is numerous, but has a smaller biomass than *P. calcar-avis* because its cells are ten-folds smaller. The distribution of marine species increased from 7% in northern part of the sea up to 27% in more southern regions (Kosarev & Yablonskaya 1994; Dumont, 1998; Aladin & Plotnikov 2003).

In recent years, a few studies have been conducted on distribution and composition of phytoplankton in the Caspian Sea waters of Iran (Nasrollahzadeh, 2008; Bagheri, *et al.*, 2010, 2011, 2012a, b; Ganjian *et al.*, 2012), while there is no study that work on checklist of phytoplankton species in this area. In order to study the trend of changes, the multi-year survey on the phytoplankton taxa in the Caspian Sea

waters of Iran was undertaken with the data collected from 1996 to 2010.

MATERIALS AND METHODS

Phytoplankton taxa composition of the Caspian Sea were evaluated by using samples collected at 12 stations along three transects (Lisar, Anzali, & Sefidrood) at 5m, 10m, 20m, and 50m depths along Iranian coast of the Caspian Sea in different years between 1996 and 2010 (Fig. 1). Phytoplankton samples were collected with a Nansen water sampler. In total, a collection of 964 samples were carried out during these periods (Table 1). The samples were kept in 500 ml bottles and preserved using buffered formaldehyde (4%). A detailed treatment of the samples were the same as described by Bagheri *et al.* (2012a). The phytoplankton community was analyzed using the MVSP software for the Shannon-Wiener diversity index and evenness index.

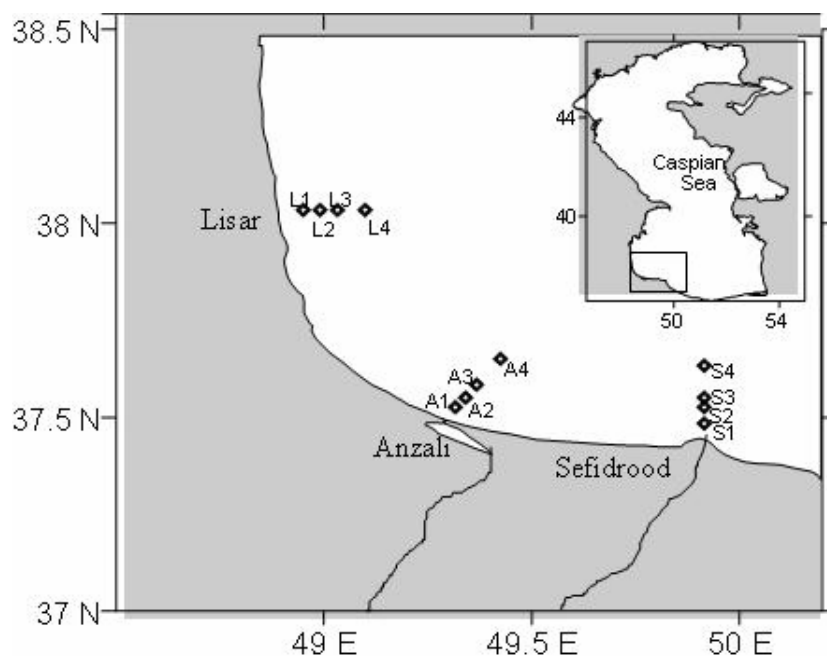


Fig. 1. Study sites from 1996 to 2010 in Iranian waters of the Caspian Sea. L = Lisar, A = Anzali, S = Sefidrood, 5 m (L1, A1, S1), 10 m (L2, A2, S2), 20 m (L3, A3, S3), and 50 m (L4, A4, S4)

Table 1. Samples collected in the Iranian waters of the Caspian Sea during 1996-2010

Year	Season			
	Winter	Spring	Summer	Autumn
1996		x	X	X
1997	x			
1999			X	X
2000	x	x		
2001	x		X	X
2002	x	x	X	X
2003	x			X
2004	x	x	X	x
2005	x	x	X	x
2006	x		X	x
2007				
2008	x	x	X	x
2009			X	x
2010	x	x		x

RESULTS

Phytoplankton taxa varied between 32 and 69, respectively from 1996 to 2001, and a total of 158 phytoplankton taxa were identified (Tables 2 and 3). Of these taxa, 70 taxa (44.3%) diatoms (34 genera, 70 species), 31 taxa (19.6%) Cyanophyta (13 genera, 31 species), 29 taxa (18.4%) Chlorophyta (16 genera, 29 species), 23 taxa (14.6%) Dinoflagellata (10 genera, 23 species) and 5

taxa (3.2%) Euglenophyta (3 genera, 5 species) were identified in the southwestern Caspian Sea during 1996-2010 (Table 3).

