Supplementary Material

1. **Supplementary Tables**

**Table S1:** References for the construction of the graphical summary shown in Figure 1
\* MLD is highly variable depending on how it is defined.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tropical ocean Summer | Tropical ocean Winter | Southern Ocean Summer | Southern Ocean Winter |
| Limiting environmental factor | Nitrate or Phosphate(Tyrrell, 1999; Moore et al., 2001; Aumont et al. 2003; Moore et al., 2013; Arteaga et al., 2014)  | Nitrate or Phosphate (Arteaga et al., 2014) | Iron (Moore et al., 2001; Boyd and Ellwood, 2010; Venables and Moore, 2010; Moore et al., 2013) | Light (Boyd and Ellwood, 2010; Venables and Moore, 2010) |
| MLD\* | < 50m (Kara et al., 2003; de Boyer Montégut et al., 2004) | < 100 m (Kara et al., 2003; de Boyer Montégut et al., 2004) | < 150m (Kara et al., 2003; de Boyer Montégut et al., 2004; Boyd et al., 2008; Dong et al., 2008; Buongiorno Nardelli et al., 2017; Mtshali et al., 2019)  | > 100m and can be much deeper (>500m) around ACC (de Boyer Montégut et al., 2004; Boyd et al., 2008; Dong et al., 2008; Mtshali et al., 2019) |
| Downwelling Irradiance | High (Bouvet et al., 2002) | High (Bouvet et al., 2002) | High (Bouvet et al., 2002) | Low (Bouvet et al., 2002) |
| Macronutrients | Low (Louanchi and Najjar, 2000; Dong et al., 2008; Moore et al., 2013) | Low (Louanchi and Najjar, 2000; Moore et al., 2013)Deepening nitracline (Herbland and Voituriez, 1979; Cullen, 2015) | High (Louanchi and Najjar, 2000; Dong et al., 2008; Moore et al., 2013) | High (Louanchi and Najjar, 2000) |
| Iron | High (Parekh et al., 2004; Tagliabue et al., 2012; Fitzsimmons et al., 2013; Sedwick et al., 2015) | High (Bergquist and Boyle, 2006) | Low with small ferricline across mixed layer (Parekh et al., 2004; Tagliabue et al., 2012) | Replenished mixed layer from winter mixing (Tagliabue et al., 2014; Mtshali et al., 2019) |
| Phytoplankton | High with SCM present above pycnocline (Cullen, 1982; Yoder et al., 1993; Ma et al., 2014; Cullen, 2015) | High with SCM present above pycnocline (Cullen, 1982; Yoder et al., 1993; Ma et al., 2014; Cullen, 2015) | Low, SCM presence not determined by macronutrients (Mitchell et al., 1991; Yoder et al., 1993; Holm-Hansen and Hewes, 2004; Uitz et al., 2006; Ma et al., 2014; Cullen, 2015) | Almost no growth (Mitchell et al., 1991; Yoder et al., 1993; Venables and Moore, 2010; Ma et al., 2014; Ardyna et al., 2017) |