During these years, the diatoms *Thalassionema nitzschioides*, *Dactyliosolen fragilissimus*, dinoflagellate *Prorocentrum cordatum*, and cyanophyte *Oscillatoria* sp. were the most dominant species.

Table 2. Checklist of phytoplankton taxa in the Iranian waters of the Caspian Sea during 1996-2010

Phytoplankton	Year								
	1996-1997	1999-2000	2001	2002	2003	2004	2006	2008	2009-2010
Chlorophyta									
<i>Actinastrum hantzschii</i> Lagerheim, 1882	-	-	-	-	-	+	+	+	+
<i>Ankistrodesmus</i> sp. Corda, 1838	-	-	-	-	-	-	-	+	+
<i>Ankistrodesmus acicularis</i> Korshikov, 1987	-	-	-	-	+	-	+	-	-
<i>Ankistrodesmus arcuatus</i> Korshikov, 1953	+	-	-	-	-	-	-	+	-
<i>Ankistrodesmus convolutus</i> Corda, 1838	-	-	-	-	-	+	+	-	+
<i>Ankistrodesmus falcatus</i> (Corda) Ralfs, 1848	-	+	-	+	-	+	-	-	+
<i>Binuclearia</i> sp. Wittrock, 1886	-	-	-	-	+	-	-	-	-
<i>Binuclearia lauterbornii</i> Proschkina, 1966	+	+	+	+	+	-	-	+	+
<i>Chlamydomonas olifani</i> A.A. Korshikov, 1833	-	-	-	-	-	+	-	-	-
<i>Coelastrum microporum</i> Nageli, 1855	-	-	-	-	-	+	-	-	-
<i>Coelastrum sphaericum</i> Nageli, 1849	-	-	+	-	+	-	-	-	-
<i>Closterium parvulum</i> Nageli, 1849	-	-	-	-	-	-	-	+	-
<i>Crucigenia tetrapedia</i> W. West & G.S. West, 1902	-	-	-	-	-	-	+	-	-
<i>Dictyosphaerium pulchellum</i> H.C. Wood, 1873	-	-	-	-	+	-	-	-	-
<i>Golenkinia</i> sp. R. Chodat, 1894	-	-	-	-	-	+	-	-	-
<i>Golenkinia radiata</i> Chodat, 1894	-	-	-	-	-	-	-	-	+
<i>Lagerheimia genevensis</i> Chodat, 1895	-	-	-	-	-	-	-	+	-
<i>Krichneriella</i> sp. Schmidle, 1893	-	-	-	-	-	+	-	-	-
<i>Mougeotia</i> sp. C. Agardh, 1824	-	-	+	+	+	-	-	-	-

Table 2 (Continued)

Phytoplankton Taxonomic Groups and Species	Year								
	1996-1997	1999-2000	2001	2002	2003	2004	2006	2008	2009-2010
Chlorophyta									
<i>Oocystis</i> sp. Naegeli Ex A. Braun, 1855	-	+	-	-	-	-	-	-	-
<i>Pinnularia nobilis</i> Ehrenberg, 1843 nom. cons	-	-	-	+	-	-	-	-	-
<i>Scenedesmus</i> sp. Meyen, 1829	-	-	-	-	+	-	-	-	+
<i>Scenedesmus acuminatus</i> Chodat, 1902	-	-	-	-	-	+	+	-	+
<i>Scenedesmus bijuga</i> Lagerheim, 1893	-	-	-	-	-	-	-	-	+
<i>Scenedesmus communis</i> Hegewald, 1977	+	+	+	+	-	+	+	-	-
<i>Scenedesmus obtusus</i> Meyen, 1829	-	-	-	-	-	-	-	-	+
<i>Scenedesmus opoliensis</i> Richter, 1897	-	-	-	-	-	-	-	-	+
<i>Schroederia</i> sp. Lemmermann, 1898	-	-	-	-	-	+	-	-	-
<i>Tetraselmis</i> sp. F. Stein, 1878	-	-	+	-	-	+	+	-	-
Cyanophyta									
<i>Anabaena</i> sp. Vincent ex Bornet & Flah, 1886	+	+	-	-	-	-	-	-	+
<i>Anabaena aphanizomenoides</i> Forti, 1912	-	-	-	-	+	+	-	-	-
<i>Anabaena crassa</i> Komarkova and cronberg, 1992	-	-	-	+	-	-	-	-	-
<i>Anabaena kisseleaii</i> Proshkina-Lavrenko, 1961	-	-	+	+	+	-	-	-	-
<i>Anabaenopsis</i> sp. Miller, 1923	-	+	+	+	+	-	-	-	+
<i>Anabaenopsis arnoldii</i> Aptekar, 1926	-	+	-	-	-	-	-	-	-
<i>Anabaenopsis cunningtonii</i> Tylor, 1932	+	-	+	-	-	-	+	-	-