**Table S2:** Evidence of the SCM formation mechanisms discussed in this Review from 18 key studies.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Paper** | **Months** | **Year** | **Region** | **Mechanisms** | **SCM Depth** | **Evidence** |
| Tripathy et al. (2015) | Feb | 2011 | PFZ | Deep diatom-dominated communities | Below pycnocline | HPLC pigments show increasing fucoxanthin with depth.  |
| Parslow et al. (2001) | Dec-March | multiple | PFZ | Deep diatom-dominated communities | Below pycnocline | HPLC pigments show increasing fucoxanthin with depth. Microscopic analysis confirmed dominance (70-80%) of diatoms in SCM compared to the upper mixed layer (30%) in March 1998. |
| Gomi et al. (2007) | Nov-March  | 2001 | SIZ | Sea-ice retreat | Above pycnocline | Microsocopic analysis coupled with visual sea-ice observations. Sea-ice algae is found in a bloom that occurs after melt, where a SCM is formed. |
| Mikaelyan et al. (1995) | Feb-April | 1989 | SIZ | Photoacclimation | Below pycnocline | Increased cellular chlorophyll-a content measured by microscopy, cellular fluorescence intensities and spectrofluorometric determination. |
| Wright and Van Eden (2001) | Jan-Mar | 1996 | POOZ | Eddies | Below pycnocline | Co-located SCM with center of a cold-core eddy and a warm-core eddy. |
| Erikson et al. (2016) | Feb-March  | 2016 | SIZ | Shelf subduction | Below pycnocline | Glider profiles taken from onshelf to offshelf transects. The fluorescence signal moves along isopycnals into winter waters, developing a SCM below the pycnocline. |
| Rembauville et al. (2016) | Jan-Feb | 2014 | PFZ  | Photoacclimation | Below pycnocline | Increased chlorophyll-a to particulate organic carbon in transition layer compared to the upper mixed layer. |
| Rembauville et al. (2016) | Jan-Feb | 2014 | SAZ | Photoacclimation | Above pycnocline | Increased chlorophyll-a to particulate organic carbon in transition layer compared to the upper mixed layer. |
| Armand et al. (2008) | Jan-Feb | 2005 | PFZ | Deep diatom-dominated communities | Below pycnocline | Increased, BSi, Fucoxanthin and diatom counts in microscopic analysis within the SCM compared to the upper mixed layer. |
| Bathmann et al. (1997) | Oct-Nov | 1992 | PFZ | Deep diatom-dominated communities | Undetermined | Microscopic analysis identified a subsurface bloom dominated by three diatom species. |
| Westwood et al. (2011) | Jan-Feb | 2007 | PFZ | Deep diatom-dominated communities | Below pycnocline | HPLC pigments show increasing fucoxanthin with depth which is supported by microscopic analysis.  |
| Clementson et al (1998) | Jan | 1990 | SAZ | Eddies | Above pycnocline | Deep mixing associated with a warm-core eddy produced a localised, strong SCM above the pycnocline with nitrate stripped from the surface.  |
| Daly et al. (2001) | Jan | 1996 | SAZ | Eddies | Below pycnocline | Particulate organic carbon accumulation at 120-160m at the center of a warm-core eddy |
| Whitehouse et al. (2008) | Dec-Jan  | 2004 | SOI | Iron fertilisation by land mass | Below pycnocline | Silicate is stripped from the surface and a SCM forms above the pycnocline, at the location of the silicline. |
| Kopczynska et al. (2001) | March-April | 1998 | PFZ | Deep diatom-dominated communities | Below pycnocline | Microscopic analysis identified that the highest concentration of diatoms is at the SCM |
| Armand et al (2008) | Jan-Feb | 2005 | SIO | Deep diatom-dominated communities | Below pycnocline | Increased, biogenic silica, fucoxanthin and diatom counts in microscopic analysis within the SCM compared to the upper mixed layer. |
| Gomi et al. (2010) | Feb-March  | multiple | PFZ | Deep diatom-dominated communities | Below pycnocline | Microscopic analysis revealed diatom dominance at the SCM |
| Cailliau et al. (1999) | Feb-March  | 1994 | SIZ | Sea-ice retreat | Above pycnocline | Chemeotaxonomic analysis of pigment ratios to determine selective sinking by degradation products. |
| Cailliau et al. (1999) | Feb-March  | 1994 | SIZ | Deep diatom-dominated communities | Below pycnocline | Chemeotaxonomic analysis of pigment ratios to determine selective sinking by degradation products. |
| Gomi et al. (2007) | Nov-March  | 2001 | SIZ | Deep diatom-dominated communities | Below pycnocline | Microscopic analysis revealed diatom dominance at the SCM |
| Wright and Van Eden (2001) | Jan-Mar | 1996 | SIZ | Deep diatom-dominated communities | Below pycnocline | CHEMTAX analysis |
| Fiala et al. (1998) | Feb-March  | 1994 | ACZ | Deep diatom-dominated communities | Below pycnocline | Microscopic analysis revealed diatom dominance at the SCM |
| Quilty et al. (1985) | Feb | 1982 | ACZ | Deep diatom-dominated communities | Below pycnocline | Echogram and microscopic analysis revealed the aggregation was diatom dominated |
| Westwood et al. (2011) | Jan-Feb | 2007 | SAZ | Eddies | Above pycnocline | SCM in center of eddy above the pycnocline. Iron concentrations were elevated within the eddy. |

1. **Supplementary Text**

**Text S1**: Derivatives of “subsurface chlorophyll-a maxima” used in the literature search

* Subsurface chlorophyll maximum
* Subsurface chlorophyll-a maxima
* Subsurface chlorophyll-a maximum
* Deep chlorophyll maxima
* Deep chlorophyll maximum
* Deep chlorophyll-a maxima
* Deep chlorophyll-a maximum