Table 2 (Continued)

Phytoplankton Taxonomic Groups and Species	Year								
	1996-1997	1999-2000	2001	2002	2003	2004	2006	2008	2009-2010
Bacillariophyta									
<i>Cocconeis scutellum</i> Ehrenberg, 1838	-	-	-	-	+	-	-	-	-
<i>Coscinodiscus</i> sp. Ehrenberg, 1839	-	-	-	-	+	-	-	-	-
<i>Coscinodiscus granii</i> Gough, 1905	+	+	+	+	+	+	-	+	+
<i>Coscinodiscus perforatus</i> Ehrenberg, 1844	-	+	-	+	-	-	-	+	+
<i>Coscinodiscus proximus</i> Makarova, 1957	-	-	-	+	-	-	-	-	-
<i>Ctenophora pulchella</i> Williams & Round, 1986	+	-	-	-	-	-	-	-	-
<i>Cyclotella caspia</i> Grunow, 1878	+	+	+	-	+	-	-	-	-
<i>Cyclotella meneghiniana</i> Kutzinger, 1844	+	+	+	+	+	+	+	+	+
<i>Cymatopleura solea</i> Smith, 1851	+	-	-	-	-	-	-	-	-
<i>Cymbella</i> sp. C.A. Agardh, 1830	-	-	+	+	-	-	-	+	+
<i>Cymbella tumida</i> Van Heurck, 1880	-	-	-	-	-	-	-	+	-
<i>Dactyliosolen fragilissimus</i> G.R.Hasle, 1997	-	+	+	+	+	+	+	+	+
<i>Diatoma</i> sp. Bory, 1824	-	-	-	+	-	-	-	-	-
<i>Diatoma elongatum</i> C.A. Agardh, 1824	-	-	-	-	-	-	-	-	+
<i>Diatoma vulgare</i> Bory de Saint-Vincent, 1824	-	+	+	-	-	-	+	-	+
<i>Diploneis interrupta</i> P.T. Cleve, 1894	+	+	+	-	-	+	-	-	+
<i>Fragilaria capucina</i> Desmazieres, 1825	-	-	+	-	-	-	-	-	-
<i>Gyrosigma</i> sp. Hassall, 1845 nom. cons.	-	-	-	-	+	-	-	-	+
<i>Gyrosigma acuminatum</i> Rabenhorst, 1853	-	-	+	+	-	+	-	+	+
<i>Gyrosigma attenuatum</i> Rabenhorst, 1853	+	+	+	+	+	+	+	+	-
<i>Gyrosigma strigile</i> (W. Smith) Cleve, 1894	-	-	-	-	+	-	-	-	-

Table 2 (Continued)

Phytoplankton Taxonomic Groups and Species	Year								
	1996-1997	1999-2000	2001	2002	2003	2004	2006	2008	2009-2010
Bacillariophyta (Diatoms)									
<i>Pseudosolenia calcar-avis</i> Sundstrom, 1986	+	+	+	+	+	+	-	+	+
<i>Rhoicosphenia curvata</i> Grunow, 1860	-	-	-	-	-	-	-	-	+
<i>Skeletonema cylindraceum</i> Makarova, 1964	-	-	-	-	-	-	-	-	+
<i>Skeletonema costatum</i> P.T.Cleve, 1878	+	+	-	+	+	+	+	+	+
<i>Skeletonema subsalsum</i> Bethge, 1878	-	-	+	+	+	-	-	-	-
<i>Stephanodiscus</i> sp. Ehrenberg, 1846	-	-	-	-	-	-	-	-	+
<i>Stephanodiscus minutulus</i> Cleve & Moller 1987	-	-	-	-	-	-	-	+	-
<i>Stephanodiscus socialis</i> Makarova & Proshkina 1958	-	-	+	-	-	+	-	-	-
<i>Synedra</i> sp. Ehrenberg, 1830	-	-	-	-	-	-	-	+	+
<i>Synedra acus</i> Kützing, 1844	-	-	-	-	+	-	-	-	-
<i>Thalassionema nitzschioides</i> Van Heurck, 1896	+	+	+	+	+	+	+	+	+
<i>Thalassiosira caspica</i> Makarova, 1957	+	-	-	-	-	-	-	-	-
<i>Thalassiosira aculaeta</i> Makarova, 1958	-	-	+	-	-	-	-	-	-
<i>Thalassiosira variabilis</i> Makarova, 1959	+	+	+	+	+	-	-	-	+
<i>Tryblionella gracilis</i> W. Smith, 1853	-	-	-	-	-	-	-	+	-
<i>Ulnaria ulna</i> P.Compere in Jahn., 2001	-	+	+	+	-	+	+	+	+

Table 2 (Continued)

Phytoplankton Taxonomic Groups and Species	Year								
	1996-1997	1999-2000	2001	2002	2003	2004	2006	2008	2009-2010
Dinoflagellata									
<i>Prorocentrum obtusum</i> Ostenfeld, 1908	-	-	+	-	-	-	-	-	-
<i>Prorocentrum scutellum</i> Schroder, 1900	+	+	+	+	+	+	+	+	+
<i>Protooperidinium granii</i> Balech, 1974	-	-	-	-	+	-	-	-	-
<i>Protooperidinium pallidum</i> Balech, 1973	-	-	-	-	-	-	+	-	-
Euglenophyta									
<i>Euglena</i> sp. Ehrenberg, 1838	-	-	-	-	+	+	-	+	+
<i>Lepocinclis acus</i> , Marin & Melkonian, 2003	-	+	+	+	-	-	-	-	-
<i>Euglena viridis</i> (O.F.Müller) Ehrenberg, 1832	+	-	+	+	-	-	+	-	-
<i>Phacus</i> sp. Dujardin, 1841	-	-	+	-	+	+	-	-	-
<i>Trachelomonas</i> sp. Ehrenberg, 1833	-	-	+	-	+	-	+	-	-

Table 3. Annual variations of taxonomic composition in phytoplankton and number of species in the Iranian waters of the Caspian Sea during 1996-2010.

Taxa	Year									Total no. of species
	1996/1997	1999/2000	2001	2002	2003	2004	2006	2008	2009/2010	
Chlorophytes	3	4	5	5	7	11	7	6	11	29
Cyanophytes	6	7	12	5	8	7	8	4	12	31
Diatoms	16	23	33	25	25	21	16	25	31	70
Dinoflagellates	6	7	15	9	8	5	6	7	8	23
Euglenophytes	1	1	4	2	3	2	2	1	1	5
Total	32	42	69	46	51	46	39	43	63	158

Species diversity index (H') increased in value after 2002 to 2009-2010. The highest species diversity recorded ($H' = 2.58$) was during 2009-2010, while the lowest was ($H' = 1.18$) during 1996-1997. Average species

diversity was at 1.88. Evenness ranged between 0.28 and 0.64 in 2001 and 2006 respectively, with the evenness average of 0.48 during the period of study. The evenness index rose between 2002 and 2009-2010.

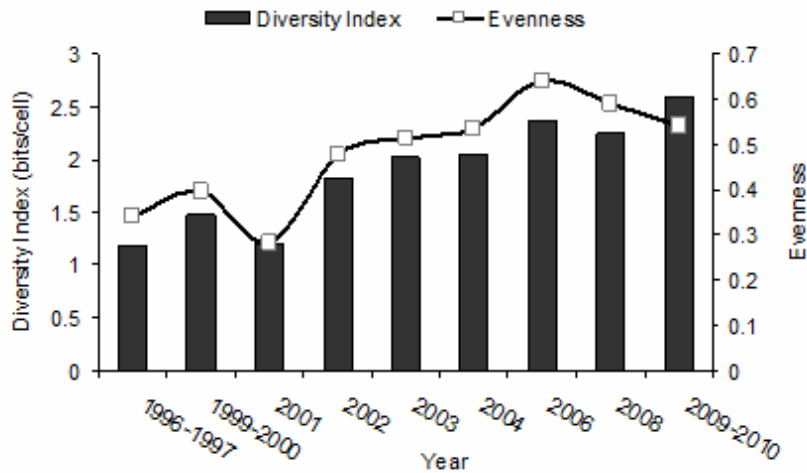


Fig. 2 Annual variations of species diversity and evenness of phytoplankton in the Iranian waters of the Caspian Sea during 1996-2010.

DISCUSSION

As compared to earlier surveys, changes in phytoplankton communities became visible during 1990s and 2000s. This study compares to three phytoplankton surveys carried: 1996-1997 (Nasrollahzade, 2008); 2005 (Ganjian *et al.*, 2010); 2001-2006 (Roohi *et al.*, 2010). It has proved difficult to equate the earlier surveys of phytoplankton (Nasrollahzadeh, 2008; Roohi *et al.*, 2010; Ghanjian *et al.*, 2010), with the present findings in the main, because all of these earlier work contain very considerable taxonomic and nomenclatural mistakes. According to Kosarev and Yablonskaya (1994), phytoplankton species composition of Caspian Sea includes more than 400 species. Roohi *et al.* (2010) reported 233 and 226 species of phytoplankton without list of taxa (taken from their figure 6; Roohi *et al.*, 2010), respectively during 1986-1994 and 2001-2006, and noted a high species of Euglenophyta which did not consist of species list (17 and 19 species; taken from their figure 6; Roohi *et al.*, 2010), while Kosarev and Yablonskaya (1994), and Nasrollahzadeh (2008) reported the seven and five species respectively. The present study in the Caspian Sea also revealed the five Euglenophyta species (Table 3). This is in accordance to Kangro *et al.* (2005), Makaremi *et al.* (2006), Turkoglu (2008 & 2010), and Turkoglu and Oner (2010) who showed Euglenophyta species were low in the Caspian Sea and Black Sea.

Nasrollahzadeh (2008), Roohi (2009), and Ganjian *et al.* (2010) reported different number of phytoplankton species (96, 142, and 163 species) in the southern Caspian Sea in 2005. However, there were no significant variations in species number in this study (Tables 2 and 3). Based on the findings, they were almost similar to those reported by Dumont (1998) which was 71 species during 1990s, and Makaremi *et al.* (2006), 53 species during 1997-1999 in the Caspian Sea.

The average species diversity index of phytoplankton community was at 1.88 throughout the study period (Fig. 2).

Moncheva *et al.* (2001) and Islam (2008) noted that there was a negative correlation between species diversity index and marine pollution, for which they suggested a categorization. According to this classification, the coast of the Caspian Sea is moderately polluted. The low species diversity index and evenness in 1996-1997 and 2001 (Fig. 2) could be related to the blooming of the diatom *Thalassionema nitzschioides* and the dinoflagellate *Prorocentrum cordatum* in the southwestern Caspian Sea (Bagheri, 2012 and 2014).

CONCLUSION

This study documented the checklist of phytoplankton taxa in the Iranian waters of the Caspian Sea during 1996-2010 and attempted to consider variation of phytoplankton taxa. The study revealed that diatoms (70 taxa), cyanophytes (31 taxa) and dinoflagellates (29 taxa) dominated in the Iranian waters of the Caspian Sea. Further studies specifically focus on the effects of environmental degradation on phytoplankton community should be given high priority in the immediate future.

ACKNOWLEDGMENTS

We are appreciative to Peter C. Boyce for improving the English of the draft manuscript. We would like to express thanks to the Inland Waters Aquaculture Institute and Iranian Fisheries Research Organization (IFRO) for financial supporting the survey. We really welcome the help of T. Mohammadjani, M. Makaremi, O. Heidari, J. Sabkara, and F. Madadi in this study.

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چک لیست گروه های فیتوپلانکتونی در آبهای ایرانی دریای خزر

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تاریخ دریافت: 91/9/5 - تاریخ پذیرش: 92/2/21

چکیده

ترکیبات گروههای فیتوپلانکتونی در 12 ایستگاه در سواحل ایرانی دریای خزر بین سالهای 1375 و 1389 بررسی گردید. در این مطالعه 158 گونه فیتوپلانکتون شامل، diatoms (70 گونه)، dinoflagellates (23 گونه)، chlorophytes (29 گونه)، cyanophytes (31 گونه) و euglenophytes (5 گونه) شناسایی گردید. گونه های غالب شاخه diatoms از گونه *Thalassionema nitzschioides*, *Dactyliosolen fragilissimus* و شاخه dinoflagellates از گونه *Prorocentrum cordatum* و شاخه cyanophytes از جنس *Oscillatoria* sp. بودند. مطالعه نشان داد، میانگین شاخص تنوع گونه ای در اجتماعات فیتوپلانکتون 1/88 بود. تغییرات عمده ای در ترکیبات فیتوپلانکتون در مقایسه با مطالعات پیشین مشاهده گردید، این تغییرات می تواند در ارتباط با فعالیتهای شدید انسانی و ناهمسانی در استراتژی نمونه برداری ها باشد.

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